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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

HOW TO START MANUFACTURING INDUSTRIES

Technological and Investment Perspectives

Volume II

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

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* International Standard Industrial Classification number

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ISIC 3118

MINI WHITE SUGAR MILL */

Introduction

This mini white sugar mill employs the technology to acquire, with relatively small energy requirements largely met by the mill's own by-products.

Production process

The incoming raw material, sugar cane, is weighed and fed manually to the cane carrier.

This conveys the cane to the levelling and cutting station, where two sets of knives cut the cane into small pieces suitable for milling.

At the milling tandem, the cane is crushed. The juice goes from here to the clarification station, while the residue, bagasse, is sent to the boiler station to be used as fuel. The steam produced by the boiler drives the turbines and the exhaust is used for boiling purposes.

The freshly crushed juice is warmed and moved to the juice treatment tank, where sulphitation takes place. Sulphur dioxide gas and lime solution are used to help precipitate out impurities.

The treated juice is then reheated and moved to the settling tank. After settling, the clarified juice is separated out for further processing, while the settled mud is sent to filter presses.

The juice obtained from the filtration process is sent for reprocessing, and the residual mud is weighed and sent out for use as manure.

Meanwhile, from the clear juice obtained from the settling tank, a concentrated syrup is prepared. This is done under vacuum, in triple effect evaporators.

This concentrated syrup is further concentrated in vacuum pans, where the bulk of the crystallisation takes place. This process is completed in the crystallisers.

From the crystallisers, the massecuite is fed to centrifugal machines, where the sugar crystals are separated from the mother liquour.

The sugar crystals thus obtained are dried on the hopper and are ready for bagging or packing.

The mother liquour, meantime, is sent back for recrystallisation.

The recrystallisation process yields both sugar crystals and molasses with a high content of fermentable material. The molasses thus obtained makes an ideal raw material for a distillery.

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*/ This information was prepared for UNIDO by Shree Gopal International, India. Inquiries should be sent to: IO/COOP, Registry file No. ID562/12, UNIDO, P.O. Box 300, A-1400 Vienna, Austria.

Typical specifications of single-sulphitation sugar

Polarisation S	99.0	±	0.2
Moisture (%)	0.10	±	0.02
Sulphated ash (%)	0.12	±	0.01
Reducing sugar (%)	0.09	±	0.01

Note: This are average results. Actual results may vary from plant to plant, depending on climate, soil conditions and the variety of cane used.

Production capacity

Cane crushing capacity	350 T/day
Working days in a year	240
Annual sugarcane requirement	84000 tonnes
Gestation period to achieve 100% utilisation of capacity	3 seasons

Land requirement

(a) Agricultural land, assuming an average yield of 60 tonnes of sugar cane per hectare and a 3-year cropping cycle.

For one year's operation	1400 hectares
Total agricultural land	4200 hectares

(b) Factory, warehousing, water storage and other utilities — 6 hectares

Power

Total power required — 450 kwh (generated by 500 kw turbine)

Fuel

Bagasse (produced as by-product of crushing operations	105 T/day approx.
OR furnace oil	25 T/day

Water

For plant operations, excluding agricultural purposes — 570 m^3/day

Personnel

Requirements based on MSM model for plant and machinery and assuming availability of trained technical personnel; actual requirements may vary slightly.

General manager	1
Chief engineer	1
Chief chemist	1
Engineers	4
Chemists	7
Skilled workers	102
Unskilled workers	184
Total	300

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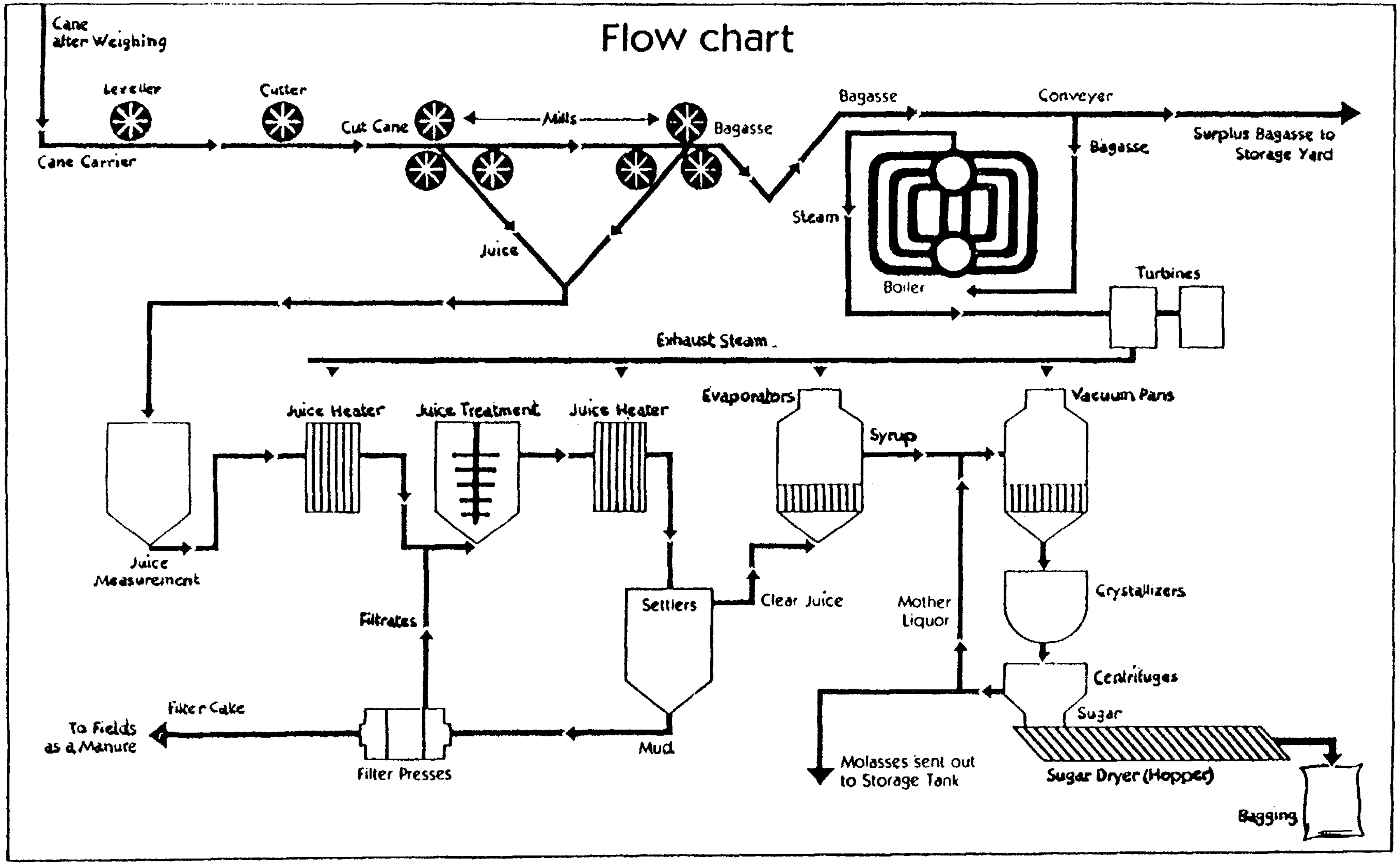

Cost of plant and machinery

F.O.B. (Bombay, India), cost of the above mill is approximately $US 3.5 million.

CUBE SUGAR */

Introduction

Sugar cubes have a sophisticated neat look which has gained total acceptance in the hotel and hospitality industry as well as affluent homes. The small scale unit envisaged in this profile is one which can be ancillarised to a local sugar refinery. the man-power requirements being small and the inherent compactness of the plant and machinery lend themselves for a low investment, high turnover business.

Process

High grade refined sugar is taken to the mixer platform where arrangement to moisten the refined sugar with sugar syrup or distilled water is made. The sugar is made ot pass through a set of rolls, which breaks up the lumps, if any. The sugar mixer consists of a revolving intertupted screw which thoroughly mixes up the syrup/water with the sugar and ensures uniform consistency. This moist sugar is conveyed by the screw conveyor into the inlet chute of the cube making machine. In order to mix the sugar thoroughly and break the lumps, if any formed, the moist sugar is taken into a specially designed mixer installed at the top of the cube making drum. From this mixer the sugar is delivered by gravity to the sugar cube making machine.

The cube making machine (drum) is provided with a number of cubical shaped pockets throughout its circumferential surface. These pockets are filled by gravity with the moist sugar as the drum revolves. A stationary pressure plate is located slightly below the centre of the cylineer against which the sugar is compressed by outward movement of the plungers. Sufficient pressure is applied so that when the cubes are discharged at the lower side of the drum, they are sufficiently hard to retain their shape.

The cubes are dried in a drying oven. After ensuring that the cubes are adequately dried and have the desired hardness, they are ready for packing, as required.

Specifications of the plan

Capacity of the plant	4 to 7 tonnes/day
Size & weight of the cubes	
Size	Weight
(a) 16 mm x 16 mm x 16 mm to 17 mm	4.25 grams
(b) 17 mm x 17 mm x 17 mm to 18 mm	5 grams
(c) 18 mm x 18 mm x 18 mm to 19 mm	6.4 grams
Number of cubes per hour	50,000 to 1.08.000 depending upon the speed of the machine
Size of the cube tray	495 mm x 270 mm

*/ This information was prepared for UNIDO by Shree Gopal International, India. Inquiries should be sent to: IO/COOP, Registry file No. ID562/12, UNIDO, P.O. Box 300, A-1400 Vienna, Austria.

Number of trays	800 per oven
Power requirement	125 kW - 50 cycles - 440 volts AC supply
Distilled Water requirement	100 gallons per day.

Cost of plant and machinery (F.O.B. Bombay, India) : $ US 300,000.

GARI PRODUCTION

(prepared 1979)

Gari, a dried cassava product, is an important carbohydrate food consumed in particular in West and Centrel Africa. The production process described in this profile involves washing and peeling the tubers, which are then grated and subjected to fermentation, before being dewatered, cooked and dried. The plant uses about 18 tonnes of tubers per day, producing 800 tonnes of gari per year of 250 working days. It provides employment for 54 persons in single shift working. The initial investment is almost $ 2.5 million.

1. PRODUCT DESCRIPTION

Gari is the name given to a dried cassava product. Grating and fermenting the washed and peeled tubers are essential stages in the process before drying.

It is a very important carbohydrate food consumed in most West African and Central African countries and is a main article in the diet of about 100 million people.

As normally prepared it is a straw-coloured, coarse-textured meal. It has usually a characteristic acid odour. At normal moisture levels (8 to 10%) it keeps well at ambient temperature for several months. When kept at higher moisture levels mould growth and unacceptable off-flavours develop.

Gari is usually cooked with boiling water into a thick paste or dough and used as a side dish with a meat, fish or chicken stew. It is also made up into a thick suspension in cold water with added sugar and supped with spoon or drunk as a beverage.

The preparation of gari has been traditionally done in most African societies by women and girls but in the last few decades it has become a much disliked household task, especially by the younger. Attempts to mechanize the process have been attempted at different times but it was only in the early 1960's that serious sustained research was done on it by the Federal Institute of Industrial Research, Oshodi, NIgeria. With this work as a basis later collaboration between the FIIR and a British firm of engineers resulted in the development of an industrial process with suitable machinery for gari manufacture.

Any inquiry about the information contained should be sent to: IO/COOP, Registry file NO.ID/562/12, UNIDO, P.O. Box 300, A-1400 Vienna, Austria.

Gari produced by this method on the plant designed for it is indistinguishable from gari produced by the traditional method. Patents are held by the engineering company in respect of different parts of the plant.

2. LOCATION

Gari processing plants could be established at suitable sites throughout the West African countries from Gambia to Cameroun and even to Zaire.

Commercial plants, including two very large ones, are already operating successfully in several of these countries, especially in Nigeria and Guinea.

3. Description of technology

The main stages in the process can be briefly described as follows:

(a) Washing and peeling the tubers

After harvesting washing the tubers is normally done in cold water in galvanised iron tanks made for the job or in large plastic baths. Adhering soil and other dirt can be readily removed by brushing the tubers with a stiff brush.

Peeling can be done manually with sharp steel knives and, in labour-intensive plant, this would be the preferred method. Surface blemishes, protuberances, or small holes can be dealt with at the same time.

A method of mechanical removal of the skin (strictly speaking, the cortex) by abrasion on a carborundum plate rotating at the bottom of a special vessel has been developed. But to obtain complete removal of the cortex and to deal with surface blemishes it may be necessary to remove up to one-third of the substance of the tuber - an economically unsatisfactory position.

(b) Grating the peeled tubers

This is done mechanically on rotary graters and presents no significant problems. The degree of fineness of the grated particles can be varied within limits by adjustments to the grater. This is important since the degree of fineness of the finished gari can be an important factor in consumer acceptance.

(c) Fermentation

This process is of fundamental importance for the development of the highly-valued sharp flavour of the finished gari. Much research on the microbiology of the process has been done and different micro-organisms have been isolated from the fermenting material and are believed to have some part in the final flavour. Both lactic acid and acetic producing organisms appear to be involved in the process.

In the process now being described the fermentation takes place in a stainless steel fermentation vessel. As in the traditional process this takes place at ambient temperature (28 to 30° C) for a period of 48 to 72 hours.

(d) Pressing (or dewatering)

This process involves the removal of the liquid material which has been produced from the grated cassava particles during the fermentation process.

(e) Cooking and drying

It is now recognised that one of the critical factors in the production of gari of the desired consistency and swelling properties is the degree of gelatinisation of the starch granules. Virtually all the granules have to be gelatinised and this stage is carried on in the cooking operation.

The gelatinised gari is then transferred to the separate drying vessel for drying at a slow rate. Both the cooking and drying vessels are fitted with screw stirrers to maintain the material in constant movement during these stages of the process.

(f) Packaging

Normally large cotton bags are used for packing the dry gari for transportation to wholesalers. In turn they transfer it in weighed quantities into flexible heat-sealed plastic containers for retail sale.

4. LEVEL OF OUTPUT

In the notes which are developed for investment and other costs in the next section one of the plants available commercially is used as a basis of calculation. This plant utilizes 2240 kg. of raw cassava tubers per hour and produces 400 kg. of finished cassava (at 8 to 10% moisture) per hour. It is assumed that the plant would work 250 days per year with an 8-hour working day.

5. EMPLOYMENT

Manager 1, Administrative and office staff 5, Shift Supervisors 2, Process operators 8, Quality Control staff 4, Labour (mainly for tuber cleaning and peeling) 24, Engineering staff 6, Drivers 4, making a total of 54 persons.

It should be noted that this total does not take into account staff who would be involved in the actual agricultural operations. It further assumes that the total of about 18 tonnes of cassava tubers due to be processed each day are within easy reach of the factory and are loaded on to the lorries by the agricultural labour force.

No provision is made for labour used in the operation of any sewage disposal plant in use.

The following rates of pay have been used in the economic evaluation (mid 1978 prices):

(i) annual rates: Manager $ 7000, executive office $ 4500, clerk (2) $ 2500, supervisor (2) $ 4500, senior quality control staff $ 4500, junior quality control staff (3) $ 3500.

(ii) daily rates: typist (2) $ 7, process operators (8) $ 7, craftsmen (6) $ 10, driver $ 6, unskilled labour (24) $ 3.

6. ECONOMIC ANALYSIS

A. INVESTMENT COST

Fixed investment

Item	Local cost $	Imported cost $	Total $
Land, incl.agricultural land	20,000		20,000
All civil work incl. site preparation	550,000	120,000	670,000
Plant and equipment	150,000	780,000	930,000
Freight and insurance	15,000	310,000	325,000
Installation costs	35,000	130,000	165,000
Transport	40,000	100,000	140,000*
Contingencies at 10%			225,000
Total			2,475,000

* This item is assumed to be repeated at end year 5 and end year 10.

B. ANNUAL OPERATING COSTS	$	Total $
(i) Materials:		
Cassava tuber	89,600	
Detergents	4,000	
Packaging	13,000	
Boiler water treatment	10,000	116,600
(ii) Wages and Salaries:		92,500
(iii) Water and Fuel:		
Electricity	60,000	
Process water	15,000	
Fuel for steam	12,500	87,500
(iv) Motor transport		
Fuel and oil	40,000	
Insurance	15,000	
Servicing	5,000	
Spares	20,000	80,000
(v) Repairs and maintenance: (5% installed plant and equipment)		71,000
(vi) Overheads:		
1% fixed capital	24,730	
5% working capital	2,885	27,615
		475,215

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C. Working Capital 12% annual operating costs	57,026	
D. Residual Value after 15 years 10% of the equipment value and on transport of material		153,500
50% of land and civil owrks		375,000
		528,500

E. EVALUATION (values in US $)

This is based on 15 year operating life, a 3 year build up to full capacity production, and a residual value for land, guilding and equipment. Fixed investment is 2,475,000 including for the pre-investment expenses. Working capital, 57,026, is taken in 3 instalments. On year 1 : 19,010; on year 2 : 19,008; on year 3 : 19,008. The residual value, 528,500, and working capital 57,026, are returned in the 15th year of operation.

Thus, production costs build up as follows:

	Year 1 (1/3)	Year 2 (2/3)	Year 3 (full)
Materials	38,866	77,734	116,600
Wages and salaries	92,500	92,500	92,500
Fuel and water	29,167	58,333	87,500
Motor transport	48,000	64,000	80,000
Repairs and maintenance	23,667	47,333	71,000
Overheads	27,615	27,615	27,615
	259,815	307,515	475,215

The following are the results of NPV analysis :

Discount Rate	Present value of total costs	Annual revenue required	Revenue required per kilo
10%	5,783,027	860,101	1.07
20%	4,482,229	1,153,038	1.44
30%	3,833,970	1,498,815	1.70

DECORTICATION OF GROUNDNUTS AND MILLET/SORGHUM

(prepared 1979)

Decortication of both groundnuts and millet/sorghum is considered in one decorticating machine. A scale of 1 tonne/hr of paddy or 2 tonnes/hr of groundnuts is viewed. Total employment is seven people; the total investment required is US $ 40,000.

1. TECHNOLOGY

A machine is used for decorticating both groundnuts and millet/sorghum. The machine was designed, and has been built and field tested specifically for husking paddy, as a decorticator. Breakage of rice and groundnuts during decortication has been very low indeed; the husks and shells come off cleanly and are separated by a flow of air and are blown aside. Breakage is low, power consumption is also low and little heating of the grains or nuts occurs. Tests have not been made on millet or sorghum on the full-scale machine because they have not yet been available in sufficient quantity at the machine. Laboratory-scale tests indicated that millet could be decorticated with the same material.

Primary decorticating (shelling) of groundnut pods has traditionally been done by hand, one by one; a tedious process and a bottle-neck in the farmer getting the shelled crop fresh to the market. Hand-operated machines have been in use for years in some countries, a swinging bar and screen mechanism. The fact that they are by no means universal indicates that they have their limitations and hand decortication remains common. Power-operated decorticators have also been built in the past, and appear to have died out.

Groundnuts normally have high oil content, one reason for growing them. The oil extracted is edible, and the residual cake is a stock-feed concentrate.

To offset the very high cost of almonds, pistachios and hazelnuts, all extremely labour-intensive crops, a low-oil content groundnut has been bred for use in the confectionary trades to replace nuts traditionally used. For confectionary purposes, these nuts must be shelled without being broken in the process. Having a low oil content, they can be cooked in oil, at a controlled temperature and evenly browned. They have then the suitable quality to replace the traditional confectionary nuts.

Secondary decorticating removes the brown skin of the nut. Nuts are usually marketed raw, with this skin intact. The skin falls off when

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the nut is grilled or roasted and it can be removed by aspiration.

No machines appear to be on the market which have a large hourly capacity, say half a tonne of white nuts an hour, and able to carry out the two decorticating operations in succession, and without breaking the nuts. Machinery now in an advanced stage of development for primary and secondary decortication of paddy and rice has been laboratory tested with groundnuts in the shell. The machine settings had to be considerably altered to cope with the nuts but white nuts did emerge unbroken and free of shells and brown skins.

2. LOCATION

Groundnuts are mainly a cash crop with a large proportion being exported after shelling, that is, after the first of two decorticating processes. Unlike paddy, groundnuts grow on dry soil dependent on rainfall but better yields may be obtained with supplementary irrigation in the drier areas. It is important to dig up the pods and sun-dry them as soon as they are ripe. Shelling should follow soon, but a farm family with a tonne or more of harvested pods has a long task on their hands. Delay in harvesting can lead to development of a fungus on the nuts which is dangerous to livestock and ultimately to men.

A groundnut farmer usually grows his own basic food, maize, as well; the two harvests coincide. The result is that harvesting and shelling the groundnut pods is put off until the maize cobs are harvested and safely stored. Marketing centres and co-operatives, to which the farmers can bring their pods for shelling and sale, are the obvious locations for shelling machinery. The time for shelling is the early dry season so the machines are liable to be idle for most months in a year. Ideally, the marketing centres will also purchase paddy which, properly dried and stored, will keep well for a year or more. If there is no paddy grown in the immediate area, it can be brought in sacks by road for decorticating when the machinery is not needed for groundnuts.

For the groundnuts, the paddy husking machinery is adjusted to deal with the much larger groundnut pods. If the market wants white nuts, the second decorticating process used to whiten brown rice from the husker, can also be adjusted to remove the brown skin, or bran, from the shelled nuts.

3. LEVEL OF OUTPUT

The two-stage decorticators developed for extracting white rice from paddy are designed for a feed of 500 kg of paddy per hour. Two, three or four units can be sited side by side and driven by the same motor or diesel engine.

(a) Groundnuts

The diameter of the small types of groundnuts is about 8 mm, against 2.5 mm for long grain rice. The capacity of the decorticator husker is proportional to the gap between the rollers, so the 1/2 tonne an hour paddy decorticator should have at least double that capacity for small groundnuts and more for the larger variety. There are about 2,200 small variety nuts per kg. The yield of nuts from pods is about 70 percent by weight and a nimble-fingered child might shell 1,000 pods an hour and produce 1 kg of nuts from 1,40 kg of pods. If the family group of pods is 1,000 kg, hand shelling may take about 700 hours. The farmer's options are to use his children's free labour for some months, or to carry say 50 loads of pods, each of 20 kg. to the nearest shelling machine for sale, in the shell, at a slightly lower price per tonne based on the nuts. But he is able to sell his crop as soon as it is harvested and dried, instead of in odd loads of nuts shelled by his children over a period of months. From the national viewpoint, the fresh machine-shelled nuts are of better quality and can be sold some months earlier to earn foreign exchange.

(b) Millet/Sorghum

Crushed, i.e. milled or pounded grain millet, is used for bread-making. Each grain is encased in a very thin brittle shell which is crushed with the starchy contents. The flour is, therefore, gritty and the bread likewise. If the shells could be removed and separated, the contents could be readily milled to flour for bread of better eating quality. Crushed millet is already used to "stretch" imported wheat for bread-making, in millet growing countries.

Attempts have been made to decorticate millet grains, using machinery in rice mills, but apparently without success. The only rice milling machine that might have been successful is the high speed rubber roll sheller, but the impact of the grain between the pair of hard rubber rollers is likely to smash both shell and contents, making separation impossible.

4. EMPLOYMENT

If some paddy decorticators are to be used after the groundnut harvest to shell the nuts, then more decorticators will be needed to cope with the paddy crop throughout the year. Only two men are needed to run a 1/2 tonne an hour paddy decorticator. With the same machine dealing with groundnuts at 1 tonne an hour, another two men will be required full-time for handling the pods, filling sacks of nuts, 700 kg an hour, and disposing of 300 kg of shell an hour, with casual labour for loading nuts, 7 to 10 tonnes a day, onto trucks for export.

The equivalent labour is seven men fully employed at $ 700 a year each.

5. ECONOMIC ANALYSIS

Input: 1 tonne/hour of paddy or 2 tonnes/hour of groundnuts.

A. FIXED INVESTMENT

Fixed investment	$
Equipment	25,000
Land, building and handling equipment	10,000
	35,000
Working capital	5,000

B. ANNUAL OPERATION COSTS

	$
Salaries and wages	4,900
Repairs and maintenance	2,500
Energy	1,000
	8,400

6. EVALUATION (values in US $)

This is based on 10 year operating life, a 3 year build up to full capacity production, and a residual value for land, building and equipment. Fixed investment is 35,000. Working capital, 5,000, is taken in one instalment on year 1. Tne residual value, 5,000, and working capital 5,000, are returned in the 10th year of operation.

Thus, production costs build up as follows:

	Year 1 capacity (1/3)	Year 2 capacity (2/3)	Year 3 capacity (full)
Wages and salaries	4,900	4,900	4,900
Energy	400	700	1,000
Repairs and maintenance	900	1,700	2,500
	6,200	7,300	8,400

The following are the results of NPV analysis:

Discount Rate	Present value of total costs	Annual revenue required	Revenue required per hour of production
10%	84,395	16,037	7.12
20%	70,171	20,612	9.16
30%	61,242	25,710	11.42

FILE: A22
ISIC 3117

PASTA PRODUCTION

(prepared 1979)

This profile deals with the production of pasta in a small factory capable of producing about 150 tonnes per year. The investment cost for this project is about $ 85,000 and 10 people would be employed.

1. PRODUCT DESCRIPTION

Pasta is commonly made by kneading semolina or wheat flour and water. Other substances can be added to modify the pasta. Eggs, gluten and casein are often used to modify the composition of the pasta; spinach, tomatoes and carrots are used to alter the taste. It is possible to use raw materials other than semolina or wheat flour. Using locally available raw materials - such as cassava or maize - would make the importation of smolina or wheat flour unnecessary, and would produce a pasta more adapted to the taste of the local people. This profile concentrates on a long pasta obtained from a laminated pasta cut lengthwise.

3. DESCRIPTION OF TECHNOLOGY

The manufacturing of pasta is basically quite simple, but requires a high degree of cleanliness and perfectly adjusted machines.

The stages involved are:

(a) Raw materials purification;
(b) Kneading and homogenization which takes place in a mechanical kneader;
(c) Pressing and drawing, which gives the pasta the desired shape by pushing it through the dies of a mould. Pressing can be done by a screw press, a hydraulic press, or a three-phase continuous press, which carries out all three operations of kneading, homogenization and drawing.
(d) On leaving the machines the pasta is cooled by ventilation. For long pasta, the pasta is delivered onto rods called "canes", and then taken to the driers.

The equipment needed is as follows:

1 mechanical kneader (trough capacity 25 kg)
1 calendering machine
1 longitudinal cutter
1 cane-loading gear
2 cane-driers (electric)

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(e) Drying evaporates the excess water from the pasta, and must follow immediately after the drawing and pressing phase. There are three phases:

(i) pre-drying - surface evaporation removing 30-35% of water
(ii) softening - pasta is left to re-establish a moisture balance
(iii) final drying - reduces the moisture content to a normal 12-13%
Long pasta is dried in "cane" driers; and

(f) Packaging takes place after the pasta leaves the driers. Carton boxes of about 250 grammes are commonly used.

3. LEVEL OF OUTPUT

The output planned for in this profile is 75kg/hour, or about 150 tonnes per year.

4. EMPLOYMENT AND EMPLOYMENT COSTS

		$
1 Manager	at $ 4,000 per annum	4,000
1 Office clerk	at $ 1,200 " "	1,200
1 Keeper	at $ 720 " "	720
1 Plant Superviser (foreman)	at $ 2,400 " "	2,400
2 Skilled workers	at $ 1,920 " "	3,840
4 Unskilled workers	at $ 720 " "	2,880
10		15,040
	Other Annual Labour Costs:	1,504
	Total Annual Labour Costs:	16,544

5. DATA FOR ECONOMIC ANALYSIS

A. INVESTMENT COST

(i) Fixed Investment:

	$
Machinery and Equipment	40,000
Land and Building ($500m^2$ x \$20; $175m^2$ x\$120)	31,000
Freight and Insurance	6,000
Erection and Start-up Costs	8,000
	85,000

(ii) Working Capital:

	$
Stock and material (3 months)	6,435
Wages and Salaries (2 months)	2,757
	9,192

(iii) Residual Value:

10% of Equipment cost (cif)	4,600
50% of Building cost	15,500
	20,100

B. ANNUAL OPERATING COSTS

		$
(i)	Materials	
	Semolina or flour (130t)	23,400
	Other Ingredients	2,340
(ii)	Wages and Salaries	16,544
	Water and Fuel:	
	Energy (12,000 kw)	480
	Filtered Water	132
(iv)	Maintenance	2,550
	Overheads	1,000
	Total Annual Operating Costs:	46,446

C. EVALUATION (Values in US $)

This is based on a 10 year project life, a 2 year build up to full capacity, and a residual value for buildings and equipment. Fixed investment amounts to $ 85,000. Working capital ($ 9,192) taken in two installments over the first two years, and residual value ($ 20,100) are returned in the tenth year of operation.

Costs build up over the first two years as follows:

	Year 1 (65%)	Year 2 (100%)
Semolina	15,210	23,400
Other Ingredients	1,521	2,340
Wages and Salaries	10,754	16,544
Water and Electricity	398	612
Maintenance	1,658	2,550
Overheads	650	1,000
	$30,191	$46,446

The following are the results of NPV analysis:

Discount Rate	Present Value of Total Costs	Annual Revenue Required for Given Discount Rate	Revenue Required per kilogram
10%	352,673	60,530	0.40
20%	269,113	68,984	0.46
30%	220,995	78,316	0.52

FRUIT PROCESSING AND SOFT DRINKS

1. PREFACE

The manufacture of pasteurized fruit juice has three stages:

- Fruit treatment
- Juice treatment
- Product packaging

Before details can be given, samples of the raw materials must be tested. The results of these tests are important in predicting the performance of the full-scale installation.

The plant is suitable for producing pasteurized juice from citrus-type and mango-type fruits.

After pasteurization, the juice is treated aseptically such that it can be stored for a long period in a tank without suffering any damage.

The juice can be filled into bottles and jars as well as plastic pots.

The equipment and the plant can be easily tailored to suit different requirements, ranging from plants using production methods which require a high proportion of manual work to others equipped with automatic machinery lines which require a relatively small amount of labor.

2. CAPACITY OF THE PLANT

The capacity of the plant for fruit processing and soft-drink production is medium-sized.

Basic materials consumption may be up to 4,000 kg/hour for an output of approx. 3,250,000 kg of finished juice per annum. The capacity of the plant can be increased by increasing the number of shifts.

3. BRIEF DESCRIPTION OF THE PROCESS

The fruit is fed into the brush washing machine. The remaining impurities are then removed by an air-injection washing machine. It then passes to the sorting line where damaged fruit is eliminated.

The citrus fruit is transported to the fruit extraction device, which is connected to the oil separating device and the oil expeller device.

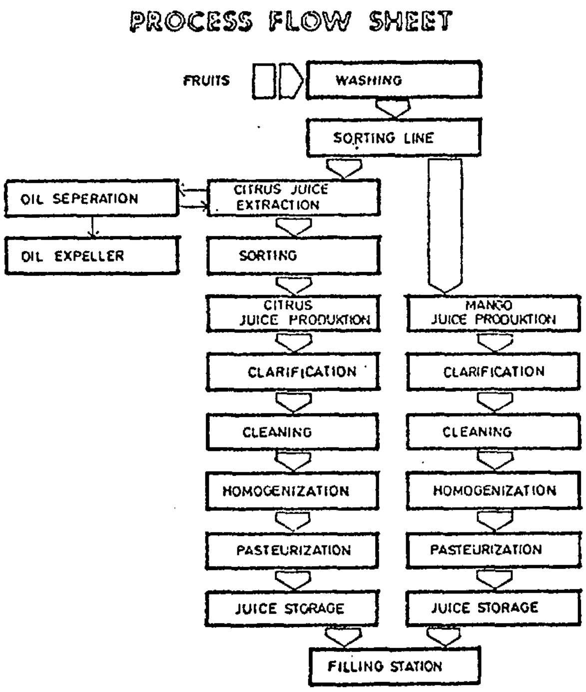
Whole fruits are sorted according to size. After sorting according to size, the fruit passes in groups into the juice maker.

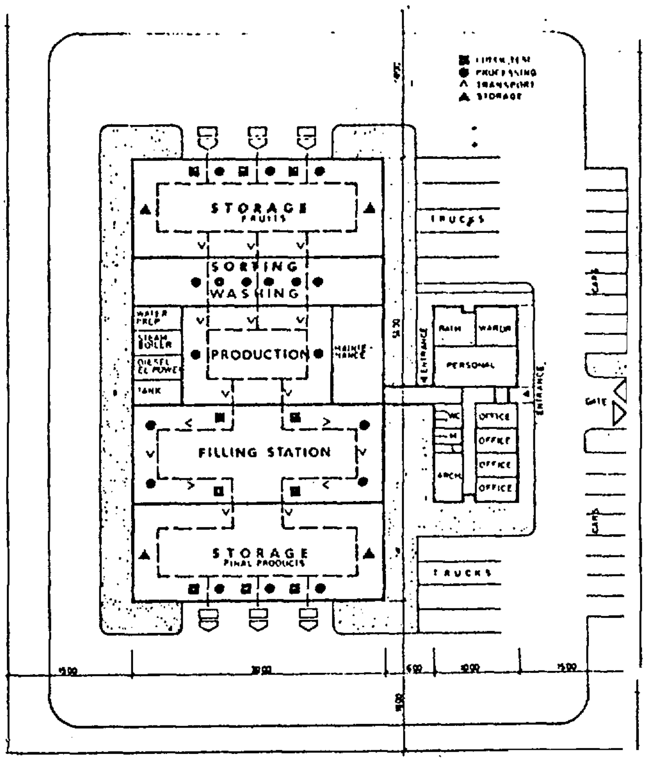
From there the juice is delivered by pump to the clarification device where solid impurities are removed.

Mixed with syrup, the purified fruit juice is pumped to the homogenizer. It passes through a preheater,an aerator and a condenser and is delivered to the homogenizer by screw pump. The homogenizer makes the micro-structure of the juice more homogeneous and improves its quality.

The juice is then delivered to the pasteurizer and pumped in. It is sterilized by being kept for a period at the proper temperature. On leaving the pasteurizer, the juice passes either to the juice store or to the filling and bottling section.

The filling machine fills the juice into bottles, jars or plastic containers





4. REQUIRED BASIC AND AUXILIARY MATERIALS

The quantity of the various materials used depends on the particular product mex and the methods used.

Below are the approximate material requirements of the plant for one year's production:

- Fruits, 300 mm dia. to 106 mm dia.	8,000 tons
- Water (drinking quality)	40,000 Nm^3
- Compressed air, 6 bar	200,000 Nm^3
- Steam, saturated, 6 bar	2,000 tons

- Liquid sugar
- Diesel fuel
- Lubrication oil and grease
- Sealing materials
- Plastic foil
- Various additional materials

5. AREA REQUIREMENTS

Required site area:	6,840 m^2
Required building area	
Production hangar:	900 m^2
Storage hangar:	720 m^2
Office building:	252 m^2

Structural:

Production hangar, storage hangar

Columns and beams	- prefabricated concrete or steel construction
Walls	- corrugated iron sheets, partly brick-lined, tiled
Floors	- concrete, tiled
Roof	- metal sheets on sawtooth roof construction

Office building

Columns and beams	- prefabricated concrete or steel construction
Walls	- bricks, plastered
Floors	- PVC-paved
Roof	- concrete ceiling with metal sheeting

6. MACHINERY AND EQUIPMENT (Estimated total FOB price: approx. $ US 2,900,000)

Description:	Quantity:	Description:	Quantity:
Brush-type fruit washer	1	Automatic equipment	1 set
Air-injection fruit washer	1	Electric fittings and materials	1 set
Fruit sorting line	1	Special tools	1 set
Extraction device	1	Air compressor	1
Oil separation device	1	Filler	1
Oil expeller	1	Pot manufacturing device	1
Fruit sorting device	1	Water preparation unit	1
Juice processor	2	Diesel electric power station	1
Clarificator	2	Steam boiler	1
Cleaning device	2	Lathe	1
Homogenizer	2	Bench drill	1
Pasteurizer	2	Milling machine	1
Process pipeline	1 set	Bench grinder	1
		Mechanic's tool kit	2
		Electrician's tool kit	1
		Tool cabinet with tools	2

7. POWER REQUIREMENTS

Power type:	3 x 380 V, 50 Hz
Built-in capacity:	270 kW
Total power consumption during simultaneous use:	210 kW
Power consumption per year:	420,000 kWh

8. PERSONNEL REQUIREMENTS

Production staff

- Master technicians	3
- Master skilled workers	6
- Skilled workers	6
- Semi-skilled workers	6
- Unskilled workers	23

Management and administration staff

- Plant managers	1
- Technicians	1
- Chemical engineers	1
- Clerical staff	3

Work-time base

Number of shifts taken into consideration:	1 shift per day
Work-time taken into consideration :	8 hours per day
Number of work-days :	250 days per year

The plant is also suitable for operation in more shifts.

Flour Milling Plant

View of Roller Mill

The flour milling is a process in which wheat is first milled into flour and then classified into the endosperm, bran and germ, of which wheat is composed. The most important technology in the flour milling relates to the adjustment of stream and process and the layout of appropriate machines to extract high-purity endosperm to the maximum possible extent.

Particularly, since Korea heavily relies on the import of all required wheat, the flour milling technology has been developed with basic emphasis placed on its yield. At the same time, the flour milling technology has been so attained as to suit the Korean situation with the target of energy-saving effects and reduction of plant construction costs. Its characteristics are summarized as follows:

- High yield and low ash content
- Production of various kinds of flours (ease of changing flours)
- Low plant construction costs
- Ease of maintenance
- Low power consumption

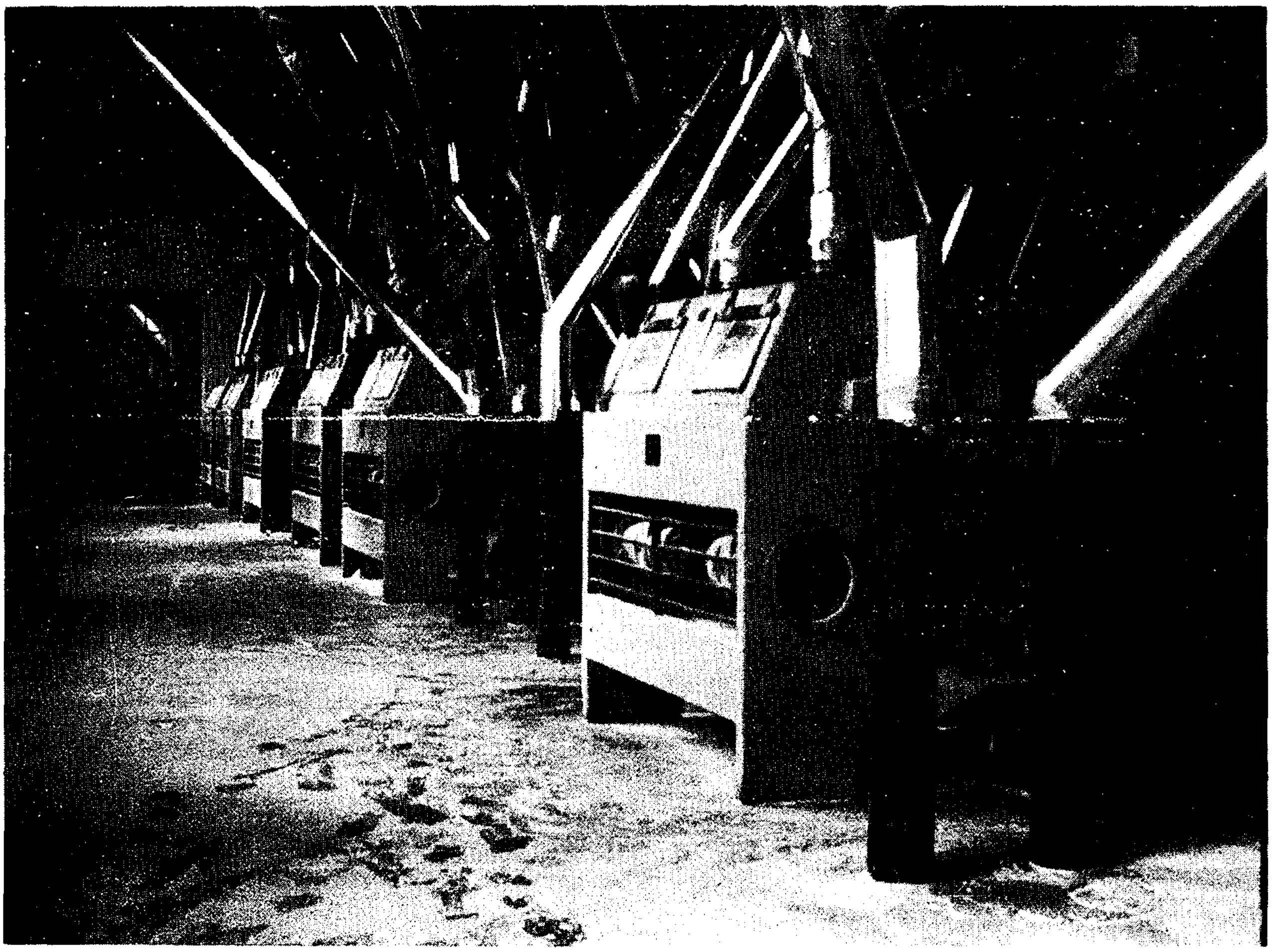
Products and Specifications

In this plant, various kinds of flour products, such as bread flour, medium flour and cake flour, are produced and their specifications are as shown in table 1.

Table 1. Specifications of Flour

Spec. \ Product	Bread flour	Medium flour	Cake flour
Ash	0.45 - 0.52%	0.38 - 0.42%	0.38 - 0.42%
Protein	12 - 13%	8.8 - 9.2%	7.5 - 8.0%
Moisture	14.3 - 14.8%	13.7 - 14.2%	13.4 - 13.8%
Total flour yield	77%	77%	77%
1st grade flour yield	65%	58%	58%
Uses	White bread Spaghetti Macaroni	All purpose chinese noodle	Flying flour Biscuit Spongecake

* By-products : Bran, germ.



View of Purifier

Contents of Technology

1) Process Description

The milling process starts with the unloading of wheat as shown in the following process flow chart. The unloaded wheat is first stored in a silo for prior cleaning. The cleaning process consists of machines removing all impurities contained in the wheat. The wheat undegoes tempering with the addition of water in the first and second tempering bins.

The wheat adjusted with water after tempering is fed into the main process for breaking. It is sifted and extracted of semolina in a purifier, followed by sorting to be refed into the roller mill. By the repetition of such a process and final sifting, the flour, bran and germ are separately extracted.

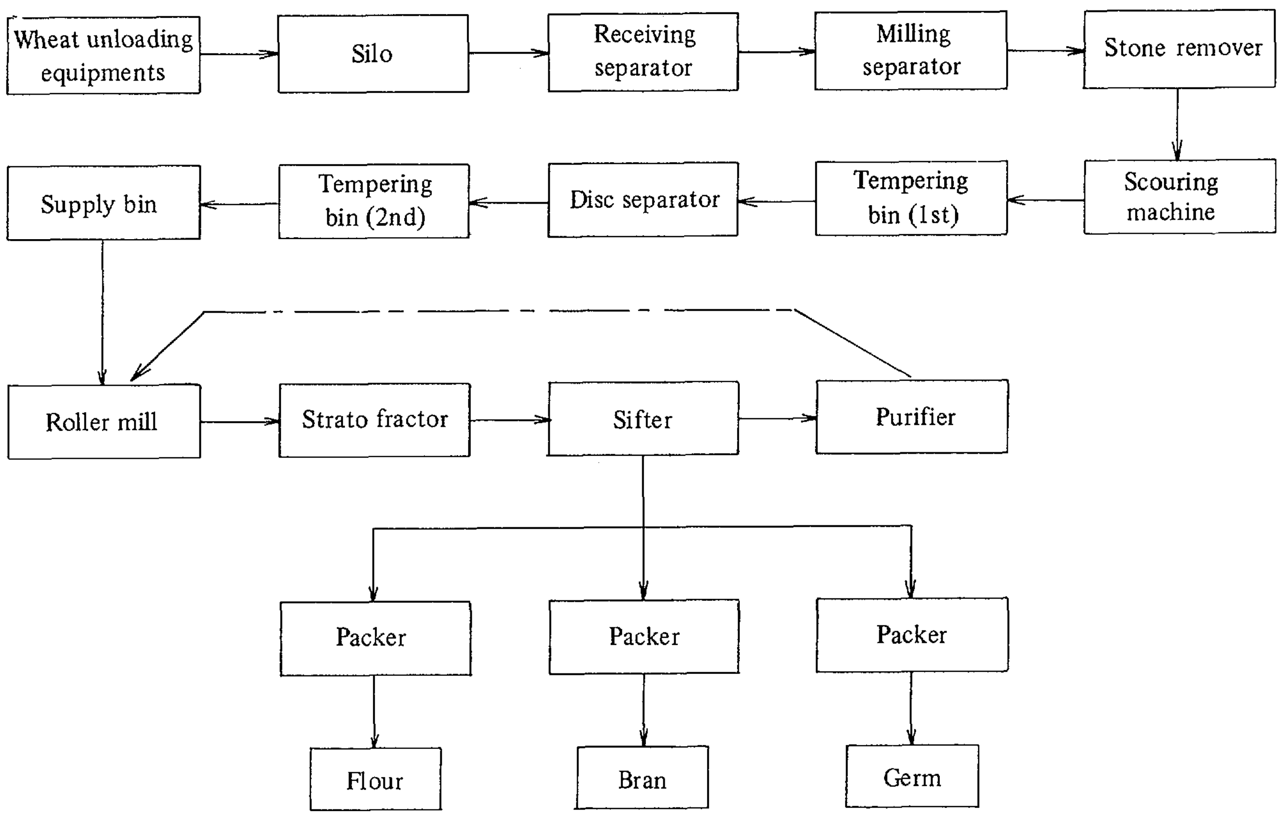
The most important process in terms of flour milling technology in the above process is the technical adjustment of wheat breaking in the roller mill.

The extraction of high-purity semolina will greatly improve the first grade flour yield, while an appropriate arrangement of the process, coupled with optimum stream dividing, will reduce the requirement of machines as well as power cost to a great extent. The current milling technology is summarized as follows:

- Required roll length : 8.5 mm/100kg/24hrs
  (Others : over 25mm/100kg/24hrs)
- Required sifter area : 0.062m^2/100kg/24hrs
  (Others : over 0.15m^2/100kg/24hrs
- Power consumption : 50 kwh/ton (wheat)
  (Others : over 80 kwh/ton)

* Others are examples of America

Flour Milling Process Block Diagram



2) Equipment & Machinery

- Wheat unloading equipment
  - Crane
  - Barge
  - Chain conveyor
- Silo equipment & wheat bin
  - Silo (Concrete)
  - Tempering bin (1st)
  - Tempering bin (2nd)
  - Supply bin
- Cleaning machinery
  - Magnet separator
  - Receiving separator
  - Milling separator
  - Stone remover
  - Disc separator
  - Scouring machine
- Milling machinery
  - Roller mill
  - Sifter
  - Purifier
  - Strato fractor
  - Vibro bran finisher
  - Gyratory sifter
  - Packer
  - Air jet filter
- Transportation equipment
  - Bucket elevator
  - Chain conveyor
  - Screw conveyor
  - Belt conveyor
- Laboratory equipment
  - Test mill
  - Farino graph
  - Extenso graph
  - Amylo graph
  - Protein analyzer
  - Moisture tester
  - Balance weigher
  - PH-meter
  - Muffle furnace
  - Chemical balance
- Maintenance machinery
  - Lathe

Grinder
Drilling machine
Roll fluting & grinding machine
Shaper

Others

Turbo fan
Spouting
Power transmission equipment
Electric power distributing equipment

3) Raw Materials and Utilities

Raw materials and utilities	Requirement (per ton of product)
Soft white wheat (W)	a. Bread flour : 1.3 ton (DNS)
Hard Red winter wheat(R)	b. Medium flour : 1.3 ton (W + R)
Dark Northern Spring wheat (DNS)	c. Cake flour : 1.3 ton (W)
Electric power	65.6 kwh
Process water	65 ℓ
Compressed air	12 m^3

Example of Plant Capacity and Construction Cost

1) Plant capacity : 2,000 BBL (180 m/t/day, flour)
 * Basis : 3 shifts, 24 hours/day

2) Estimated construction costs (as of 1983)

- Equipment and machinery : US$2,000,000
- Utilities : US$ 300,000
- Installation cost : US$1,000,000
- Engineering fee : US$ 35,000
- Test operation fee : US$ 10,000

Total : US$3,345,000

3) Required space

- Site area : 6,500m^2
- Building area : 4,000m^2

4) Personnel requirement

- Plant engineer : 10 persons
- Engineer : 15 persons
- Operator : 75 persons
- Others : 45 persons

Total : 145 persons

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DRY MILLING OF MAIZE

(prepared 1979)

Wet milling of maize is a highly sophisticated and capital-intensive process. Pounding, the traditional small-scale method for the production of meal, on the other hand is very wasteful. This profile describes an alternative small-scale method, dry milling by machine, which greatly reduces waste. The milling capacity is 250 kg. maize per hour (500 tonnes per year); employment is 2 people; and total investment is approximately $ 8,100.

1. INTRODUCTION

Africa produces about 17 million tonnes of maize annually out of a world total of over 300 million tonnes. Egypt and South Africa together account for about 11 million tonnes of the African total and South Africa exports more than 3 million tonnes of its 8 million tonnes a year.

Maize is the dominant cereal crop in East Central and Southern Africa and it is also grown in West Africa. Some form of pounding or dry milling is used to prepare the grains for cooking. Little is fed to animals. Wet milling on the other hand is a highly sophisticated and capital-intensive process which separates out the starch which is sold as corn flour; the yield is 70 per cent of the maize. The remaining 30 per cent is the raw material for cooking oil, adhesives, edible colouring, corn syrup animal feedstuffs, etc. which are by-products of the wet mill.

2. LOCATION

Since maize has been pounded in large mortars to meal for some centuries in Africa, the farmer has to see positive advantages to himself before he carries his maize to a mill. Maize is stored at the farm on the cob and with the sheath still in place. Small silos of timber, mud and thatch are used, proof against rain, minor flooding, rodents and birds.

When required for food, the cobs are stripped and the grains, cleaned of rubbish, are ready for processing. Pounding is not only hard work but wasteful of food. It is usual to pound and then winnow the broken grains to separate out the "peels" (the coating on each grain) and the embryos. The operations are required until the maize left is reduced to a suitable mealiness for cooking. Losses are high and can be as much as 40 per cent if all traces of peel and embryos, as well as some starch, are removed, leaving almost pure white starch.

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The alternative, to carry the maize grains to the nearest mill which may be a two hour walk, 8-10 km there and back, is generally acceptable. The mill should be located so that more than enough maize is grown within a radius of 4-5 km to provide the mill with 2,000 hours work per year. A circle of 5 km encloses nearly 2,000 ha and the yield per ha is likely to be 250 tonnes. Generally, maize fields are small and scattered and the area may in practice only contain 250 ha of maize, yielding 500 tonnes.

Farmers usually live in small villages, surrounded by their fields and grazing areas. The mill should be located in the main village of the area likely to supply maize for milling. This village probably has the best access to the nearest main road for the supply of diesel oil and for transport of surplus meal for sale elsewhere.

3. TECHNOLOGY OF MACHINE MILLING

A great advantage of machine milling over pounding is that the relatively hard and tough peels and embryos are thoroughly broken up and incorporated in the meal, together with the starch. The starch provides calories for energy but the peels and embryos supply oil and protein, giving an almost balanced human food, after cooking. This whole meal does not keep well due to the oil in the embryos going rancid, so a farmer has to go fairly frequently to the mill with his maize.

Machine mills can separate out the peels and embryos which are valuable concentrates for stock-feeding; the fairly pure starch then keeps for longer periods but it has little nutritional value. In view of the deteriorating relation of food production to population in Africa it is desirable that maize mills should produce whole meal. Milled maize is becoming popular and is being productd in increasing quantitites. It can replace the white maize meal preferred by the higher income groups.

The commonest forms of power mills are hammer mills and plate mills. They are single-stage; a stator with an internal power-driwen rotor which pulverizes the grains of maize, the meal escaping through a fine steel or brass screen. The loss, as flour dust, is low, under 1 per cent, a notable improvement on hand pounding.

Mills are on the market for rural use, with hourly capacities ranging from 100 to 1,000 kg of meal. Their power requirement is about 25 HP/hour per tonne of meal. Much bigger capacity mills are built for areas with large quantities of maize surplus to the needs of the growers. Roller mills are manufactured mainly for the production of fine corn-flour. The peels and embryos are discarded and used for stock-feed. Hand-powered maize mills are available, based on a small coffee mill design and therefore requiring much effort.

In view of the cost of fuel there is now a case for making more use of oxen. A pair of small animals can supply about 0.2 HP or more for some hours a day. If they produce 1 HP/hour in a day, this is power enough to mill 40 kg of maize, which will feed twenty people for five days, on a basis of 150 kg a head annually. This is a typical average consumption for a predominantly maize eating people.

4. INVESTMENT COST

A typical hammer or plate mill with a capacity of 250 kg of maize an hour needs about 6 HP to drive it. Operating in daylight hours only, for 2,000 hours annually, it will mill 500 tonnes of maize, the production of about 250 ha.

The cost of such a mill, including its engine, is $ 4,400 f.o.b. A small platform scale costs $ 600 f.o.b. The building and other auxiliary equipment are of local manufacture costing $ 2,000; giving a total investment in local terms of about $ 8,000 including freight and insurance on the mill and platform scale.

5. EMPLOYMENT

With a supply of about 2 tonnes of maize a day to be weighed before and after milling and also fed to the hopper of the mill, not more than two full-time jobs are created.

6. MAINTENANCE

Day to day maintenance of the machinery is of a very minor nature, well within the capacity of the mill staff. A visit from a qualified mechanic with access to spare parts, is desirable once every few months. These mills and engines are designed for minimum attention in rural areas.

7. ANNUAL REVENUE AND OPERATING COSTS

In the rural areas for which these small mills were designed, it is probable that the mill income is in the form of maize or meal at a rate of 10 to 15 per cent of the maize brought to the mill. A 15 per cent milling charge is now more likely on 500 tonnes a year, at $ 110 per tonne worth about $ 8,250.

8. ECONOMIC ANALYSIS

The profitability of a 250 kg/hour maize mill is analysed, using the preceding data.

A. INVESTMENT COST

	$
Fixed investment	
Machinery price f.o.b.	5,000
Freight and insurance	1,000
Building and auxiliary equipment	2,000
	8,000
Working capital	
1 month's wages and salaries	117
Total investment	8,117

B. ANNUAL OPERATING COSTS

	$
Wages and salaries	1,400
Fuel	900
Lubricants	90
Repairs and maintenance	300
Miscellaneous	210
	2,900

C. ANNUAL REVENUE $

8,000

D. EVALUATION (values in US $)

This is based on 10 year operating life and a 3 year build up to full capacity production. Fixed investment is 8,000 including for the pre-investment expenses. Working capital, 117, is taken on year 1. The residual value, 800, and working capital 117, are returned in the 10th year of operatio

Thus, production costs build up as follows:

	Year 1 (1/3)	Year 2 (2/3)	Year 3 (full)
Wages and salaries	1,400	1,400	1,400
Fuel	300	600	900
Lubricants	30	60	90
Repairs and maintenance	100	200	300
Miscellaneous	70	140	210
	1,900	2,400	2,900

The following are the results of NPV analysis:

Discount Rate	Present value of total costs	Annual revenue required	Revenue required per tonne of milling
10%	24,250	4,608	9.21
20%	18,926	5,559	11.11
30%	15,922	6,684	13.36

B

FILE: B6
ISIC 3212

PP Woven Bag Making Plant

The kinds of heavy-duty bags which are being used in Korea at present include paper bags, polyethylene bags and PP woven bags. These bags are respectively used for proper purposes.

Paper bags, which usually have the capacity of packaging 20-30kg, are used for feeding-stuffs, flour, sugar, rice and wheat, as well as for PVC resin or cement which is relatively heavy (40-50kg) packed in paper bags to avoid inconveniences in filling and handling.

Polyethylene bags for 20-30kg capacity are used for packing chemical fertilizers and industrial chemical products which must be protected from moisture.

PP woven bags, compared with paper and polyethylene bags, are strong and suitable for packing and carrying heavy items. It does not tear or break easily by rough handling or transporting. So the PP woven bags are usually used for packing chemical fertilizer, rice and wheat requiring more than 50kg in a bag.

Also, since the raw material for PP woven bag is not a natural fiber as in jute bag and the raw material (PP resin) is manufactured in many countries of the world, it can be easily obtained at any place and at any time.

Due to the good feature of the PP woven bag, it is expected that this bag will be used more widely in the future. Therefore, the market for woven bags will rapidly increase, especially in the field of export industries.

There are two different types of PP woven bag making plants differentiated by weaving methods. One is a plant adopting the flat weaving method, and the other is a plant using the circular weaving method. The plant of latter type, widely adopted in Korea, will be mainly explained here.

Products and Specifications

P.P. woven bags of diverse specifications can be produced in this plant response to orders from customers. Typical specification is as follows:

- Bag size : 20" x 40"
- Yarn denier : 1,000 D
- Mesh : 10 x 10/sq. in.
- Weight : Approx. 100 gr.

Contents of Technology

1) Process Description

The process of woven bag making plant generally consists of three steps: production of yarn, weaving and bag making.

Production of yarn

Polypropylene pellet is charged in the hopper of the extruder, heated, melted and extruded through a die in a form of inflation film. The film is cooled, slitted into predetermined width, then delivered continually to the stretching equipment.

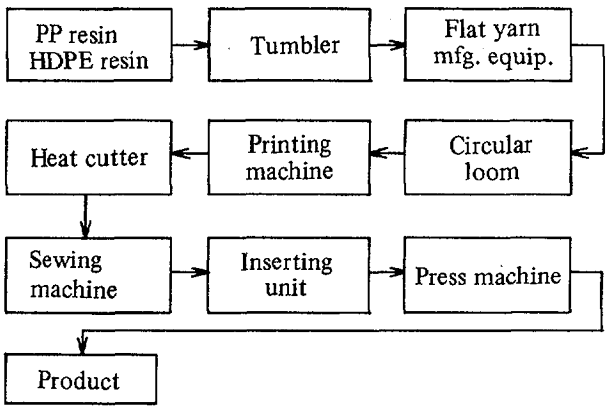
The slitted film is heated by the hot plate of the stretching equipment, stretched by the high-speed revolving roll and formed into a stretched yarn. When left in a free state, the stretched yarn will shrink; therefore, annealing is done. The annealed tape yarn is wound by take-up winder on each bobbin.

Weaving

Bobbins are provided to the creel stand arranged on both sides of the circular loom. The yarn drawn out of the creel stand is set on the loom in a circular shape and is used as the warp.

The pick is set on four shuttles which are inside the loom, and when the loom is operated the shuttles rotate in a circular shape. The pick moves through the warp in a circular shape, and a seamless tube is woven. The woven seamless tube is wound off by a

Woven Bag Manufacturing Process Block Diagram



winder.

Bag making

The seamless woven tube cloth is put through the printing and cutting machines. Printing is done on the face of the seamless tube; then, the tube is heat-cut to the prescribed bag size. The bottom of the heat-cut tube is folded and sewn to obtain the finished woven bag.

2) Equipment and Machinery

Manufacturing equipment
- Tumbler
- Flat yarn manufacturing equipment
- Circular loom
- Printing machine
- Heat cutter
- Sewing machine

Laboratory equipment
- Tensile strength tester
- Chemical balance

3) Raw Materials and Utilities

Raw materials and utilities	Requirement
PP resin	Approx. 1,300 tons
Electric power	305 kwh
Industrial water	24 m^3/day
Compressed air	72 m^3/day

* Estimated for the plant with the capacity, 12,000,000 bags/year

* Standard bag size: 20" x 40"

Example of Plant Capacity and Construction Cost

1) Plant capacity: 12,000,000 bags/year (tublar, bottom sewn)

* Basis a) Bag size: 20" x 40"
b) Yarn denier: 1,000D
c) Mesh: 10 x 10/sq. in.
d) Weight: approx. 100gr.

* Working condition: 24 hrs/day, 300 days/year

2) Estimated equipment cost (as of Dec. 1981)

- o Manufacturing equipment: US$1,154,680
- o Laboratory equipment : US$ 30,000

Total : US$1,184,680

* Utility facilities and tools for maintenance are not included.

3) Required space

- o Site area : 8,100 m^2
- o Building area : 3,040 m^2

4) Personnel requirement

- o Plant manager : 1 person
- o Engineer : 1 person
- o Operator : 110 persons

Tumbler	:	1 person (1/3 person/shift)
Flat yarn mfg. equip.	:	9 persons (3 persons/shift)
Circular loom	:	30 persons (10 persons shift)
Printing m/c	:	6 persons(2 persons/shift)
Heat cutter	:	18 prsons (6 persons/shift)
Sewing m/c	:	42 persons(14 persons/ shift)
Testing equip.	:	1 person (1/3 person/shift)
Maintenance & power service	:	3 persons
Total	:	112 persons

Any inquiry about the information contained should be sent to:
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C

LEATHER PRODUCTION

The hides and skins of wild and domesticated animals have always been treated in some way to serve human beings as clothing. Leather is obtained if the treatment removes the hair and makes the hide or skin resistant to disintegration and above all to putrefaction in hot and humid environments. Such treatment is called tanning.

Materials imparting resistance are called tanning materials and they may be of natural or synthetic origin. Vegetable resins, usually obtained from trees or bushes such as quebracho, mimosa (wattle), chestnut, oak etc., were the first and, up to this century, the most important tanning materials.

Similar in most respects to the vegetable materials, many synthetic tanning materials are also available at present and to these have been added mineral tanning agents, e.g. salts of aluminium, chromium and zirconium.

The chrome salts, and especially the basic chromic sulfate, have in fact gained in importance to such an extent that they are used today for tanning the bulk of the world's hides and skins. Vegetable and synthetic tanning materials are now used mainly to produce heavy leathers (e.g. sole leather) and to retan chrome-tanned leather in order to modify its properties.

Production of heavy leather has lost ground because of the growing use of rubber and synthetics for footwear soles and other "leather goods" products. Many heavy cattle hides, formerly used almost exclusively for heavy leathers, are now processed into light, chrome-tanned leathers.

Several auxiliary materials and chemicals are used in leather production to control processes or impart required properties. Among these materials are wetting agents, acids, alkalies and salts for regulating the pH (level of acidity or basicity), enzymatic bates to digest unwanted hide constituents, fats and oils for softness, aniline dyes for colouring and special products for finishing leather.

The above indicates that the reactions in hides or skins to chemical processes are important for satisfactory leather production, but so are also the mechanical operations needed to reduce and/or equalize the thickness, to regulate the water content or to mechanically adjust the softness of the leather.

In the past many of these operations were performed manually but today almost all are executed with the help of machines. In some caes machines are also essential in order to reach an acceptable leather quality.

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The hides and skins of all kinds of animals of sufficient size may be tanned to leather and most kinds are in fact processed somewhere in the world. However, by far the greatest part of all leather produced is obtained from domestic animals, i.e. cattle, goats, sheep and pigs. It is roughly estimated that annual world production of all types of leather is 1,200 million m^2 (13,000 million ft sq[1/]), more than 80% of which is of bovine origin.

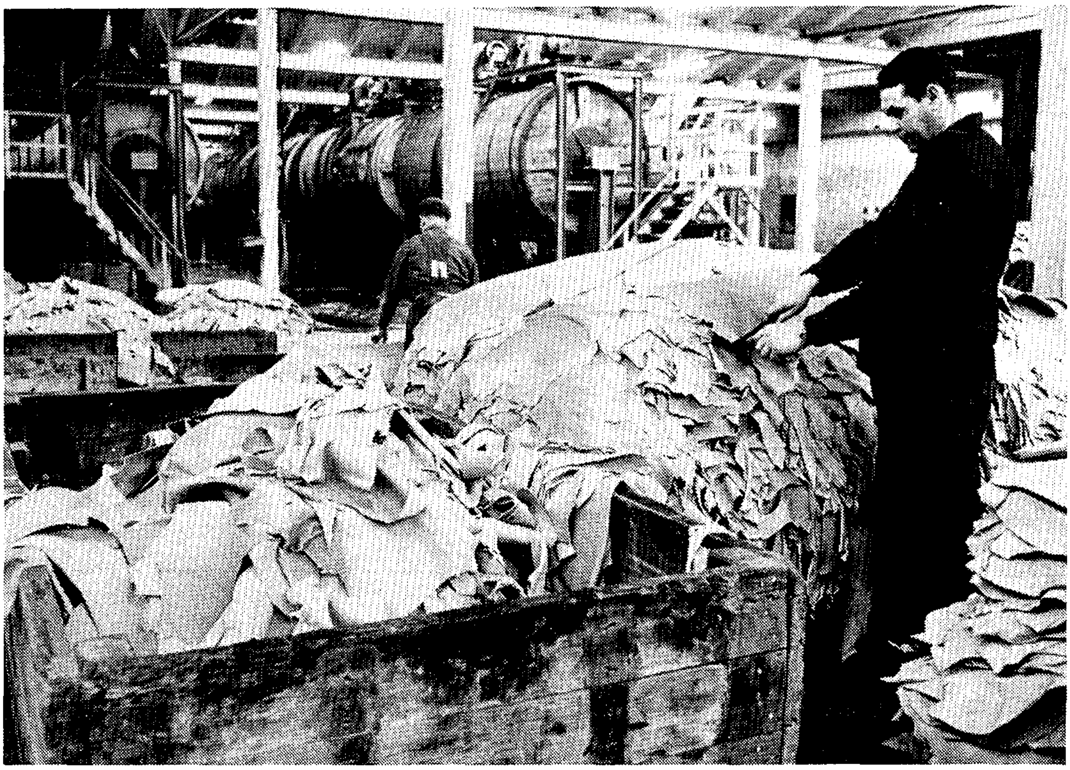
The quality of leather used for varioud purposes fluctuates from year to year because of fashion and price changes in the leather and leather products trade. The footwear industry, however, absorbs the largest quantity of finished leather, most of it as light, i.e. as shoe upper and lining, leather. The remaining part, again mostly light leather, will be used in quantities of more or less the same magnitude for garments, for ladies' handbags and for all other kinds of leather goods combined.

The production of light leather may be divided into three phases: (a) semi-tanned leather - usually in the form of chrome-tanned, wet-blue leather; (b) semi-finished leather - often called crust leather from wet-blue; and (c) finished leather from crust.

Due to the many different kinds, sizes, qualities and types of preserved raw hides and skins and to the many tanning and auxiliary materials, processing methods and equipment used in the tanning industry, there are an almost infinite number of ways to make leather. The following section gives examples of typical, modern tanning practices for 60,000 dried cattle hides (or 50,000 wet-salted cattle hides or 400,000 dried goat skins) per year. Many variations would be possible. A combination of the three phases into a complete finished leather factory is usual, especially after management and operators have gained experience in the first two pfaese.

1/ 1 m^2 = 10.76 ft sq.

WET-BLUE LEATHER*



Developing countries that export raw hides and skins often wish to make better use of this indigenous raw material - often one of the few resources available - by producing leather locally. However, building a complete finished-leather factory could result in economic failure. Entering the international leather market and obtaining a satisfactory price for finished leather are extremely difficult, especially at first. Therefore, finished leather should be produced only if a reliable outlet, providing an adequate price guarantee, is assured.

The production of wet-blue leather does not entail the same risks. Ordinarily it is easy even for a new manufacturer to obtain reasonable prices, since the customer does not need much time to determine whether the product is suitable for his needs. International demand for wet-blue leather is generally very high.

The process

The process for making wet-blue leather is described below and illustrated in figure I.

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* Before reading this information readers are advised to read through the earlier information entitled "Leather Production" (File C5).

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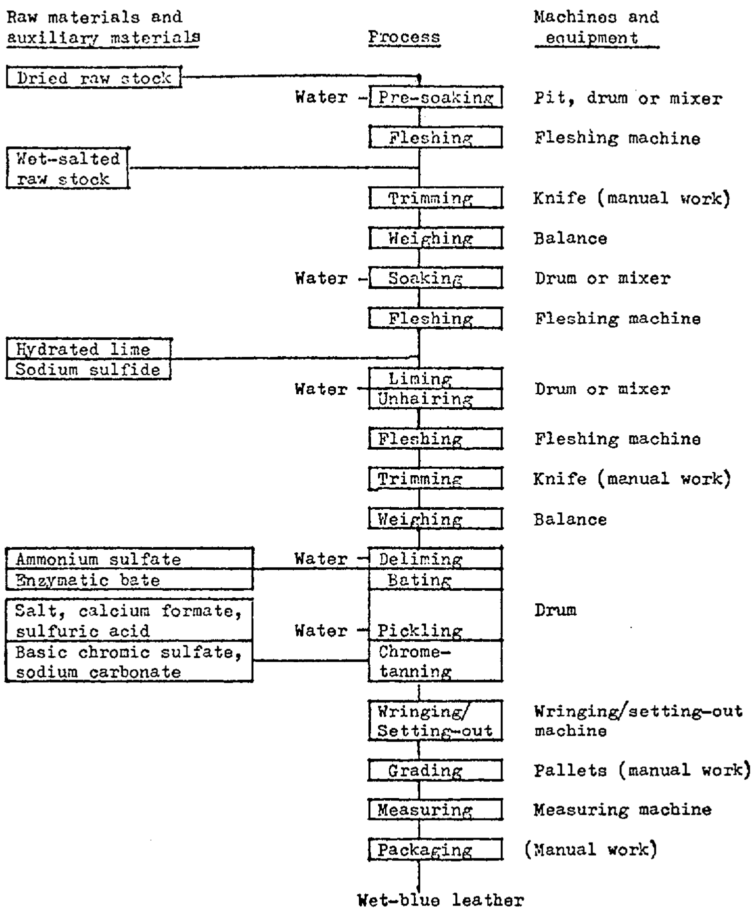
Figure I. Process flow sheet for wet-blue leather production



Soaking is aimed at restoring hides and skins to the state they had immediately after the flaying from the animals. Flayed hides and skins are in most cases cured to prevent putrefaction before reaching the tanneries. In industrialized countries fresh hides are wet salted, while in developing countries they are usually salted and dried or air dried without salt. Dried stock requires pre-soaking and a more intensive mechanical treatment (fleshing) than wet-salted hides.

Trimming is carried out to remove those parts of raw hides which would be of no use as leather and which could cause difficulties in later operations.

Fleshing is performed to break up the fibres of the hide substance and to remove flesh tissues. Wet-salted stock of good condition may not need the fleshing after soaking, but all stock should be fleshed after liming.

Liming/unhairing is required to open up the hide structure and to disolve the hair roots, leaving a clean grain side free from hair.

Deliming/bating removes the lime and certain hide constituents and degradation products that are detrimental to a satisfactory result in the subsequent processes.

Pickling conditions the hide for easy and sound chrome tanning.

Wringing is used to remove mechanically as much water as possible from the wet-blue leather. This also facilitates grading, which is usually necessary for successful marketing. A combination of wringing and setting-out will enhance the appearance of the product and is therefore economically advantageous. This could be omitted by simply piling the hides for a considerable period of time, but the result is usually unsatisfactory.

The factory

A medium-sized tannery using dried cattle hides as its main raw material is described below as an example. Capacity can be expressed in numbers, in weight of processed stock or in produced surface area. Since the type, source, weight, cure etc. of the hides or skins have considerable influence on the conversion factors, these may vary widely. The factory's approximate capacity for dried cattle hides as well as wet-salted cattle hides or dried goat skins is shown in table 1.

Table 1. Estimated annual capacity a/

	Dried cattle hides	Wet-salted cattle hides	Dried goat skin
Pieces (number)	60,000	50,000	400,000
Weight (kg raw)	600,000	1,000,000	200,000
Area (m^2, wet-blue)	190,000	200,000	220,000

a/ The figures given are only indicative and must be adjusted with respect to the condition of the local raw hides and skins.

Machinery and equipment required for the tannery shown in table 1 is listed in table 2. The total FOB cost incluting appropriate spare parts would be US$345,600.-.

Table 2. Machines and equipment

Item	Number
Mixer	2
Drum	2
Fleshing machine	2
Wringing/setting-out machine	1
Measuring machine	1
Balance, heavy duty	1
Hot water generator	1
Scales, hand tools, transport wagons, pallets, work tables, wooden horses and pipings	

Annual raw material and utility requirements are shown in table 3.

Table 3. Estimated annual requirement of raw materials and utilities

Item	Amount
Raw cattle hides, dried	600 tons
Chrome salt, 26% Cr_2O_3	70 tons
Common salt	60 tons
Calcium hydroxide, powder	40 tons
Sodium sulfide, 60%	40 tons
Ammonium sulfate	15 tons
Sulfuric acid	12 tons
Sodium carbonate	10 tons
Enzymatic bate	6 tons
Calcium formate	5 tons
Fuel oil	5 m^3
Electricity	120,000 kwh
Process water	25,000 m^3

An ample supply of process water is absolutely necessary for a tannery. Although in recent years there has been a clear trend towards less water use, the quantities needed are still considerable. For a wet-blue tannery a consumption of 25 m^3 or more per ton of wet-salted hides or skins is still fairly narmal. Water may be taken from a river or from a deep well. Generally it does not need any treatment. Drinking water has to be supplied separately.

The effluents from tanneries have caused growing concern everywhere. As a rule some kind of treatment is necessary in order to comply with sanitary laws or to avoid serious complaints. Locating the tannery close to a fast-flowing river will usually make the problem easier to solve. The river may supply the process water and at the same time serve as an acceptable recipient for the tannery effluent. The tannery given as an example here would need approximately 100 m^3 of water per day, but the supply of larger quantities should be ensured for expansion.

Table 4. Plant size

Area	Size (m^2)
Raw stock store	90
Chemical store	45
Production area	450
Grading/packaging room	90
Mechanical workshop	30
Offices	45
Total	750

Table 5. Personnel

Post	Number
General and technical manager	1
Mechanical/electrical technician	1
Supervisors	2
Skilled workers	12
Unskilled workers	9
Office workers	4
Total	29

The factory building (see table 4) may be of a fairy simple construction but the concrete foundation in the production area should be designed with the disposal of the different effluents in mind. The total factory site should be about 5,000 m^2 to include space for effluent treatment which might be necessary and for future expansion.

CRUST LEATHER *

Compared with wet-blue leather the marketing of crust leather is much more difficult, above all because customers have fewer options for further processing. The visible properties such as size, thickness, fullness, loseness of grain and grain damages together with the physical and chemical properties such as tensile and tear strength, chrome and fat content etc. constitute the leather quality and have a decisive influence on the obtainable price. It also takes time, often years, to convince prospective customers of the consistency in quality and deliveries from a new leather supplier.

The added value and the lighter shipping weight of crust leather are, however, obvious advantages. The experience gained in the production and marketing of wet-blue leather and a gradually increasing volume should in time make crust leather production profitable.

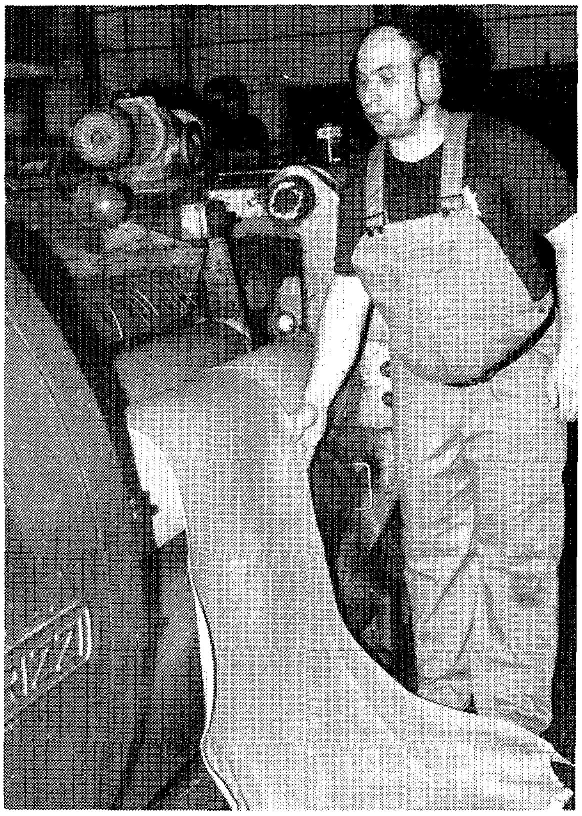
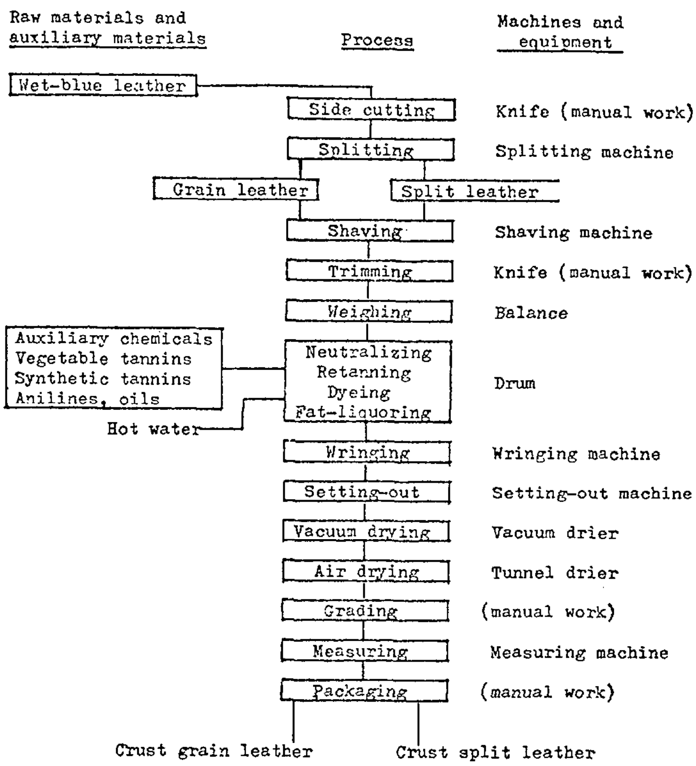


Figure I. Process flow sheet for crust leather production



The process

The crust leather production process is described below and illustrated in figure I.

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Most bovine crust leather is sold as sides (halves); whole hides are cut into two sides along the backbone line. It is usually an advantage to perform side cutting before splitting, in which the hides are cut parallel to the grain (upper surface) in order to get an even and appropriate thickness. The piece of material obtained from the backside is normally processed into split leather.

Neutralizing, retanning, dyeing and fat-liquoring will confer the more or less final characteristics to the body of the leather. Today these steps are generally combined as one operation in the same drum.

Wringing lowers the water content in the leather mechanically. Removing water by evaporation, i.e. heat drying the leather is much more costly.

Setting-out aids in obtaining a smooth leather and a larger surface.

Vacuum drying will help in fixing a smooth grain; air drying in a tunnel will then dry out the leather to the required final water content. Other drying methods are possible and could be preferable in specific cases.

The factory

As a second stage, the wet-blue tannery could be integrated into crust leather making plant, the capacity remaining the same. Some of the process sequences in the wet-blue tannery could be changed to suit the new processes better; for example, splitting could be done in lime instead of in blue. This would be more difficult but would give certain advantages in the processing of the splits.

Table 1. Estimated annual capacity [a]

	Dried cattle hides	Wet-salted cattle hides	Dried goat skins
Pieces (number)	60,000	50,000	400,000
Weight (kg, raw)	600,000	1,000,000	200,000
Area (m^2, crust)	180,000	190,000	210,000

a/ The figures given are only indicative and must be adjusted with respect to the condition of the local hides and skins.

Tables 2 - 5 show machines and equipment, raw materials and utilities, plant size and personnel required for the combined wet-blue and crust leather plant

Table 2. Machines and equipment

Item	Number
Mixer	2
Drum (chrome-tanning)	2
Drum (retanning/dyeing)	2
Fleshing machine	2
Wringing machine	2
Setting-out machine	1
Splitting machine	1
Shaving machine	2
Vacuum drier, 2-plate	1
Drying machine	1
Measuring machine	1
Balance, heavy duty	1
Boiler	1
Scales, hand tools, transport wagons, pallets, work tables, wooden horses and pipings	
Total FOB cost including appropriate spare parts: US$864,900.-	

Table 3. Estimated annual requirement of raw materials and utilitie

Item	Amount
Raw cattle hides, dried	600 tons
Chrome salts, 26% Cr_2O_3	75 tons
Common salt	60 tons
Calcium hydroxide, powder	40 tons
Sodium sulfide, 60%	40 tons
Oils, 4 types	35 tons
Synthetic tannins, powder	25 tons
Vegetable tannins	20 tons
Ammonium sulfate	15 tons
Sulfuric acid	12 tons
Sodium carbonate	10 tons
Enzymatic bate	6 tons
Calcium formate	5 tons
Aniline dyes, 8 types	5 tons
Sodium bicarbonate	4 tons
Sodium acetate	3 tons
Formic acid	3 tons
Auxiliary products, unspecified	2 tons
Fuel oil	330 m^3
Electricity	250,000 Kwh
Process water	30,000 m^3

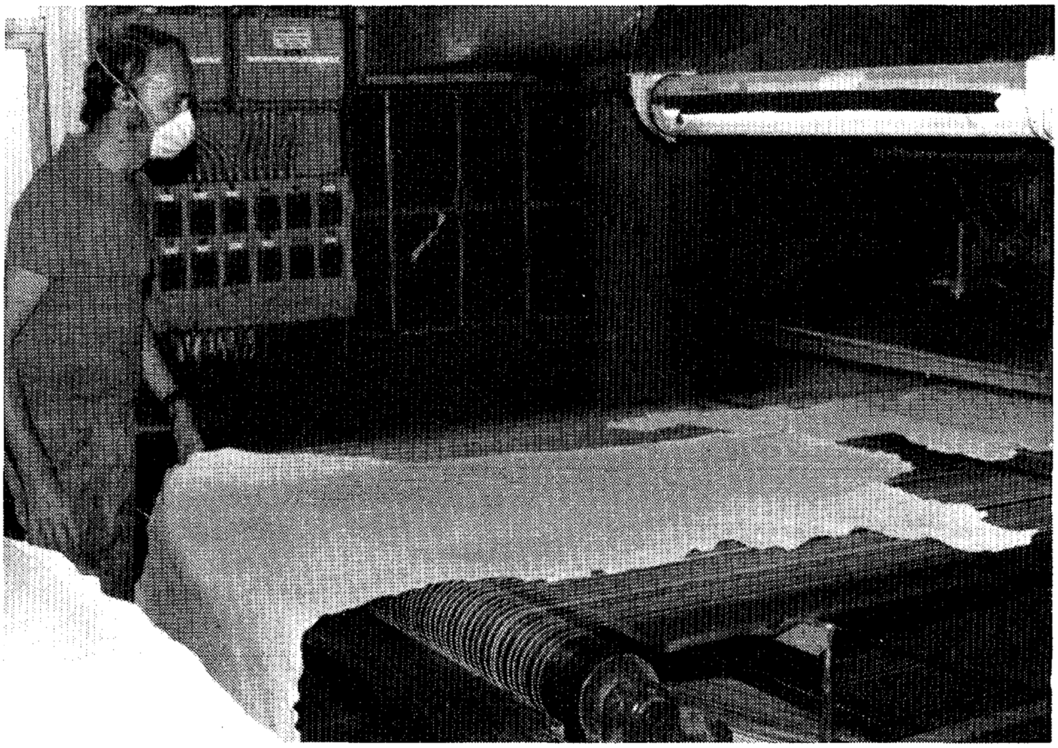
Table 4. Plant size

Area	Size (m^2)
Raw stock store	90
Chemicals store	60
Production area	870
Grading/packaging room	90
Mechanical workshop	60
Boiler room	30
Offices	60
Total	1,260

Table 5. Personnel

Post	Number
General and technical manager	1
Mechanical/electrical technician	1
Supervisors	4
Skilled workers	24
Unskilled workers	12
Office workers	6
Total	48

FINISHED LEATHER *



As noted earlier, it is much more difficult to market leather, at acceptable prices, finished than crust leather. This is especially true when trying to export. Therefore, sufficiently large domestic market, i.e. local leather shoe and leather goods industries that require substantially more finished leather than the tannery plans to produce would be a good prerequisite for establishing a finished leather factory.

This prerequisite should be disregarded only if there is a firm agreement to purchase the tannery's finished leather. A local market must be available in any case for lower grade leathers that cannot be sold on the international market or only at ruinous prices there.

A long introduction period must also be allowed for, a fact that favours a phased development of the tannery - first the production of wet-blue, then crust and finally finished leather.

The process

The process for finished leather production is described below and illustrated in figure I.

* Before reading this information reader are advised to read through the earlier information entitled "Leather Production" (File C5).

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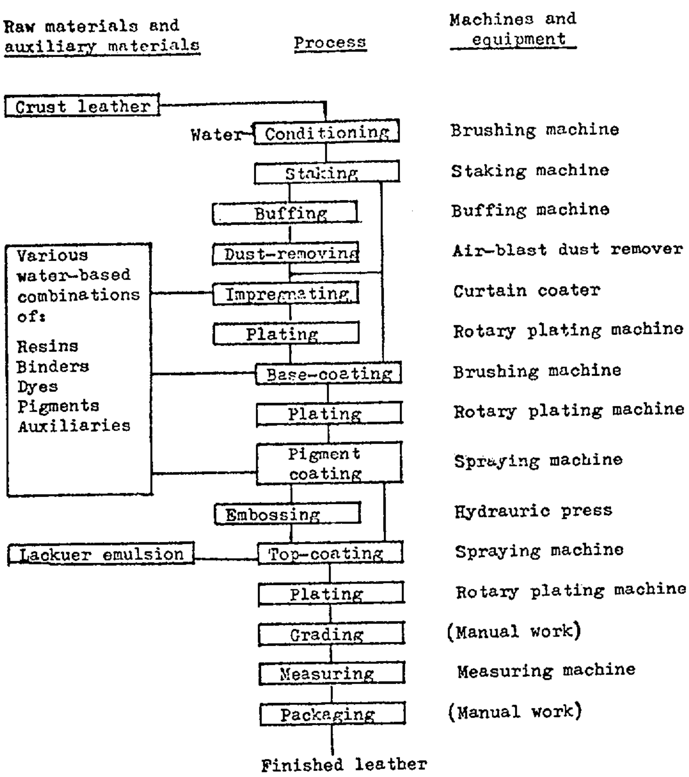
Inquiries should be sent to: IO/COOP, Registry file No. ID/562/12, UNIDO, P.O. Box 300, A-1400 Vienna, Austria.

Figure I. Process flow sheet for finished leather production



Conditioning by uniformly increasing the water content in the dried leather is necessary before staking. This operation will mechanically soften the leather. Too low a water content will cause a loose grain, while too high a water content will make staking easy but the stiffness of the leather will return after drying out again. Different parts of the leather area may need more intensive mechanical treatment, necessitating a second partial staking.

A grain-damaged leather can be improved considerably by buffing the grain surface; the resulting product is called corrected leather. After buffing the leather dust has to be removed because it would interfere with a proper finishing. The whole operation should be avoided when producing higher quality leather (full-grain leather).

Plating will close and smooth any coat of binders and resins. Several coatings of various kinds are normally necessary to supply colour and wear resistance to grain side.

Embossing is a way of pressing a specific pattern, e.g. a reptile grain, into the cattle hide grain. The new pattern will cover many grain damages and is consequently used primarily on the lowest leather qualities.

The factory

Table 1 to 5 show the effect of adding a finished-leather plant to the wet-blue and crust leather tanneries, the capacity remaining the same. The integration might again necessitate the reorganization of a few processes such as grading/sorting etc.

Table 1: Estimated annual capacity a/

	Drie cattle hides	Wet-salted cattle hides	Dried goat skins
Pieces (number)	60,000	50,000	400,000
Weight (kg, raw)	600,000	1,000,000	200,000
Area (m^2, finished leather)	165,000	175,000	200,000

a/ The figures given are only indicative and must be adjusted with respect to the condition of the local hides and skins

Table 2. Machines and equipment

Item	Number
Mixer	2
Drum (chrome-tanning)	2
Drum (retanning/dyeing)	4
Fleshing machine	2
Wringing machine	2
Setting-out machine	1
Splitting machine	1
Shaving machine	2
Vacuum drier, 2-plate	1
Drying tunnel	1
Vibrating staking machine	1
Jaw staking machine	1
Buffing machine	2
Air-blast, dust removing machine	1
Curtain coater with drier	1
Brushing machine with drier	1
Spraying machine with drier	1
Rotary plating machine	1
Hydraulic press	1
Measuring machine	1
Balance, heavy duty	1
Air compressor	1
Boiler	1
Embossing plates, scales, hand tools, transport wagons, pallets, work tables, wooden horses and pipings	

Total FOB cost including appropriate spare parts: US$1,357,100.-

Table 3. Estimated annual requirement of raw materials and utilities

Item	Amount
Raw cattle hides, dried	600 tons
Chrome salts, 26% Cr_2O_3	75 tons
Common salts	60 tons
Calcium hydroxide, powder	40 tons
Sodium sulfide, 60%	40 tons
Resins and binders, 5 types	40 tons
Oils, 4 types	35 tons
Synthetic tannins, powder	25 tons
Vegetable tannins	20 tons
Ammonium sulfate	15 tons
Pigment paste, 7 types	15 tons
Sulfuric acid, conc.	12 tons
Sodium carbonate	10 tons
Enzymatic bate	6 tons
Calcium formate	5 tons
Aniline dyes, 8 types	5 tons
Lacquer emulsins, 2 types	5 tons
Sodium bicarbonate	4 tons
Sodium acetate	3 tons
Formid acid	3 tons
Formaldehyde, 30%	1 ton
Auxiliary products, unspecified	3 tons
Fuel oil	350 m^3
Electricity	310,000 kwh
Process water	30,000 m^3

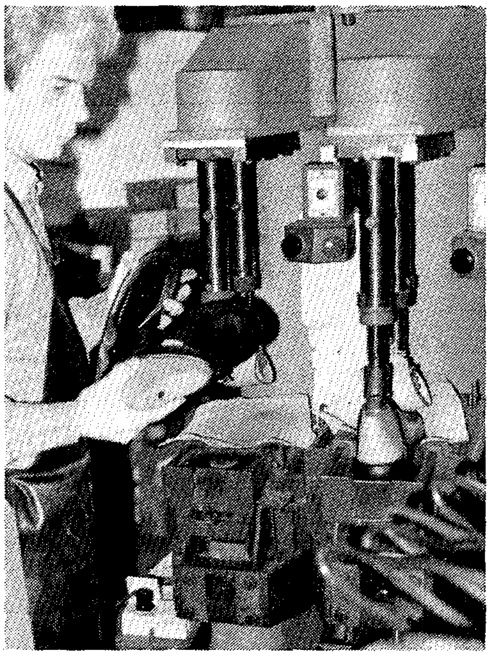
Table 4. Plant size

Area	Size (m^2)
Raw stock store	90
Chemicals store	60
Production area	1,260
Finish mixing room	60
Grading/packaging room	150
Mechanical workshop	60
Boiler room	30
Offices	90
Total	1,800

Table 5. Personnel

Post	Number
General and sales manager	1
Technical manager	1
Mechanical/electrical technician	1
Supervisors	5
Skilled workers	32
Unskilled workers	18
Office workers	8
Total	66

FOOTWEAR PRODUCTION *



In all countries of the world the demand for footwear is high and in most developing countries growing. Yearly consumption is estimated to be between 3 and 5 pairs per capita in industrialized countries and 1 pair in developing countries. In many of the least developed countries consumption is only 1 pair for every 10 people. Thus, at least in the developing countries there is considerable scope for shoe production.

It is also estimated that about 60% of the world's total consumption consists of simple footwear made entirely of non-leather materials and that for the remaining 40% only the upper part of the shoe is made of leather.

In countries that plan to begin manufacture of finished leather, a leather shoe factory is almost imperative in order to dispose of at least the lower quality leathers that are inevitably produced and that can only be sold at an acceptable price on the local market. A shoe factory, on the other hand, can usually import its raw materials without any real problems.

A shoe factory, even if highly mechanized, is still very labour intensive. There is a definite trend to transfer shoe industries from developed to developing countries where the labour situation is more favourable. However, it must be borne in mind that footwear export is very exacting and competitive and demands high quality. Concentration on the domestic market is therefore advisable, at least during first years of production.

Production methods

Most leather shoes - for both adults and children - today are of cemented construction. The upper part is formed over a wooden or plastic last and bonded to the insole and later to the outsole with the aid of cements. Details may vary, for example tacks can be used on certain parts of the shoe.

Goodyear welted is the most labour- and material-intensive construction, the insole being sewn to the welt and this later to the outsole. The best quality footwear is produced by this method

* Before reading this information, readers are advised to read information contained in the document "Leather Production" (File C5).

This information was prepared for UNIDO by Mr. Bo Lunden, Sweden.
Inquiries should be sent to: IO/COOP, Registry file No. ID/562/12, UNIDO, P.O. Box 300, A-1400 Vienna, Austria.

although even in industrialized countries it is used only by very few shoe factories.

Force-lasted construction, where the last is forced into the stitched-around upper, is used for moccasins and California shoes.

Veldtschoen is a construction method used for simple derby shoes, safari boots and other, usually unlined, types employing fairly heavy upper leathers.

Moulded footwear, either vulcanized or injection moulded, is characterized by the outsole being attached to the shoe by direct moulding.

The factory

The shoe factory given as an example here has a capacity of about 1,000 pairs per day or 250,000 pairs a year of common type of cemented women's shoe. Men's or children's shoes could be produced at about the same capacity with, in a few cases, some minor additions to the machinery.

Leather is used for the uppers as well as for the lining, but substitutes could be utilized without undue difficulty. Many parts of the shoes can be purchased prefabricated, which would simplify the process and, under certain circumstances, make it easier to start up production.

The process

It is important that cutting through clicking be carried out carefully, especially taking into account the difference in quality between leather sides as well as between different parts of the sides themselves. Occasionally, it is better to cut by hand using edge-reinforced cardboard templets.

The skiving of leather is necessary to obtain a satisfactory edge in the folding operation and an adequate bond between two parts cemented together.

Stitching is done on different types of sewing machines, each selected and equipped according to the thickness, hardness etc. of the raw material to be sewn, the thread, the needle and the stitch length. Some stitching jobs need considerable skill.

In toe, side and heal-seat lasting the shoe upper is formed over the last, using one or several machines, and bonded to the insole with cement or tacks.

Roughing, in which the excess leather on the bottom is removed and the parts to be cemented are roughened, is an important operation because an adequate bond from a visual as well as from a strength point of view is necessary.

Heat setting is used to set the leather enough for the last to be removed without the shoe losing its shape. The number of lasts needed is thus reduced considerably.

The outsole is attached to the shoe with cement, usually a heat activated one, using a sole laying machine that applies sufficient and evenly distributed pressure. The heal is both cemented and nailed to the shoe.

Tables 1 to 4 give the machines and equipment, materials and utilities, plant size and personnel required for the shoe factory and figure I show the process flow for its production.

Table 1. Machines and equipment

Item	Number
Hydraulic clicking machine	11
Splitting machine	1
Marking machine	1
Skiving machine	2
Sewing machine	22
Toe-puff fusing press	1
Taping ans seam pressingmachine	1
Cementing and folding machine	2
Insole moulding equipment	1
Stapling machine	2
Backpart moulding machine	2
Pulling amd lasting machine	2
Cement side-lasting machine	1
Heal seat-lasting machine	1
Humid heat-setting plant	1
Roughing and scouring machine	2
Automatic roughing machine	1
Bottom cementing machine	2
Sole prefinishing machine	1
Sole attachine machine with heat-activating equipment	2
Last-pulling machine	1
Heal-nailing machine	1
Pasting machine	1
Heat-blowing equipment	2
Spray booth	2
Pattern-making equipment	1
Air compressor	1
Work tables and chairs, lasts, pipings, hand tools and accessories	

Total FOB cost including appropriate spare parts: approx. US$362,200.-

Table 2. Estimated annual requirements of raw materials and utilities

Item	Amount
Shoe upper leather	35,000 m^2
Lining leather	20,000 m^2
Rubber sheet	10,000 m^2
Fibre board	12,000 m^2
Synthetic counter material	3,500 m^2
Toe-puff thermo material	1,000 m^2
Cement, latex	10 ton
Thread and yarn	1,200 km
Steal shanks	500,000 pieces
Heel lifts	500,000 pieces
Top lifts	500,000 pieces
Electricity	80,000 kwh

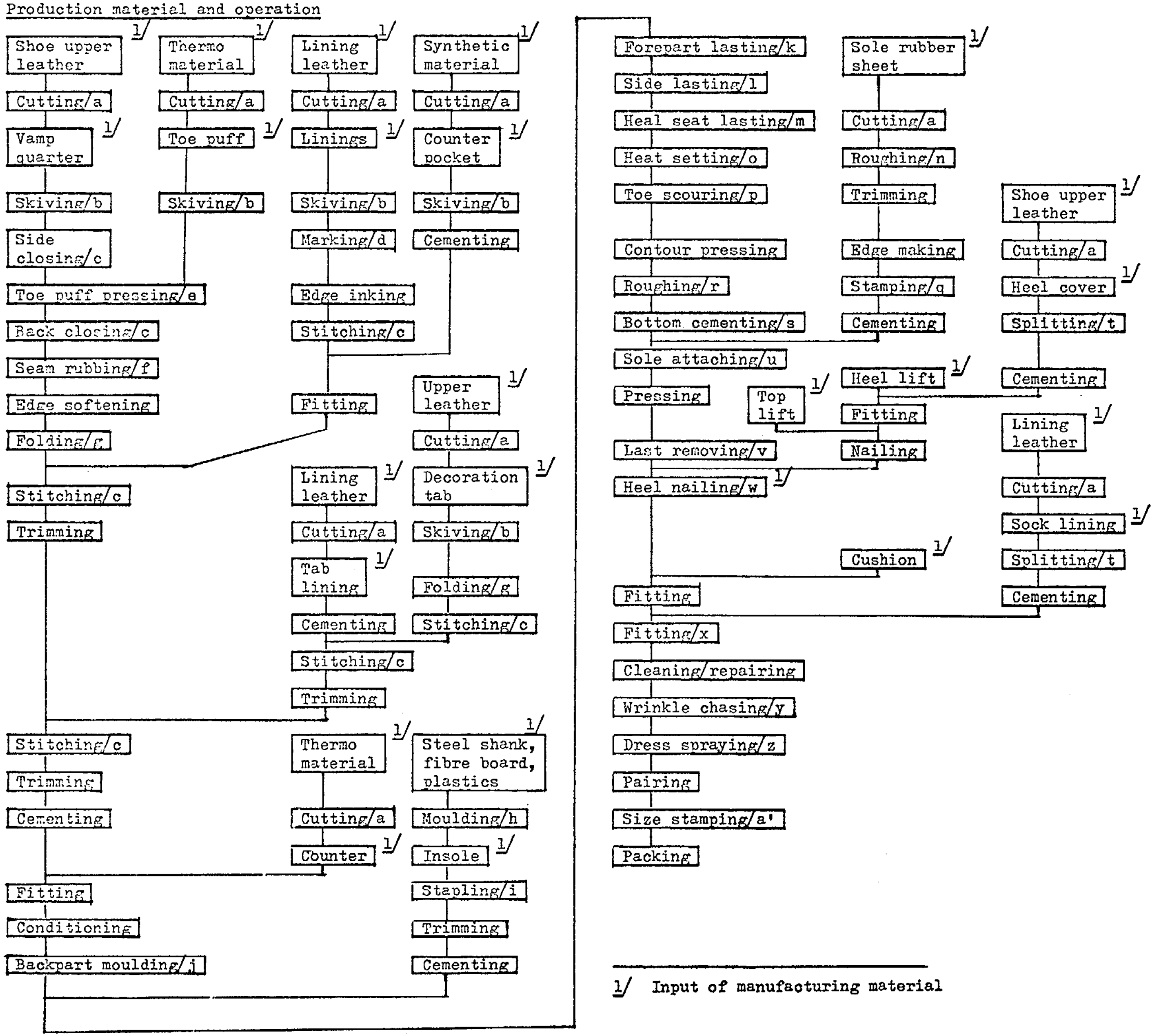
Table 3. Plant size

Area	Size (m^2)
Cutting department	150
Closing department	420
Bottom preparation	100
Lasting	480
Shoe room	150
Stores	400
Offices	100
Total	1,800

Table 4. Required personnel

Post	Number
General manager	1
Sales manager	1
Technical manager	1
Designer	1
Engineer/mechanic	2
Supervisors	6
Skilled workers	42
Unskilled workers	58
Office workers	10
Total	126

Figure I. Process flow sheet for shoe making factory



1/ Input of manufacturing material

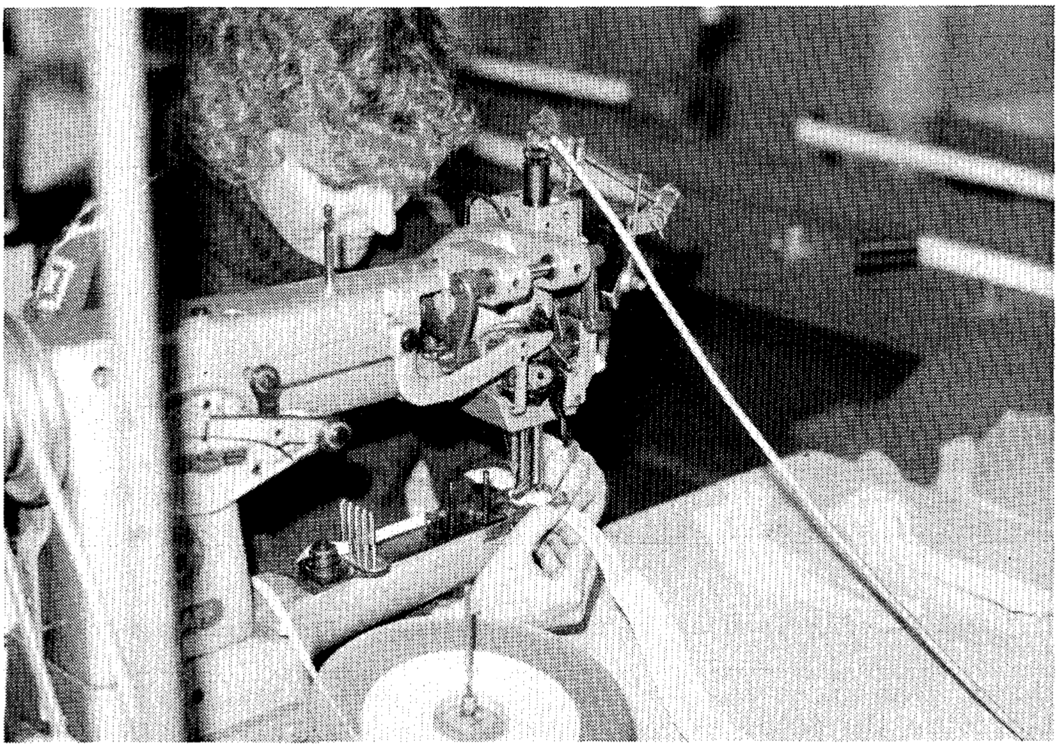
Machine or equipment

a: Clickinh machine
b: Skiving machine
c: Sewing machine
d: Marking machine
e: Toe puff fusing press
f: Taping amd seam pressing machine
g: Thermo cementing and folding machine
h: Automatic moulding unit
i: Staple fastening machine
j: Backpart moulding machine
k: Pulling and lasting machine
l: Side lasting machine
m: Heal seat lasting machine
n: Roughing machine
o: Humid heat setting unit
p: Upper roughing and scouring machine
q: Stamping machine
r: Automatic roughing machine
s: Bottom cementing machine
t: Splitting machine
u: Heat activating unit with sole attaching machine
v: Last pulling machine
w: Heal nailing machine
x: Pasting machine
y: Heat blowing machine
z: Spray booth
a': Sole stamping machine

FILE: C10
ISIC 3233

How to Start Manufacturing Industries

LEATHER GOODS PRODUCTION *



Most of the leather produced in the world today is used for the manufacture of shoes, garments and gloves. These leather products are, however, traditionally excluded from the articles embraced by the term "leather goods", which covers such articles as ladies' handbags and other bags, cases of all kinds - from suitcases to small eye-glass cases, wallets and purses as well as belts and straps. The term "fancy leather goods" is usually applied to products that are made from exotic materials such as reptile, bird or fish skins or extensively decorated ordinary leather.

Leather goods are made in almost all the countries of the world and demand is usually quite high and constant. Production is highly labour intensive, needing in extreme cases almost no machinery. In many developing countries there are often many small production units manufacturing leather goods, mainly for the local tourist trade. Such production, however, has various shortcomings - inferior workmanship, inadequate tools and low quality auxiliary raw materials often considerably reduce the value of the goods. To reach a resonable level of quality as well as productivity, a basic set of machines is necessary as are appropriate tools and skills and good organization.

* Before reading this information, readers are advised to read information contained in the document "Leather Production" (File C5).

This information was prepared for UNIDO by Mr. Bo Lunden, Sweden.
Inquiries should be sent to: IO/COOP, Registry file No. ID/562/12, UNIDO, P.O. Box 300, A-1400 Vienna, Austria.

The factory

Because of the variety of articles as well as the many construction methods and levels of sophistication, it is impossible to define "typical" leather goods production. As an example, a factory equipped to produce a few commonplace articles, namely a ladies' handbag, a wallet and belt, with an arbitrarily chosen capacity of 10,000 pieces per year, is described below. Requirements for other types of production are then relatively easy to estimate.

The flow sheets demonstrate the manufacture of a fairly complicated ladies's handbag (figure I) and an ordinary men's belt (figure II). Materials, machines and equipment, utilities, personnel and plant size required are given in tables 1 to 4.

The process

Cutting, either by hand, with the aid of knife and templets, or in the clicking machine, is an important operation in order to obtain consistent production and a satisfactory final appearance of the product. The same applies to the cutting of straps and belts with the strap cutter and of cardboard reinforcements with the guillotine cutter.

Skiving and folding is done to secure straight and even edges.

Stitching, done on sewing machines of different types, must take into consideration the materials to be sewn together, thread, needle, stitch length etc. In some cases considerable skill is needed to obtain a satisfactory result.

Slpitting is sometimes required to reduce the thickness of the leather or other sheet materials to be used.

The application of glue or cement and the subsequent joining of the parts in the cementing operation has to be done carefully to obtain a satisfactory bond as well as a clean look.

Table 1. Machines and equipment

Item	Number
Hydraulic clicking machine	1
Guillotine cutter	1
Strap cutter	1
Splitting machine	1
Skiving machine	1
Folding machine	1
Sewing machine	8
Work tables and chairs, shelves, hand tools and accessories	
Total FOB cost including appropriate spare parts: approx: US$75,600.-	

Table 2. Estimated annual requirements of raw materials and utilities

Item	Handbags	Wallets	Belts	Total
Upper leather (m^2)	4,200	1,200	800	6,200
Lining fabric (m^2)	5,600	1,000	-	6,600
Cardboard (m^2)	2,200	-	-	2,200
Lining paper (m^2)	4,000	-	-	4,000
Locks (number)	10,000	-	-	10,000
Zippers (number)	10,000	-	-	10,000
Buckles (number)	-	-	10,000	10,000
Glue, cement (kg)	300	50	50	400
Thread (km)	240	50	60	350
Electricity (kwh)				25,000

Figure II. Process flow sheet for belt production

Production material and operation

Belt leather 1/ — Lining leather 1/

Cutting/a — Cutting/a — Leather 1/

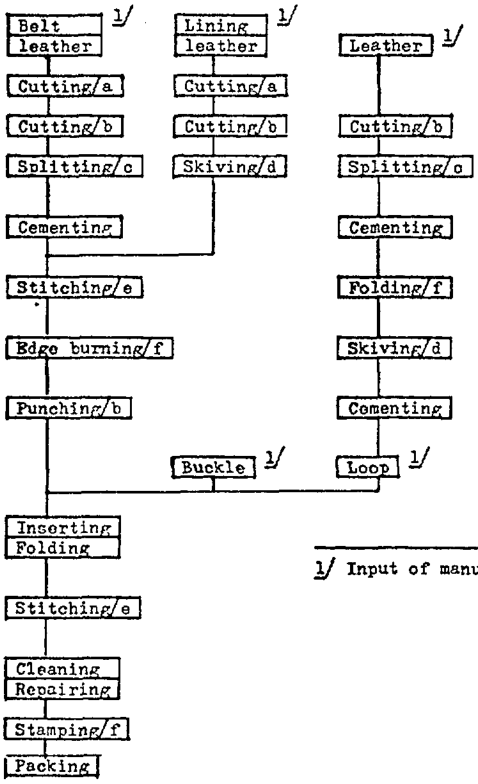
Cutting/b — Cutting/b — Cutting/b

Machine or equipment

a: Strap cutter
b: Clicking machine
c: Splitting machine
d: Skiving machine
e: Sewing machine

Figure II. Process flow sheet for belt production

Production material and operation



Machine or equipment

a: Strap cutter
b: Clicking machine
c: Splitting machine
d: Skiving machine
e: Sewing machine
f: Hand tools

1/ Input of manufacturing material

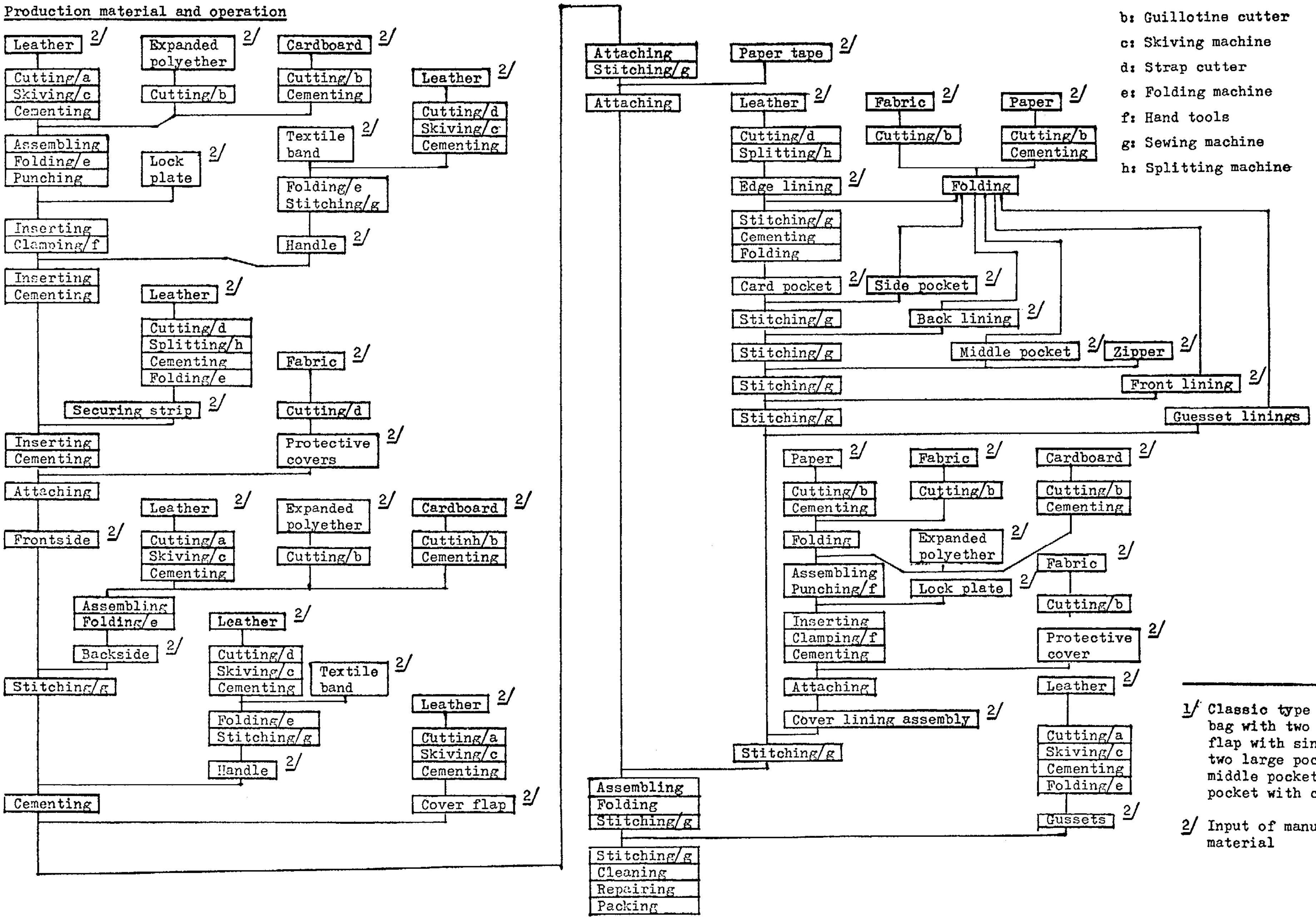
Table 3. Plant size

Area	Size (m^2)
Cutting department	50
Stitching department	60
Assembling department	210
Stores	180
Offices	100
Total	600

Table 4. Personnel

Post	Number
General manager	1
Sales manager	1
Technical manager	1
Designer	1
Engineer/mechanic	1
Supervisors	4
Skilled workers	16
Unskilled workers	32
Office workers	5
Total	62

Figure I. Process flow sheet for ladies' handbag production[1/]



Machine or equipment

a: Clicking machine
b: Guillotine cutter
c: Skiving machine
d: Strap cutter
e: Folding machine
f: Hand tools
g: Sewing machine
h: Splitting machine

[1/] Classic type ladies' handbag with two handles, cover flap with single press lock, two large pockets, zippered middle pocket and a side pocket with card pocket

[2/] Input of manufacturing material

Shoe Making Plant


View of Product

The shoe making technology was originated from a hand-making household industry, and in recent years most of the shoes have come to be mechanically produced on a large scale.

Depending upon basic materials used, the shoes are divided into man-made leather shoes and natural leather shoes. However, most of the high-class shoes are made of natural leather characteristic of its superior aesthetic sense, softness and light weight.

The technology and plant introduced here are related to the manufacture of natural leather shoes, characterized by such key factors as the basic material treatment, overall manuafacturing technology and mechanical mass production. Outstanding in aesthetic sense, most practical and beautifully designed, these shoes are highly reputed all over the world at present.

Products and Specifications

In this plant, various types of shoes are produced as shown in table 1.

Table 1. Products and Specifications

Product		Type
Men's shoes	Dress shoes	Cementing type Mckay type Moccasin type
	Casual shoes	Stitch down type Mold type Cementing type
Women's shoes	Dress shoes	Cementing type Moccasin type

Contents of Technology

1) Process Description

Cutting

The original leather is selected and then cut to prescribed pattern and size. This is the first of the process making the upper leather regarded as the most important step requiring an exact cutting to specified sizes.

Fitting

It is a process in which the upper leather is prepared by skiving, reinforcing, bond applying and sewing. The upper is readied by fixing the lining, thus finishing the upper portion to be assembled with the bottom portion.

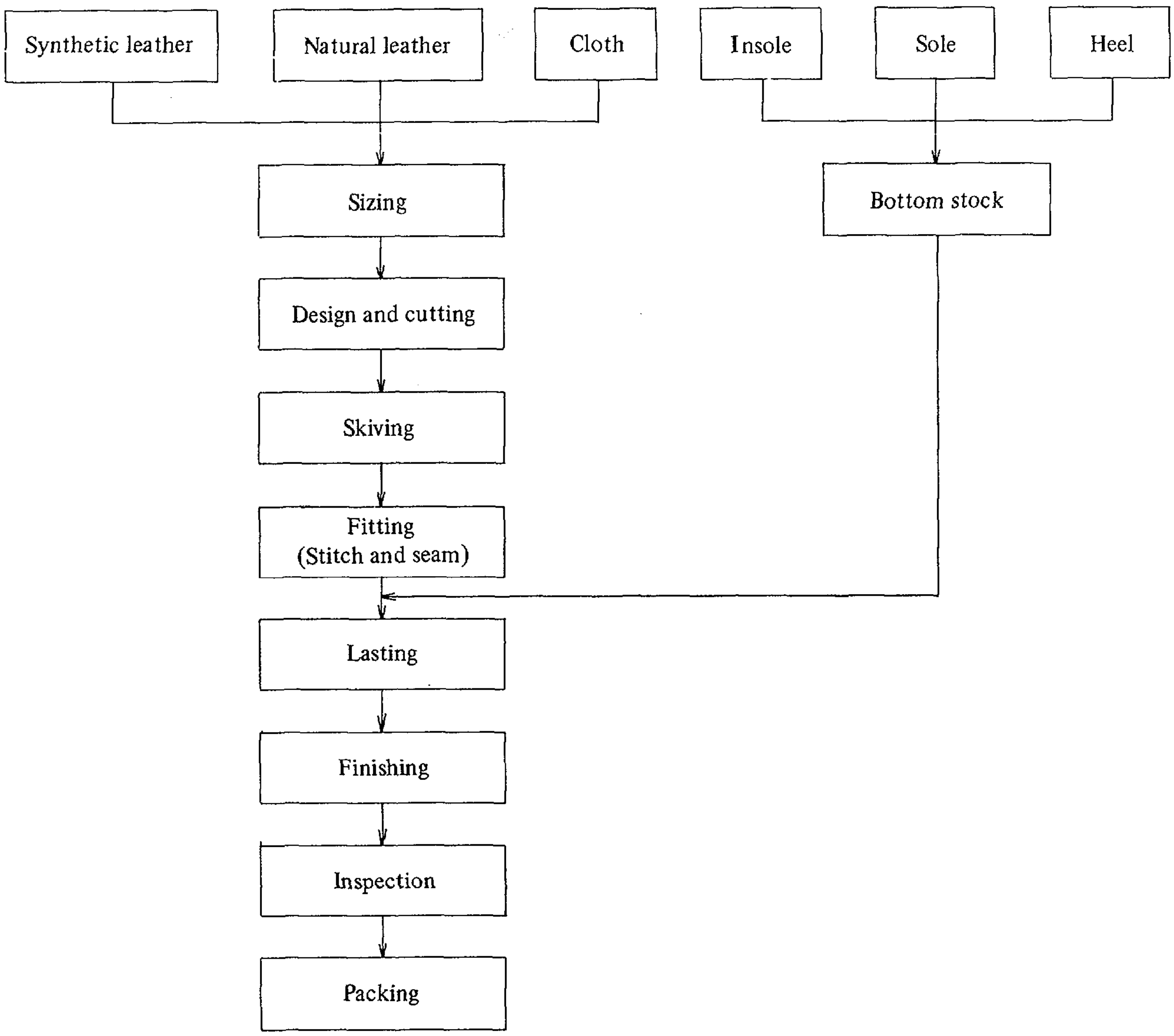
Bottom stock making

The process wherein a sole, insole and heel are manufactured as parts of the bottom stock to be combined with the upper leather. It is cut to the size and finished as the bottom stock by skiving and scouring.

Assembling

Its is a process in which the finished upper portion and the bottom stock are put together to produce the shoes by using a last. There are assembling methods of cementing type fixing the bottom stock by bonding and the Mckay type using a sewing machine. After assembling, the shoes are finished as products.

Shoe Manufacturing Process Flow Diagram



2) Equipment and Machinery

Insole moulding machine
Insole tacking & trimming machine
Counter moulding machine
Toe puff press
Loose lining/upper roughing machine
Upper toe moistening machine
Pulling over & toe side lasting machine
Heel seat (& waist) lasting machine
Moist air wrinkle chasing machine
Heat setter
Pounding up & ironing machine
Heel seat crown beating machine
Bottom roughing machine
Hand roughing machine
Bottom cementing machine
Sole cementing machine
Sole heat activating machine
Sole press
Brusher
Last removing machine
Heel screwing & nailing machine
Lining trimming machine
Sprayer
Moist air wrinkle chasing machine
Socks cementing machine
Back part ironing & forming machine
Box stamping machine

3) Raw Materials

Upper leather
Rubber and leather sole
Rubber, leather, plastic heel
Pressboard insole
Lining leather
Bonding agent
Tacks and nails
Counter
Toe puff

Example of Plant Capacity and Construction Cost

1) Plant capacity : 1,200 pairs/day

2) Estimated equipment cost

- Equipment and machinery : US$646,000
- Utilities : US$ 50,000

Total : US$696,000

3) Required space

- Site area : 6,000m^2
- Building area : 3,700m^2

4) Personnel requirement

- Plant manager : 3 persons
- Engineer : 4 persons
- Operator : 154 persons

Total : 161 persons

D

PRODUCTION OF PARQUET FLOORING

1. PREFACE

The small-scale parquet flooring plant is suitable for producing average-sized grooved parquet (360 x 60 mm) with tounged-and grooved blocks (for left-hand and righthand use), skirting board and fitting pieces.

The basic materials used in the plant are normal oak and beech in different qualities.

The equipment and the plant can be easily tailored to suit different requirements, ranging from plants using production methods which require a high proportion of manual work to others equipped with machinery lines which require a relatively small amount of labor.

2. CAPACITY OF THE PLANT

The plant's capacity for producing average-sized grooved parquet (360 x 60 x 22 mm) with tongued-and-grooved blocks (for lefthand and righthand use), skirting board and fitting pieces is small.

Basic materials consumption may be up to 2,530 m^3 per year for an output of approx. 100,000 m^2.

The capacity of the plant can be increased by additional shifts.

3. BRIEF DESCRIPTION OF THE PROCESS

The basic materials are stored according to type in the storage area, whence they are taken to the machining shop by hand or machine-powered materials handling equipment.

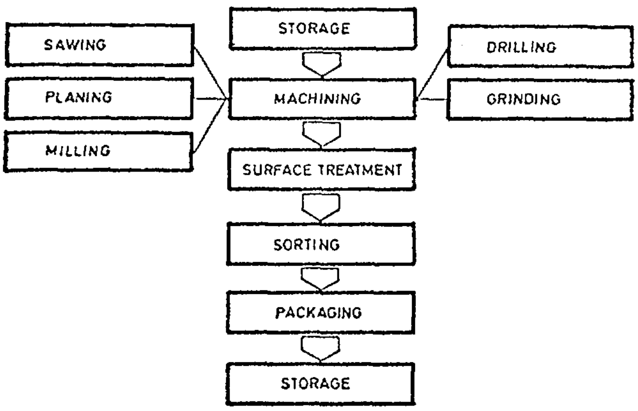
The manufacturing process is made up of the machining stage, the surface treatment stage and the sorting stage.

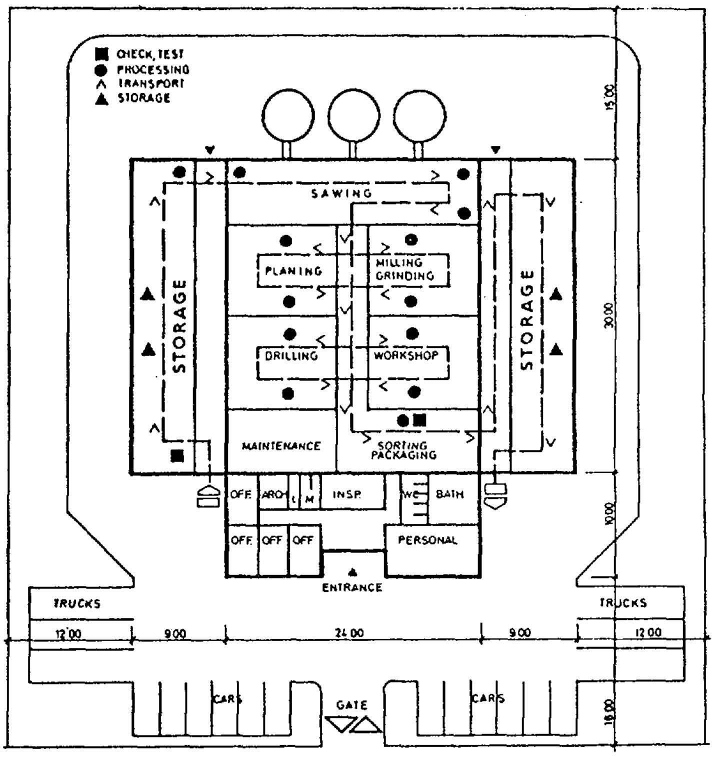
In the machining stage, the basic materials are prepared and machined to become finished products. In the workshop, basic machinery of the best available type has been allowed for, suitable for carrying out all the necessary operations.

The machined products pass to the surface treatment stage where they are impregnated.

In the sorting section the pieces are checked and sorted according to quality. They are then wrapped 940 pieces = 1 m^2) in the packing section. The packages are taken from there to the final storage area.

PROCESS FLOW SHEET





4. REQUIRED BASIC AND AUXILIARY MATERIALS

The quantities of the various materials needed depend on the actual product mix and the methods used.

Below are the approximate requirements of the plant for one year's production:

- Oak wood 2,530 m^2
- Various additional materials
- Machine oil
- Soldering brass
- Abrasive disks

5. AREA REQUIREMENTS

Required site area:	4,686 m^2
Required building area	
Production hangar:	720 m^2
Storage hangar:	540 m^2
Office building:	225 m^2

Structural:
Production hangar, storage hangar

Columns and beams	- steel construction
Walls	- corrugated iron sheets
Floors	- concrete
Roof	- metal sheeting on a sawtooth roof construction

Office building

Columns and beams	- concrete
Walls	- brick-lined, plastered
Floors	- PVC-paved
Roof	- concrete ceiling with metal sheeting

Special installations

Shavings extraction

6. MACHINERY AND EQUIPMENT (Estimated total FOB price: approx. US$ 1.130.000)

Description:	Quantity
Special circular saw	4
Special plane	6
Special milling machine	7
Band saw	3
Drill	2
Universal grinder	2
Universal plane	2
Surface treatment equipment	1 set
Maintenance and grinding equipment	1 set
Compressed air supply	1 set
Dust chip exhaustor	1 set
Grindings exhaustor	1 set

7. POWER REQUIREMENTS

Power type:	3 x 380 V, 50 Hz
Built-in capacity:	175 kW
Total power consumption during simultaneous operation:	140 kW
Power consumption per year:	280,000 kWh

8. PERSONNEL REQUIREMENTS

Production staff

- Works superintendents	1
- Skilled workers	3
- Semi-skilled workers	26
- Unskilled workers	4

Management and administration staff

- Plant managers	1
- Technicians	3
- Clerical staff	3

Work-time base

Number of shifts taken into consideration:	1 shift per day
Work-time taken into consideration:	8 hours per day
Number of work-days:	250 days per year

This information has been prepared for UNIDO by Horst Langbauer, Austria. Any inquiry about the information contained should be sent to: IO/COOP, Registry file No.ID/562/12, UNIDO, P.O. Box 300, A-1400 Vienna, Austria.

JOINERY PLANT

1. PREFACE

The small-scale joinery plant is suitable for the manufacture of kitchen and garden furniture as well as other products (e.g. tool handles) and for maintenance and repair work for a wide range of community needs.

The basic materials used in the plant are normal timber, fiberboard, veneer, chipboard and plywood.

The equipment and the plant can be easily tailored to suit different requirements, ranging from plants which require a high proportion of manual work to others equipped with automatic machinery lines which require a relatively small amount of labor.

2. CAPACITY OF THE PLANT

The capacity of the plant for the manufacture of kitchen and garden furniture and other wood products is small.

The basic materials used may be up to 550 m^3 per year of timber, chipboard, plywood, veneer or fiberboard for an output of approximately 350 sets of furniture and 25,000 units of other products.

The capacity of the plant can be increased by increasing the number of shifts.

3. BRIEF DESCRIPTION OF THE PROCESS

The basic materials are stored according to type in the wood store, from where they are taken to the machining shop by hand or machine-powered materials handling equipment.

The manufacturing process is made up of the machining stage, the surface treatment stage, the assembly stage and the finishing stage.

In the machining stage, the basic materials are prepared and machined to become semi-finished products. In the workshop, basic machinery of the best available type has been allowed for carrying out all the necessary operations.

For planing of the veneer, a smooth-planing machine has been allowed for in the profile. Gluing is carried out by hand.

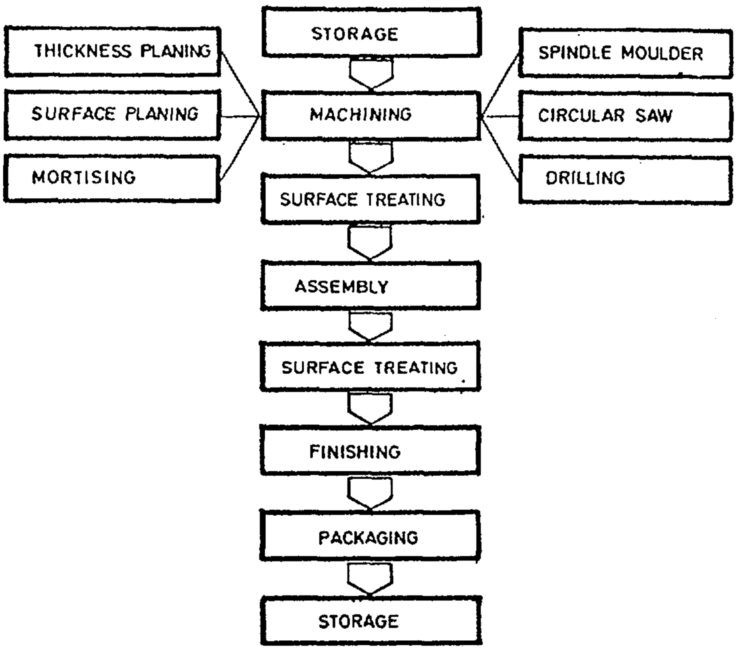
Longitudinal timber feed can be carried out on the portable circular saw bench. It can be split by the band saw and the circular bench saw. For further processing, universal planing and smooth planing, the universal grinding, milling and drilling machines are used.

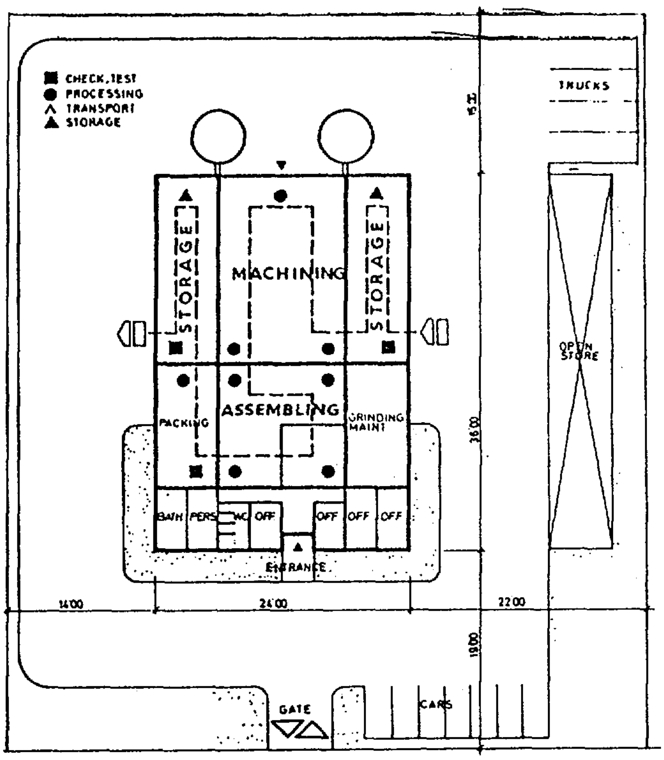
The wooden slab and board materials can be cut by the universal circular saw.

The veneer isglued on to the wooden board by hand. Until the glue binds, it is held by presses.

The semi-finished products are surface treated, assembled and then surface treated again, after which the finished product is wrapped and put into storage.

PROCESS FLOW SHEET





4. REQUIRED BASIC AND AUXILIARY MATERIALS

The quantity of the various materials used depends on the particular product mix and on the production methods used. Below are approximate material requirements of the plant for one year's production:

- Timber
- Chipboard
- Plywood
- Veneer
- Fiberboard

550 m3 (Timber, Chipboard, Plywood, Veneer and Fiberboard together)

- Machine oil
- Binding plastic
- Electrodes
- Grinding disks
- Soldering brass

- Varnish
- Nails, screws
- Glue
- Various additional materials

5. AREA REQUIREMENTS

Required site area:	4,200 m^2
Required building area	
Production hangar;	504 m^2
Storage hangar:	216 m^2
Office building:	144 m^2

Structural:

Production hangar, storage hangar

Columns and beams	- prefabricated concrete or steel construction
Walls	- brick-lined or corrugated iron sheets
Floors	- concrete
Roof	- metal sheets on sawtooth roof construction

Office building

Columns and beams	- prefabricated concrete or steel construction
Walls	- brick-lined, plastered
Floors	- PVC-paved
Roof	- concrete ceiling with metal sheets

Special installations

Shavings extraction system

6. MACHINERY AND EQUIPMENT (Estimated total FOB price: approx. $ US 200,000)

Description:	Quantity:	Description:	Quantity:
Cutting-off circular saw (portable)	1	Electric manual saw	1
Smooth planing machine	1	Electric manual vibrating sander	1
Band saw	1	Mechanical component press	1
Circular bench saw	1	Planing bench	4
Universal plane	1	Maintenance and grinding equipment	1 set
Bench drill	1	Compressed air supply	1 set
Universal grinding machine	1	Dust-chip exhaustor	1 set
Surface treatment equipment	1 set	Grindings exhaustor	1 set
Electric manual drill	4	Joiner's tool kit	8 sets
Electric manual milling machine	1		

7. POWER REQUIREMENTS

Power type :	3 x 380 V, 50 Hz
Built-in capacity:	90 kW
Total power consumption during simultaneous use:	70 kW
Power consumption per year:	140,000 kWh

8. PERSONNEL REQUIREMENTS

Production staff

- Works superintendents	1
- Skilled workers	6
- Semi-skilled workers	9
- Unskilled workers	3

Management and administrative staff

- Plant managers	1
- Technicians	1
- Clerical staff	2

Work- time table

Number of shifts taken into consideration: 1 shift per day
Work-time taken into consideration: 8 hours per day
Number of work-days: 250 days per year.

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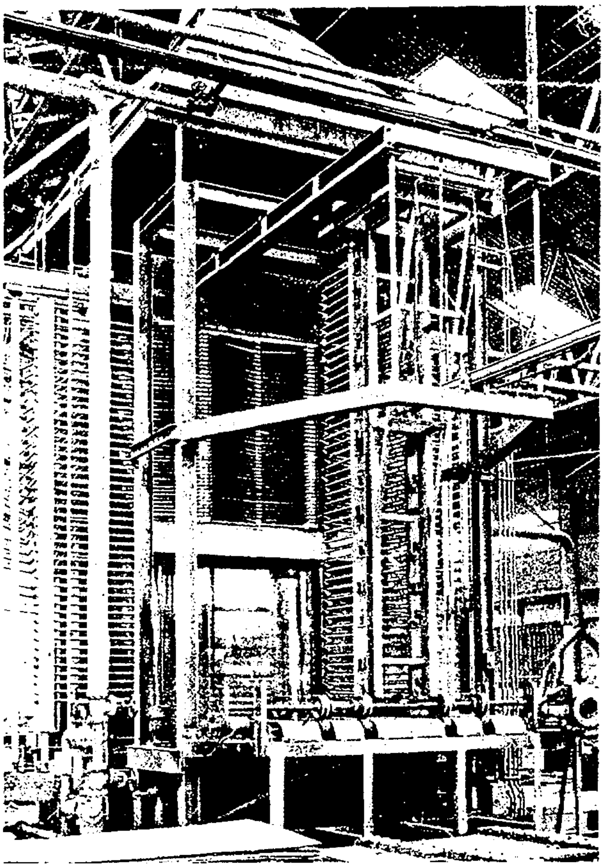
FILE: D6
ISIC 3310

Plywood Making Plant



View of Plywood Plant

The plywood industry has achieved a relatively rapid growth since the invention of plywood by Veneer Lathe in 1880.

Reaching a peak in 1973 with the global production of some 42 million cubic meters of plywood, it then turned sluggish due to so-called worldwide oil shock but shows signs of gradual recovery in recent years. Major producing countries are in order of the United States, Japan, Canada, Korea and Russia, while main exporting nations are Korea, Taiwan, Singapore, Canada and Finland. Importing countries are in the order of the United States, England, West Germany and the Netherlands.

In the plywood industry, logs need forst to be dried, requring to be located in dry areas. Since logs constitute a large volume freight, the place should also be where a manual handling is possible in most cases or a convenient means of transportation is available. The river, sea coast, or port area are preferable in this respect.

Compared with other wood-related industries, workers for the plywood manufacturing need to be highly skilled, and as products are standardized and made uniform in quality, many good engineers as well as skilled workers are also required.

Among the plywood-related industries, the industry for urea and melamine resins as adhesives first contributes to the development of paint and varnish manufacturing industries in a sort of chain reactions. The transportation of logs also contributes to the development of a shipping business.

With the improved living standard and sophisticated products, the plywood is used not only as basic building materials but also as materials for television and radio cabinets, vehicles, interior decoration of vessels and other packing containers.

As referred to in the above, the plywood industry is definitely suitable for many countries in Southeast Asia and middle and south America where rich resources of logs and skilled work force are available, not to speak of well-developed traffic.

Products and Specifications

The plywood is a most widely used commodity among the processed wood products. It is produced by putting numbers of thinly sliced wood sheets together by means of adhesives, usually being 3-ply, 5-ply, 7-ply and 9-ply with the thickness of 1-30mm. Depending upon its uses, the size is usually 91cm x 182cm or 122cm x 243cm.

Depending upon its manufacturing process, the plywood is divided into the rotary cut veneer, sliced veneer, sewn veneer and half-round veneer with a wide range of uses for wood products, furniture, metallic furniture and electronics goods.

Logs as its raw material are of teak, kapur kapor, apitong keruing, beech, birch, oak and other needle-leaved trees. As adhesives, resorcinol resin, phenolic resin, melamine resin and the like are used.

The plywood produced in various kinds of raw materials in accordance with its uses can be easily worked on including bending, is sturdy compared with its weight, low in thermal conductivity even in dried plywood condition and excellent in adsortivity of sound or mechanical oscillation with wide uses.

In this plant, an example of the most widely used product out of diversified veneers is given for explanation in terms of its manufacturing plant.

- Size: 1,200mm x 2,400mm x 4.0mm
- Veneer composition: face 0.95mm, core 2.4mm, back 0.95mm
- Moisture content: 10-20 percent

Contents of Technology

1) Process Description

i) Kogs transported from the storage yard are first sorted in accordance with uses and then cut laterally prior to peeling.

The log roller conveyor in use is a long drum type roller with the dimension of 300mm in diameter and 950mm in length and feed speed of 10m/min.

The chain saw has the maximum cutting diameter of 1800mm with the chain speed of m/sec. The permissible length of a log for the log charger is 1,800-2,760mm and the maximum diameter of the log to be loaded is 1,650mm, the charging speed being 25m/min.

The rotary lathe is a heavy duty, high speed and precision type with hydraulic unit for both spindles. The permissible peeling length is 1,800-2,760mm with the maximum block diameter of 1,650mm and spindle revolution of 200 rpm. The thickness of a veneer is 0.5-6.0mm.

ii) The next processes are the reeling and unreeling. The reeling machine in use is of automatic circulation system with the length of 9 feet or 5 feet. In the case of 9-ft reeling machine, the length is 15,000mm and the width is 3,500mm, the maximum diameter to be reeled being 1,000mm. In case of 5-ft reeling machine, it is of single deck with the length of 10,000mm, width of 2,550mm and maximum diameter of 1,000mm.

iii) Raw single veneer sheets thus prepared are dried in a dryer to the moisture content of 5-1 percent. The face and back are dried in a continuous net dryer while the core is dried in a roller veneer dryer. The continuous net dryer with the width of 2,740mm is of three decks, the heating section measuring 28,000mm (2,000 x 14 sec) and the cooling section 4,500mm (1,500 x 3 sec).

There are 20 sets of fans for charging the steam with the pressure of 15kg/cm^2. The roller veneer dryer for drying the core is of 4-deck type with the width of 4,450mm, the heating section measuring 28,000mm in length. The pressure of steam used is also 15kg/cm^2 and its feed speed is 0.9-9.0m/min.

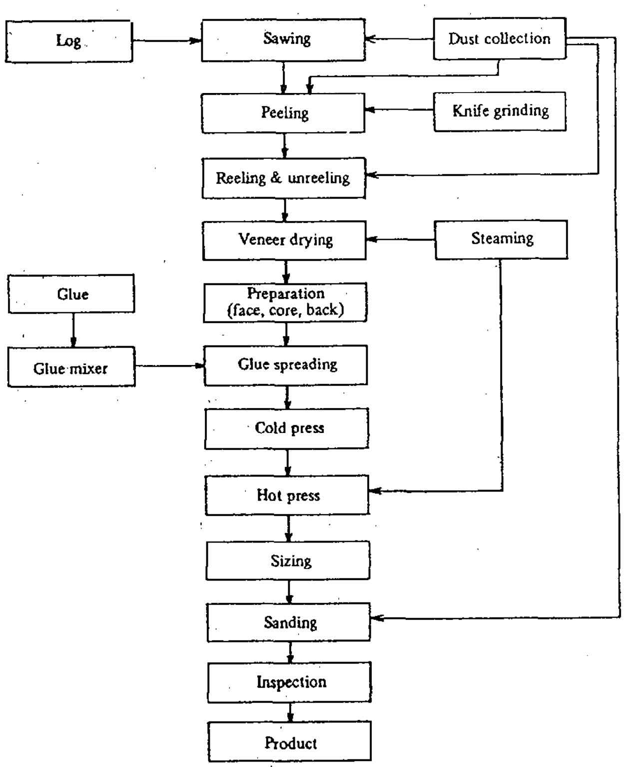
iv) The face, core and back thus prepared are coated with glue by means of a glue mixer. The glue spreader used is of rubber roll and doctor roll system. The glue roller diameter is 305mm while the doctor roll diameter is 230mm with the feed speed of 70-90m/min.

v) A fixed quantity of unifinished products are left alone under constant pressure. The pressing is first done by a hydraulic cold press which is of down stroke type making use of an infeed conveyor. The total working pressure is 500 tons with the table size of 1,400 x 2,700mm and the rising and descending speed of 50mm/sec. The hydraulic hot press is then used, pressing 40 veneer sheets each time. This press is of fully automatic hot press type with 200kg/cm^2 working pressure

vi) The glued products undergo the sizing and finishing. The surface treatment is carried out by sanding. There are two different types of bottom sander and top sander. The bottom sander is of heavy duty type, maximum working width being 1,220mm and the permissible thickness 2.5-25mm with the feed speed of 25-92m/min. The top sander is of three-head type with maximum working width of 1,220mm and the permissible thickness of 2.5-25mm.

vii) The finished products are moved by a sorting conveyor for inspection and packing.

Plywood Manufacturing Process Block Diagram



2) Equipment and Machinery

- Log roll conveyor
- Hoist with structure
- Log chain conveyor (9 feet)
- Knife grinder
- Reeling, unreeling system
- Continuous net dryer
- Infeed synchro-conveyor
- Outfeed synchro-conveyor
- Roller veneer dryer
- Auto feeder
- Rotary clipper with stacker
- Glue spreader
- Hot press 40 opening
- Chain saw
- Log charger 9 feet
- Rotary veneer lathe 9 feet
- Trip saw grinder
- Auto-clipper for dry veneer
- Auto-stacker
- Core builder
- Cold press
- Double saw with auto-pusher
- Bottom sander
- Out feed conveyor for sander
- Width wise roll conveyor
- Waste green veneer conveyor
- Waste dried veneer conveyor
- Dust collecting system
- Air compressor (50 hp)
- Table lifter (3 ton-1, open)
- Rail car
- Top sander
- Plywood inspection & sorting conveyor
- Log core disposal conveyor
- Boiler (20 ton)
- Glue mixer
- Chipper
- Table lifter (3 ton, 2 open)
- Cooling unit for hydraulic unit

3) Raw Materials and Utilities

Raw materials and utilities	Requirement
Log	$380m^3$/day
Water	14 ton/hour
Steam	20 ton/hour
Electricity	3,000 kwh

* Plywood $160m^3$/16 hours/day

Example of Plant Capacity and Construction Cost

1) Plant capacity : Plywood $160m^3$/day
   * Basis : 16 hours/day

2) Example of estimated equipment cost: (as of 1982)
   - Manufacturing machineries & utility facilities: US$2,144,400

3) Required space
   - Site area : $70,000m^2$
   - Building area : $30,000m^2$

4) Personnel requirement (per one shift)

o Log pond, chain saw	: 11 persons
o Peeling section	: 25 persons
o Drying section	: 14 persons
o Face/back section	: 15 persons
o Core section	: 29 persons
o Glue spreading/hot pressing section	: 24 persons
o Sanding section	: 14 persons
o Inspection/packing section	: 20 persons
o Auxiliary equipment section	: 38 persons
Total	: 190 persons

Chalkboard Making Plant

The technology introduced here is related to a special process in which chalkboards are coated with oil-mixed paint in the course of manufacture contrary to the prior art, whereas in schools and offices, most of the chalkboards are currently coated with gelatine-mixed paint.

However, such a chalkboard is very susceptible to moisture, and when its surface is moistened, it is discolored or deteriorated, and to make the matter worse, the chalkboard is weak in durability and short in service life to the extent of causing cracks on the surface if touched by other objects, because the coated surface is not substantial enough.

Not affected by the temperature or humidity, the chalkboards coated with oil-mixed paint is excellent in durability and can be used in the regions highly humid all year round. With almost no luster, the chalkboard causes no visual distrubances. Another advantage is that its life is 10 times as long as conventional chalkboards in terms of durability.

Products and Specifications

The standard size of chorkboard produced in this plant are as shown in table 1.

Table 1. Standard Size of Chalkboard

Size No.	Size	
	Width	Length
1	60	45
2	90	60
3	90	90
4	120	45
5	120	60
6	120	90
7	120	120
8	180	90
9	180	120
10	240	120
11	270	90
12	300	120
13	360	90
14	360	120
15	420	120
16	480	120

Contents of Technology

1) Process Description

Frame making process
The wood is prepared by cutting lumbers to be fabricated into frames by means of air tackers.

Pressing process
Polyvinylacetate emulsion adhesive is applied to the fabricated unit frames for adhering the cut or jointed plywood boards. The frames are piled one by one for pressing with a press machine for about 15 minutes.

Adhering process
The polyvinylacetate emulsion adhesive is applied to the pressed product for pasting kraft papers on it and dried for four hours.

Painting process (first and second paints)
Following the adhering process, the semi-product is worked on with adhesive papers (No. 80) to be coated with paint, prepared by mixing in a mixing machine, and, dried for about four hours.

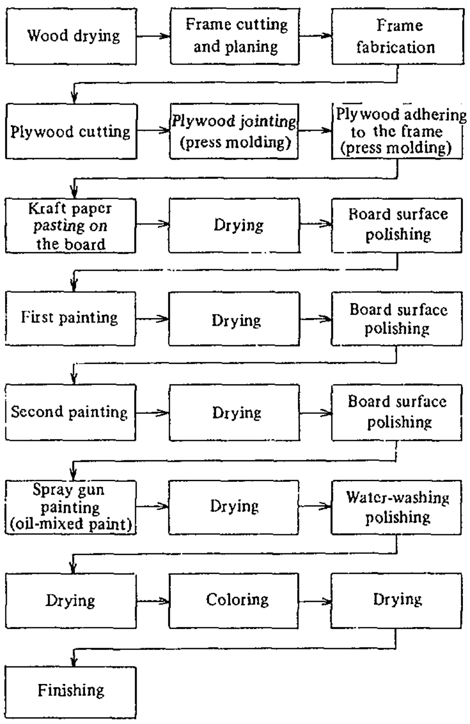
Spray painting process (preliminary coloring process)
After painting, the oil-mixed (toluene, xylene, paint, etc.) paint, prepared by special TK mixing machine, is sprayed by means of spray gun on the semi-product and then dried for 12 hours.

Water-washing polishing process
Following the spraying process, the semi-product is polished by adhesive papers (No. 320) with simultaneous water washing and then dried for four hours.

Coloring process
After water-washing polishing, specially prepared pigment (chrome green, marine blue) is applied with brush for coloring. It is wiped with dry blanket and then dried for five hours.

Finishing process
Following the coloring process, the rim of the product is polished with abrasive papers (No. 220) and then applied with pigment, prepared by mixing carbon black and water. The work is finished by fixing a chalk holding board.

Chalkboard Manufacturing Process Block Diagram



2) Equipment and Machinery

Sawing machine
S. Joint machine
Wood cutting machine
Electric planer
Electric saw
Press machine
Mixing machine
Heater
Air compressor
Spray machine
Shelf dryer
Manual scale

3) Raw Materials

Raw materials	Requirement (per ea of product) * basis ; 360cm x 120cm
Wood	7.8 ea (1ea; 3cm x 3cm x 360cm)
Plywood	1.5 ea (1ea; 240cm x 120cm)
Polyvinyl acetate emulsion adhesive for woods	1,600 g
Kraft paper	1200m x 360cm
Glue	120 g
Paste powder	250 g
Feldspar powder	2,300 g
Toluene	800 g
Paint	650 g
Anti-precipitation agent	10 g
Hardening agent	3 g
Bond	3 g
Chrone-green	110 g
Iron Blue	35 g
Carbon klack	15 g
Thinner	2 g
Lacquer	3 g
Abrasive paper	5 sheet
Chalkboard iron rings	2 ea
Nails	6 ea

Example of Plant Capacity and Construction Cost

1) Plant capacity : 6,000 sheets/year

2) Estimated construction cost (as of 1982)

- Equipment and machinery : US$65,000
- Utilities : US$13,000
- Installation cost : US$10,000

Total : US$88,000

3) Required space

- Site area : 2,000 m^2
- Building area : 1,000 m^2

4) Personnel requirement

- Plant manager : 4 persons
- Engineer : 3 persons
- Operator : 20 persons
- Others : 3 persons

Total : 30 persons

E

F

G

FATTY ACIDS *

Natural oils may be split by hydrolysis to obtain fatty acids or by saponification to obtain soaps. Organic fatty acids, their salts and esters play a key role in emulsion polymerization. Sodium and lithium salts are used extensively in the manufacture of lubricating greases. Other salts are important additives in rubber and plastics processing and finishing. Fatty acids are also important raw materials in the production of higher alcohols and synthetic surfactants.

Production process

A flow-sheet of the production process is given below. There are two technological concepts of natural oils hydrolysis processes: batch and continuous.

The batch process is preferred at capacities of below 50 t/d of oil processed. Natural oil from storage is pumped into a splitting autoclave into which water and steam are also injected. After the hydrolysis reaction is completed, the content of the reactor is transferred through the expansion vessel into settlers, where the fatty acids are removed.

Continuous process. Natural oil is vacuum-stripped from the air and, with assistance from the piston pump, passes through the heat exchangers to enter a battery of continuous splitting autoclaves. Sprays of condensate and steam are introduced to each vessel from the counter-current direction. After expansion of the flow, the fatty acids settle and are then removed to the storage tank. The water phase, which contains glycerine ("sweet water") is concentrated to a glycerine content of 15-20% and, after filtering on a centrifuge, transferred to a storage tank.

A stoichiometric equation of the main reaction would appear as follows:

$$\begin{array}{lcl} CH_2OCOR & & CH_2OH \\ | & & | \\ CHOCOR + H_2O \rightarrow RCOOH + & & CHOH \\ | & & | \\ CH_2OCOR & & CH_2OH \end{array}$$

The equipment and machinery required for various stages of production are listed below:

Stage	Equipment
Raw materials and product storage	Heated vessels, pumps
Splitting	Pressure vessels, pumps, heat exchangers, separators, centrifuge

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*This information was prepared for UNIDO by J.A. Kopytowski, Instytut Chemii Prezemyslowej, Poland. Inquiries should be sent to: IO/COOP, Registry file No.ID/562/12, UNIDO, P.O. Box 300, A-1400 Vienna, Austria.

To avoid corrosion, part of the equipment should be lined with stainless steel. A continuous process installation can achieve a capacity of 300 t/d. The approximate price of a capacity of this size would be $US 6 million, f.o.b.

Major properties

The chemical composition of fatty acids derived from natural oils is given below (percentage):

	Palm-oil fatty acids	Rapeseed-oil fatty acids
Myristic acid	1.2-5.9	0.1
Palmitic acid	37.5-43.8	2.5-3.5
Stearic acid	2.2-5.9	1.0-1.5
Oleic acid	38.4-49.5	11-31
Linoleic acid	6.5-11.2	12-18
Ficosenic acid	-	7-11
Erucic acid	-	25-52
Linolenic acid	-	7-19

Rapeseed fatty acids have the following specifications:

Ethyl ether extract	98 wt.%
Fatty acids content	96 wt.%
Acidic value	165
Saponification value	170-185
Non-saponified substances	max 1.5 wt.%
Iodine value	90-110
Water content	max 2.0 wt.%

Materials and inputs

The raw materials, processed materials and utilities required per tonne of fatty acids mixture are:

	Palm oil[a/]	Rapeseed oil
	Fatty acids	
Natural oil (kg)	1 150	1 040
Steam (t)	1.0 (3MPa)	0.52 (6 Mpa)
Electrical energy (MJ)	18	40
Water (m^3)	20	20
Heating (gas-oil) (kg)	28	-

a/ Batch process.

The manpower requirements for a 50 t/d capacity installation of batcn process would be:

	Number
Office staff and engineers	4
Skilled workers	16
Unskilled workers	18
Total	38

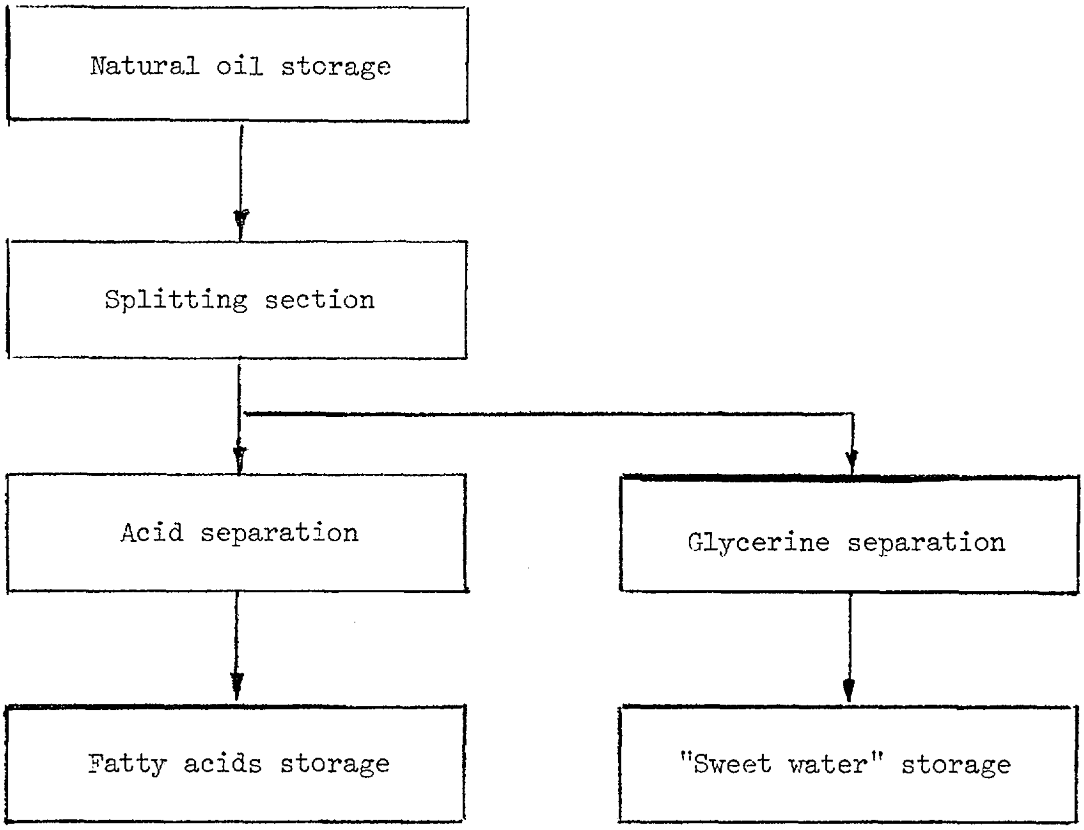
Location

The locational requirements are typical of those for most processing plants. The installation is usually part of bigger complex treating natural oils. The connected power should be about 400 kW. The cooling water consumption would be 300 m^3/h. The steam medium pressure should be 6.3 t/h. Ground stress resistance should be 0.2 MPa, and the underground water level, without drainage, should be 6 m. The production part of the installa- tion and the storage space may be of open-air construction. However, a small building - for control room, laboratories and social services - should be erected.

The approximate area of the plant site would be:

	m^2
Splitting installation	720
Storage and pumping station	520
Building	240
Total	1,480
Land	6,000

The technological process described above belongs to the Industrial Chemistry Research Institute, Warsaw Rydygiera 8, and the Engineering Co. of the Chemical Works at Kedzierzyn, Poland.



Splitting of natural oils: flow-sheet of production process

FRACTIONATION OF FATTY ACIDS*

Cotton-seed oil, palm-oil and certain kinds of animal fats are composed of two groups of fatty acids: liquid fraction (unsaturated fatty acids) and solid fraction (saturated fatty acids). It is often desirable to separate both fractions into two commercial products: technical stearin and technical olein. This process is more economical than fractional distillation. Moreover, thermal destruction of fatty acids is considerably less, and in most cases the products satisfy the customers. The separation is based on the crystallization of solid fatty acids and the emulsification of liquid fatty acids, followed by filtration.

Production process

Melted and heated fatty acids from the raw materials storage are pumped through cooling heat exchangers to the continuous crystallizer where small crystals precipitate. A washing mixture, composed of a watery solution of epsom salt and sodium salt of lauric sulphate is then added to the suspension flow. The mixed flows are vigorously agitated and sent on to the drum vacuum filter. Pure crystals of the stearic fraction are scraped from the filter surface and allowed to fall to the melter.

The stearin is then washed in the tower, using water, the upper layer being dehydrated, under vacuum, in a heated vessel. If required, the product can be crystallized on the conveyor prior to packing. Filtrate from the vacuum filter is cooled and pumped to the separator, where the emulsion is destroyed. The upper layer is next washed in the tower, using water, and the olein is heated and dehydrated in a heated vessel. The liquid product may be packed in tank-cars or barrels.

A flow-sheet of the production process is given below.

The equipment and machinery required for the various stages of production are listed below:

Stage	Equipment
Storage of raw materials and products	Vessels, melters, pumps
Emulsification	Heat exchangers, crystallizers, mixers, pumps
Filtration	Vacuum drum filter, pumps, melter, separator
Washing and drying	Washing columns, heat exchangers, adiabatic evaporators, pumps

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*This information was prepared for UNIDO by J.A. Kopytowski, Instytut Chemii Prezemyslowej, Poland. Inquiries should be sent to: IO/COOP, Registry file No.ID/562/12, UNIDO, P.O. Box 300, A-1400 Vienna, Austria.

To avoid corrosion, about 50% of the equipment should be made from stainless steel. The process is economiocally attractive because the price for both fractions is twice as high as that for the fatty acids mixture. The feasible capacity range, therefore, is wide: from 10,000 to 50,000 t/a. The process described here is designed for a 100 t/d installation. The price of the battery limit installation would be about $US 9 million.

Major properties

The major characteristics of the product are:

	Solid fraction	Liquid fraction
Melting point	min 45°C	max 15°C
Iodine value	30	80-96
Unsaponifiables	max 1 wt.%	max 4 wt.%
Water content	max 1 wt.%	max 1 wt.%
Ash content	max 0.2 wt.%	max 0.1 wt.%

Materials and inputs

The raw materials, processed materials and utilities required for 1 t of product are:

Fatty acids	1,005 kg
Emulsifying solution[a/]	15 kg
Steam (0.4 MPa)	370 kg
Cooling water	18 m^3
Water (15°C)	15 m^3
Electrical energy	80 MJ

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a/ Water solution containing 4% epsom salt and 2.3% sodium lauric sulphate.

The manpower requirements of a 100 t/d installation would be:

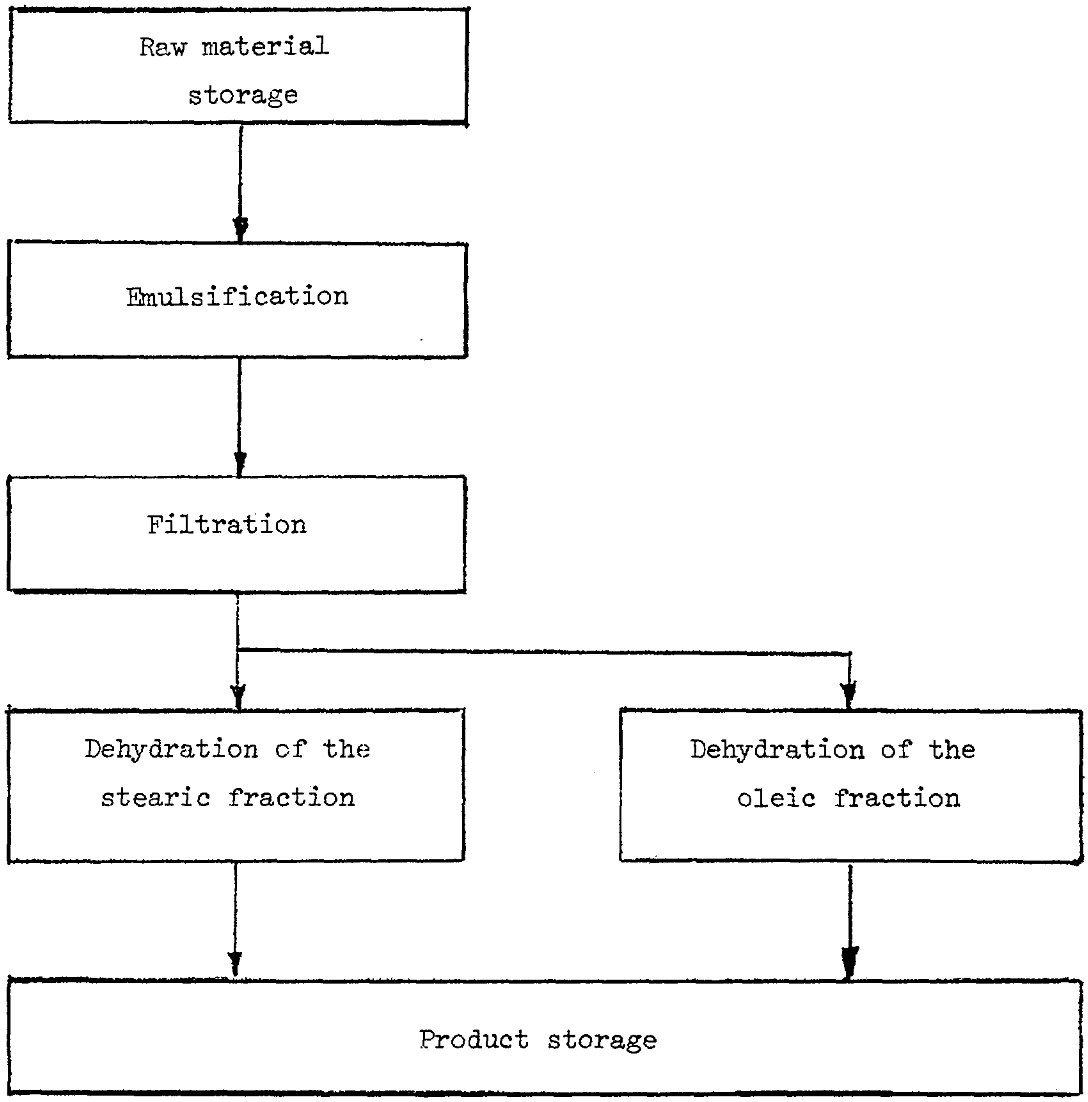
	Number
Office staff and engineers	4
Skilled workers	24
Unskilled workers	12
Total	40

Location

The locational conditions would be those of a typical chemical processing plant. The connected power capacity should be about 100 kW. The installation would use 1.6 t steam and 140 m^3 water per hour. Of the latter, 50% should be cooled to 15°C. Ground stress resistance should be 0.2 MPa, and the underground water level should be lower than 6 m. The approximate area of the plant site would be:

	m^2
Open-air construction	720
Buildings	140
Total	860
Land	4,000

The technological process described above belongs to the Industrical Chemistry Research Institute, Rydygiera 8, Warsaw and the Engineering Co. of the Chemical Works at Oswiecim, Poland.



Fatty acids fractionation: flow-sheet of production process

FURFURYL ALCOHOL*

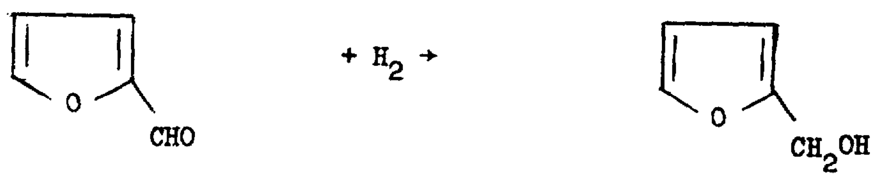
The rapid development of precision metal casting was a main reason for the growth in furfuryl alcohol production all over the world. Its applicability in the production of a wide range of furan resins, as a disperser of dyes and as a selective extraction solvent, together with the availability of the primary natural resources used in the production of furfuryl alcohol, created the demand for a feasible technological process. In response to that demand, the technology described below was developed, based on the continuous liquid-phase reduction of furfural.

Production process

A flow-sheet of the production process is given below. Furfural from storage is pumped up to the top of the hydrogenation reactor where it joins a stream of circulating furfuryl alcohol. Hydrogen from a compressor, mixed with the liquid, passes through the catalyst bed. A system of internal and external heat exchangers maintains a constant temperature in the reactor. The hydrogenated product, after expansion in a separator, flows to an azeotropic distillation column where the water and α-methylfuran are separated.

The bottoms from the column are rectified under reduced pressure. The top product is furfural, which is recycled to the reactor. The bottoms from the second column may be used as raw furfuryl alcohol. If, however, the highest quality product is required - free from polymers and heavy residue - the bottoms are purified in the film evaporator. The condensed and cooled furfuryl alcohol is then transferred to the storage tank. Distillation residues from the evaporator are burnt in the boiler house. Activation of the fresh catalyst charge and start-up of the reactor requires an auxiliary closed-cycle nitrogen system.

A stoichometric equation of the main reaction would appear as follows:



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The equipment and machinery required for various stages of production are specified below:

Stage	Equipment
Storage	Storage tanks, pumps
Reaction	Reactor, compressor, heat exchangers, pumps, separator, nitrogen blower
Distillation	Rectification columns, heat exchangers, pumps, film evaporator, tanks

To avoid corrosion, about half of the equipment should be made from stainless steel. Feasible installation capacity is in the 3,000-10,000 t/a range. Basic engineering, however, is available for a unit of 5,000 t/a capacity. In 1981, the price for a battery limit installation of 5,000 t/a capacity was about $US 3.38 million.

Major properties

After purification in the evaporator, the furfuryl alcohol has the following specifications:

Furfuryl alcohol content	min. 98%
Furfural content	max. 1%
Water content	max. 1%
Acidic value (as acetic acid)	max. 0.05%
Boiling range	162-172 $^{\circ}C$
Relative density	1.132-1.137
Refraction index	1.482-1.486

Materials and inputs

The raw materials, processed materials and utilities required for 1 t of furfuryl alcohol are:

Furfural	1.09 t
Hydrogen (99.5%)	280 m^3
Catalyst	10 kg
Electrical energy	575 MJ
Steam (0.7 MPa)	2.3 t
Cooling water	230 m^3

The manpower requirements for an installation of capacity of 5,000 t/a would be:

	Number
Office staff and engineers	5
Skilled workers	8
Unskilled workers	12
Total	25

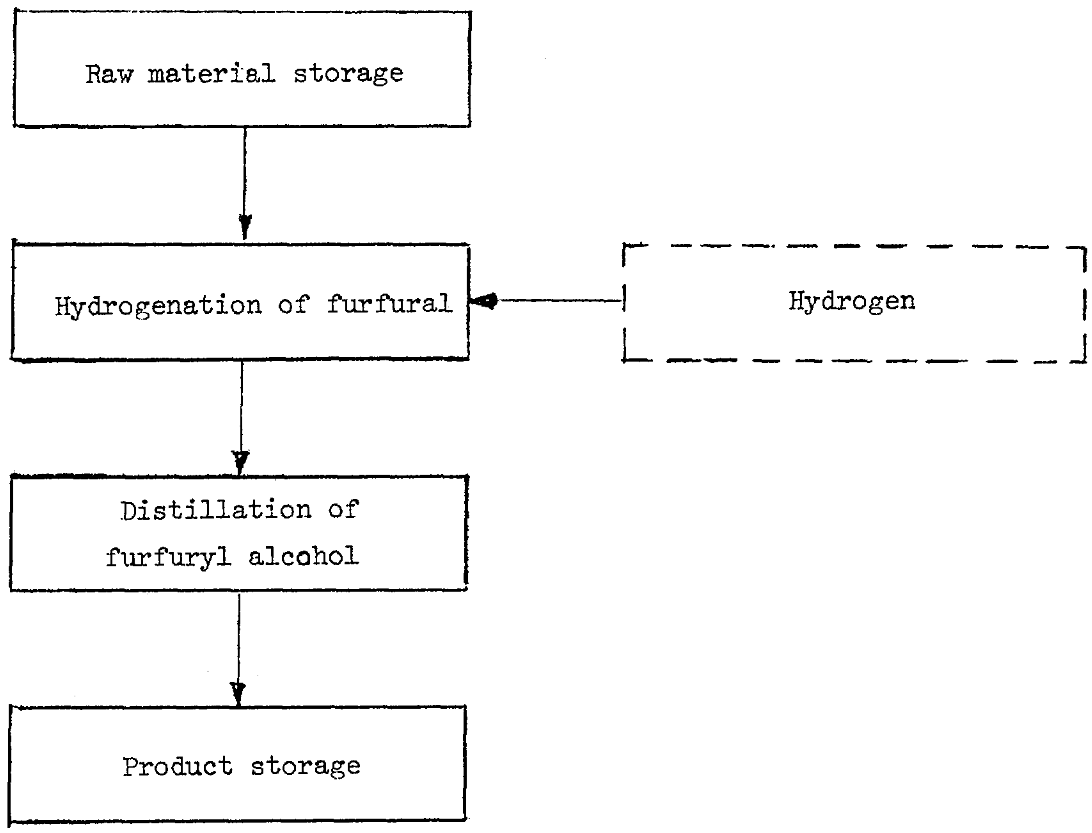
Location

No special restrictions pertain to the location of the installation, although as a small quantity of hydrogen is consumed, the preferred location should be adjacent to an existing fertilizer factory or chlorine production facility. Ground stress resistance is standard (0.15-0.20 MPa). The level of underground water, without drainage, should be lower than 4 m. The production part of installation, as well as the raw materials and product storage, should be erected as open-air constructions. A small building, however, should be provided for control room, laboratory and social services.

The approximate area of the plant site would be:

	m^2
Building	360
Open-air installation	288
Tank farm	450
Total	1,098
Land	5,000

The technological process described above is the property of the Industrial Chemistry Research Institute, Warsaw, Rydygiera 8, and the Engineering Co. Prosynchem, at Gliwice, Poland.



Furfuryl alcohol: flow-sheet of production process

FURFURYLIC RESINS FROM ORGANIC WASTES*

Furfurylic resins are a recent development in the manufacture of polymers. The basic raw material - furfuryl alcohol - is obtained from furfural, which can be produced from renewable resources or wastes such as bagasse, sunflower stalks, cotton bags or wood chips. Furfuryl resins have special application in metal casting as foundry binders of the "no bake" or "hot box" type.

Production process

Furfuryl resins are produced on equipment typically used in factories producing phenol-formaldehyde, melamineand urea-formaldehyde resins. The wide range of types (including 7-10 "standard") that may be produced using such ingredients as phenol, formaldehyde, urea and furfuryl alcohol makes it possible to create combinations for special applications. In view of the multiplicity of possibilities, two examples of cold setting for highand medium-content furfuryl alcohol resins ("F" and "H") are described here.

Resin "F" is used in steel casting as well as grey-iron and non-ferrous metal casting as the fume emission is low and there is no pin-holing effect. The furfuryl alcohol and trioxane are mixed together and a medium acidic condensation occurs. Then the pH is stabilized at 1.8-3.0 and active condensation occurs, which calls for intensive cooling of the reactor. After alkalization of the mixture, an extra quantity of furfuryl alcohol is added and vacuum dehydration carried out. Small quantities of metal oxides and trioxane are added. The resin is cured using a acid catalyst, in accordance with standard practices.

Resin "H" is used in "ultra-critical" grey-iron casting. Formalin and urea from the storage tanks are mixed and alkaline condensation takes place at boiling temperature. After p-toluenesulphonic acid has been added, the second stage of condensation (at pH 5.0-5.5) occurs. The mixture is neutralized with alkali, at which point the third step in the condenviscosity of 2,500-3,500 mPa.s, cooled, and other additives introduced. The resin is cured using an acid catalyst.

A flow-sheet of the production process is given below. The equipment and machinery required for various stages of production are specified below:

Stage	Equipment
Raw materials storage	Tanks, vessels, pumps
Condensation	Reactors with agitators and cooling-heating coils and jackets, heat exchangers, pumps
Distillation	Evaporators, heat exchangers, pumps
Glue and resin preparation	Stirred tanks, heat exchangers, pumps

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To avoid corrosion, part of the equipment should be made from stainless steel. The feasible capacity range is wide, some factories producing up to 300 t/d. In 1981, the f.o.b. price for a battery limit installation of 2,000 t/a capacity was about $US 0.9 million.

Major properties

Characteristic	Value "H" type	"F" type
Furfuryl alcohol content (%)	65-75	95-98
Free formaldehyde content (%)	max. 1.5	max. 1.0
Free urea content (%)	max. 5	-
Viscosity (mPa.s)	70-120	30-80
Relative density	1.190-1.220	1.160-1.190
pH	7.0-7.5	neutral

Materials and inputs

The raw materials, processed materials and utilities required for a 1 t of product are as follows:

Item	Consumption per tonne of product Type "H"	Type "F"
Furfuryl alcohol (kg)	705	1 035
Formaldehyde (as 100%) (kg)	143	35
Urea (kg)	159	-
Toluene (kg)	30	30
Triethanolamine (kg)	2.3	7.0
p-Toluenesulphonic acid (kg)	1.2	-
Electric energy (MJ)	125	110
Steam at 0.7 MPa (t)	0.7	0.3
Cooling water (m^3)	30	26

The manpower requirements for an installation of the same capacity would be:

	Number
Office staff and engineers	5
Skilled workers	8
Unskilled workers	8
Total	21

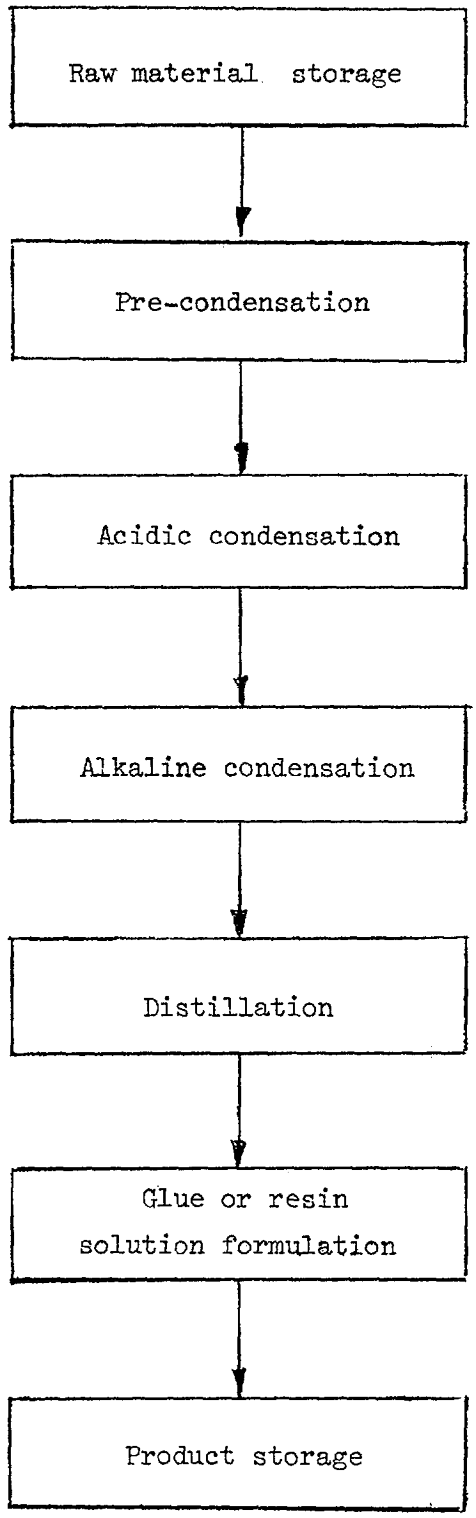
Location

The installation should be part of a bigger complex producing different types of resins and glues. The reaction area is small and the demand for utilities is low. Ground stress resistance should be 0.15 MPa, and the underground water level lower than 4 m, without drainage.

The approximate area of the plant site would be:

	m^2
Storage	80
Open-air structure	150
Building	40
Total	270
Land	1,000

The technological process described above is the property of the Industrial Chemistry Research Institute, Warsaw, Rydygiera 8, Poland.



Furfurylic resins from organic wastes: flow-sheet of production process

SULPHATION OF HIGHER ALCOHOLS*

Sulphated alcohols have found wide application in the textile industry as wetting agents in fibre preparation, dyeing, printing and finishing. They are also used in the leather industry, in degreasing and promoting the tanning and dyeing of high-quality leather. They are used, moreover, as the effective surfocant in herbicide insecticide and fungicide sprays as well as in polymerization processes and plastics coating and laminating. All kinds of laundry detergents contain alkylsulphates as an active substance. The requirements of the market-place led to the adoption by the sulphation technology of new materials such as ethoxylates. Modern sulphation installations are equipped to sulphate alcohols and ethoxylates as well as alkylbenzenes.

The process described below is capable of producing a mixture of active substances in a water solution containing:

Straight-chain alcohol sodium sulphate	(not less than 14.8%)
Straight-chain alcohol sodium ether sulphate	(not less than 14.8%)
Nonylphenol sodium ether sulphate	(not less than 5.2%)
Alkylbenzene sodium sulphonate	(not less than 5.2%)

Production process

Liquid sulphur dioxide is pumped from the storage vessel to the evaporator and mixed with a circulating flow of gas containing 6-8% sulphur trioxide. An appropriate quantity of oxygen is added and the gas mixture is passed through several types of catalytic reactor. Reaction heat is recuperated by the fresh gas. Part of the gas mixture is then used to stabilize the reaction temperature.

A mixture of straight-chain alcohols and ethoxylates is pumped from the storage tank through the sulphating reactors cascade. Sulphating gas is added to each reactor and, after sulphation, passes through the cyclone and demister and finally returns to the circulation cycle. Some additives are introduced to the first reactor in order to prevent double bond sulphation being present in the unsaturated alcohols. The mixture of sulphate esters from the sulphation process is transferred to a continuous-operation neutralizer equipped with an external heat exchanger and a circulating pump. Hydroxide and bleaching agents are added to the flow solution of sodium. After neutralizing, the mixture of sulphates-sulphonates is diluted with demineralized water to the required concentration and transferred to the storage tank.

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*This information was prepared for UNIDO by J.A. Kopytowski, Instytut Chemii Prezemyslowej, Poland. Inquiries should be sent to: IO/COOP, Registry file No.ID/562/12, UNIDO, P.O. Box 300, A-1400 Vienna, Austria.

A flow-sheet of the production process is given below. Stoichiometric equations of the main reactions would appear as follows:

$$\begin{cases} C_nH_{2n+1}OH + SO_3 \rightarrow C_nH_{2n+1}OSO_3H \\ C_nH_{2n+1}OSO_3H + NaOH \rightarrow C_nH_{2n+1}OSO_3Na + H_2O \end{cases}$$

The equipment and machinery requirements for the various stages of production are listed below.

Stage	Equipment
Raw materials and product storage	Tanks, vessels, pumps
Oxidation of sulphur dioxide	Reactors with agitators having cooling coils and jackets, heat exchangers, pumps, fans
Neutralization	Reactors with agitators, heat exchangers, pumps

To avoid corrosion and to assure a light-coloured product, practically all equipment should be made of stainless steel or specially lined. Feasible installation capacity is in the 4,000-15,000 t/a range. Smaller capacities are feasible where a sulphuric acid factory is located in the neighbourhood. The f.o.b. price for a battery limits installation of 7,000 t/a capacity would be approximately $US 9.1 million.

Major properties

Characteristics	Value
Active substance content	min 40 wt.%
Free oil (unsulphated)	max 1.5 wt.%
Sodium sulphate content	max 4 wt.%
pH of 10% solution	7.5-9.5
Colour of 10% solution (iodine scale)	max 35

The product specification can be easily adapted to local requirements.

Materials and inputs

The raw materials, processed materials and utilities required for 1 t of product are:

	kg
Active components	
Rape-seed alcohol	117.4
Stearic ethoxylate	135.6
Nonylphenol etoxylate	52.0
Alkylbenzenesulfo acid	52.0

Sulphating agents	
Sulphur dioxide	40.7
Oxygen	10.2
Other components	
Urea	22.0
Sodium hydroxide 40% solution	78.0
Sodium hypochlorite 14% solution	18.0
Demineralized water	478

Note: Consumption figures are given for a specific recipe. After adaptation to local conditions, figures would be subject to recalculation.

The utility requirements would be:

Steam (0.25 MPa)	0.9 t
Electrical energy	1 180 MJ
Cooling water	90 m^3

The manpower requirements for a 7,000 t/a capacity installation would be:

	Number
Office staff and engineers	5
Skilled workers	12
Unskilled workers	30
Total	47

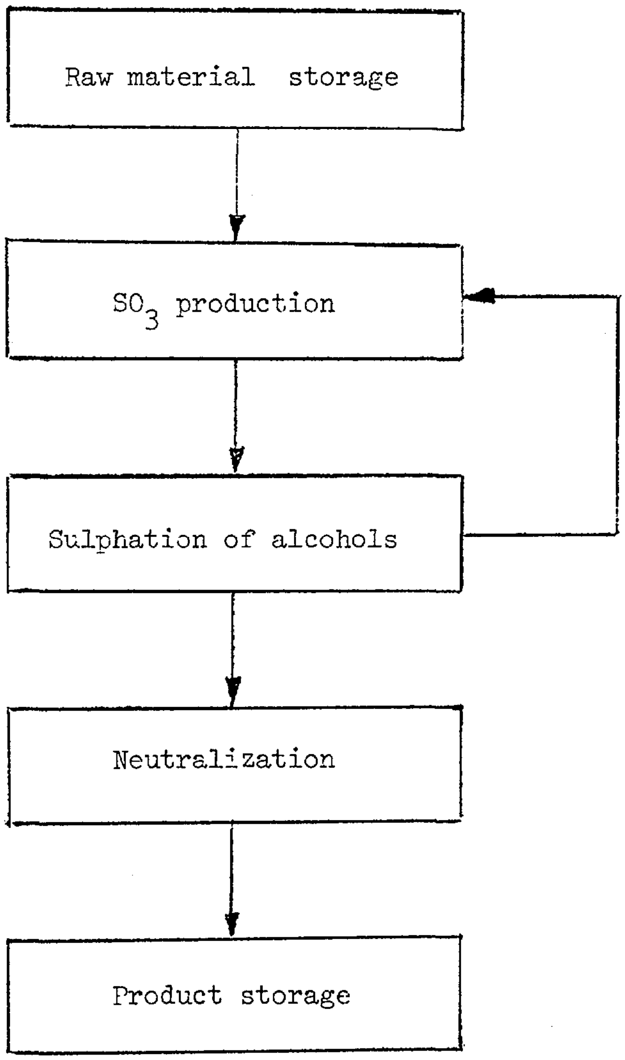
Location

As all the raw materials and products are transportable by rail or car tanks, the plant may be located anywhere that an adequate supply of water, steam and electricity is assured. Ground stress resistance should be of the order of 0.15 MPa, and the underground water level, without drainage, should be lower than 4 m.

The approximate area of the plant site would be:

	m^2
Storage	360
Open-air structures and buildings	640
Total	1,000
Land	5,000

The technological process described above is the property of the Heavy Organic Synthesis Institute at Blachownia, and the Engineering Co. of the Chemical Works at Oswiecim, Poland.



Sulphation of higher alcohols: flow-sheet of production process

SYNTHESIS OF HIGHER ALCOHOLS*

Long-chain alcohols are valuable raw materials in the detergent, textile and leather industries. Total synthesis from olefins is highly capital-intensive, and feasible only when undertaken in large petrochemical complexes. Much smaller installations, however, 1.5-3.0 t/h in size, can be built using a process of selective hydrogenation of the saturated and unsaturated fatty acids supplied by the domestic market. The main reaction is reduction of the carboxylic group of fatty acids. The selectivity of the process ensures only partial saturation of the double bond in unsaturated acids and prevents deep hydrogenation of neutral hydrocarbons.

Production process

A flow-sheet of the production process is given below. Saturated aliphatic fatty acids from raw materials storage are heated to reaction temperature and pumped to the hydrogenation reactor. Compressed hydrogen and catalysts suspended in higher alcohols are then added. A continuous flow of the product is separated from hydrogen excess in separators and cooled in heat exchangers.

The liquid fraction, following pressure reduction, is filtered on the centrifuge in order to separate the catalyst. The paste is then diluted in a mixer to a concentration of 15% and then returned to the reaction cycle. The alcohols, after additional filtering in the filter press, are transferred to the distillation chamber. Hydrogen - separated from the main flow after cooling and demisting - is directed to the suction valve of the circulation compressor, where it is mixed with a fresh portion of hydrogen; after heating, it is recycled to the process.

Hydrogenation of the unsaturated fatty acids, using butyl alcohol, in practically equimolar proportions, is carried out in the reactor with a stationary catalyst. Circulating hydrogen is then added to the reactor. After the hydrogen has been separated from the flow from the reactor - in another evaporator - the butanol and water are separated; the butanol is then distilled and recycled to the process.

Distillation of the hydrogenated mixture is accomplished in two steps: (1) By dehydrating the columns under a pressure of 4kPa; (2) By separating the alcohols from the hydrocarbons and heavy residues under a pressure of 0.4 kPa. The purified alcohols are transferred to the storage tank.

A stoichiometric equation of the main reaction would appear as follows:

$$RCOOH + H_2 \rightarrow ROH + H_2O$$

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*This information was prepared for UNIDO by J.A. Kopytowski, Instytut Chemii Prezemyslowej, Poland. Inquiries should be sent to: IO/COOP, Registry file No.ID/562/12, UNIDO, P.O. Box 300, A-1400 Vienna, Austria.

The equipment and machinery required for various stages of production are listed below:

Stage	Equipment
Storage of fatty acids and higher alcohols	Heated tanks, vessels, pumps
Hydrogenation	Pressure reactors, heat exchangers, separators, centrifuge, press filter settlers, mixers, electric heaters
Distillation	Vacuum distillation columns, heat exchangers, pumps, booster compressors, water ring vacuum pump
Catalyst preparation	Mixers, vessels, pumps

About 35% of this equipment should be made from stainless steel. A feasible installation capacity would be in the 10,000-40,000 t/a range, depending of the availability of raw materials. Where necessary, smaller installations can also be designed. The price for a battery limit installation of 20,000 t/a capacity, hydrogenating either saturated or unsaturated fatty acids, is about $US 14.5 million.

Major properties

Characteristic	Fraction C_{12}-C_{14}	Fraction C_{16}-C_{18}
Acidic value	max 1	max 1
Saponification value	max 1	max 1
Iodine value	max 1	max 1
Melting point	20-25°C	60-80°C
Content of main fraction	98 wt.%	98 wt.%

The properties indicated in the above table are of information value only because of the nature of the raw materials used. A laboratory test should always be carried out before design of the factory.

Materials and inputs

The raw materials, processed materials and utilities required to produce 1 t of alcohol are:

	Saturated	Unsaturated
Distilled fatty acids (kg)	1,100	1,200
Hydrogen (m^3)	365	395
Catalyst[a/] (kg)	16	4.3
Butyl alcohol (kg)	-	1.2
Electrical energy (MJ)	3,600	3,600

a/ Unit price for the catalyst is about $US 3.5/kg.

The manpower requirements for a 20,000 t/a capacity installation would be:

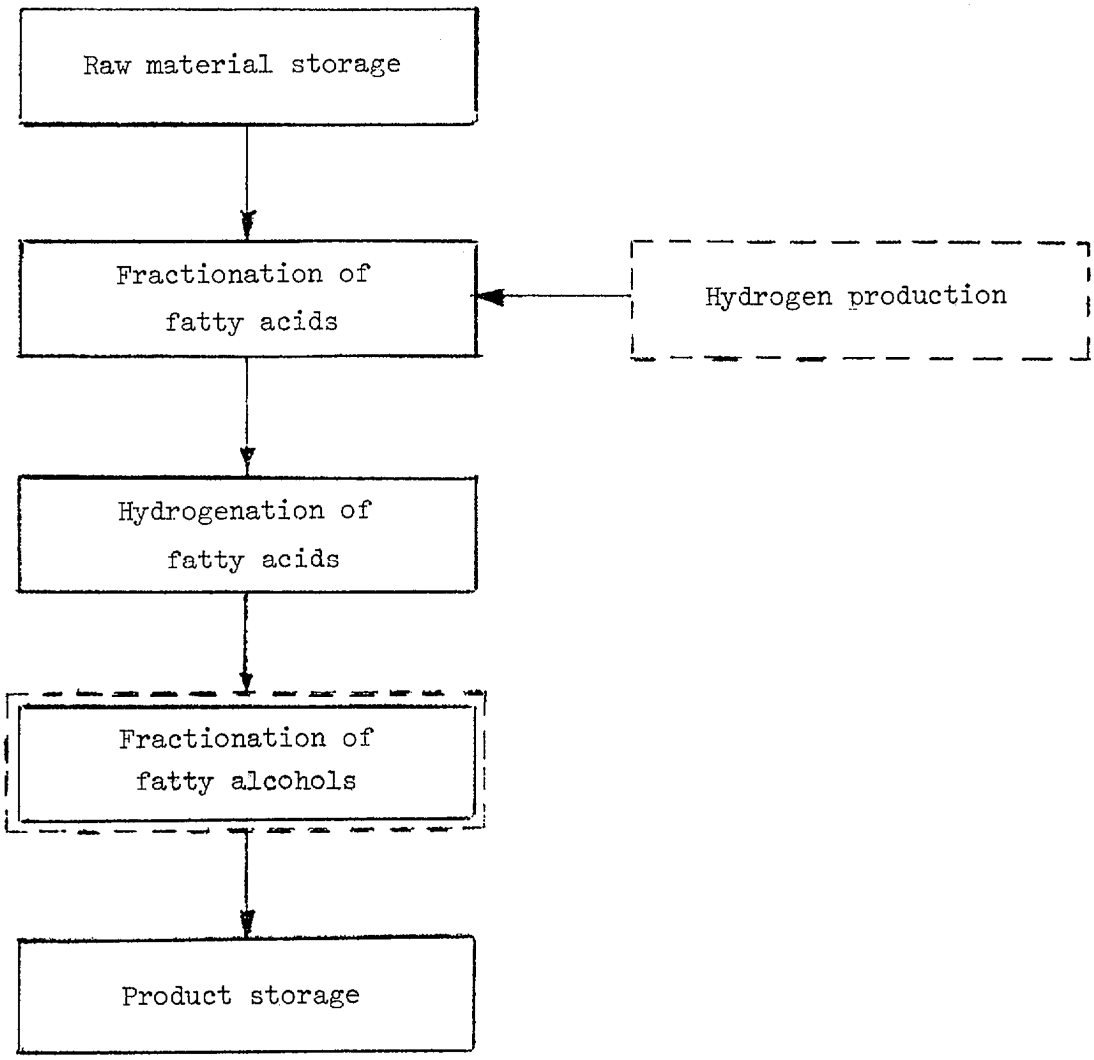
	Number
Office staff and engineers	12
Skilled workers	24
Unskilled workers	16
Total	52

Location

In view of the particular technological requirements of the process, the installation is best located at a nitrogen fertilizer factory, where an abundance of hydrogen is available and different pressures of steam generated. The connected electrical power should be about 3,000 kW. The required ground stress resistance would be about 2.2 MPa, and the underground water level, without drainage, should be 6 m. The approximate area of the plant site would be:

	m^2
Open-air steel structure	2,400
Compressor house	400
Storage	600
Total	3,400
Land	12,000

The technological process described above belongs to the Institute of Heavy Organic Synthesis at Blachownia and the Chemical Works at Kedzierzyn, Poland.



Synthetic higher alcohols: flow-sheet of production process

SULPHURIC ACID*

Sulphuric acid is a heavy-tonnage chemical product with universal industrial application.

Production process

Melted and filtered sulphur is pumped through a heat exchanger to an oxidation furnace where air is added. Reaction gases containing sulphur dioxide pass to a recuperation boiler where medium-pressure steam (2.5-6.0 MPa) is produced. This steam is used in melting and heating processes throughout the entire installation, any excess being directed to the electric generator or driving turbines. Further oxidation, to sulphur trioxide, is carried out in several steps in a catalytic reactor and the reaction heat recuperated.

After the first conversion step, the gas is directed to the first absorption chamber. Non-absorbed gas is recycled to the second step of the conversion process. The gas, after the second conversion step, is directed to the second absorption chamber. The absorption process is carried out in towers in which sulphuric acid is being recycled. Water is added. The sulphuric acid, at the required concentration, is transferred to the product tank.

A flow-sheet of the production process is given below. The equipment and machinery required for various stages of production are specified below:

Stage	Equipment
Raw materials and product storage	Storage tanks, heated vessels, pumps, filters
Oxidation of the sulphur	Furnance, heater, heat exchangers, air blower, gas blower, steam boiler
Catalytic oxidation	Catalytic reactor, heat exchangers
Absorption	Absorption towers, heat exchangers, pumps

The equipment should be made from mild steel, some ceramic and special lining being applied. A feasible installation size may be as small as 10 t/h, in special conditions even less. The highest feasible capacity can achieve production of 1 million t/a. The price for a battery limit installation depends on capacity requirements: the cost of the machinery and equipment f.o.b. for a 1,000 t/d installation being in the region of $US 15 million.

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*This information was prepared for UNIDO by J.A. Kopytowski, Instytut Chemii Prezemyslowej, Poland. Inquiries should be sent to: IO/COOP, Registry file No.ID/562/12, UNIDO, P.O. Box 300, A-1400 Vienna, Austria.

Major properties

Characteristic	Value
Sulphuric acid content	94-99%
Nitrogen oxides (as N_2O_3)	max. 0.001%
Solids content	max. 0.03%
Iron content (as Fe)	max. 0.0002%
Lead content (as Pb)	max. 0.005%
Relative density	1.836

Materials and inputs

The raw materials, processed materials and utilities required for 1 t of product are:

Sulphur (as 100%)	328 kg
Demineralized water	1,362 kg
Cooling water	56 m^3
Electrical energy	43[a/] MJ

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a/ Blower driven by steam turbine.

The manpower requirements for an installation of the same capacity would be:

	Number
Office staff and engineers	8
Skilled workers	40
Unskilled workers	16
Total	64

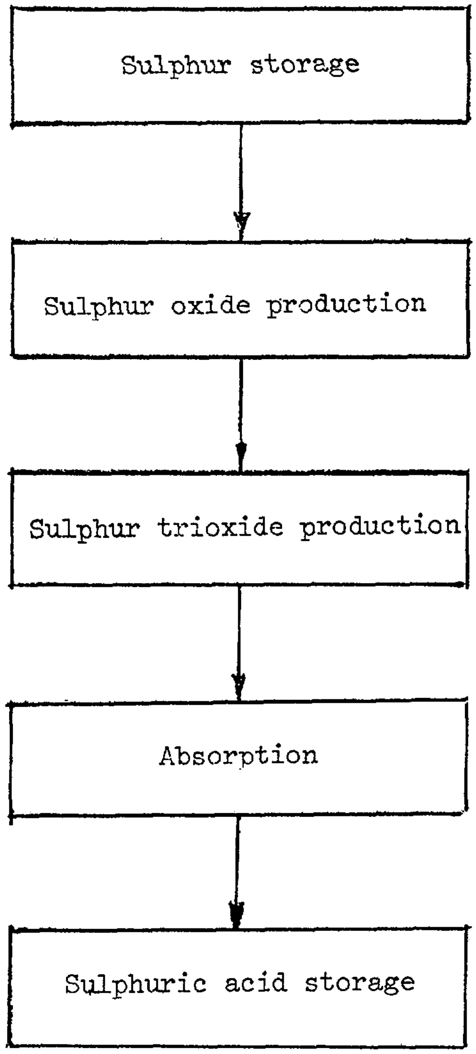
Location

High-tonnage consumers such as phosphoric fertilizer producers prefer that the installation be located adjacent to the industrial complex. In the case of small consumers, no special locational criteria need be observed, save that water should be available. The prefered ground stress resistance is 0.2 MPa, and the underground water level, without drainage, should be 4 m.

The approximate area of a plant site would be:

	m^2
Buildings	300
Open-air constructions	8,000
Total	8,300
Land	15,000

The technological process described above is the property of the Engineering Co. Biprokwas Gliwice ul., Konstytucji 11, Poland.



Sulphuric acid: flow-sheet of production process

PHENOL*

Phenol is a basic chemical that is produced in many countries. It has a wide range of high-tonnage uses in the production of phenol-formaldehyde, phenol-furfuryl and other resins. Because of its chemical reactivity, it is used as a raw material in the production of adipic acid, caprolactam and bisphenol-A. Phenol is also used as a component in dyes and insecticides.

The technological process described below is based on the well-known cumene route. In this process, another important product - acetone - is produced. This is an important raw material used in methyl methacrylate and bisphenol-A production, and is widely used as a solvent and flotation agent.

Production process

A flow-sheet of the production process is given below. Cumene from the storage tank is pumped to the oxidation reactor where, under pressure, it is oxidized with compressed air. A diluted solution of the hydroperoxide is concentrated under vacuum, the unreacted cumene being recycled to the oxidation reactor, and the concentrated hydroperoxide being transferred to an acidic decomposition unit where a mixture of phenol and acetone is produced. After neutralization, the mixture is separated from the water and pumped to the distillation section.

In the first step, acetone is separated and purified; in the other distillation columns, phenol, a hydrocarbon fraction and heavy residue are produced. If necessary, part of the distilled phenol may be further refined on an ion-exchange resin. The hydrocarbon fraction, following hydrogenation, is recycled to the oxidation reactor.

Stoichiometric equations of the main reactions would appear as follows:

$$\begin{cases} C_6H_5C_3H_7 + O_2 \rightarrow C_6H_5C_3(OOH)H_6 \\ C_6H_5C_3(OOH)H_6 \rightarrow C_6H_5OH + (CH_3)_2CO \end{cases}$$

The equipment and machinery requirements for various stages of production are specified below:

Stage	Equipment
Cumene oxidation	Oxidation reactors, pumps, vacuum distillation columns, heat exchangers, vessels, booster, compressor
Hydroperoxide decomposition	Vessels, pumps, mixers, heat exchangers

*This information was prepared for UNIDO by J.A. Kopytowski, Instytut Chemii Prezemyslowej, Poland. Inquiries should be sent to: IO/COOP, Registry file No.ID/562/12, UNIDO, P.O. Box 300, A-1400 Vienna, Austria.

Distillation	Distillation columns, heat exchangers, vessels, pumps
Hydrogenation of hydrocarbon fraction	Pressure reactor, rectification heat exchangers, vessels, pumps
Storage of raw materials and products	Tanks, vessels, pumps, heat exchangers

To avoid corrosion, part of the equipment should be made from stainless steel or lined mild steel. A feasible size for the project depends on local conditions (e.g. the availability of cheap C_3 fraction): realistic capacities are in the 30,000-150,000 t/a range. In 1981, the price for a battery limit installation of 7 t/h capacity was about $US 40 million.

Major properties

Characteristic	Value
Phenol	
Phenol content	99.9%
Organic impurities content	max. 200 ppm
Carbonyl substances content	max. 70 ppm
Mesityl oxide	max. 50 ppm
Total sulphur content	max. 1 ppm
Melting point	min. 40.6°C
Colour (Pt-Co scale)	max. 30
Acetone	
Acetone content	99.5%
Acids content (as acetic acid)	max. 20 ppm
Aldehydes content (as acetaldehyde)	max. 300 ppm
Methanol content	max. 400 ppm
Water content	max. 0.3%
Relative density	0.790-0.792

Materials and inputs

The raw materials, processed materials and utilities required to produce 1 t of phenol are:

Cumene	1.4 t
Hydrogen (standard volume)	15 m^3
Sulphuric acid (as 100%)	4.4 kg
Sodium hydroxide (as 100%)	3.5 kg
Steam (1.7 MPa and 0.5 MPa)	4.8 t
Electrical energy	870 MJ
Cooling water	460 m^3

The manpower requirements for an installation of 7 t/h capacity would be:

	Number
Office staff and engineers	14
Skilled workers	40
Unskilled workers	19
Total	73

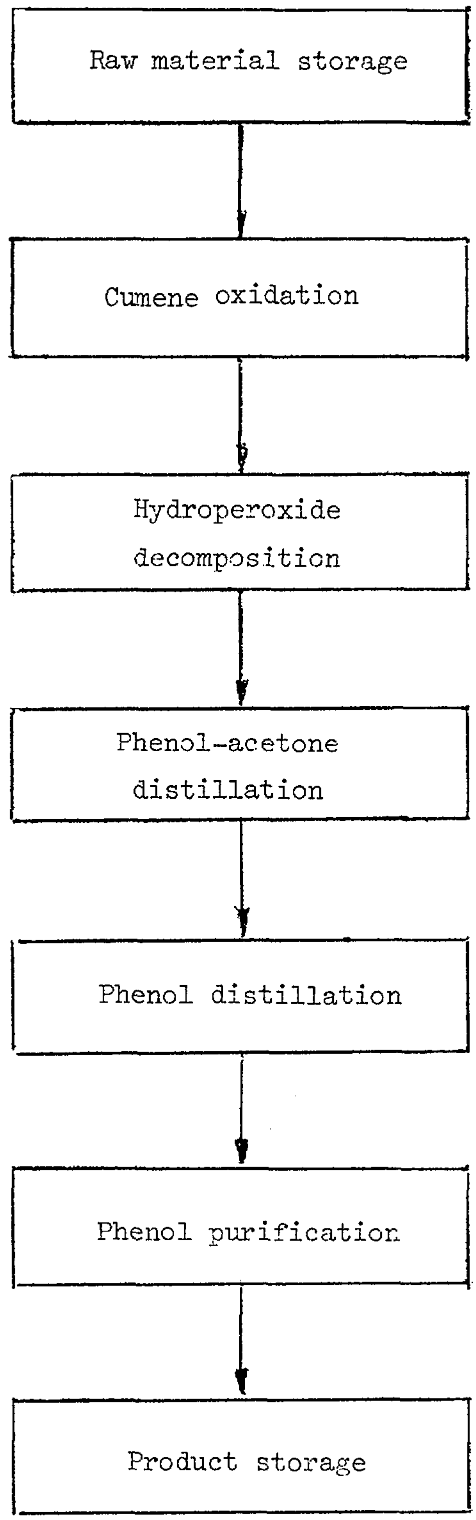
Location

Locational conditions should be the same as those for a petrochemicals processing industry, and preferably, because of dispersed consumption, close to the source of raw materials. Infrastructural investment may be necessary to ensure adequate supplied of steam, water and other utilities.

The approximate area of a plant site would be:

	m^2
Open-air constructions	2,800
Buildings	1,700
Total	4,500
Land	15,000

The technological process described above belongs to the Industrial Chemistry Research Institute and Engineering Co. Prosynchem, at Gliwice, Poland.



Phenol: flow-sheet of production process

GLYCERINE FROM NATURAL PRODUCTS*

Several commercial grades of glycerine are produced with different specifications regarding purity and glycerine content. Its chemical properties are the reason for its wide application in such industries as pharmaceuticals, cosmetics, and explosive and epoxy resin manufacturing. Natural oils and fats are important resources from which glycerine is recovered, two main processes being used: fat-splitting hydrolysis (from which 15-20% crude results) and saponification (crude recovered from spent lyes at 10-15% glycerine content).

Production process

A flow-sheet of the production process is given below. Diluted crude ("sweet water") from the storage is cooled and filtered on a centrifuge to separate part of the dissolved fatty acids. The next step is chemical purification, through the addition of sodium hydroxide, aluminium sulphate and soda ash.

In static mixers, soaps and other salts are precipitated and filtered on a filter press. The clear crude is then pumped to the concentration section in a triple-effect evaporator, under vacuum. The crude glycerine (about 80%) is bleached with activated carbon in the mixer, filtered in a special tube filter with elements of porous stone, and distilled under vacuum. The distillate is condensed in fractions of different glycerine concentration, each fraction being deodorized and dried. Grades of the highest purity are, in addition, bleached with activated carbon and filtered.

The equipment and machinery for various stages of production are specified below:

Stage	Equipment
Storage of raw materials and products	Tanks, vessels, pumps
Chemical purification	Mixing vessels, static mixers, press filters, centrifuges, pumps
Concentration	Heat exchangers, evaporators, pumps, booster-compressor
Distillation	Mixing vessels, tube filters, distillation columns, heat exchangers, pumps

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To avoid corrosion, about 20% of the equipment should be made from stainless steel. Economic feasibility should be estimated taking into account the feasibility of establishing an installation for splitting (by hydrolysis) of fats, because the glycerine content of the fats is about 10%. This means that the glycerine production capacity described should be attached to a splitting installation of 300 t/d capacity. The approximate price of a battery limit installation of 7,000 t/a capacity is $US 9.6 million.

Major properties

Characteristic	Value	
	Dynamite grade	Technical grade
Glycerine content (%)	98.5	90
Saponification value (mg KOH per g)	0.5	1.0
Transparency (%)	70	80

Materials and inputs

The raw materials, processed materials and utilities required for 1 t of commercial product are:

	Dynamite grade	Technical grade
Glycerine in the diluted crude (t)	1.05	0.96
Sodium hydroxide (kg)	7.5	7.0
Aluminium sulphate (kg)	25	23
Soda ash (kg)	25	23
Activated carbon (kg)	7.8	3.5
Steam at 1.7 MPa (t)	1.8	1.6
Steam at 0.7 MPa (t)	2.1	1.9
Electrical energy (MJ)	314	287
Water at 15°C (m^3)	18	16
Cooling water (m^3)	280	280
Compressed air at standard conditions (m^3)	15	13

The manpower requirements for an installation of the same capacity would be:

	Number
Office staff and engineers	5
Skilled workers	12
Unskilled workers	20
Total	37

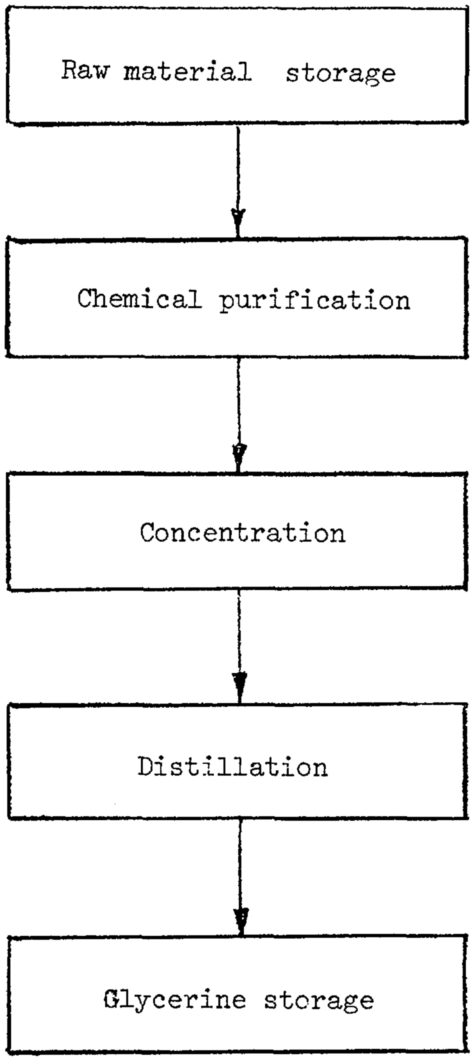
Location

Preferably, the plant should be located near existing splitting and saponification installations for fats and oils, in order to avoid the costly transportation of diluted solutions. The connected electrical power capacity should be 110 kW; the consumption of water 320 m^3/h; and the steam pressure about 4 t/h - which indicates the need for an industrial infrastructure. If necessary, steam (1.7 MPa) can be partially substituted for by electrical energy.

The approximate area of the plant site would be:

	m^2
Open-air construction	640
Building	240
Tank farm	160
Total	1,040
Land	5,000

The technological process described above belongs to the Industrial Chemistry Research Institute and the Engineering Co. of the Chemical Works at Oswiecim, Poland.



Glycerine from natural products: flow-sheet of production process

SOAP*

Natural oils and fats are the oldest raw materials used in the production of surfactant, i.e. soap. Synthetic detergents have largely displaced soap as a heavy-duty washing material, but soap - especially toilet and fine laundry soap - continues to enjoy consumer popularity and is preferred where soft water is available, whether from natural resources or by treatment. In many countries, soap is still the primary washing product for domestic and commercial laundering as well as personal hygiene.

It has, moreover, a wide range of industrial applications: textile mills still use it in kier-boiling cotton, scouring wool and degumming silk, and it plays an important role in emulsion polymerization. Sodium and lithium soaps are used extensively to thicken mineral oils in the manufacture of lubricating greases, and soaps are used as spreading agents to improve the dispersion properties of insecticides and fungicides.

Production process

Fatty raw materials are melted in a vessel by direct steam injection. Natural oils are heated and transferred to a bleaching operation. In the first step, vacuum dehydration is carried out at a temperature of 120-130°C. After elimination of the moisture, bleaching earths are added and the composition vigorously stirred. The content of the mixer is then cooled and circulated through the filter press. Fats or oils, separated from the bleaching earths, are pumped to saponification kettles which are simultaneously charged with a solution of caustic soda.

During the saponification process, heat, varying in intensity, is released. The kettles are equipped with coils and direct steam injectors. When the saponification process is finished, a concentrated salt solution (or grain salt) is added to separate the lye. The graining operation may be repeated two or three times, the lyes being collected and sent to glycerine recovery.

The mass of soap is submitted to additional settling treatment, where some additives and antioxidants may be introduced. Liquid soap (60% fatty acids) from the tank is heated and pumped to the vacuum spray-drying unit. Soap powder from the dryer is removed by a set of scrapers and directed to the plodder. Noodles from the plodder are cut into pieces. To produce laundry soap, these pieces are given further homogenization and, together with some additives, pressed into bars. To produce toilet soap, the noodles are collected in feeding hoppers from which - through weighting - they are directed to the homogenization process, additives and dyes being introduced. Paste from the feeding screw is finished in the roll mill and transferred to the plodder and the cutter. The pieces of soap, cut to the desired size, are then stamped and wrapped.

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*This information was prepared for UNIDO by J.A. Kopytowski, Instytut Chemii Prezemyslowej, Poland. Inquiries should be sent to: IO/COOP, Registry file No.ID/562/12, UNIDO, P.O. Box 300, A-1400 Vienna, Austria.

A flow-sheet of the production process is given below. The equipment and machinery requirements for the various stages of production are listed below.

Stage	Equipment
Fats and oils storage	Heated vessels, pumps
Bleaching	Mixers with agitator and heating coil, vacuum water ring pump, filter press
Saponification	Saponification kettles, recovery vessels, pumps
Drying	Filter press, heat exchangers, atomiser, separator, booster-compressor, plodder
Finishing	Plodder, screw feeder, weights mixer, stamper, wrapper

The range of feasible capacities is wide - 3,000-10,000 t/a - and depends on the availability of local resources and finishing technology as well as the potential market. The installation price for a battery limit of 1 t/h capacity is about $US 3.6 million.

Major properties

Characteristic	Value (wt.%)
Sodium salt of fatty acids	83
Water content and volatiles (up to 105°C)	max. 15
Free alkalies	max. 0.1

Local products will have further specific properties with regard to, for example, colour and aroma.

Materials and inputs

The raw materials, processed materials and utilities required for 1 t of commercial product are:

Fats or oils as fatty acids	900 kg
Sodium hydroxide (40% solution)	370 kg
Bleaching earth	20 kg
Sodium chloride (33% solution)	350-500 kg
Additives	30 kg
Steam (1.2 MPa)	2 500 kg
Cooling water	45 m^3
Process water	2.5 m^3
Electrical energy	720 MJ

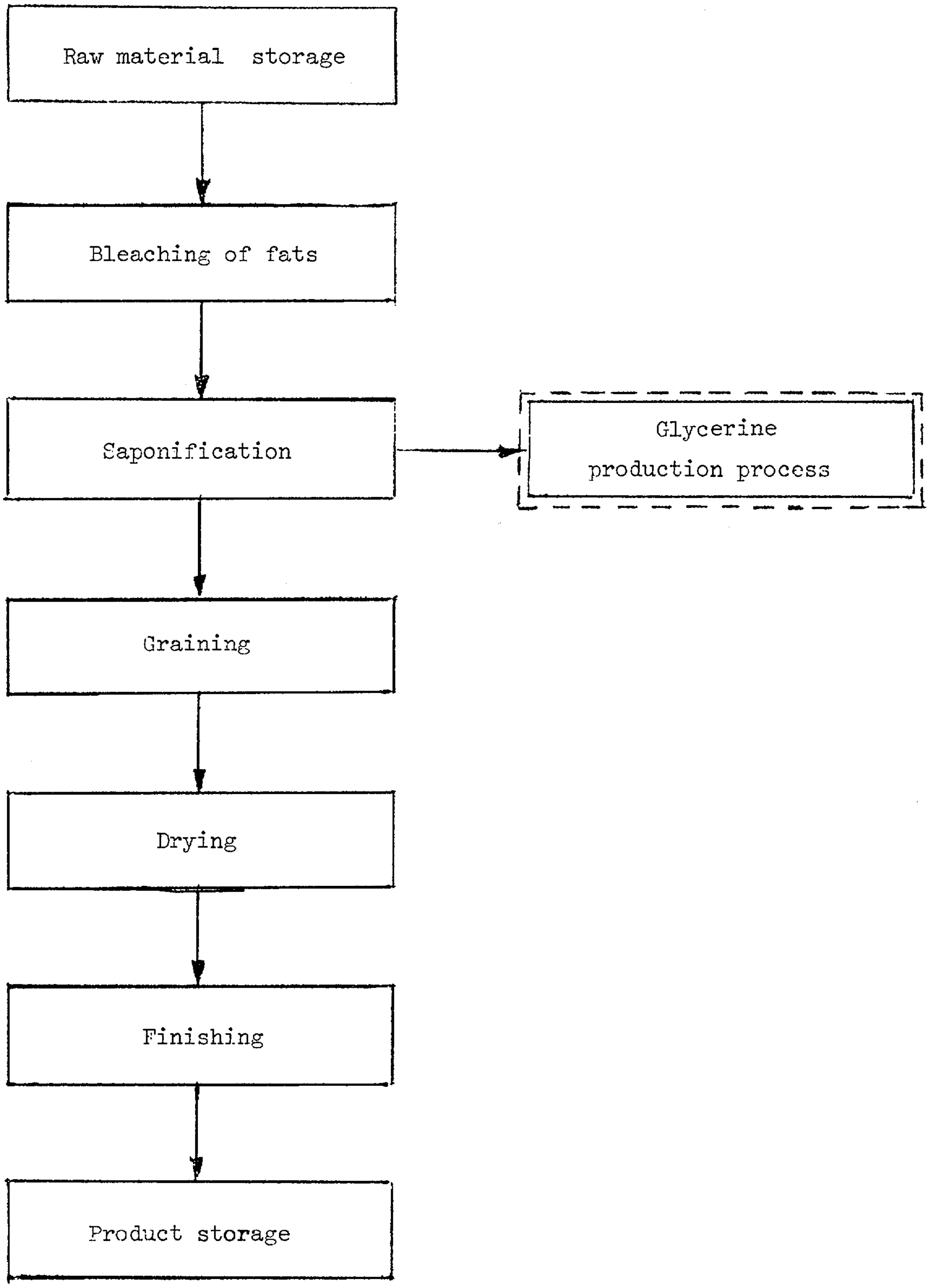
The manpower requirements for an installation of the same capacity would be:

	Number
Office staff and engineers	5
Skilled workers	8
Unskilled workers	12
Total	25

Location

Soap can be produced anywhere. The equipment and machinery are easy to operate. Ground stress resistance should be 0.15 MPa, and the underground water level should be 4 m, without drainage. The approximate area of a plant site would be:

	m^2
Tank farm	600
Buildings and open-air structures	1,200
Total	1,800
Land	5,000



Soap: flow-sheet of production process

SULPHONATION OF ALKYLBENZENE*

Sulphonated and sulphated products, in the form of solutions of their sodium salts, are main components in the world-wide manufacture of detergents. These products have found application also in many of the processes of the textile and leather industries. But the use of detergents, in solid and liquid form, has been the main reason for production capacity growth in sulphonated alkylbenzenes. Sulphonation of linear or branched alkylbenzenes may be achieved through application of sulphuric acid, chlorosulphonic acid or sulphur trioxide. The last-mentioned process is widely used because there are no problems in disposing of residual acids; moreover, the product's sodium sulphate content is low.

Production process

The liquid sulphur dioxide is pumped from the raw materials storage tank through an evaporator. Gas is mixed with the circulating, diluted sulphur trioxide. A small quantity of oxygen is added, and the mixture is catalytically oxidized in a reactor. Low-concentration gases (6-8% of SO_3) are cooled at several levels of heat exchangers by the counter-current flow of gas before the reaction. Sulphonation gas is barboted through each reactor in a sulphonating cascade. Dry alkylbenzene is pumped from storage to the first sulphonating reactor.

The partially sulphonated mixture is then transferred to the remaining sulphonating reactors. Each reactor is equipped with an agitator, cooling coil and water jacket. Unreacted sulphur trioxide passes back to the circulation fan through the cyclones, filters, heat exchangers and demisters.

The sulphonated product then goes to the digestion reactor, where dissolved sulphur trioxide and anhydrides react. After a small quantity of water has been added in the heat exchanger, the mixture is transferred to the neutralizer. The diluted solution of the sodium hydroxide is used as a neutralizing agent. The process is carried out in a circulation pump and heat exchanger. A product with pH 7-8.5 and containing buffer is then pumped to the storage tank. At the neutralizing stage, correct concentration of the sulphonate solution is maintained by adding demineralized water.

A block flow sheet of the production process is given below. Stoichometric equations of the main reactions would appear as follows:

$$\begin{cases} C_nH_{2n+1}\ C_6H_5 + SO_3 \rightarrow C_nH_{2n+1}\ C_6H_4\ SO_3H \\ C_nH_{2n+1}\ C_6H_4SO_3H + NaOH \rightarrow C_nH_{2n+1}\ C_6H_4SO_3Na + H_2O \end{cases}$$

*This information was prepared for UNIDO by J.A. Kopytowski, Instytut Chemii Prezemyslowej, Poland. Inquiries should be sent to: IO/COOP, Registry file No.ID/562/12, UNIDO, P.O. Box 300, A-1400 Vienna, Austria.

The equipment and machinery required for various production stages are listed below.

Stage	Equipment
Raw materials and product storage	Pressure vessels, tanks, pumps
Sulphonation	Reactors with agitators, pumps, heat exchangers, cyclones filters, demisters
Neutralization	Pumps, mixers, heat exchangers
Oxidation of sulphur dioxide	Reactor, circulating fan, heat exchangers

Equipment used in the sulphonation process should be made from stainless steel. Part of the equipment in the neutralization section should be rubber lined. The feasible capacity of an installation has broad limits. If the installation is attached to an already existing detergent factory, a capacity of 3,000-5,000 t/a is feasible. The upper limit depends on the cost of transportation of the diluted liquid and amounts up to 5 t/h. In 1981, the approximate price for a battery limit installation of 7,000 t/a capacity was $US 9 million.

Major properties

Three factors are important when the product is used as a detergent:

Lightness of colour
Low free oil-content (unsulphonated product)
Low inorganic salts content.

The specification for linear sodium alkylbenzene sulphate is given below:

Active substance content	45-50 wt.%
Free-oil content	0.7-2.0 wt.%
Sodium sulphate content	0.7-2.0 wt.%
Colour (iodine scale of 10% solution)	35

Materials and inputs

The raw materials, processed materials and utilities required to produce 1 t of dry detergent are:

Linear alkylbenzene (C_{16})	808 kg
Sulphur dioxide	153 kg
Oxygen	38 kg
Sodium hydroxide (40%)	250 kg
Sodium hypochlorite (13%)	60 kg
Steam (0.25 MPa)	1,700 kg
Cooling water	30 m^3
Demineralized water	1.05 m^3
Electrical energy	1,180 MJ

The manpower requirements for a plant of 7,000 t/a capacity would be:

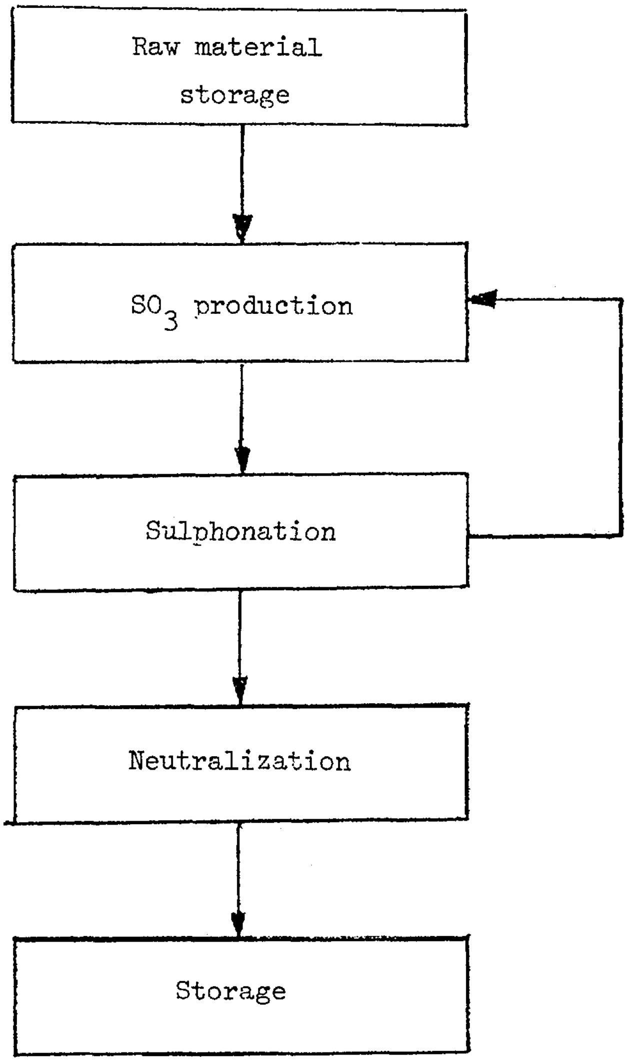
	Number
Office staff and engineers	5
Skilled workers	12
Unskilled workers	30
Total	47

Location

Plant location presents little problem as all raw materials and products are readily transportable in rail or car tanks; it is only necessary to ensure an adequate supply of water, steam and electricity. Ground conditions are normal: stress resistance should be of the order of 0.15 MPa, and the underground water level should be lower than 4 m. The approximate area of the plant site would be:

	m^2
Storage area	360
Buildings and installations	640
Total	1,000
Land	5,000

The technological process described above is the property of the Heavy Organic Synthesis Institute at Blachownia and the Engineering Co. of the Chemical Works at Oswiecim, Poland.



Sulphonation of alkybenzene: flow-sheet of production process

ALKYLATION OF BENZENE*

Alkylbenzene, a basic raw material used in detergents production, may be synthesized from alkanes or alkenes and benzene. The alkylation process chosen will depend on whatever raw materials are available, but all processes are complicated and call for experience on the part of operatives. The most elastic of the production processes features the alkylation of benzene with chloroderivatives of linear or branched alkanes. (Linear alkylbenzene is the more desirable product as detergents having this as their basis are more easily biologically destroyed in sewerage and industrial effluents.) In the process, a linear dodecane fraction containing no more than 3% nonane and 0.3% tetradecane is used.

Production process

A flow-sheet of the linear alkylbenzene production process is given below. The dodecane fraction is pumped from the raw materials storage tank and, after being mixed with recycling alkane, absorbs the rest of the chlorine from the flow of the post-chlorination gases. From the bottom of the washing tower, dodecane is transferred to the cascade of two chlorination reactors where fresh chlorine is added. Reaction heat is recovered in external heat exchangers.

The catalytic complex necessary for the alkylation process is prepared in a periodic reactor filled with alumina sticks. Alkylbenzene and a gas mixture of hydrogen and hydrochloric acid are then added to the reactor, and benzene from the storage tank pumped to the azeotropic distillation. The bottom dry product is mixed with chlorinated alkane and the catalytic complex in the alkylation reactor, and the reaction heat recovered in internal heat exchangers.

The catalytic complex is separated from the alkylate in settlers and pumped to the decomposition section. Hydrochloric acid is absorbed from the raw alkylbenzene and part of the unreacted benzene is distilled. The bottom product, after settling the rest of the catalytic complex, is neutralized in a vessel filled with solid sodium hydroxide. The neutral product is then distilled in several columns where the rest of the unreacted benzene and alkanes, as well as the pure fraction of alkylbenzene, are separated.

The bottom product of the last column is low-grade alkylbenzene. This is refined with sulphuric acid, distilled in a vacuum column, and transferred to the storage tank. The catalytic complex is decomposed in a special reactor where bauxite, water and steam are added. Dissolved in water, aluminium chloride has commercial application.

In the process, considerable quantities of hydrochloric acid are produced (in alkylation and chlorination sections). Acid from the alkylation process is cooled to a low temperature in several steps in order to condense the organic compounds. After passing through the washing tower, it is mixed with the flow from the chlorination of alkane. Dry hydrochloric acid, after passing

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through an active carbon filter, is absorbed in water. The acid (concentration 33%) is then pumped to the storage tank.

The cooling and heating agents used in production are prepared in special sections and introduced into the process.

The stoichometric equations of the main reactions would appear as follows:

$$\begin{cases} C_nH_{2n+2} + Cl_2 \rightarrow C_nH_{2n+1}Cl + HCl \\ C_nH_{2n+1}Cl + C_6H_6 \xrightarrow{cat.} C_nH_{2n+1}C_6H_5 + HCl \end{cases}$$

The equipment and machinery needed for various stages of production are listed below.

Stage	Equipment
Raw materials and product storage	Storage vessels, tanks, pressure vessels, pumps
Chlorination	Chlorination towers, heat exchangers, pumps
Alkylation	Alkylation reactors, heat exchangers, pumps, settlers
Distillation	Distillation columns, heat exchangers, pumps, vacuum pumps, booster-compressors
Refining	Mixers, heat exchangers, pumps, distillation column, vessels

To avoid corrosion, part of the equipment should be made from stainless steel, and part lined with carbatite and rubber. A feasible installation capacity would be in the 20,000-40,000 t/a range. In 1981, the price of a battery limit installation of 25,000 t/a capacity was of the order of $US 90 million.

Major properties

Refined and distilled alkylbenzene has the following specifications:

Boiling range	280^{o}-$310^{o}C$
Relative density (d_4^{20})	0.861-0.865
Non-sulphonating components	max. 1.8 wt.%
Free chlorine content	max. 0.1 wt.%
Iron content (as Fe)	5 ppm
Bromine value	max. 0.05
Water content	max. 0.05 wt.%

Materials and inputs

The raw material, processed material and utility required for a 25,000 t/a capacity installation to produce 1 t of alkylbenzene are as follows:

n-Alkanes	800 kg
Benzene	350 kg
Chlorine	380 kg
Alumina	3.5 kg
Sodium hydroxide (100%)	12 kg
Sulphuric acid (96%)	55 kg
Boxite	2 kg
Steam 0.35 MPa	610 kg
Steam 1.3 MPa	836 kg
Electrical energy	223 MJ
Cooling water	132 m^3
Deep freeze energy	227 MJ
Methane (standard volume)	560 m^3

The following by-products are produced:

	kg
Hydrochloric acid (33%)	960
Aluminium chloride (as 100%)	9
Steam (0.05 MPa)	690

The manpower requirements of a 25,000 t/a capacity installation would be:

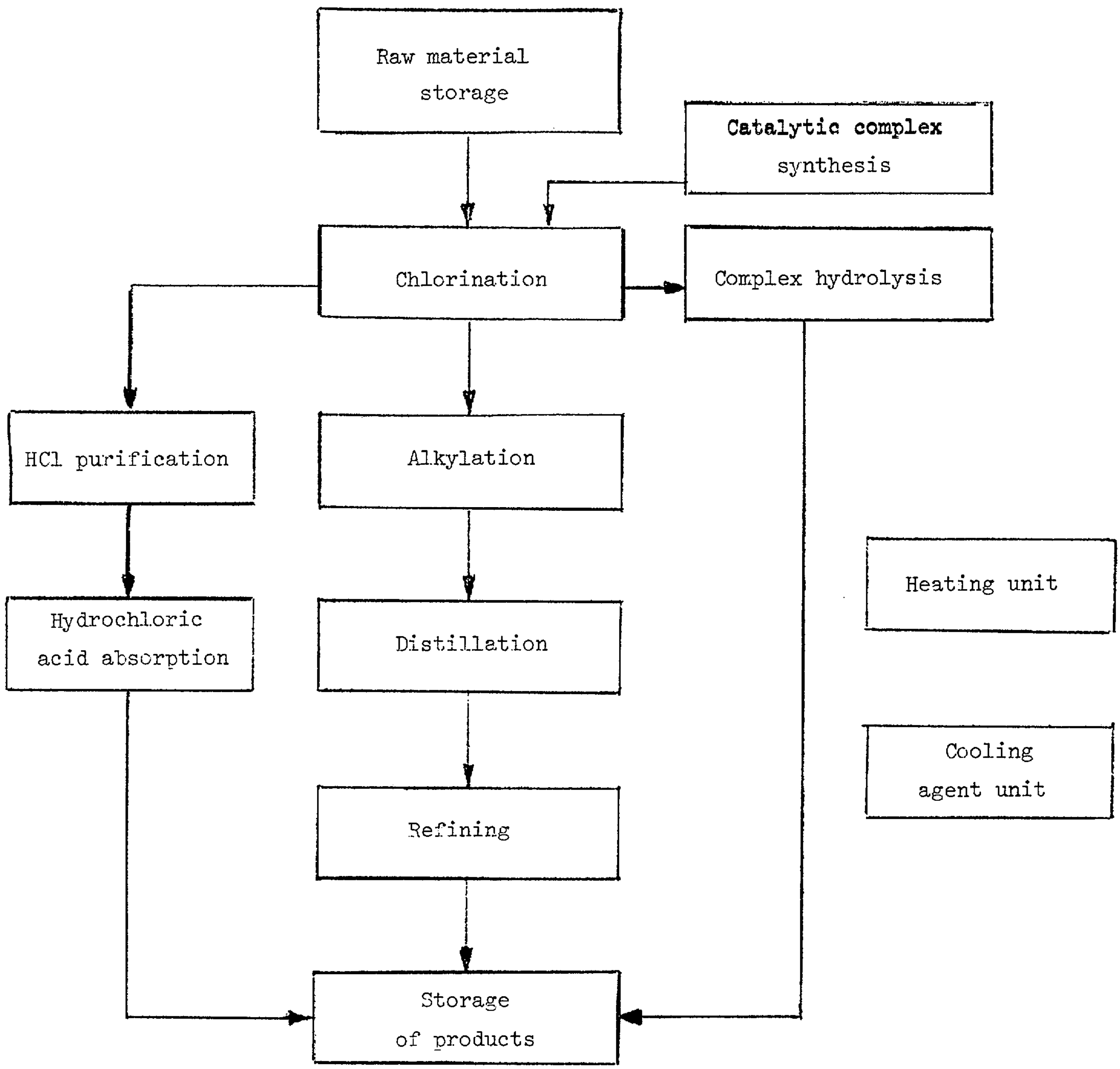
	Number
Office staff and engineers	5
Skilled workers	26
Unskilled workers	14
Total	45

Location

An installation of this capacity implies the availability of substantial utilities. The connected electrical service should furnish about 1,000 MJ/h (280 kW). The rate of consumption of methane reaches 2,000 m^3 (volume at standard temperature and pressure) per hour. The factory uses 5 t/h of different pressure steam, and returns low-pressure steam. The best location, therefore, would be in an already existing petrochemical complex. The ground stress resistance should be 0.2 MPa, and the underground water level, without drainage, should be lower than 6 m. Where the climate is mild enough, the production part of the installation may be an open-air construction. A small building - to house the control room, laboratory, offices and social services - should be provided, however. The plant site area would be as set out below:

	m^2
Building	450
Open-air installation	5,000
Storage	600
Total	6,000
Land	20,000

The technological process described above is the property of the Heavy Organic Synthesis Institute at Blachownia and the Chemical Works at Oswiecim, Poland.



Alkylation of benzene: flow-sheet of production process

DEFINITIONS

BASIS OF CALCULATIONS

1. Introduction

These short chemical process summary sheets have been extracted from a much larger study by Chem Systems entitled 'Chemical Process Economics', details of which will be made available on request.

Much of the data presented has been obtained through intensive research by Chem Systems, via contractors or licensers. The various processes considered are current conventional Western technology, having a sound basis in operation. Minimum feasible capacities have also been quoted for a West European economy. In many of the batch processes, very low capacities are possible depending on the size and number of batches. In a developing nation this minimum size would depend on local factors which would have to be evaluated on an individual basis. These factors may be feedstock restrictions, the total capital available, power costs and availability etc. It may therefore, be entirely possible to erect a plant of a smaller output than the smallest given herein.

It must be emphasised that the plot areas quoted herein are intended for guidance purposes only. The actual area will vary considerably on location and size of plant. There is also no relationship between plot area and plant capacity. An effort has been made to slightly exaggerate these areas and a more detailed project evaluation would be necessary to arrive at a more realistic figure. In certain cases it has been possible to quote areas from actual plants constructed.

2. Chem Systems Plant Construction Index

All the capital costs estimated in this volume are based on an instantaneous plant erection on a 'green-field' site expressed in US dollars at current (1980) exchange rates.

Thus the cost of production estimates are in real terms, ie the costs are expressed in terms of the purchasing power of the prevailing (1980 in this case) dollar. These costs are expected to escalate according to the Gross Domestic Product (GDP) deflator for the given project location, or where the plant equipment is being manufactured in the case of import.

Table A.1. gives Chem Systems best estimates of historic capital cost escalation and that of expected rises in construction costs for the future. Mid-year 1980 has been taken as being the base year.

In the cost of production analysis, estimates are made of both direct expenditures (feedstocks, utilities, manpower costs, overheads, etc) and 'capital charges' comprising depreciation, interest on working capital and return on fixed capital. Hence by assuming an expected return on fixed investment for production by the proposed plant at full capacity a cost based projection of product selling prices can be developed. It is recognised that supply/demand imbalances cause substantial fluctuations in petroleum and petrochemical product prices but these price projections, expressed in terms of present day dollars, are expected, (after adjusting for inflation), to be indicative of future prices, averaged over the long term.

TABLE A.1.

PLANT CONSTRUCTION INDEX

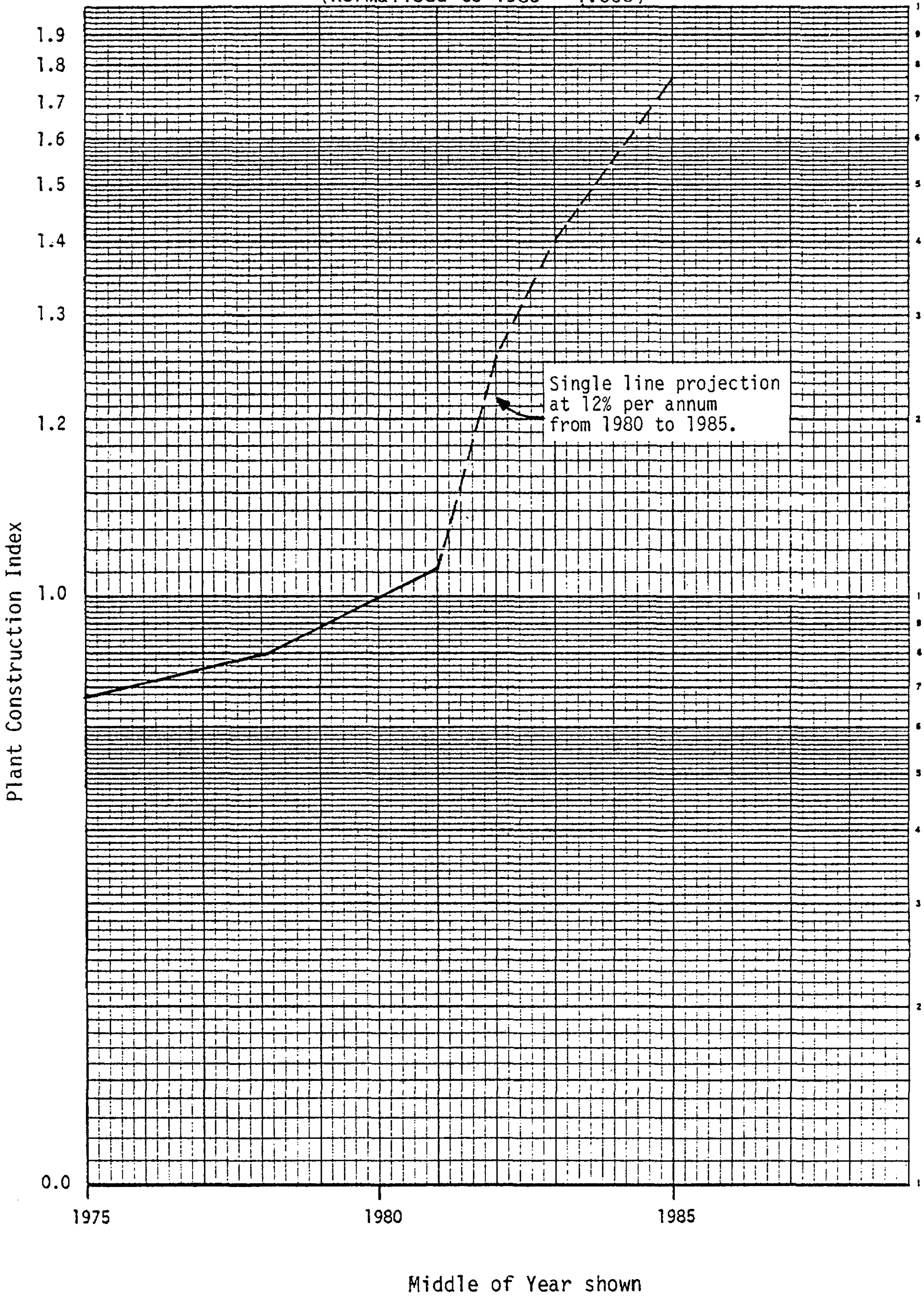
Mid Year	Factors to Give Current Dollar Cost From 1980 Dollars
1975	0.679
1976	0.722
1977	0.754
1978	0.794
1979	0.887
1980	1.000
1981	1.120
1982	1.254
1983	1.405
1984	1.574
1985	1.762

From Figure A.1 the capital cost for a production unit can easily be calculated for any point in line if a starting cost between the years 1975 and 1985 is given.

The capital cost of a given plant is divided into that of the production unit proper (battery limits capital cost - BLCC) and that of the off-unit facilities (offsites capital cost) required to support the production unit, including storage, effluent treatment, laboratories, etc and a share of the general facilities such as workshops, offices and roads. The main utilities' plant such as boilers, power generation, and cooling-water towers and treatment facilities are excluded from the offsites scope as the transfer prices assumed for these utilities in the cost of production estimates cover both basic production costs and capital charges. The estimate of offsites cost is commonly calculated by applying an offsites factor to the battery limits capital cost estimate. This factor is dependent on the type of project (eg a totally new complex or just a single

PLANT CONSTRUCTION INDEX

(Normalised to 1980 - 1.000)



production unit) and on project location (in developing areas the project might have to 'carry' a significant infrastructure development cost). For the average plant in Western Europe it has been found that 40 percent of the BLCC represents a good estimate of the offsites factor. This factor has been used except where specific features dictate otherwise.

Cost factors assumed in calculating the cost of production estimated have been summarised in Table A.2.

TABLE A.2.

COST OF PRODUCTION FACTORS

Maintenance Cost Factor (Materials and Labour)	4 percent of battery limits capital (6 percent for selected high maintenance cost processes)
Direct Overhead	40 percent of cost of direct operating labour and supervision
General Plant Overhead	65 percent of operating costs (operating costs = direct manpower plus maintenance)
Insurance and Property Taxes (ie 'Rates' or Land Charges)	1.5 percent of total fixed capital
Depreciation	10 percent of battery limit capital plus 5 percent of offsites capital
Interest on Working Capital	10 percent
Return on Total Fixed Investment (ROI)	5, 10 and 15 percent return

How to Start Manufacturing Industries

ABS RESINS

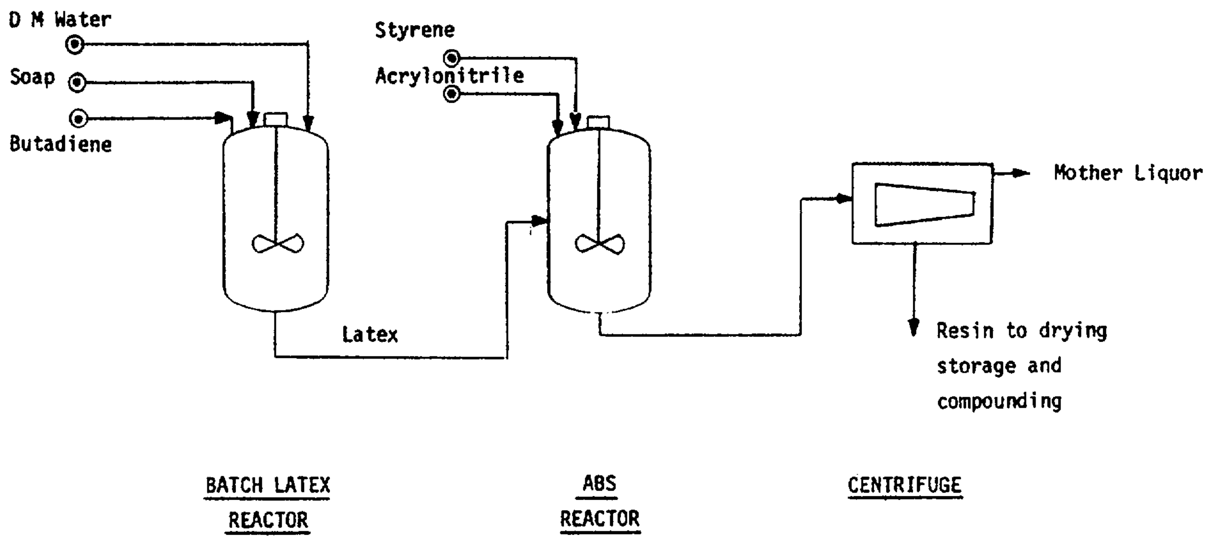
Process Description

The emulsion route to ABS involves the preparation of rubber latex - usually non-stereospecific polybutadiene. This latex is emulsified with styrene, acrylonitrile, and other components at a pH of 10-10.5 and 57-60°C. Residence time in the reactors is 100-120 minutes.

The resin latex is then coagulated and the ABS removed from the resulting mixture. The remaining operations dry, compound, and convert the resin to a saleable form.

Uses

The 'main' uses are in the pipe and fittings industry, automotive, recreation appliances etc, mainly due to its characteristics of toughness, rigidity, appearance and processability.



A typical capacity for this plant is 50 000 tonnes per year occupying a land area of around 3 000 square metres. The minimum feasible capacity is dependent on the actual location, however, in Italy a plant of 3 000 tonnes per year has been built.

This information has been prepared for UNIDO by Chem Systems International Ltd., United Kingdom.

Any inquiry about the information contained should be sent to: IO/COOP, Registry file No. ID/562/12, UNIDO, P.O. Box 300, A-1400, Vienna, Austria.

COST OF PRODUCTION ESTIMATE FOR ABS
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - CONT.EMULSION

BASIS		CAPITAL COST	$ MILL
LOCATION-	BENELUX	BATTERY LIMITS	21.44
CAPACITY-	50 000 TONNES PER YEAR	OFFSITES	8.78
PRODUCTN-	50 000 TONNES PER YEAR		
YEAR -	1980	TOTAL FIXED INV.	30.21
STR.TIME-	8000 HOURS PER YEAR	WORKING	18.72

RAW MATERIALS	QUANTITY/TONNE		PRICE*	ANNUAL COST	UNIT* COST
STYRENE	.5200	TONNE	770.000	20 020 000	
ACRYLONITRILE	.2800	TONNE	840.000	11 760 000	
BUTADIENE	.2000	TONNE	690.000	6 900 000	
EMULSIFIERS	.0200	TONNE	200.000	200 000	
DODECYL MERCAP	.0060	TONNE	3100.000	930 000	
CATALYST+CHEMS	62.0000	DOLLARS	1.000	3 100 000	
TOTAL RAW MATERIALS				42 910 000	858.20
UTILITIES					
POWER	.3700	MWH	61.500	1 137 750	
COOLING WATER	.0180	KTONNE	17.000	15 300	
L.P.STEAM	1.5000	TONNE	16.700	1 252 500	
BLR.FEED WATER	.0020	KTONNE	450.000	45 000	
PROCESS WATER	.0080	KTONNE	230.000	92 000	
INERT GAS	45.0000	NM3	.000	0	
FUEL	.5000	GCAL	18.100	452 500	
TOTAL UTILITIES COST				2 995 050	59.90

OPERATING COSTS

		ANNUAL COST	UNIT* COST
LABOUR	107.00 MEN @ 17 700 $/YEAR	1 893 900	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR	29 200	
MAINTENANCE	@ .04×BLCC	857 478	
TOTAL OPERATING COST		2 780 578	55.61
OVERHEAD EXPENSES			
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION	769 240	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS	1 807 376	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP	453 185	
DEPRECIATION	@ .100× BLCC+ .050×OFFS	2 582 464	
INTEREST	@ .100× WORKING CAPITAL	1 872 341	
TOTAL OVERHEAD EXPENSES		7 484 606	149.69
BYPRODUCT CREDIT			
TOTAL BYPRODUCT CREDIT		0	.00
NET COST OF PRODUCTION		56 170 234	1123.40

VARIABLE COST OF PRODUCTION	918.10
CASH COST OF PRODUCTION	1071.76
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	1183.83
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	1214.04
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV	1244.25

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR ABS CONT.EMULSION BENELUX LANG FACTOR 0.65

CASE NO	1	2	3	4	5	6	7
<u>TONNES PER ANNUM</u>							
PLANT CAPACITY	50000	50000	50000	50000	40000	30000	20000
PLANT OUTPUT	50000	42500	37500	30000	40000	30000	20000
<u>CAPITAL COST</u> <u>MILLION DOLLARS</u>							
BLCC	21.4	21.4	21.4	21.4	18.5	15.4	11.8
OFFSITES	8.8	8.8	8.8	8.8	7.6	6.3	4.8
TOTAL FIXED	30.2	30.2	30.2	30.2	26.1	21.7	16.7
WORKING	18.7	16.3	14.8	12.4	15.4	12.0	8.5
<u>DOLLARS PER TONNE PRODUCT</u> - (BASED ON STYRENE AT $770/TONNE)							
RAW MATERIALS	858.2	858.2	858.2	858.2	858.2	858.2	858.2
UTILITIES	59.9	59.9	59.9	59.9	59.9	59.9	59.9
BYPROD. CREDIT	.0	.0	.0	.0	.0	.0	.0
VARIABLE COST	918.1	918.1	918.1	918.1	918.1	918.1	918.1
OPERATION	55.6	65.4	74.1	92.7	66.6	84.6	119.8
OVERHEAD(EXCL.DEPN)	98.0	109.8	120.2	142.3	110.7	131.3	171.5
CASH COST	1071.8	1093.3	1112.4	1153.1	1095.4	1134.0	1209.4
DEPRECIATION	51.6	60.8	68.9	86.1	55.8	61.8	71.2
NET COST OF PRODN	1123.4	1154.0	1181.3	1239.2	1151.3	1195.8	1280.6
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	90.6	106.6	120.8	151.1	98.0	108.4	124.9
TRANSFER PRICE	1214.0	1260.7	1302.1	1390.2	1249.3	1304.2	1405.5

EFFECT OF STYRENE PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	924.0	616.0	924.0	616.0	924.0	616.0	924.0	616.0	924.0	616.0	924.0	616.0	924.0	616.0
NET COST OF PRODN	1203.5	1043.3	1234.1	1074.0	1261.4	1101.2	1319.2	1159.1	1231.4	1071.2	1275.9	1115.7	1360.6	1200.5
TRANSFER PRICE	1294.1	1134.0	1340.8	1180.6	1382.2	1222.1	1470.3	1310.1	1329.4	1169.2	1384.3	1224.1	1485.6	1325.4

File: G18
ISIC 3511

How to Start Manufacturing Industries

ACETIC ACID VIA ACETALDEHYDE OXIDATION

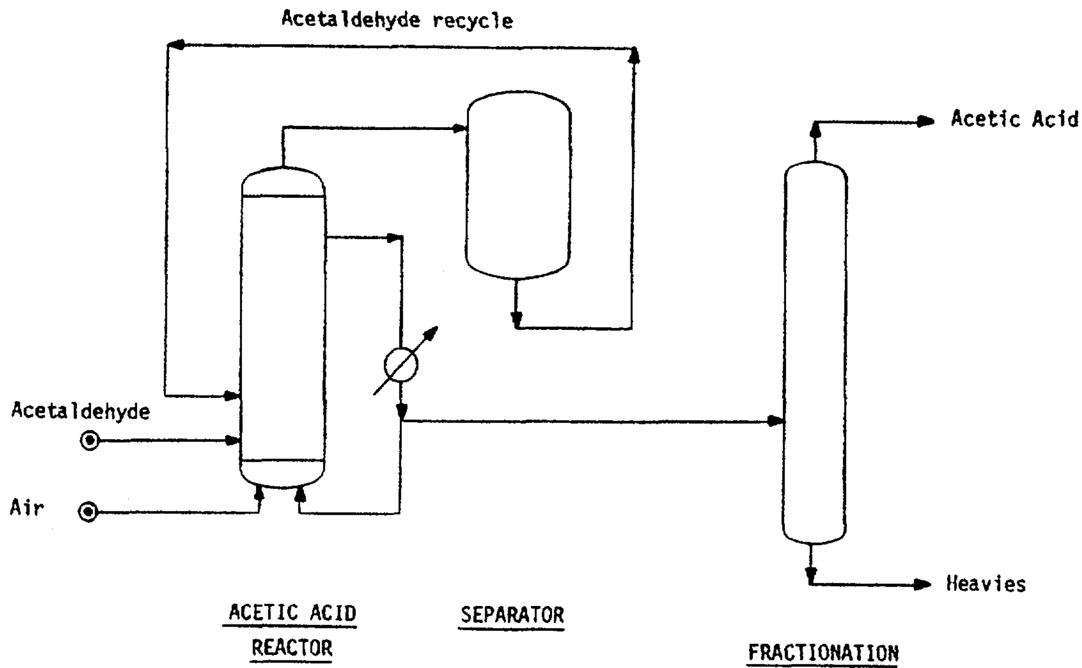
Process Description

Liquid phase oxidation of acetaldehyde occurs at 55-65°C and 4.8-5 bar with manganous acetate as catalyst. If oxygen is used in place of air, the reaction temperature is raised to 70-80°C.

The unreacted acetaldehyde and solvent are condensed and recycled back to the reactor. The liquid product stream is sent to a series of four distillation columns where 99.8 percent acetic acid is recovered.

Uses

A large amount of acetic acid is used for vinyl acetate production, and some goes into the fermentation industry. It is also used as the solvent in the liquid-phase oxidation of p-xylene to terephthalic acid.



Plot area for a plant producing 80 000 tonnes per year acetic acid would be of the order of 1 500 square metres. Minimum feasible capacity from a technical viewpoint can be as small as 25 000 tonnes per year.

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COST OF PRODUCTION ESTIMATE FOR ACETIC ACID
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - VIA ACETALDEHYDE

BASIS	CAPITAL COST	$ MILL
LOCATION- BENELUX	BATTERY LIMITS	14.20
CAPACITY- 80 000 TONNES PER YEAR	OFFSITES	5.70
PRODUCTN- 80 000 TONNES PER YEAR		
YEAR - 1980	TOTAL FIXED INV.	19.90
STR.TIME- 8000 HOURS PER YEAR	WORKING	18.30

RAW MATERIALS	QUANTITY/TONNE	PRICE*	ANNUAL COST	UNIT* COST
ACETALDEHYDE	.7640 TONNE	765.000	46 756 800	
OXYGEN	.2050 TONNE	87.000	1 426 800	
CATALYST+CHEMS	4.3750 DOLLARS	1.000	350 000	
TOTAL RAW MATERIALS			48 533 600	606.67
UTILITIES				
POWER	.0060 MWH	61.500	29 520	
COOLING WATER	.1600 KTONNE	17.000	217 600	
LP.STEAM	.7000 TONNE	16.700	935 200	
NITROGEN	4.0000 NM3	.085	27 200	
TOTAL UTILITIES COST			1 209 520	15.12
OPERATING COSTS				
LABOUR	9.00 MEN @ 17 700 $/YEAR		159 300	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR		29 200	
MAINTENANCE	@ .04×BLCC		568 000	
TOTAL OPERATING COST			756 500	9.46
OVERHEAD EXPENSES				
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION		75 400	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS		491 725	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP		298 500	
DEPRECIATION	@ .100× BLCC+ .050×OFFS		1 705 000	
INTEREST	@ .100× WORKING CAPITAL		1 830 008	
TOTAL OVERHEAD EXPENSES			4 400 633	55.01
BYPRODUCT CREDIT				
TOTAL BYPRODUCT CREDIT			0	.00
NET COST OF PRODUCTION			54 900 253	686.25

VARIABLE COST OF PRODUCTION	621.79
CASH COST OF PRODUCTION	664.94
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	711.13
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	723.57
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV	736.00

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR ACETIC ACID VIA ACETALDEHYDE BENELUX LANG FACTOR 0.65

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	80000	80000	80000	80000	64000	48000	32000
PLANT OUTPUT	80000	68000	60000	48000	64000	48000	32000
CAPITAL COST — **MILLION DOLLARS**							
BLCC	14.2	14.2	14.2	14.2	12.3	10.2	7.8
OFFSITES	5.7	5.7	5.7	5.7	4.9	4.1	3.1
TOTAL FIXED	19.9	19.9	19.9	19.9	17.2	14.3	11.0
WORKING	18.3	15.7	14.0	11.4	14.7	11.2	7.6
DOLLARS PER TONNE PRODUCT - (BASED ON ACETALDEHYDE AT $765/TONNE)							
RAW MATERIALS	606.7	606.7	606.7	606.7	606.7	606.7	606.7
UTILITIES	15.1	15.1	15.1	15.1	15.1	15.1	15.1
BYPROD. CREDIT	.0	.0	.0	.0	.0	.0	.0
VARIABLE COST	621.8	621.8	621.8	621.8	621.8	621.8	621.8
OPERATION	9.5	11.1	12.6	15.8	10.6	12.4	15.7
OVERHEAD(EXCL.DEPN)	33.7	35.9	37.8	41.9	35.1	37.3	41.3
CASH COST	664.9	668.8	672.2	679.4	667.5	671.5	678.8
DEPRECIATION	21.3	25.1	28.4	35.5	23.0	25.5	29.4
NET COST OF PRODN	686.3	693.8	700.6	714.9	690.6	697.0	708.1
RETURN ON INVESTMENT	37.3	43.9	49.7	62.2	40.3	44.6	51.4
(AT 15% ON TOTAL FIXED INVESTMENT)							
TRANSFER PRICE	723.6	737.7	750.3	777.1	730.9	741.6	759.5

EFFECT OF ACETALDEHYDE PRICE VARIATION

	1		2		3		4		5		6		7	
PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	918.0	612.0	918.0	612.0	918.0	612.0	918.0	612.0	918.0	612.0	918.0	612.0	918.0	612.0
NET COST OF PRODN	803.1	569.4	810.7	577.0	817.5	583.7	831.8	598.0	807.5	573.7	813.9	580.1	825.0	591.2
TRANSFER PRICE	840.5	606.7	854.6	620.9	867.2	633.5	894.0	660.2	847.8	614.0	858.5	624.0	876.4	642.7

How to Start Manufacturing Industries

ACETIC ACID FROM METHANOL AND CO

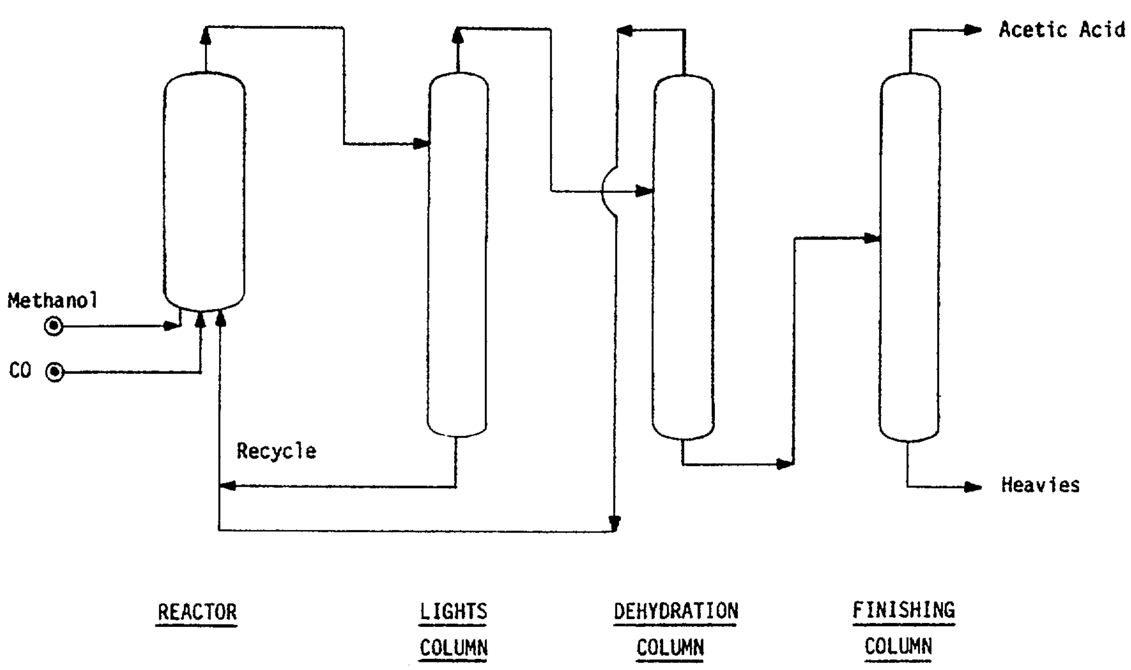
Process Description

Methanol and carbon monoxide are reacted in a hastelloy reactor operating at 170°C and 30-40 bar. The reactor contents are a liquid phase mixture of ethers, esters, acids and water together with an iodide promoted rhodium liquid catalyst.

The crude products are led off at the top of the tower and separated under a low pressure of 5-10 bar. Separation of the acetic acid takes place by removing the lights, dehydrating by azeotropic distillation, and a final finishing column.

Uses

A large amount of acetic acid is used for vinyl acetate production, and some go into the fermentation industry. It is also used as the solvent in the liquid-phase oxidation of p-xylene to terephthalic acid.



Economics of an acetic acid plant producing 150 000 tonnes per year acetic acid have been estimated. Such a plant would occupy a plot area of the order of 50 000 square metres. Minimum capacity possible is 25 000 tonnes per year.

This information has been prepared for UNIDO by Chem Systems International Ltd., United Kingdom.

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COST OF PRODUCTION ESTIMATE FOR ACETIC ACID
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - METHANOL + CO

BASIS		CAPITAL COST	$ MILL
LOCATION-	BENELUX	BATTERY LIMITS	36.61
CAPACITY-	150 000 TONNES PER YEAR	OFFSITES	16.30
PRODUCTN-	150 000 TONNES PER YEAR		
YEAR -	1980	TOTAL FIXED INV	52.90
STR.TIME-	8000 HOURS PER YEAR	WORKING	18.69

RAW MATERIALS	QUANTITY/TONNE	PRICE*	ANNUAL COST	UNIT* COST
METHANOL	.5370 TONNE	270.000	21 748 500	
CARB.MONOXIDE	.5060 TONNE	205.000	15 559 500	
CATALYST+CHEMS	8.3333 DOLLARS	1.000	1 250 000	
TOTAL RAW MATERIALS			38 558 000	257.05
UTILITIES				
POWER	.1840 MWH	61.500	1 697 400	
COOLING WATER	.1400 KTONNE	17.000	357 000	
L.P.STEAM	2.0000 TONNE	16.700	5 010 000	
TOTAL UTILITIES COST			7 064 400	47.10
OPERATING COSTS				
LABOUR	23.00 MEN @ 17 700 $/YEAR		407 100	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR		29 200	
MAINTENANCE	@ .04×BLCC		1 464 232	
TOTAL OPERATING COST			1 900 532	12.67
OVERHEAD EXPENSES				
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION		174 520	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS		1 235 346	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP		793 543	
DEPRECIATION	@ .100× BLCC+ .050×OFFS		4 475 435	
INTEREST	@ .100× WORKING CAPITAL		1 869 027	
TOTAL OVERHEAD EXPENSES			8 547 871	56.99
BYPRODUCT CREDIT				
TOTAL BYPRODUCT CREDIT			0	.00
NET COST OF PRODUCTION			56 070 803	373.81

VARIABLE COST OF PRODUCTION	304.15
CASH COST OF PRODUCTION	343.97
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	409.07
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	426.71
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV	444.34

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR ACETIC ACID METHANOL + CO BENELUX LANG FACTOR 0.65

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	150000	150000	150000	150000	120000	90000	60000
PLANT OUTPUT	150000	127500	112500	90000	120000	90000	60000
CAPITAL COST MILLION DOLLARS							
BLCC	36.6	36.6	36.6	36.6	31.7	26.3	20.2
OFFSITES	16.3	16.3	16.3	16.3	14.1	11.7	9.0
TOTAL FIXED	52.9	52.9	52.9	52.9	45.8	38.0	29.2
WORKING	18.7	16.3	14.8	12.4	15.2	11.6	8.1
DOLLARS PER TONNE PRODUCT - (BASED ON METHANOL AT $270/TONNE)							
RAW MATERIALS	257.1	257.1	257.1	257.1	257.1	257.1	257.1
UTILITIES	47.1	47.1	47.1	47.1	47.1	47.1	47.1
BYPROD. CREDIT	.0	.0	.0	.0	.0	.0	.0
VARIABLE COST	304.1	304.1	304.1	304.1	304.1	304.1	304.1
OPERATION	12.7	14.9	16.9	21.1	14.2	16.5	20.7
OVERHEAD(EXCL.DEPN)	27.1	30.1	32.7	38.3	29.1	31.9	37.1
CASH COST	344.0	349.1	353.7	363.5	347.4	352.6	362.0
DEPRECIATION	29.8	35.1	39.8	49.7	32.3	35.7	41.1
NET COST OF PRODN	373.8	384.2	393.5	413.3	379.7	388.3	403.1
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	52.9	62.2	70.5	88.2	57.2	63.3	72.9
TRANSFER PRICE	426.7	446.5	464.1	501.4	436.9	451.6	476.0

EFFECT OF METHANOL PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	324.0	216.0	324.0	216.0	324.0	216.0	324.0	216.0	324.0	216.0	324.0	216.0	324.0	216.0
NET COST OF PRODN	402.8	344.8	413.2	355.2	422.5	364.5	442.2	384.3	408.7	350.7	417.3	359.3	432.1	374.1
TRANSFER PRICE	455.7	397.7	475.5	417.5	493.1	435.1	530.4	472.4	465.9	407.9	480.6	422.6	505.0	447.0

ACETALDEHYDE

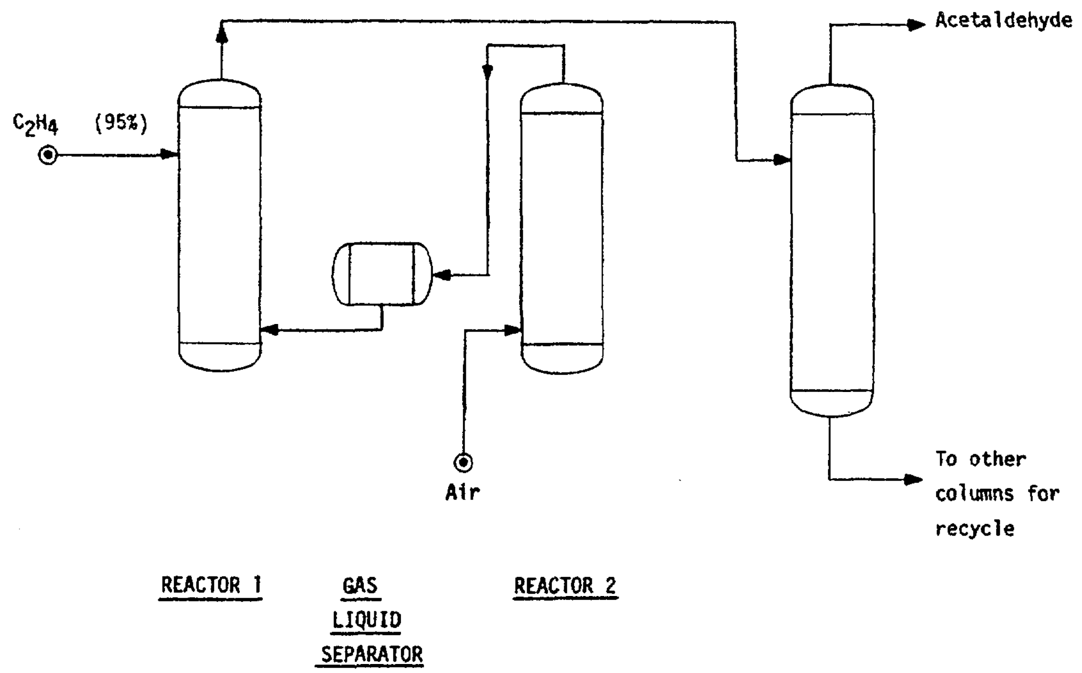
Process Description

Two reactors are used in this process. In the first, acetaldehyde is formed by reduction of cupric chloride to cuprous chloride in the presence of palladium chloride at a pressure of 11.2 bar. In the second, the cuprous ion is oxidised back to cupric. Air and 95 percent pure ethylene are used as raw materials. The yield to acetaldehyde is over 95 percent.

The pressure is reduced to atmospheric in a flash tower where the reaction heat serves for evaporation of acetaldehyde and water vapour. The acetaldehyde is distilled to 60-90 percent concentration before being separated from water and higher boilers in a rectifying column. The acetaldehyde-free catalyst solution is treated with air in a separate reactor to reoxidise the copper.

Uses

Acetaldehyde production is mainly linked with the demand for acetic acid, acetic anhydride, cellulose acetate, vinyl acetate resins, synthetic pyridine derivatives and terephthalic acid.



Land area required for a typical plant of 50 000 tonnes per year capacity is approximately 25 000 square metres. The minimum capacity built to date for this plant is 20 000 tonnes per year.

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COST OF PRODUCTION ESTIMATE FOR ACETALDEHYDE
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - WACKER-2 ST.OXIDN

BASIS		CAPITAL COST	$ MILL
LOCATION-	BENELUX	BATTERY LIMITS	15.50
CAPACITY-	50 000 TONNES PER YEAR	OFFSITES	6.20
PRODUCTN-	50 000 TONNES PER YEAR		
YEAR	- 1980	TOTAL FIXED INV.	21.70
STR.TIME-	8000 HOURS PER YEAR	WORKING	11.00

RAW MATERIALS	QUANTITY/TONNE	PRICE*	ANNUAL COST	UNIT* COST
ETHYLENE	.6720 TONNE	750.000	25 200 000	
CATALYST+CHEMS	5.8200 DOLLARS	1.000	291 000	
TOTAL RAW MATERIALS			25 491 000	509.82
UTILITIES				
POWER	.3000 MWH	61.500	922 500	
COOLING WATER	.2000 KTONNE	17.000	170 000	
HP.STEAM	1.2000 TONNE	20.200	1 212 000	
OTHERS	.0024 KDLRS	1000.000	120 000	
TOTAL UTILITIES COST			2 424 500	48.49
OPERATING COSTS				
LABOUR	20.00 MEN @ 17 700 $/YEAR		354 000	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR		29 200	
MAINTENANCE	@ .04×BLCC		620 000	
TOTAL OPERATING COST			1 003 200	20.06
OVERHEAD EXPENSES				
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION		153 280	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS		652 080	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP		325 500	
DEPRECIATION	@ .100× BLCC+ .050×OFFS		1 860 000	
INTEREST	@ .100× WORKING CAPITAL		1 100 330	
TOTAL OVERHEAD EXPENSES			4 091 190	81.82
BYPRODUCT CREDIT				
TOTAL BYPRODUCT CREDIT			0	.00
NET COST OF PRODUCTION			33 009 890	660.20

VARIABLE COST OF PRODUCTION	558.31
CASH COST OF PRODUCTION	623.00
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	703.60
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	725.30
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV	747.00

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR ACETALDEHYDE WACKER-2 ST.OXIDN BENELUX LANG FACTOR 0.65

CASE NO		1	2	3	4	5	6	7
	TONNES PER ANNUM							
PLANT CAPACITY		50000	50000	50000	50000	40000	30000	20000
PLANT OUTPUT		50000	42500	37500	30000	40000	30000	20000
CAPITAL COST	MILLION DOLLARS							
BLCC		15.5	15.5	15.5	15.5	13.4	11.1	8.5
OFFSITES		6.2	6.2	6.2	6.2	5.4	4.4	3.4
TOTAL FIXED		21.7	21.7	21.7	21.7	18.8	15.6	12.0
WORKING		11.0	9.6	8.6	7.2	8.9	6.8	4.7
	DOLLARS PER TONNE PRODUCT - (BASED ON ETHYLENE AT $750/TONNE)							
RAW MATERIALS		509.8	509.8	509.8	509.8	509.8	509.8	509.8
UTILITIES		48.5	48.5	48.5	48.5	48.5	48.5	48.5
BYPROD. CREDIT		.0	.0	.0	.0	.0	.0	.0
VARIABLE COST		558.3	558.3	558.3	558.3	558.3	558.3	558.3
OPERATION		20.1	23.6	26.8	33.4	23.0	27.6	36.2
OVERHEAD(EXCL.DEPN)		44.6	49.1	53.1	61.5	48.1	53.6	63.9
CASH COST		623.0	631.0	638.1	653.3	629.4	639.5	658.4
DEPRECIATION		37.2	43.8	49.6	62.0	40.2	44.5	51.3
NET COST OF PRODN		660.2	674.8	687.7	715.3	669.7	684.0	709.7
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)		65.1	76.6	86.8	108.5	70.4	77.8	89.7
TRANSFER PRICE		725.3	751.4	774.5	823.8	740.0	761.9	799.4

EFFECT OF ETHYLENE PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	900.0	600.0	900.0	600.0	900.0	600.0	900.0	600.0	900.0	600.0	900.0	600.0	900.0	600.0
NET COST OF PRODN	761.0	559.4	775.6	574.0	788.5	586.9	816.1	614.5	770.5	568.9	784.8	583.2	810.5	608.9
TRANSFER PRICE	826.1	624.5	852.2	650.6	875.3	673.7	924.6	723.0	840.8	639.2	862.7	661.1	900.2	698.6

-4-

File: G21
ISIC 3511

How to Start Manufacturing Industries

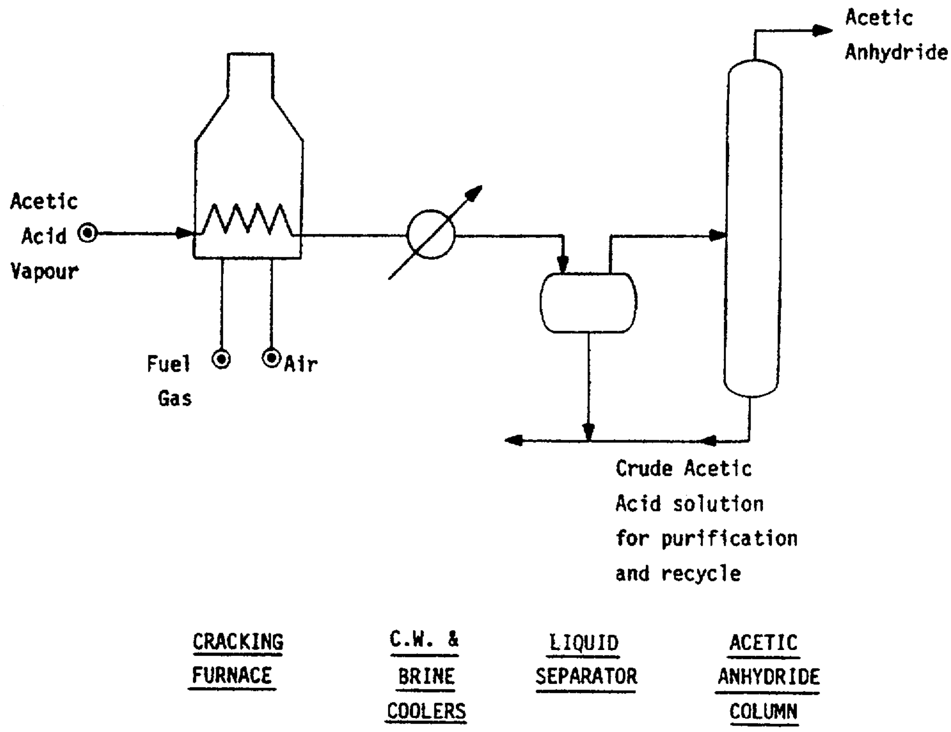
ACETIC ANHYDRIDE

Process Description

A mixture of vapourised acetic acid and 0.25 percent triethylphosphate is fed into a tubular reactor. Pyrolysis takes place at 750°C under a pressure of 200 mmHg. The cracking furnace exit gases containing acetic anhydride, acetic acid, ketene and water are cooled and condensed. 30-35 percent aqueous acetic acid is withdrawn in a separator. The uncondensed gases of almost pure ketene, are reacted with acetic acid in a series of scrubbers. The conversion of acetic acid is about 90 percent per pass and a selectivity of acetic anhydride based on acetic acid is about 90 percent. Acetic acid is recovered in a raw acetic anhydride column and recycled. Raw acetic anhydride is finished to remove low boilers and tars.

Uses

The greatest single application for acetic anhydride is in the manufacture of cellulose esters, chiefly cellulose acetate. Other applications are starch acetylation to make textile sizing agents, electrolytic polishing of metals, especially aluminium and semiconductor processing.



Plot area required for a plant of 135 000 tonnes per year nameplate capacity is approximately 3 000 square metres. Minimum capacity built to date in Western Europe is 25 000 tonnes per year.

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COST OF PRODUCTION ESTIMATE FOR ACETIC ANHYDRIDE
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - KETENE PROCESS

BASIS	CAPITAL COST	$ MILL
LOCATION- BENELUX	BATTERY LIMITS	95.10
CAPACITY- 135 000 TONNES PER YEAR	OFFSITES	47.60
PRODUCTN- 135 000 TONNES PER YEAR		
YEAR - 1980	TOTAL FIXED INV.	142.70
STR.TIME- 8000 HOURS PER YEAR	WORKING	36.83

RAW MATERIALS	QUANTITY/TONNE	PRICE*	ANNUAL COST	UNIT* COST
ACETIC ACID	1.3090 TONNE	380.000	67 151 700	
CATALYST+CHEMS	5.7852 DOLLARS	1.000	781 000	
TOTAL RAW MATERIALS			67 932 700	503.21
UTILITIES				
POWER	.3880 MWH	61.500	3 221 370	
COOLING WATER	.2340 KTONNE	17.000	537 030	
LP.STEAM	4.1000 TONNE	16.700	9 243 450	
INERT GAS	50.0000 NM3	.085	573 750	
FUEL	1.6660 GCAL	18.100	4 070 871	
TOTAL UTILITIES COST			17 646 471	130.71
OPERATING COSTS				
LABOUR	24.00 MEN @ 17 700 $/YEAR		424 800	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR		29 200	
MAINTENANCE	@ .04×BLCC		3 804 000	
TOTAL OPERATING COST			4 258 000	31.54
OVERHEAD EXPENSES				
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION		181 600	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS		2 767 700	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP		2 140 500	
DEPRECIATION	@ .100× BLCC+ .050×OFFS		11 890 000	
INTEREST	@ .100× WORKING CAPITAL		3 683 344	
TOTAL OVERHEAD EXPENSES			20 663 144	153.06
BYPRODUCT CREDIT				
TOTAL BYPRODUCT CREDIT			0	.00
NET COST OF PRODUCTION			110 500 315	818.52

VARIABLE COST OF PRODUCTION	633.92
CASH COST OF PRODUCTION	730.45
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	924.22
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	977.08
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV	1029.93

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR ACETIC ANHYDRIDE KETENE PROCESS BENELUX LANG FACTOR 0.65

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	135000	135000	135000	135000	108000	81000	54000
PLANT OUTPUT	135000	114750	101250	81000	108000	81000	54000
CAPITAL COST — MILLION DOLLARS							
BLCC	95.1	95.1	95.1	95.1	82.3	68.2	52.4
OFFSITES	47.6	47.6	47.6	47.6	41.2	34.2	26.2
TOTAL FIXED	142.7	142.7	142.7	142.7	123.4	102.4	78.7
WORKING	36.8	32.4	29.5	25.0	30.0	23.1	16.0
DOLLARS PER TONNE PRODUCT - (BASED ON ACETIC ACID AT $380/TONNE)							
RAW MATERIALS	503.2	503.2	503.2	503.2	503.2	503.2	503.2
UTILITIES	130.7	130.7	130.7	130.7	130.7	130.7	130.7
BYPROD. CREDIT	.0	.0	.0	.0	.0	.0	.0
VARIABLE COST	633.9	633.9	633.9	633.9	633.9	633.9	633.9
OPERATION	31.5	37.1	42.1	52.6	34.7	39.3	47.2
OVERHEAD(EXCL.DEPN)	65.0	72.6	79.4	93.7	69.1	75.2	85.5
CASH COST	730.4	743.6	755.3	780.2	737.7	748.4	766.7
DEPRECIATION	88.1	103.6	117.4	146.8	95.2	105.3	121.4
NET COST OF PRODN	818.5	847.2	872.8	927.0	832.9	853.7	888.1
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	158.6	186.5	211.4	264.3	171.4	189.6	218.5
TRANSFER PRICE	977.1	1033.8	1084.2	1191.3	1004.4	1043.3	1106.6

EFFECT OF ACETIC ACID PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	456.0	304.0	456.0	304.0	456.0	304.0	456.0	304.0	456.0	304.0	456.0	304.0	456.0	304.0
NET COST OF PRODN	918.0	719.0	946.7	747.8	972.3	773.3	1026.5	827.5	932.4	733.5	953.2	754.3	987.5	788.6
TRANSFER PRICE	1076.6	877.6	1133.3	934.3	1183.7	984.7	1290.8	1091.8	1103.9	904.9	1142.8	943.9	1206.0	1007.1

How to Start Manufacturing Industries

ACETONE FROM PROPYLENE

Process Description

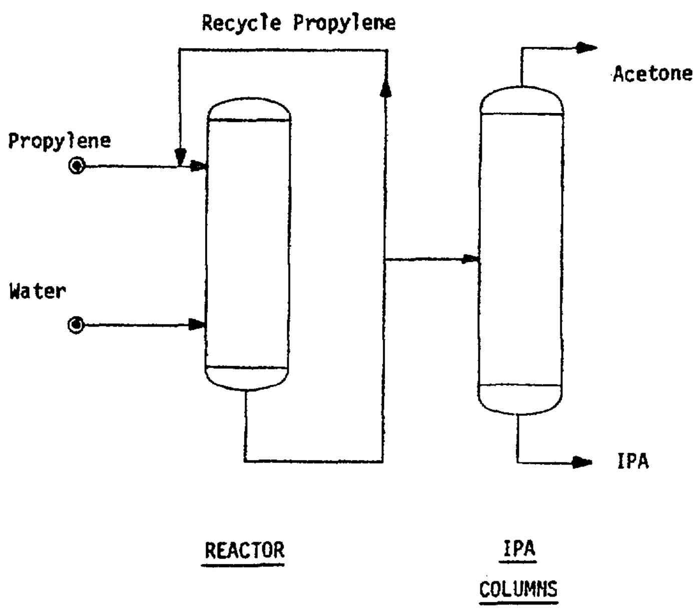
In the direct hydration process, propylene and water are preheated and fed to a catalytic reactor, where isopropanol is formed. This reaction may be carried out in the vapour or liquid phase at pressures of 25-250 bar and at temperatures of 150-300^{o}C.

Aqueous isopropanol is separated from water and small amounts of other light and heavy ends in a series of 3 to 6 distillation columns.

It is then vapourised and dehydrogenated in a fixed bed catalyst reactor, typical operating conditions are 0.34 bar and 530-550^{o}C. Purification is carried out using conventional fractionation techniques.

Uses

Acetone is used primarily as a chemical intermediate for methacrylates and as solvent. Other applications are in the manufacture of MIBK (methyl isobutyl ketone) and Bisphenol-A.



The plot area required for a plant of 100 000 tonnes per year capacity is approximately 25 000 square metres. The smaller capacity built to date in Europe is 10 000 tonnes per year.

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COST OF PRODUCTION ESTIMATE FOR ACETONE
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - VIA IPA DEHYDROGN

BASIS	CAPITAL COST	$ MILL
LOCATION- BENELUX	BATTERY LIMITS	25.50
CAPACITY- 100 000 TONNES PER YEAR	OFFSITES	18.10
PRODUCTN- 100 000 TONNES PER YEAR		
YEAR - 1980	TOTAL FIXED INV.	43.60
STR.TIME- 8000 HOURS PER YEAR	WORKING	20.88

RAW MATERIALS	QUANTITY/TONNE	PRICE*	ANNUAL COST	UNIT* COST
PROPYLENE	.8042 TONNE	480.000	38 601 600	
CATALYST+CHEMS	10.4000 DOLLARS	1.000	1 040 000	
TOTAL RAW MATERIALS			39 641 600	396.42
UTILITIES				
POWER	.3310 MWH	61.500	2 035 650	
COOLING WATER	.3760 KTONNE	17.000	639 200	
MP.STEAM	6.0000 TONNE	19.200	11 520 000	
PROCESS WATER	.0008 KTONNE	230.000	18 400	
TOTAL UTILITIES COST			14 213 250	142.13
OPERATING COSTS				
LABOUR	23.00 MEN @ 17 700 $/YEAR		407 100	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR		29 200	
MAINTENANCE	@ .04×BLCC		1 020 000	
TOTAL OPERATING COST			1 456 300	14.56
OVERHEAD EXPENSES				
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION		174 520	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS		946 595	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP		654 000	
DEPRECIATION	@ .100× BLCC+ .050×OFFS		3 455 000	
INTEREST	@ .100× WORKING CAPITAL		2 087 630	
TOTAL OVERHEAD EXPENSES			7 317 745	73.18
BYPRODUCT CREDIT				
TOTAL BYPRODUCT CREDIT			0	.00
NET COST OF PRODUCTION			62 628 895	626.29

VARIABLE COST OF PRODUCTION	538.55
CASH COST OF PRODUCTION	591.74
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	669.89
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	691.69
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV	713.49

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR ACETONE VIA IPA DEHYDROGN BENELUX LANG FACTOR 0.65

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	100000	100000	100000	100000	80000	60000	40000
PLANT OUTPUT	100000	85000	75000	60000	80000	60000	40000
CAPITAL COST — MILLION DOLLARS							
BLCC	25.5	25.5	25.5	25.5	22.1	18.3	14.1
OFFSITES	18.1	18.1	18.1	18.1	15.7	13.0	10.0
TOTAL FIXED	43.6	43.6	43.6	43.6	37.7	31.3	24.0
WORKING	20.9	18.1	16.2	13.4	16.9	12.9	8.8
DOLLARS PER TONNE PRODUCT - (BASED ON PROPYLENE AT $480/TONNE)							
RAW MATERIALS	396.4	396.4	396.4	396.4	396.4	396.4	396.4
UTILITIES	142.1	142.1	142.1	142.1	142.1	142.1	142.1
BYPROD. CREDIT	.0	.0	.0	.0	.0	.0	.0
VARIABLE COST	538.5	538.5	538.5	538.5	538.5	538.5	538.5
OPERATION	14.6	17.1	19.4	24.3	16.5	19.5	25.0
OVERHEAD(EXCL.DEPN)	38.6	42.2	45.3	52.0	41.1	44.9	51.7
CASH COST	591.7	597.8	603.3	614.8	596.1	602.9	615.2
DEPRECIATION	34.5	40.6	46.1	57.6	37.4	41.3	47.6
NET COST OF PRODN	626.3	638.5	649.3	672.4	633.5	644.2	662.8
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	65.4	76.9	87.2	109.0	70.7	78.2	90.1
TRANSFER PRICE	691.7	715.4	736.5	781.4	704.2	722.4	752.9

EFFECT OF PROPYLENE PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	576.0	384.0	576.0	384.0	576.0	384.0	576.0	384.0	576.0	384.0	576.0	384.0	576.0	384.0
NET COST OF PRODN	703.5	549.1	715.7	561.3	726.5	572.1	749.6	595.2	710.7	556.3	721.4	567.0	740.0	585.6
TRANSFER PRICE	768.9	614.5	792.6	638.2	813.7	659.3	858.6	704.2	781.4	627.0	799.6	645.2	830.2	675.7

-4-

How to Start Manufacturing Industries

ACRYLIC ESTERS

Process Description

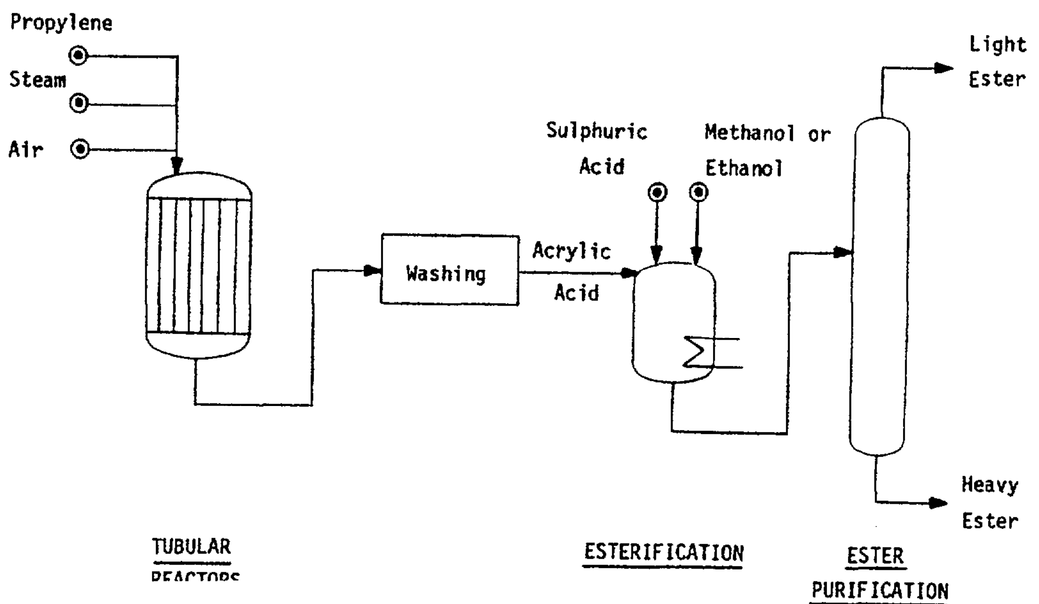
Propylene, steam and air are fed at atmospheric pressure to two tubular reactors in series. In the first, propylene is oxidised to acrolein at 370°C. In the second, the acrolein is almost completely oxidised at 270°C to acrylic acid.

The reactor effluent is partially cooled and then quenched, the acrylic acid is washed with water and solvent. The solvent is removed overhead in the solvent separation column and recycled. After removal of light ends, the acrylic acid is then distilled and removed as an overhead product and sent to storage. The heavy ends are discarded.

To produce methyl or ethyl acrylate, acrylic acid, sulphuric acid and an excess of the appropriate alcohol are esterified in a continuous esterification column, followed by purification.

Uses

Essentially all of the acrylic monomers are converted to acrylic polymers and copolymers. Acrylic ester polymers are mainly used in coating. Textile and paper industries.



A typical plot area of a plant producing 50 000 tonnes per year is estimated to be around 1 000 square metres. The minimum feasible capacity considered suitable for this plant can be 10 000 tonnes per year.

This information has been prepared for UNIDO by Chem Systems International Ltd., United Kingdom.

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COST OF PRODUCTION ESTIMATE FOR ACRYLIC ESTERS
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - 2-STAGE VAPOUR PHASE

BASIS		CAPITAL COST	$ MILL
LOCATION-	BENELUX	BATTERY LIMITS	43.70
CAPACITY-	50 000 TONNES PER YEAR	OFFSITES	17.50
PRODUCTN-	50 000 TONNES PER YEAR		
YEAR	- 1980	TOTAL FIXED INV.	61.20
STR.TIME-	8000 HOURS PER YEAR	WORKING	14.36

RAW MATERIALS	QUANTITY/TONNE		PRICE*	ANNUAL COST	UNIT* COST
PROPYLENE	.7750	TONNE	480.000	18 600 000	
ETHANOL	.3060	TONNE	450.000	6 885 000	
METHANOL	.1650	TONNE	270.000	2 227 500	
CATALYST+CHEMS	36.5000	DOLLARS	1.000	1 825 000	
TOTAL RAW MATERIALS				29 537 500	590.75
UTILITIES					
POWER	.1720	MWH	61.500	528 900	
COOLING WATER	.1670	KTONNE	17.000	141 950	
MP.STEAM	3.0000	TONNE	19.200	2 880 000	
BLR.FEED WATER	.0090	KTONNE	450.000	202 500	
TOTAL UTILITIES COST				3 753 350	75.07
OPERATING COSTS					
LABOUR	15.00 MEN @ 17 700 $/YEAR			265 500	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR			29 200	
MAINTENANCE	@ .04×BLCC			1 748 000	
TOTAL OPERATING COST				2 042 700	40.85
OVERHEAD EXPENSES					
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION			117 880	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS			1 327 755	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP			918 000	
DEPRECIATION	@ .100× BLCC+ .050×OFFS			5 245 000	
INTEREST	@ .100× WORKING CAPITAL			1 435 827	
TOTAL OVERHEAD EXPENSES				9 044 462	180.89
BYPRODUCT CREDIT					
FUEL GAS	⁻1.4400	GCAL	18.100	⁻1 303 200	
TOTAL BYPRODUCT CREDIT				⁻1 303 200	⁻26.06
NET COST OF PRODUCTION				43 074 812	861.50

VARIABLE COST OF PRODUCTION	639.75
CASH COST OF PRODUCTION	756.60
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	983.90
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	1045.10
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV	1106.30

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR ACRYLIC ESTERS 2-STAGE VAPOUR PHASEBENELUX LANG FACTOR 0.65

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	50000	50000	50000	50000	40000	30000	20000
PLANT OUTPUT	50000	42500	37500	30000	40000	30000	20000
CAPTIAL COST — MILLION DOLLARS							
BLCC	43.7	43.7	43.7	43.7	37.8	31.4	24.1
OFFSITES	17.5	17.5	17.5	17.5	15.1	12.6	9.6
TOTAL FIXED	61.2	61.2	61.2	61.2	52.9	43.9	33.7
WORKING	14.4	12.7	11.6	9.9	11.7	9.1	6.3
DOLLARS PER TONNE PRODUCT - (BASED ON PROPYLENE AT $480/TONNE)							
RAW MATERIALS	590.7	590.7	590.7	590.7	590.7	590.7	590.7
UTILITIES	75.1	75.1	75.1	75.1	75.1	75.1	75.1
BYPROD. CREDIT	¯26.1	¯26.1	¯26.1	¯26.1	¯26.1	¯26.1	¯26.1
VARIABLE COST	639.8	639.8	639.8	639.8	639.8	639.8	639.8
OPERATION	40.9	48.1	54.5	68.1	45.2	51.6	62.9
OVERHEAD(EXCL.DEPN)	76.0	85.5	94.0	111.9	81.5	89.7	103.8
CASH COST	756.6	773.3	788.2	819.8	766.4	781.0	806.5
DEPRECIATION	104.9	123.4	139.9	174.8	113.4	125.4	144.6
NET COST OF PRODN	861.5	896.7	928.1	994.6	879.8	906.5	951.0
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	183.6	216.0	244.8	306.0	198.5	219.5	253.0
TRANSFER PRICE	1045.1	1112.7	1172.9	1300.6	1078.3	1126.0	1204.0

EFFECT OF PROPYLENE PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	576.0	384.0	576.0	384.0	576.0	384.0	576.0	384.0	576.0	384.0	576.0	384.0	576.0	384.0
NET COST OF PRODN	935.9	787.1	971.1	822.3	1002.5	853.7	1069.0	920.2	954.2	805.4	980.9	832.1	1025.4	876.6
TRANSFER PRICE	1119.5	970.7	1187.1	1038.3	1247.3	1098.5	1375.0	1226.2	1152.7	1003.9	1200.4	1051.6	1278.4	1129.6

How to Start Manufacturing Industries

ACRYLONITRILE

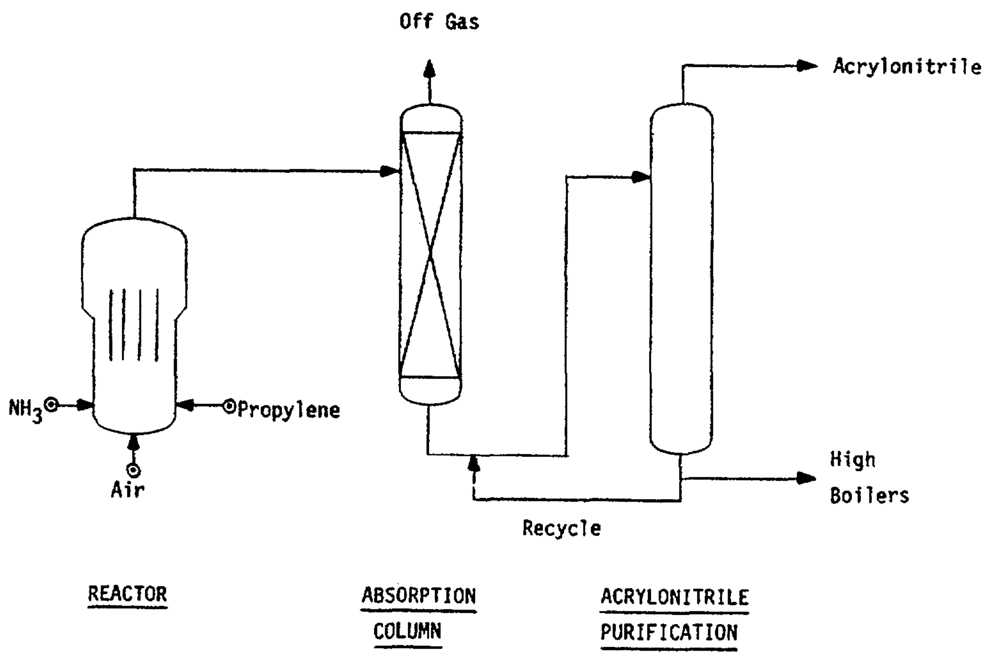
Process Description

Chemical grade propylene and fertiliser grade ammonia are fed with air to a fluid bed catalytic reactor operating at 420-480^{o}C and 1.3 to 3 bar. High conversions are obtained in 5-10 seconds in an exothermic reactor. Steam generated here is used later during purification.

The reactor effluent is scrubbed with water. Since an acrylonitrile/water azeotrope forms at 80^{o}C, a room temperature separation is performed followed by dehydration and fractionation to remove light and heavy impurities.

Uses

There are three major applications - in acrylic fibres and in copolymer resins such as ABS and in nitrile rubber and resins.



Land area for a 272 000 tonnes per year plant is estimated to be 40 000 square metres, which is a typical modern capacity. The minimum feasible capacity from a technical standpoint could be as small as 10 000 tonnes per year.

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COST OF PRODUCTION ESTIMATE FOR ACRYLONITRILE
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - PROP. AMMOXIDATION

BASIS		CAPITAL COST	$ MILL
LOCATION-	BENELUX	BATTERY LIMITS	88.63
CAPACITY-	272 000 TONNES PER YEAR	OFFSITES	42.75
PRODUCTN-	272 000 TONNES PER YEAR		
YEAR -	1980	TOTAL FIXED INV.	131.38
STR.TIME-	8000 HOURS PER YEAR	WORKING	67.77

RAW MATERIALS	QUANTITY/TONNE	PRICE*	ANNUAL COST	UNIT* COST
PROPYLENE	1.1800 TONNE	480.000	154 060 800	
AMMONIA	.4800 TONNE	195.000	25 459 200	
CATALYST+CHEMS	25.3676 DOLLARS	1.000	6 900 000	
TOTAL RAW MATERIALS			186 420 000	685.37
UTILITIES				
POWER	.2000 MWH	61.500	3 345 600	
COOLING WATER	.4100 KTONNE	17.000	1 895 840	
BLR.FEED WATER	.0003 KTONNE	450.000	40 392	
PROCESS WATER	.0022 KTONNE	230.000	140 760	
TOTAL UTILITIES COST			5 422 592	19.94
OPERATING COSTS				
LABOUR	27.00 MEN @ 17 700 $/YEAR		477 900	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR		29 200	
MAINTENANCE	@ .06×BLCC		5 317 870	
TOTAL OPERATING COST			5 824 970	21.42
OVERHEAD EXPENSES				
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION		202 840	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS		3 786 230	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP		1 970 696	
DEPRECIATION	@ .100× BLCC+ .050×OFFS		11 000 543	
INTEREST	@ .100× WORKING CAPITAL		6 777 237	
TOTAL OVERHEAD EXPENSES			23 737 546	87.27
BYPRODUCT CREDIT				
HYDROG.CYANIDE	¯.0530 TONNE	500.000	¯7 208 000	
ACETONITRILE	¯.0250 TONNE	1600.000	¯10 880 000	
TOTAL BYPRODUCT CREDIT			¯18 088 000	¯66.50
NET COST OF PRODUCTION			203 317 108	747.49

VARIABLE COST OF PRODUCTION	638.80
CASH COST OF PRODUCTION	707.05
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	795.79
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	819.94
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV	844.09

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR ACRYLONITRILE PROP. AMMOXIDATION BENELUX LANG FACTOR 0.67

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	272000	272000	272000	272000	217600	163200	108800
PLANT OUTPUT	272000	231200	204000	163200	217600	163200	108800
CAPITAL COST — MILLION DOLLARS							
BLCC	88.6	88.6	88.6	88.6	76.3	62.9	48.0
OFFSITES	42.7	42.7	42.7	42.7	36.8	30.4	23.1
TOTAL FIXED	131.4	131.4	131.4	131.4	113.1	93.3	71.1
WORKING	67.8	58.8	52.8	43.8	54.7	41.6	28.4
DOLLARS PER TONNE PRODUCT - (BASED ON PROPYLENE AT $480/TONNE)							
RAW MATERIALS	685.4	685.4	685.4	685.4	685.4	685.4	685.4
UTILITIES	19.9	19.9	19.9	19.9	19.9	19.9	19.9
BYPROD. CREDIT	¯66.5	¯66.5	¯66.5	¯66.5	¯66.5	¯66.5	¯66.5
VARIABLE COST	638.8	638.8	638.8	638.8	638.8	638.8	638.8
OPERATION	21.4	25.2	28.6	35.7	23.4	26.2	31.1
OVERHEAD(EXCL.DEPN)	46.8	51.2	55.1	63.4	49.1	52.4	58.0
CASH COST	707.0	715.2	722.5	737.9	711.3	717.4	727.9
DEPRECIATION	40.4	47.6	53.9	67.4	43.5	47.9	54.7
NET COST OF PRODN	747.5	762.8	776.4	805.3	754.8	765.3	782.6
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	72.5	85.2	96.6	120.8	78.0	85.8	98.0
TRANSFER PRICE	819.9	848.0	873.0	926.0	832.8	851.1	880.7

EFFECT OF PROPYLENE PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	576.0	384.0	576.0	384.0	576.0	384.0	576.0	384.0	576.0	384.0	576.0	384.0	576.0	384.0
NET COST OF PRODN	860.8	634.2	876.1	649.5	889.7	663.1	918.5	692.0	868.1	641.5	878.6	652.0	895.9	669.3
TRANSFER PRICE	933.2	706.7	961.3	734.7	986.3	759.7	1039.3	812.7	946.1	719.5	964.3	737.8	993.9	767.4

How to Start Manufacturing Industries

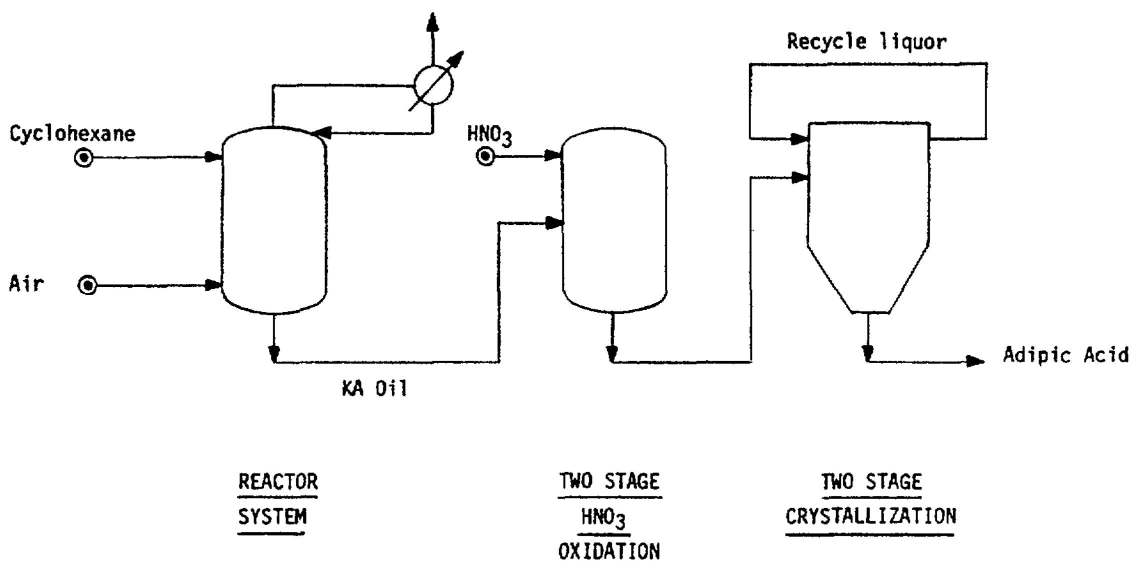
ADIPIC ACID

Cyclohexane is oxidised by air in a series of three reactors, endothermically at 165°C and 10.5 bar in the presence of boiler acid to produce a mixture of cyclohexanone and cyclohexanol, called ketone-alcohol (KA) oil. Overhead gases are condensed to remove most of the contained cyclohexane from N_2, CO and CO_2.

KA oil is oxidised to adipic acid using nitric acid in a two stage reaction system operating at 70°C and 100°C respectively. Total residence time is one and a half hours. Crude product is crystallised producing 95 percent adipic acid after centrifuging. This is recrystallised, dried and bagged.

Uses

Adipic acid is used mainly in nylon fibres production with large quantities used in polyamide production. Other applications are esters and polyesters in plasticiser and polyurethane compositions and food acidulants.



Approximately 25 000 square metres would be occupied by a plant producing 90 000 tonnes per year of adipic acid. The smallest feasible size could be as small as 25 000 tonnes per year.

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COST OF PRODUCTION ESTIMATE FOR ADIPIC ACID
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - CYCLOHEXANE

BASIS		CAPITAL COST	$ MILL
LOCATION-	BENELUX	BATTERY LIMITS	38.36
CAPACITY-	90 000 TONNES PER YEAR	OFFSITES	18.80
PRODUCTN-	90 000 TONNES PER YEAR		
YEAR -	1980	TOTAL FIXED INV.	57.17
STR.TIME-	8000 HOURS PER YEAR	WORKING	30.66

RAW MATERIALS	QUANTITY/TONNE		PRICE*	ANNUAL COST	UNIT* COST
CYCLOHEXANE	.7440	TONNE	645.000	43 189 200	
NITRIC ACID	.8700	TONNE	145.000	11 353 500	
CATALYST+CHEMS	15.2222	DOLLARS	1.000	1 370 000	
TOTAL RAW MATERIALS				55 912 700	621.25
UTILITIES					
POWER	.3900	MWH	61.500	2 158 650	
COOLING WATER	.6700	KTONNE	17.000	1 025 100	
L.P.STEAM	13.0000	TONNE	16.700	19 539 000	
PROCESS WATER	.0117	KTONNE	230.000	242 190	
INERT GAS	1.2500	NM3	.000	0	
TOTAL UTILITIES COST				22 964 940	255.17
OPERATING COSTS					
LABOUR	50.00 MEN @ 17 700 $/YEAR			885 000	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR			29 200	
MAINTENANCE	@ .04×BLCC			1 534 435	
TOTAL OPERATING COST				2 448 635	27.21
OVERHEAD EXPENSES					
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION			365 680	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS			1 591 613	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP			857 478	
DEPRECIATION	@ .100× BLCC+ .050×OFFS			4 776 304	
INTEREST	@ .100× WORKING CAPITAL			3 066 116	
TOTAL OVERHEAD EXPENSES				10 657 191	118.41
BYPRODUCT CREDIT					
TOTAL BYPRODUCT CREDIT				0	.00
NET COST OF PRODUCTION				91 983 466	1022.04

VARIABLE COST OF PRODUCTION	876.42
CASH COST OF PRODUCTION	968.97
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	1085.56
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	1117.31
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV	1149.07

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR ADIPIC ACID CYCLOHEXANE BENELUX LANG FACTOR 0.65

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	90000	90000	90000	90000	72000	54000	36000
PLANT OUTPUT	90000	76500	67500	54000	72000	54000	36000
CAPITAL COST MILLION DOLLARS							
BLCC	38.4	38.4	38.4	38.4	33.2	27.5	21.1
OFFSITES	18.8	18.8	18.8	18.8	16.3	13.5	10.4
TOTAL FIXED	57.2	57.2	57.2	57.2	49.4	41.0	31.5
WORKING	30.7	26.6	23.9	19.8	24.8	19.0	13.1
DOLLARS PER TONNE PRODUCT - (BASED ON CYCLOHEXANE AT $645/TONNE)							
RAW MATERIALS	621.3	621.3	621.3	621.3	621.3	621.3	621.3
UTILITIES	255.2	255.2	255.2	255.2	255.2	255.2	255.2
BYPROD. CREDIT	.0	.0	.0	.0	.0	.0	.0
VARIABLE COST	876.4	876.4	876.4	876.4	876.4	876.4	876.4
OPERATION	27.2	32.0	36.3	45.3	31.1	37.3	48.9
OVERHEAD(EXCL.DEPN)	65.3	71.5	77.1	88.8	70.1	77.6	91.4
CASH COST	969.0	980.0	989.7	1010.5	977.7	991.3	1016.7
DEPRECIATION	53.1	62.4	70.8	88.5	57.4	63.5	73.1
NET COST OF PRODN	1022.0	1042.4	1060.5	1099.0	1035.0	1054.8	1089.8
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	95.3	112.1	127.0	158.8	103.0	113.9	131.3
TRANSFER PRICE	1117.3	1154.5	1187.5	1257.8	1138.1	1168.7	1221.1

EFFECT OF CYCLOHEXANE PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	774.0	516.0	774.0	516.0	774.0	516.0	774.0	516.0	774.0	516.0	774.0	516.0	774.0	516.0
NET COST OF PRODN	1118.0	926.1	1138.4	946.4	1156.5	964.5	1194.9	1003.0	1131.0	939.1	1150.7	958.8	1185.8	993.9
TRANSFER PRICE	1213.3	1021.3	1250.5	1058.5	1283.5	1091.6	1353.7	1161.8	1234.0	1042.1	1264.7	1072.7	1317.1	1125.2

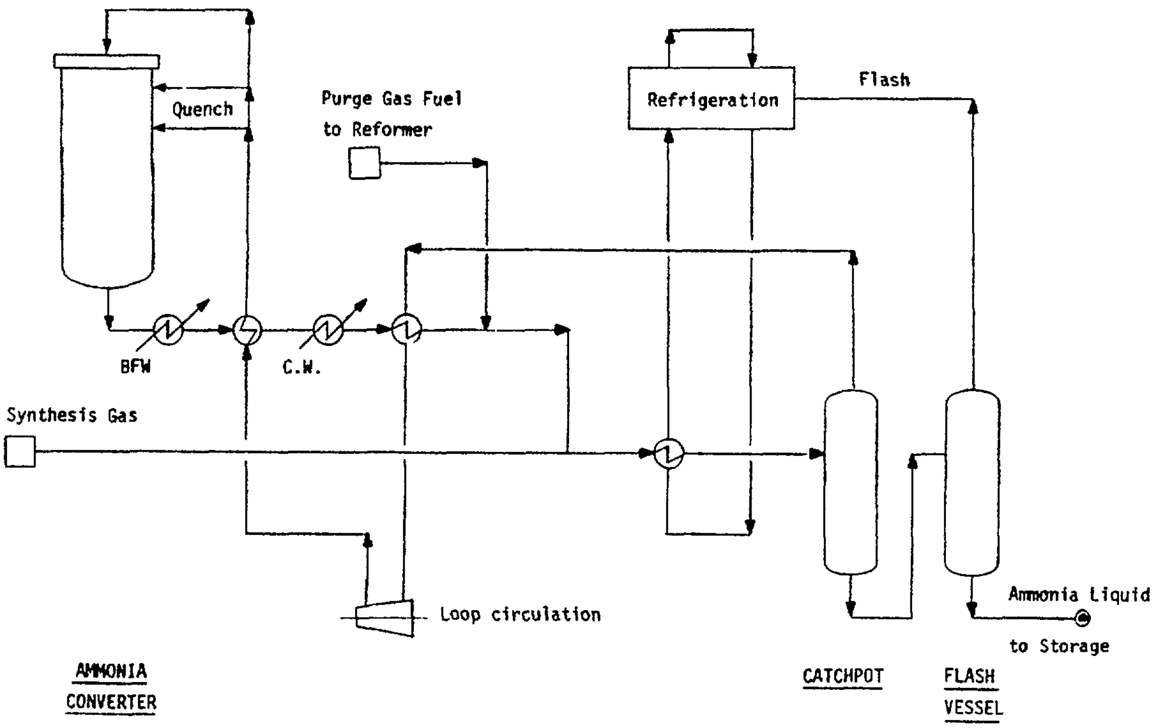
AMMONIA

Natural gas is mixed with steam and reformed over two stages to yield hydrogen and carbon monoxide. Reaction is highly endothermic and takes place at 800°C and 32 bar. In the second stage air is added so that the heat of combustion of part of the hydrogen supplies heat for the remainder of the endothermic reaction. Exit temperature is 1 000°C.

Exit gases are cooled and compressed and passed through a series of absorbers to take out water and carbon dioxide. The gases are compressed to the ammonia synthesis pressure of 225 bar. The ammonia catalyst is a promoted iron catalyst. The ammonia is condensed out of the synthesis loop by refrigerated cooling. Ammonia contents of 15-20 percent are obtained at the converter exit. Inerts are regularly purged and either burnt for fuel or processed further for hydrogen or argon recovery.

Uses

The major use for ammonia is in the fertiliser industry and containing 82 percent nitrogen, it is the most concentrated nitrogen fertiliser. Other uses are in the manufacture of nitric acid, in commercial explosives and fibres.



A plant capacity of 330 000 tonnes per year would occupy an area of 15 000 square metres. The smallest feasible size as built in Sweden is in the range 4-5 000 tonnes per year.

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COST OF PRODUCTION ESTIMATE FOR AMMONIA
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - NATURAL GAS

BASIS		CAPITAL COST	$ MILL
LOCATION-	BENELUX	BATTERY LIMITS	76.60
CAPACITY-	330 000 TONNES PER YEAR	OFFSITES	36.73
PRODUCTN-	330 000 TONNES PER YEAR		
YEAR -	1980	TOTAL FIXED INV.	113.33
STR.TIME-	8000 HOURS PER YEAR	WORKING	24.89

RAW MATERIALS	QUANTITY/TONNE	PRICE*	ANNUAL COST	UNIT* COST
NATURAL GAS	8.8200 GCAL	18.100	52 681 860	
CATALYST+CHEMS	1.0455 DOLLARS	1.000	345 000	
TOTAL RAW MATERIALS			53 026 860	160.69
UTILITIES				
POWER	.0160 MWH	61.500	324 720	
COOLING WATER	.2000 KTONNE	17.000	1 122 000	
BLR.FEED WATER	.0008 KTONNE	450.000	118 800	
TOTAL UTILITIES COST			1 565 520	4.74
OPERATING COSTS				
LABOUR	35.00 MEN @ 17 700 $/YEAR		619 500	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR		29 200	
MAINTENANCE	@ .04×BLCC		3 063 855	
TOTAL OPERATING COST			3 712 555	11.25
OVERHEAD EXPENSES				
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION		259 480	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS		2 413 161	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP		1 699 913	
DEPRECIATION	@ .100× BLCC+ .050×OFFS		9 496 196	
INTEREST	@ .100× WORKING CAPITAL		2 488 748	
TOTAL OVERHEAD EXPENSES			16 357 497	49.57
BYPRODUCT CREDIT				
TOTAL BYPRODUCT CREDIT			0	.00
NET COST OF PRODUCTION			74 662 432	226.25

VARIABLE COST OF PRODUCTION	165.43
CASH COST OF PRODUCTION	197.47
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	260.59
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	277.76
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV	294.93

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR AMMONIA NATURAL GAS BENELUX LANG FACTOR 0.65

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	330000	330000	330000	330000	264000	198000	132000
PLANT OUTPUT	330000	280500	247500	198000	264000	198000	132000
CAPITAL COST — MILLION DOLLARS							
BLCC	76.6	76.6	76.6	76.6	66.3	55.0	42.2
OFFSITES	36.7	36.7	36.7	36.7	31.8	26.4	20.2
TOTAL FIXED	113.3	113.3	113.3	113.3	98.0	81.3	62.5
WORKING	24.9	22.1	20.2	17.4	20.4	15.8	11.1
DOLLARS PER TONNE PRODUCT - (BASED ON NATURAL GAS AT $18.1/GCAL)							
RAW MATERIALS	160.7	160.7	160.7	160.7	160.7	160.7	160.7
UTILITIES	4.7	4.7	4.7	4.7	4.7	4.7	4.7
BYPROD. CREDIT	.0	.0	.0	.0	.0	.0	.0
VARIABLE COST	165.4	165.4	165.4	165.4	165.4	165.4	165.4
OPERATION	11.3	13.2	15.0	18.8	12.5	14.4	17.7
OVERHEAD(EXCL.DEPN)	20.8	23.5	25.8	30.9	22.4	24.8	29.0
CASH COST	197.5	202.1	206.3	215.0	200.3	204.6	212.1
DEPRECIATION	28.8	33.9	38.4	48.0	31.1	34.4	39.7
NET COST OF PRODN	226.2	236.0	244.6	263.0	231.4	239.0	251.8
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	51.5	60.6	68.7	85.9	55.7	61.6	71.0
TRANSFER PRICE	277.8	296.6	313.3	348.8	287.1	300.6	322.8

EFFECT OF NATURAL GAS PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/GCAL	21.7	14.5	21.7	14.5	21.7	14.5	21.7	14.5	21.7	14.5	21.7	14.5	21.7	14.5
NET COST OF PRODN	258.2	194.3	267.9	204.0	276.5	212.7	294.9	231.1	263.4	199.5	270.9	207.1	283.7	219.8
TRANSFER PRICE	309.7	245.8	328.5	264.7	345.2	281.4	380.8	316.9	319.1	255.2	332.5	268.7	354.7	290.8

File: G27
ISIC 3511

How to Start Manufacturing Industries

ANILINE

Process Description

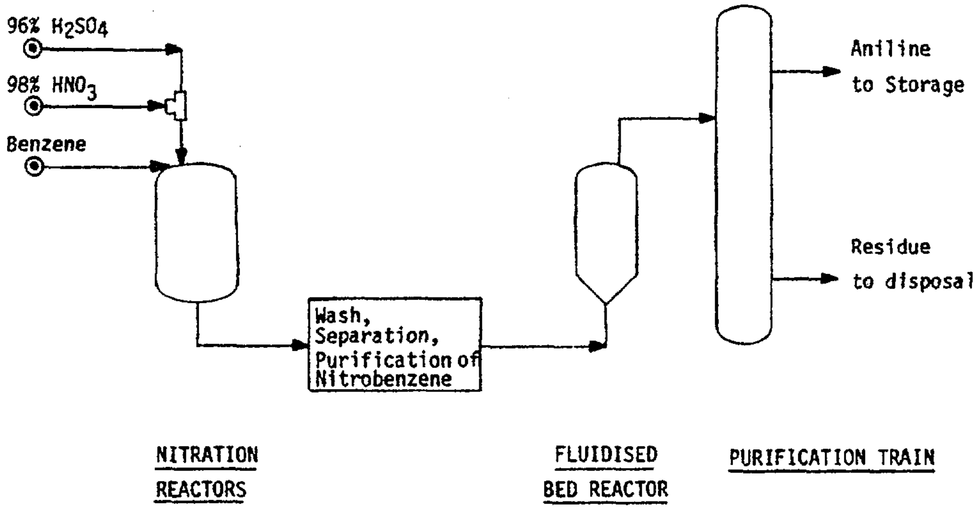
This process consists of separate nitrobenzene and aniline production sections. Primarily 96 and 98 percent sulphuric and nitric acids respectively are blended and charged to the last of three nitrators operating at 60-70°C. This is done so that the strongest acid stream always contacts the highest nitrobenzene stream. Overall selectivity of nitrobenzene is 97 percent. The emulsion from the final nitrator is decanted, with the acid phase returned to the first nitrator. Mixture from the second nitrator is separated, from which sulphuric acid is recovered and sent for further concentration. Subsequent steps wash, neutralise and purify the nitrobenzene for aniline production.

Hydrogen and nitrobenzene in a mole ratio of 10:1 is vapourised and passed to the bottom of a fluidised bed reactor maintained at 270°C and 3.4-3.7 bar. Selectivity to aniline is 98 percent. The catalyst is copper on silica having an average life of 12-15 months. A~iline water mixture from the reactor is condensed, flashed to remove the hydrogen, and then gravity separated. Further purification is done by a train of drying and purification columns.

Uses

The main uses of aniline are in the polymer industry to manufacture isocyanates; in the rubber industry for the manufacture of antioxidants, and antidegradants in the agricultural industry for herbicides, fungicides and insecticides, also in dyes and in the pharmaceutical industry.

Land area for a plant of 45 000 tonnes per year capacity is approximately 3 000 square metres. Minimum feasible capacity with two nitrators could be 50 000 tonnes per year.



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COST OF PRODUCTION ESTIMATE FOR ANILINE
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - NITROBENZENE

BASIS		CAPITAL COST	$ MILL
LOCATION-	BENELUX	BATTERY LIMITS	22.94
CAPACITY-	45 000 TONNES PER YEAR	OFFSITES	11.03
PRODUCTN-	45 000 TONNES PER YEAR		
YEAR -	1980	TOTAL FIXED INV	33.97
STR.TIME-	8000 HOURS PER YEAR	WORKING	13.56

RAW MATERIALS	QUANTITY/TONNE		PRICE*	ANNUAL COST	UNIT* COST
BENZENE	.8780	TONNE	590.000	23 310 900	
NITRIC ACID	.7260	TONNE	145.000	4 737 150	
SULPHURIC ACID	.0023	TONNE	120.000	12 420	
HYDROGEN	.0660	TONNE	1100.000	3 267 000	
CATALYST+CHEMS	5.5778	DOLLARS	1.000	251 000	
TOTAL RAW MATERIALS				31 578 470	701.74
UTILITIES					
POWER	.0820	MWH	61.500	226 935	
COOLING WATER	.3480	KTONNE	17.000	266 220	
L.P.STEAM	.9000	TONNE	16.700	676 350	
FUEL	.3900	GCAL	18.100	317 655	
TOTAL UTILITIES COST				1 487 160	33.05
OPERATING COSTS					
LABOUR	37.00 MEN @ 17 700 $/YEAR			654 900	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR			29 200	
MAINTENANCE	@ .04×BLCC			917 652	
TOTAL OPERATING COST				1 601 752	35.59
OVERHEAD EXPENSES					
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION			273 640	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS			1 041 139	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP			509 598	
DEPRECIATION	@ .100× BLCC+ .050×OFFS			2 845 725	
INTEREST	@ .100× WORKING CAPITAL			1 356 465	
TOTAL OVERHEAD EXPENSES				6 026 566	133.92
BYPRODUCT CREDIT					
TOTAL BYPRODUCT CREDIT				0	.00
NET COST OF PRODUCTION				40 693 949	904.31

VARIABLE COST OF PRODUCTION	734.79
CASH COST OF PRODUCTION	841.07
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	979.81
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	1017.55
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV	1055.30

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR ANILINE NITROBENZENE BENELUX LANG FACTOR 0.65

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	45000	45000	45000	45000	36000	27000	18000
PLANT OUTPUT	45000	38250	33750	27000	36000	27000	18000
CAPITAL COST — MILLION DOLLARS							
BLCC	22.9	22.9	22.9	22.9	19.8	16.5	12.6
OFFSITES	11.0	11.0	11.0	11.0	9.5	7.9	6.1
TOTAL FIXED	34.0	34.0	34.0	34.0	29.4	24.4	18.7
WORKING	13.6	11.9	10.7	9.0	11.1	8.5	6.0
DOLLARS PER TONNE PRODUCT - (BASED ON BENZENE AT $590/TONNE)							
RAW MATERIALS	701.7	701.7	701.7	701.7	701.7	701.7	701.7
UTILITIES	33.0	33.0	33.0	33.0	33.0	33.0	33.0
BYPROD. CREDIT	.0	.0	.0	.0	.0	.0	.0
VARIABLE COST	734.8	734.8	734.8	734.8	734.8	734.8	734.8
OPERATION	35.6	41.9	47.5	59.3	41.1	49.7	66.1
OVERHEAD(EXCL.DEPN)	70.7	78.7	85.8	100.9	77.2	87.6	106.9
CASH COST	841.1	855.4	868.1	895.0	853.1	872.1	907.8
DEPRECIATION	63.2	74.4	84.3	105.4	68.4	75.6	87.1
NET COST OF PRODN	904.3	929.8	952.4	1000.4	921.5	947.7	995.0
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	113.2	133.2	151.0	180.7	122.4	135.4	156.1
TRANSFER PRICE	1017.6	1063.0	1103.4	1189.2	1043.9	1083.1	1151.1

EFFECT OF BENZENE PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	708.0	472.0	708.0	472.0	708.0	472.0	708.0	472.0	708.0	472.0	708.0	472.0	708.0	472.0
NET COST OF PRODN	1007.9	800.7	1033.4	826.1	1056.0	848.8	1104.0	896.8	1025.1	817.9	1051.3	844.1	1098.6	891.4
TRANSFER PRICE	1121.2	913.9	1166.6	959.4	1207.0	999.8	1292.8	1085.6	1147.5	940.3	1186.7	979.5	1254.7	1047.5

File: G28
ISIC 3511

How to Start Manufacturing Industries

AROMATICS EXTRACTION - BTX FROM REFORMATE

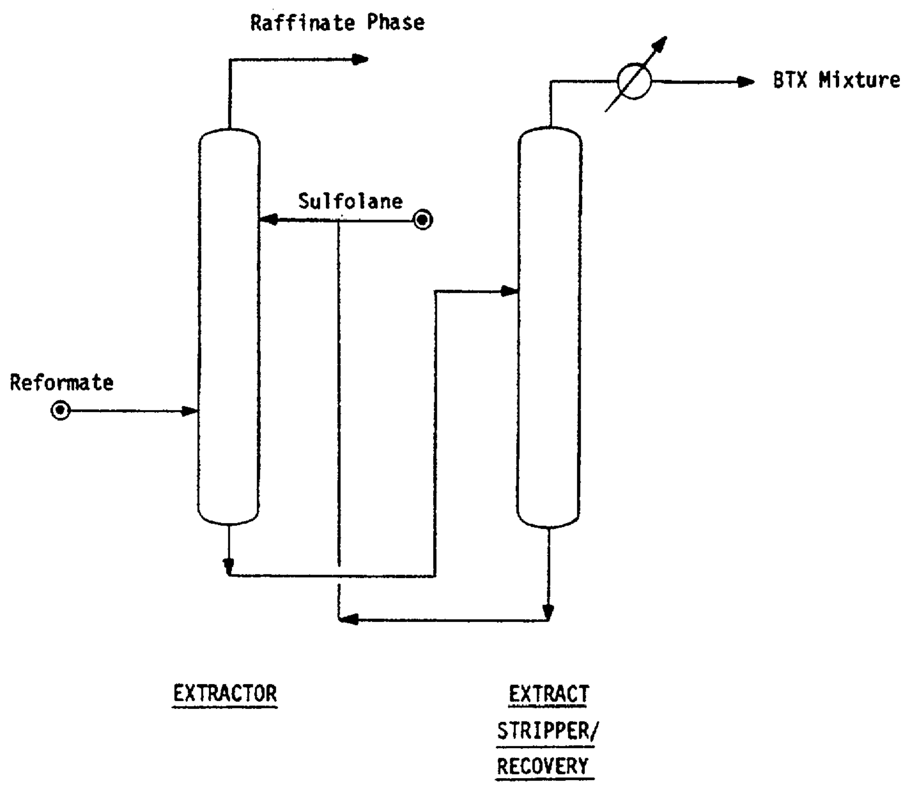
Process Description

Reformate, consisting of chiefly benzene, toluene and xylenes (BTX) is prefractionated and fed to the extractor, where it is contacted against a falling stream of sulfolane solvent. Undissolved hydrocarbons pass out as the raffinate phase.

The extract or rich solvent phase is stripped to recover the BTX as top product. The bottoms are recycled to the extractor. Further processing of the BTX mixture would yield benzene toluene and xylenes.

Uses

The benzene produced in this case has a multitude of uses in ethylbenzene, cumene and cyclohexane manufacture. Toluene to manufacture toluene diisocyanate (for polyurethanes) and phthalic anhydride (for plasticisers for plastics). Xylenes in DMT (for polyester films), isophthalic acid production etc.



An actual plant processing 5 300 barrels per day would occupy 1 800 square metres. Minimum feasible capacity can depend on a number of factors, in Europe however, this has been taken as 35 000 tonnes per year.

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COST OF PRODUCTION ESTIMATE FOR BENZENE
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - BTX REFORMATE EXTR.

BASIS		CAPITAL COST	$ MILL
LOCATION-	BENELUX	BATTERY LIMITS	26.08
CAPACITY-	44 000 TONNES PER YEAR	OFFSITES	16.92
PRODUCTN-	44 000 TONNES PER YEAR		
YEAR -	1980	TOTAL FIXED INV.	43.00
STR.TIME-	8000 HOURS PER YEAR	WORKING	21.61

RAW MATERIALS	QUANTITY/TONNE	PRICE*	ANNUAL COST	UNIT* COST
CONTAINED BTX	6.7950 TONNE	385.000	115 107 300	
CATALYST+CHEMS	5.9773 DOLLARS	1.000	263 000	
TOTAL RAW MATERIALS			115 370 300	2622.05
UTILITIES				
POWER	.3390 MWH	61.500	917 334	
COOLING WATER	.4700 KTONNE	17.000	351 560	
MP.STEAM	15.0000 TONNE	19.200	12 672 000	
TOTAL UTILITIES COST			13 940 894	316.84
OPERATING COSTS				
LABOUR	19.00 MEN @ 17 700 $/YEAR		336 300	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR		29 200	
MAINTENANCE	@ .04×BLCC		1 043 014	
TOTAL OPERATING COST			1 408 514	32.01
OVERHEAD EXPENSES				
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION		146 200	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS		915 534	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP		644 989	
DEPRECIATION	@ .100× BLCC+ .050×OFFS		3 453 732	
INTEREST	@ .100× WORKING CAPITAL		2 160 732	
TOTAL OVERHEAD EXPENSES			7 321 187	166.39
BYPRODUCT CREDIT				
TOLUENE	¯3.3640 TONNE	410.000	¯60 686 560	
XYLENES	¯2.4320 TONNE	420.000	¯44 943 360	
TOTAL BYPRODUCT CREDIT			¯105 629 920	¯2400.68
NET COST OF PRODUCTION			32 410 976	736.61

VARIABLE COST OF PRODUCTION	538.21
CASH COST OF PRODUCTION	658.12
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	834.34
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	883.20
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV	932.06

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR BENZENE — BTX REFORMATE EXTR. BENELUX — LANG FACTOR 0.65

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	44000	44000	44000	44000	35200	26400	17600
PLANT OUTPUT	44000	37400	33000	26400	35200	26400	17600
CAPITAL COST — MILLION DOLLARS							
BLCC	26.1	26.1	26.1	26.1	22.6	18.7	14.4
OFFSITES	16.9	16.9	16.9	16.9	14.6	12.1	9.3
TOTAL FIXED	43.0	43.0	43.0	43.0	37.2	30.9	23.7
WORKING	21.6	19.1	17.4	14.8	17.7	13.7	9.6
DOLLARS PER TONNE PRODUCT - (BASED ON CONTAINED BTX AT $385/TONNE)							
RAW MATERIALS	2622.1	2622.1	2622.1	2622.1	2622.1	2622.1	2622.1
UTILITIES	316.8	316.8	316.8	316.8	316.8	316.8	316.8
BYPROD. CREDIT	¯2400.7	¯2400.7	¯2400.7	¯2400.7	¯2400.7	¯2400.7	¯2400.7
VARIABLE COST	538.2	538.2	538.2	538.2	538.2	538.2	538.2
OPERATION	32.0	37.7	42.7	53.4	36.0	42.2	53.4
OVERHEAD(EXCL.DEPN)	87.9	96.6	104.4	120.9	93.6	102.3	117.7
CASH COST	658.1	672.5	685.3	712.4	667.8	682.7	709.4
DEPRECIATION	78.5	92.3	104.7	130.8	84.9	93.9	108.2
NET COST OF PRODN	736.6	764.8	789.9	843.3	752.7	776.5	817.6
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	146.6	172.5	195.5	244.3	158.5	175.3	202.0
TRANSFER PRICE	883.2	937.3	985.4	1087.6	911.2	951.8	1019.6

EFFECT OF CONTAINED BTX PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	462.0	308.0	462.0	308.0	462.0	308.0	462.0	308.0	462.0	308.0	462.0	308.0	462.0	308.0
NET COST OF PRODN	1259.8	213.4	1288.1	241.6	1313.1	266.7	1366.5	320.0	1275.9	229.5	1299.7	253.3	1340.8	294.3
TRANSFER PRICE	1406.4	360.0	1460.5	414.1	1508.6	462.2	1610.8	564.4	1434.4	388.0	1475.0	428.6	1542.8	496.4

How to Start Manufacturing Industries

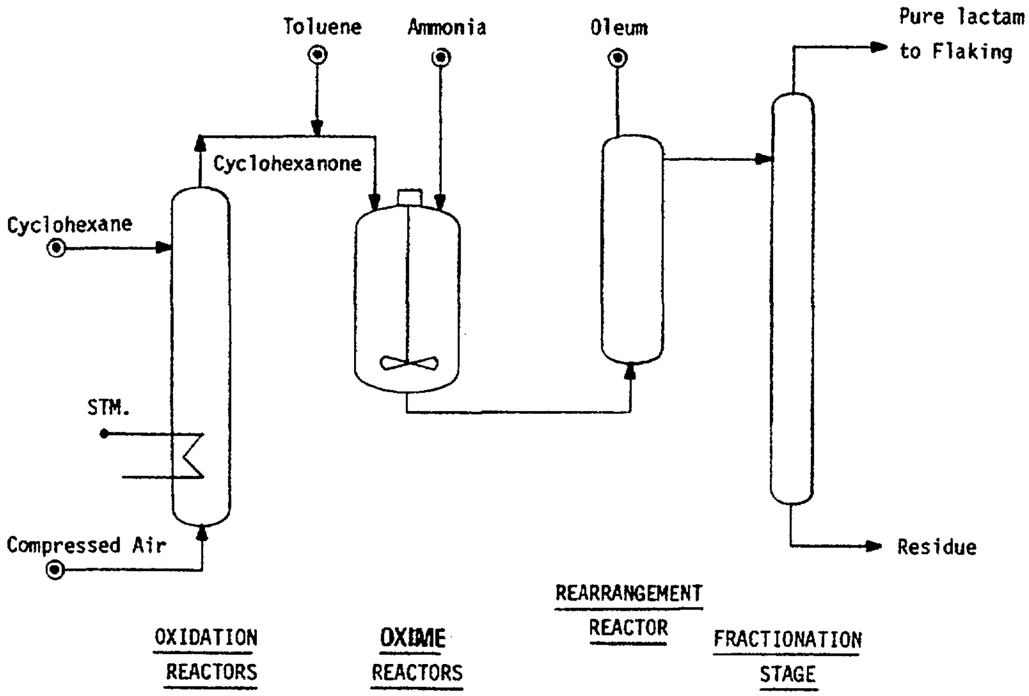
CAPROLACTAM

Process Description

Cyclohexanone (ONE) is first produced via oxidation of cyclohexane by air at 165°C and 10.7 bar. Yield of ONE is 81 mole percent. A hydroxylamine solution is then contacted with the ONE to produce the cyclohexanone oxime. Caprolactam is produced by Beckmann rearrangement in the presence of oleum and ammonia. Caprolactam is produced after purification in cation columns by ion exchange by distillation, condensation and flaking.

Uses

Nearly all the caprolactam produced is used for making nylon-6 which is really polycaprolactam. Polycaprolactam has somewhat deeper dyeing properties than nylon-6,6.



The plot area occupied by an 80 000 tonnes per year plant is approximately 25 000 square metres. The minimum feasible capacity from a technical point of view is 15 000 tonnes per year.

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COST OF PRODUCTION ESTIMATE FOR CAPROLACTAM
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - BECKMANN (DSM)

BASIS		CAPITAL COST	$ MILL
LOCATION- BENELUX		BATTERY LIMITS	114.08
CAPACITY- 80 000 TONNES PER YEAR		OFFSITES	51.40
PRODUCTN- 80 000 TONNES PER YEAR			
YEAR - 1980		TOTAL FIXED INV.	165.48
STR.TIME- 8000 HOURS PER YEAR		WORKING	46.22

RAW MATERIALS	QUANTITY/TONNE		PRICE*	ANNUAL COST	UNIT* COST
CYCLOHEXANE	1.0600	TONNE	645.000	54 696 000	
AMMONIA	.8000	TONNE	195.000	12 480 000	
OLEUM	1.3500	TONNE	140.000	15 120 000	
HYDROGEN	.1000	TONNE	1100.000	8 800 000	
CATALYST+CHEMS	19.6250	DOLLARS	1.000	1 570 000	
TOTAL RAW MATERIALS				92 666 000	1158.32
UTILITIES					
POWER	.4850	MWH	61.500	2 386 200	
COOLING WATER	1.5900	KTONNE	17.000	2 162 400	
HP.STEAM	6.2500	TONNE	20.200	10 100 000	
MP.STEAM	3.3100	TONNE	19.200	5 084 160	
LP.STEAM	3.7500	TONNE	16.700	5 010 000	
PROCESS WATER	.0060	KTONNE	230.000	110 400	
FUEL	.1900	GCAL	18.100	275 120	
TOTAL UTILITIES COST				25 128 280	314.10
OPERATING COSTS					
LABOUR	55.00 MEN @ 17 700 $/YEAR			973 500	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR			29 200	
MAINTENANCE	@ .04×BLCC			4 563 188	
TOTAL OPERATING COST				5 565 888	69.57
OVERHEAD EXPENSES					
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION			401 080	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS			3 617 827	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP			2 482 174	
DEPRECIATION	@ .100× BLCC+ .050×OFFS			13 977 899	
INTEREST	@ .100× WORKING CAPITAL			4 622 040	
TOTAL OVERHEAD EXPENSES				25 101 020	313.76
BYPRODUCT CREDIT					
AMM.SULPHATE	-1.7500	TONNE	70.000	-9 800 000	
TOTAL BYPRODUCT CREDIT				-9 800 000	-122.50
NET COST OF PRODUCTION				138 661 188	1733.26
VARIABLE COST OF PRODUCTION					1349.93
CASH COST OF PRODUCTION					1558.54
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV					1940.11
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV					2043.54
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV					2146.96

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR CAPROLACTAM BECKMANN (DSM) BENELUX LANG FACTOR 0.65

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	80000	80000	80000	80000	64000	48000	32000
PLANT OUTPUT	80000	68000	60000	48000	64000	48000	32000
CAPITAL COST MILLION DOLLARS							
DLCC	114.1	114.1	114.1	114.1	98.7	81.8	62.9
OFFSITES	51.4	51.4	51.4	51.4	44.5	36.9	28.3
TOTAL FIXED	165.5	165.5	165.5	165.5	143.1	118.7	91.2
WORKING	46.2	40.6	36.9	31.3	37.7	29.0	20.2
DOLLARS PER TONNE PRODUCT - (BASED ON CYCLOHEXANE AT $645/TONNE)							
RAW MATERIALS	1158.3	1158.3	1158.3	1158.3	1158.3	1158.3	1158.3
UTILITIES	314.1	314.1	314.1	314.1	314.1	314.1	314:1
BYPROD. CREDIT	¯122.5	¯122.5	¯122.5	¯122.5	¯122.5	¯122.5	¯122.5
VARIABLE COST	1349.9	1349.9	1349.9	1349.9	1349.9	1349.9	1349.9
OPERATION	69.6	81.9	92.8	116.0	77.3	89.1	109.9
OVERHEAD(EXCL.DEPN)	139.0	155.4	169.9	200.7	148.9	163.8	189.8
CASH COST	1558.5	1587.1	1612.6	1666.6	1576.2	1602.8	1649.6
DEPRECIATION	174.7	205.6	233.0	291.2	188.9	208.9	240.8
NET COST OF PRODN	1733.3	1792.7	1845.5	1957.8	1765.1	1811.7	1890.4
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	310.3	365.0	413.7	517.1	335.5	371.0	427.6
TRANSFER PRICE	2043.5	2157.7	2259.2	2474.9	2100.6	2182.7	2318.0

EFFECT OF CYCLOHEXANE PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	774.0	516.0	774.0	516.0	774.0	516.0	774.0	516.0	774.0	516.0	774.0	516.0	774.0	516.0
NET COST OF PRODN	1870.0	1596.5	1929.4	1656.0	1982.3	1708.8	2094.5	1821.0	1901.8	1628.4	1948.5	1675.0	2027.2	1753.7
TRANSFER PRICE	2180.3	1906.8	2294.5	2021.0	2396.0	2122.5	2611.6	2338.2	2237.3	1963.8	2319.5	2046.0	2454.7	2181.3

File: G30
ISIC 3511

How to Start Manufacturing Industries

CAUSTIC-CHLORINE (DIAPHRAGM CELL)

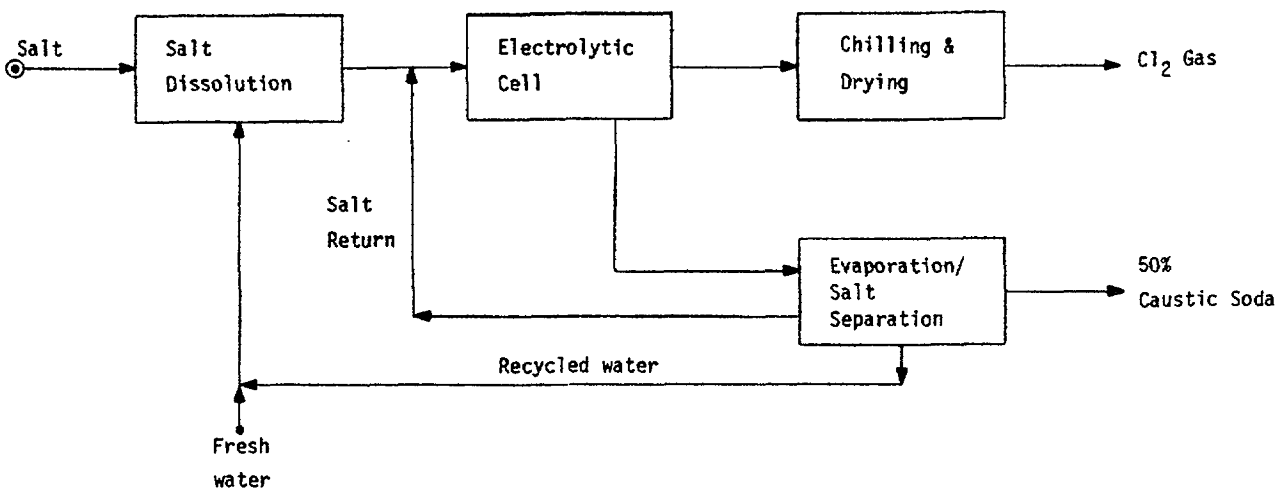
Process Description

Salt is dissolved in fresh and recycled water and sent to brine treatment for calcium and magnesium removal. The brine enters the electrolytic cells for electrolysis by low voltage direct current, produced by transforming and rectifying high voltage alternating current.

The chlorine from the cell is chilled and then dried by contact with 98 percent sulphuric acid. Gaseous chlorine is compressed for delivery. Weak caustic soda/brine mixture leaving the cell contains 11 percent caustic soda. This is concentrated to 50 percent and then cooled to crystallise out the salt.

Uses

The major uses are in the production of vinyl chloride, propylene oxide, and methylene chloride. Other uses are in chlorinated ethanes (solvents), bleaches, in the pulp and paper industries.



Land area for a 164 000 tonnes per year chlorine plant is approximately 5 000 square metres. Capacity as low as 80 000 tonnes per year is also possible technically and has been constructed in Western Europe.

This information has been prepared for UNIDO by Chem Systems International Ltd., United Kingdom.

Any inquiry about the information contained should be sent to: IO/COOP, Registry file No. ID/562/12, UNIDO, P.O. Box 300, A-1400, Vienna, Austria.

COST OF PRODUCTION ESTIMATE FOR CHLORINE
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - DIAPHRAGM CELL

BASIS		CAPITAL COST	$ MILL
LOCATION-	BENELUX	BATTERY LIMITS	105.30
CAPACITY-	164 000 TONNES PER YEAR	OFFSITES	42.62
PRODUCTN-	164 000 TONNES PER YEAR		
YEAR -	1980	TOTAL FIXED INV	147.93
STR.TIME-	8000 HOURS PER YEAR	WORKING	8.19

RAW MATERIALS	QUANTITY/TONNE		PRICE*	ANNUAL COST	UNIT* COST
SALT	1.7200	TONNE	16.000	4 513 280	
CATALYST+CHEMS	1.5061	DOLLARS	1.000	247 000	
TOTAL RAW MATERIALS				4 760 280	29.03
UTILITIES					
POWER	3.2400	MWH	61.500	32 678 640	
COOLING WATER	.2900	KTONNE	17.000	808 520	
MP.STEAM	2.3000	TONNE	19.200	7 242 240	
LP.STEAM	.4000	TONNE	16.700	1 095 520	
PROCESS WATER	.0043	KTONNE	230.000	160 310	
TOTAL UTILITIES COST				41 985 230	256.01
OPERATING COSTS					
LABOUR	45.00 MEN @ 17 700 $/YEAR			796 500	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR			29 200	
MAINTENANCE	@ .04×BLCC			4 212 174	
TOTAL OPERATING COST				5 037 874	30.72
OVERHEAD EXPENSES					
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION			330 280	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS			3 274 618	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP			2 218 913	
DEPRECIATION	@ .100× BLCC+ .050×OFFS			12 661 594	
INTEREST	@ .100× WORKING CAPITAL			819 017	
TOTAL OVERHEAD EXPENSES				19 304 423	117.71
BYPRODUCT CREDIT					
CAUSTIC SODA	¯1.1200	TONNE	240.000	¯44 083 200	
FUEL	¯.8200	GCAL	18.100	¯2 434 088	
TOTAL BYPRODUCT CREDIT				¯46 517 288	¯283.64
NET COST OF PRODUCTION				24 570 518	149.82

VARIABLE COST OF PRODUCTION	1.39
CASH COST OF PRODUCTION	72.62
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	240.02
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	285.12
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV	330.22

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR CHLORINE DIAPHRAGM CELL BENELUX LANG FACTOR 0.83

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	164000	164000	164000	164000	131200	98400	65600
PLANT OUTPUT	164000	139400	123000	98400	131200	98400	65600
CAPITAL COST — MILLION DOLLARS							
BLCC	105.3	105.3	105.3	105.3	87.5	68.9	49.2
OFFSITES	42.6	42.6	42.6	42.6	35.4	27.9	19.9
TOTAL FIXED	147.9	147.9	147.9	147.9	122.9	96.8	69.1
WORKING	8.2	8.2	8.2	8.2	6.9	5.6	4.1
DOLLARS PER TONNE PRODUCT - (BASED ON SALT AT $16/TONNE)							
RAW MATERIALS	29.0	29.0	29.0	29.0	29.0	29.0	29.0
UTILITIES	256.0	256.0	256.0	256.0	256.0	256.0	256.0
BYPROD. CREDIT	-283.6	-283.6	-283.6	-283.6	-283.6	-283.6	-283.6
VARIABLE COST	1.4	1.4	1.4	1.4	1.4	1.4	1.4
OPERATION	30.7	36.1	41.0	51.2	33.0	36.4	42.6
OVERHEAD(EXCL.DEPN)	40.5	47.6	54.0	67.5	43.3	47.4	54.8
CASH COST	72.6	85.2	96.3	120.1	77.6	85.2	98.8
DEPRECIATION	77.2	90.8	102.9	128.7	80.2	84.2	90.2
NET COST OF PRODN	149.8	176.0	199.3	248.7	157.8	169.4	189.0
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	135.3	159.2	180.4	225.5	140.5	147.6	158.1
TRANSFER PRICE	285.1	335.2	379.7	474.2	298.3	317.0	347.2

EFFECT OF SALT PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	19.2	12.8	19.2	12.8	19.2	12.8	19.2	12.8	19.2	12.8	19.2	12.8	19.2	12.8
NET COST OF PRODN	155.3	144.3	181.5	170.5	204.8	193.8	254.2	243.2	163.3	152.3	174.9	163.9	194.6	183.5
TRANSFER PRICE	290.6	279.6	340.7	329.7	385.2	374.2	479.7	468.7	303.8	292.8	322.5	311.5	352.7	341.6

How to Start Manufacturing Industries

CUMENE

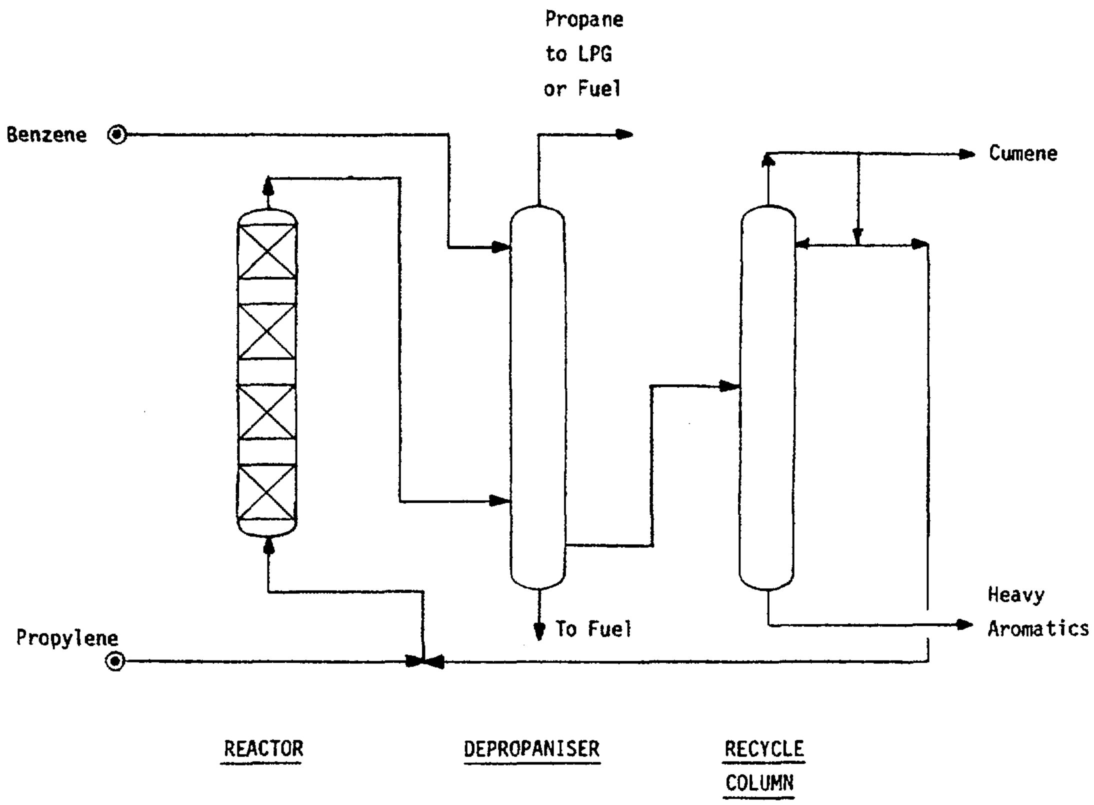
Process Description

Fresh chemical grade propylene is combined with benzene which is maintained at a high recycle rate to prevent formation of dialkylated and polymer products. Solid phosphoric acid catalyst is non-corrosive and the reactor can therefore be constructed of carbon steel.

Reactor effluent is rectified to remove propane and any unreacted benzene. The propane may be sold as LPG. Liquid from the rectifier contains cumene and unreacted benzene is charged to the recycle column. Here, high purity cumene comes off overhead, and di-isopropylbenzene etc as the bottom product.

Uses

Phenol is produced from cumene oxidation via cumene hydroperoxide. Other uses in terephthalic acid (TPA) production via diisopropylbenzene.



An actual land area occupied by a 3 130 barrels per day cumene plant is 1 600 square metres. The smallest practicable size of 100 000 tonnes per year has been constructed.

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COST OF PRODUCTION ESTIMATE FOR CUMENE
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - CAT.CONDENSATION

BASIS		CAPITAL COST	$.MILL
LOCATION- BENELUX		BATTERY LIMITS	15.04
CAPACITY-	200 000 TONNES PER YEAR	OFFSITES	7.27
PRODUCTN-	200 000 TONNES PER YEAR		
YEAR - 1980		TOTAL FIXED INV.	22.31
STR.TIME- 8000 HOURS PER YEAR		WORKING	42.43

RAW MATERIALS	QUANTITY/TONNE	PRICE*	ANNUAL COST	UNIT* COST
PROPYLENE	.4150 TONNE	480.000	39 840 000	
BENZENE	.6710 TONNE	590.000	79 178 000	
CATALYST+CHEMS	6.2500 DOLLARS	1.000	1 250 000	
TOTAL RAW MATERIALS			120 268 000	601.34
UTILITIES				
POWER	.0322 MWH	61.500	396 060	
COOLING WATER	.0226 KTONNE	17.000	76 840	
BLR.FEED WATER	.0003 KTONNE	450.000	27 000	
FUEL	1.2450 GCAL	18.100	4 506 900	
TOTAL UTILITIES COST			5 006 800	25.03
OPERATING COSTS				
LABOUR	9.00 MEN @ 17 700 $/YEAR		159 300	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR		29 200	
MAINTENANCE	@ .04×BLCC		601 739	
TOTAL OPERATING COST			790 239	3.95
OVERHEAD EXPENSES				
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION		75 400	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS		513 655	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP		334 717	
DEPRECIATION	@ .100× BLCC+ .050×OFFS		1 867 899	
INTEREST	@ .100× WORKING CAPITAL		4 242 940	
TOTAL OVERHEAD EXPENSES			7 034 612	35.17
BYPRODUCT CREDIT				
LP.STEAM	-1.1200 TONNE	16.700	-3 740 800	
PROPANE/AROM	-.5720 GCAL	18.100	-2 070 640	
TOTAL BYPRODUCT CREDIT			-5 811 440	-29.06
NET COST OF PRODUCTION			127 288 211	636.44

VARIABLE COST OF PRODUCTION	597.32
CASH COST OF PRODUCTION	627.10
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	647.60
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	653.18
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV	658.76

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR CUMENE CAT.CONDENSATION BENELUX LANG FACTOR 0.63

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	200000	200000	200000	200000	160000	120000	80000
PLANT OUTPUT	200000	170000	150000	120000	160000	120000	80000
CAPITAL COST — MILLION DOLLARS							
BLCC	15.0	15.0	15.0	15.0	13.1	10.9	8.4
OFFSITES	7.3	7.3	7.3	7.3	6.3	5.3	4.1
TOTAL FIXED	22.3	22.3	22.3	22.3	19.4	16.2	12.5
WORKING	42.4	36.3	32.1	26.0	34.0	25.6	17.2
DOLLARS PER TONNE PRODUCT - (BASED ON PROPYLENE AT $480/TONNE)							
RAW MATERIALS	601.3	601.3	601.3	601.3	601.3	601.3	601.3
UTILITIES	25.0	25.0	25.0	25.0	25.0	25.0	25.0
BYPROD. CREDIT	¯29.1	¯29.1	¯29.1	¯29.1	¯29.1	¯29.1	¯29.1
VARIABLE COST	597.3	597.3	597.3	597.3	597.3	597.3	597.3
OPERATION	4.0	4.6	5.3	6.6	4.4	5.2	6.6
OVERHEAD(EXCL.DEPN)	25.8	26.8	27.6	29.3	26.5	27.4	29.1
CASH COST	627.1	628.7	630.2	633.2	628.2	629.9	633.0
DEPRECIATION	9.3	11.0	12.5	15.6	10.1	11.3	13.1
NET COST OF PRODN	636.4	639.7	642.6	648.8	638.4	641.2	646.1
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	16.7	19.7	22.3	27.9	18.2	20.2	23.5
TRANSFER PRICE	653.2	659.4	664.9	676.7	656.5	661.4	669.6

EFFECT OF PROPYLENE PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	576.0	384.0	576.0	384.0	576.0	384.0	576.0	384.0	576.0	384.0	576.0	384.0	576.0	384.0
NET COST OF PRODN	676.3	596.6	679.6	599.9	682.5	602.8	688.6	609.0	678.2	598.5	681.1	601.4	685.9	606.3
TRANSFER PRICE	693.0	613.3	699.2	619.6	704.8	625.1	716.5	636.8	696.4	616.7	701.3	621.6	709.4	629.8

How to Start Manufacturing Industries

CYCLOHEXANE

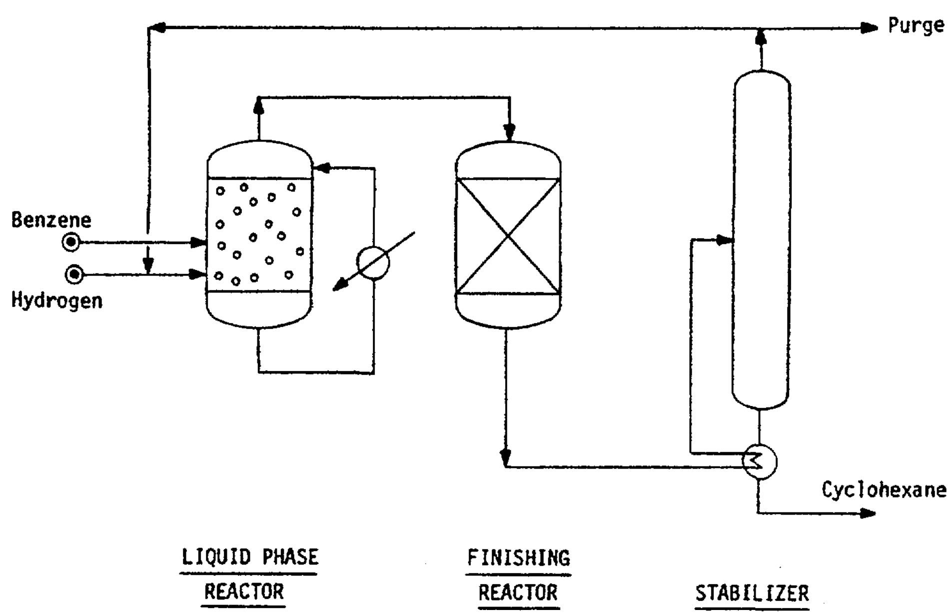
Process Description

Benzene and hydrogen-rich gas are fed to a liquid-phase reactor in which raney nickel catalyst is maintained in uniform dispersion at a temperature below 250°C and a pressure above 3 bar. Overheads are sent to a finishing reactor where the remaining benzene is converted Use of the second reactor allows the main liquid-phase reactor to be kept to a reasonable size.

Effluent from the second reactor is cooled and liquid separated in a high pressure drum. Benzene from hydrodealkylation or BTX extraction feeds may be used. Hydrogen feeds must have low sulphur and carbon oxide levels.

Uses

Major use is as a raw material in nylon-6 and nylon-6,6 manufacture. Cyclohexane is an excellent solvent for resins, waxes, fats, oils, etc when used in conjunction with other hydrocarbons. Nearly all the cyclohexane production is consumed in nylon-6 and nylon-6,6. Other uses as a solvent for cellulose ethers, resins and waxes.



Plot area required for a typical plant of 180 000 tonnes per year capacity would be in the region of 2 000 square metres. The minimum capacity of this plant may be as small as 30 000 tonnes per year from a technical point of view.

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COST OF PRODUCTION ESTIMATE FOR CYCLOHEXANE
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - BENZENE HYDROGN

BASIS		CAPITAL COST	$ MILL
LOCATION-	BENELUX	BATTERY LIMITS	8.90
CAPACITY-	180 000 TONNES PER YEAR	OFFSITES	4.01
PRODUCTN-	180 000 TONNES PER YEAR		
YEAR -	1980	TOTAL FIXED INV.	12.91
STR.TIME-	8000 HOURS PER YEAR	WORKING	40.91

RAW MATERIALS	QUANTITY/TONNE	PRICE*	ANNUAL COST	UNIT* COST
BENZENE	.9280 TONNE	590.000	98 553 600	
HYDROGEN	.0760 TONNE	1100.000	15 048 000	
CATALYST+CHEMS	1.0444 DOLLARS	1.000	188 000	
TOTAL RAW MATERIALS			113 789 600	632.16
UTILITIES				
POWER	.0270 MWH	61.500	298 890	
COOLING WATER	.5360 KTONNE	17.000	1 640 160	
TOTAL UTILITIES COST			1 939 050	10.77
OPERATING COSTS				
LABOUR	27.00 MEN @ 17 700 $/YEAR		477 900	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR		29 200	
MAINTENANCE	@ .04×BLCC		356 029	
TOTAL OPERATING COST			863 129	4.80
OVERHEAD EXPENSES				
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION		202 840	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS		561 034	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP		193 685	
DEPRECIATION	@ .100× BLCC+ .050×OFFS		1 090 652	
INTEREST	@ .100× WORKING CAPITAL		4 091 034	
TOTAL OVERHEAD EXPENSES			6 139 245	34.11
BYPRODUCT CREDIT				
TOTAL BYPRODUCT CREDIT			0	.00
NET COST OF PRODUCTION			122 731 024	681.84

VARIABLE COST OF PRODUCTION	642.94
CASH COST OF PRODUCTION	675.78
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	689.01
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	692.60
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV	696.19

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR CYCLOHEXANE BENZENE HYDROGN BENELUX LANG FACTOR 0.65

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	180000	180000	180000	180000	144000	108000	72000
PLANT OUTPUT	180000	153000	135000	108000	144000	108000	72000
CAPITAL COST — **MILLION DOLLARS**							
BLCC	8.9	8.9	8.9	8.9	7.7	6.4	4.9
OFFSITES	4.0	4.0	4.0	4.0	3.5	2.9	2.2
TOTAL FIXED	12.9	12.9	12.9	12.9	11.2	9.3	7.1
WORKING	40.9	34.9	30.9	24.9	32.8	24.8	16.7
DOLLARS PER TONNE PRODUCT - (BASED ON BENZENE AT $590/TONNE)							
RAW MATERIALS	632.2	632.2	632.2	632.2	632.2	632.2	632.2
UTILITIES	10.8	10.8	10.8	10.8	10.8	10.8	10.8
BYPROD. CREDIT	.0	.0	.0	.0	.0	.0	.0
VARIABLE COST	642.9	642.9	642.9	642.9	642.9	642.9	642.9
OPERATION	4.8	5.6	6.4	8.0	5.7	7.1	9.8
OVERHEAD(EXCL.DEPN)	28.0	29.1	-30.0	32.0	29.1	30.7	33.8
CASH COST	675.8	677.7	679.3	682.9	677.7	680.7	686.5
DEPRECIATION	6.1	7.1	8.1	10.1	6.6	7.2	8.4
NET COST OF PRODN	681.8	684.8	687.4	693.0	684.2	687.9	694.9
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	10.8	12.7	14.3	17.9	11.6	12.9	14.8
TRANSFER PRICE	692.6	697.5	701.8	710.9	695.8	700.8	709.7

EFFECT OF BENZENE PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	708.0	472.0	708.0	472.0	708.0	472.0	708.0	472.0	708.0	472.0	708.0	472.0	708.0	472.0
NET COST OF PRODN	791.3	572.3	794.3	575.3	796.9	577.9	802.5	583.5	793.7	574.7	797.4	578.4	804.4	585.4
TRANSFER PRICE	802.1	583.1	807.0	587.9	811.3	592.3	820.4	601.4	805.3	586.3	810.3	591.3	819.2	600.2

File: G33
ISIC 3511

How to Start Manufacturing Industries

DIMETHYL TEREPHTHALATE (DMT)

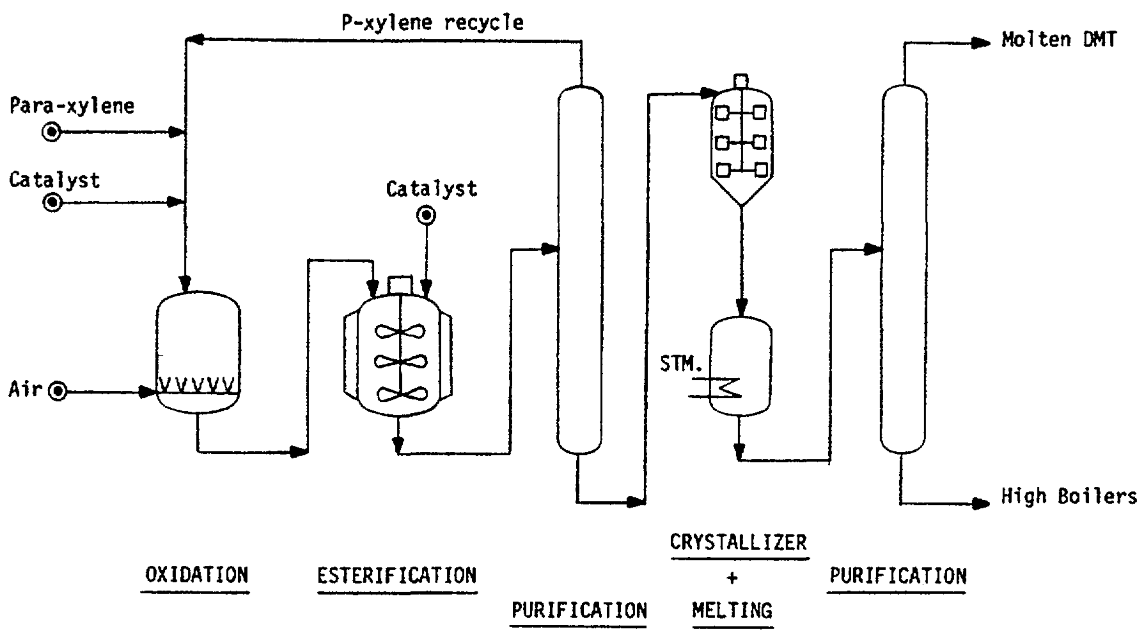
Process Description

This process also called Dynamit-Witten-Nobel process involves the oxidation of para-xylene in an oxidation reactor maintained at 15 bar and 190°C. The oxidation catalyst used may be a 0.1-0.5 percent cobaltous-manganese salt mixture used as the acetate. The oxidate is cotacted with methanol and catalyst (para-toluene sulphonic acid) at 150°C in the esterification reactor. Subsequent purification steps remove methanol, water plus other impurities. Crude DMT is vacuum crystallised, washed and centrifuged. The DMT is thereafter liquefied and sent to a DMT column for final purification.

DMT may be stored or shipped as a liquid. Alternatively, it can also be handled as solid product, a flaking and an inert gas conveying system to transfer the DMT product would be required in addition.

Uses

Most of the terephthalic acid and DMT produced is used to manufacture polyethylene terephthalate (PET), used in fibre and film production. Fibre production is the largest of these.



This process may be batch or continuous. The land area required for a plant of 185 000 tonnes per year capacity would be approximately 4 000 square metres. Smallest capacities reported have been 60 000 tonnes per year.

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COST OF PRODUCTION ESTIMATE FOR DMT
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - WITTEN

BASIS		CAPITAL COST	$ MILL
LOCATION-	BENELUX	BATTERY LIMITS	98.79
CAPACITY-	185 000 TONNES PER YEAR	OFFSITES	41.50
PRODUCTN-	185 000 TONNES PER YEAR		
YEAR -	1980	TOTAL FIXED INV.	140.28
STR.TIME-	8000 HOURS PER YEAR	WORKING	44.07

RAW MATERIALS	QUANTITY/TONNE	PRICE*	ANNUAL COST	UNIT* COST
PARA-XYLENE	.6300 TONNE	690.000	80 419 500	
METHANOL	.3800 TONNE	270.000	18 981 000	
CATALYST+CHEMS	6.0000 DOLLARS	1.000	1 110 000	
TOTAL RAW MATERIALS			100 510 500	543.30
UTILITIES				
POWER	.0050 MWH	61.500	56 888	
COOLING WATER	.1600 KTONNE	17.000	503 200	
FUEL	1.4000 GCAL	18.100	4 687 900	
TOTAL UTILITIES COST			5 247 988	28.37
OPERATING COSTS				
LABOUR	39.00 MEN @ 17 700 $/YEAR		690 300	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR		29 200	
MAINTENANCE	@ .04×BLCC		3 951 440	
TOTAL OPERATING COST			4 670 940	25.25
OVERHEAD EXPENSES				
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION		287 800	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS		3 036 111	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP		2 104 215	
DEPRECIATION	@ .100× BLCC+ .050×OFFS		11 953 350	
INTEREST	@ .100× WORKING CAPITAL		4 407 273	
TOTAL OVERHEAD EXPENSES			21 788 749	117.78
BYPRODUCT CREDIT				
TOTAL BYPRODUCT CREDIT			0	.00
NET COST OF PRODUCTION			132 218 176	714.69

VARIABLE COST OF PRODUCTION	571.67
CASH COST OF PRODUCTION	650.08
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	790.52
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	828.43
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV	866.35

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR DMT WITTEN BENELUX LANG FACTOR 0.7

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	185000	185000	185000	185000	148000	111000	74000
PLANT OUTPUT	185000	157250	138750	111000	148000	111000	74000
CAPITAL COST MILLION DOLLARS							
BLCC	98.8	98.8	98.8	98.8	84.5	69.1	52.0
OFFSITES	41.5	41.5	41.5	41.5	35.5	29.0	21.8
TOTAL FIXED	140.3	140.3	140.3	140.3	120.0	98.1	73.9
WORKING	44.1	38.6	35.0	29.5	35.8	27.4	18.8
DOLLARS PER TONNE PRODUCT - (BASED ON PARA-XYLENE AT $690/TONNE)							
RAW MATERIALS	543.3	543.3	543.3	543.3	543.3	543.3	543.3
UTILITIES	28.4	28.4	28.4	28.4	28.4	28.4	28.4
BYPROD. CREDIT	.0	.0	.0	.0	.0	.0	.0
VARIABLE COST	571.7	571.7	571.7	571.7	571.7	571.7	571.7
OPERATION	25.2	29.7	33.7	42.1	27.7	31.4	37.8
OVERHEAD(EXCL.DEPN)	53.2	59.1	64.3	75.5	56.3	60.9	68.9
CASH COST	650.1	660.4	669.6	689.2	655.6	663.9	678.4
DEPRECIATION	64.6	76.0	86.2	107.7	69.1	75.3	85.1
NET COST OF PRODN	714.7	736.5	755.8	796.9	724.7	739.2	763.5
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	113.7	133.8	151.7	189.6	121.6	132.6	149.7
TRANSFER PRICE	828.4	870.3	907.5	986.5	846.3	871.8	913.2

EFFECT OF PARA-XYLENE PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	828.0	552.0	828.0	552.0	828.0	552.0	828.0	552.0	828.0	552.0	828.0	552.0	828.0	552.0
NET COST OF PRODN	801.6	627.8	823.4	649.5	842.7	668.9	883.8	710.0	811.7	637.8	826.2	652.3	850.4	676.5
TRANSFER PRICE	915.4	741.5	957.2	783.3	994.4	820.5	1073.4	899.5	933.3	759.4	958.8	784.9	1000.1	826.3

How to Start Manufacturing Industries

ETHANOL

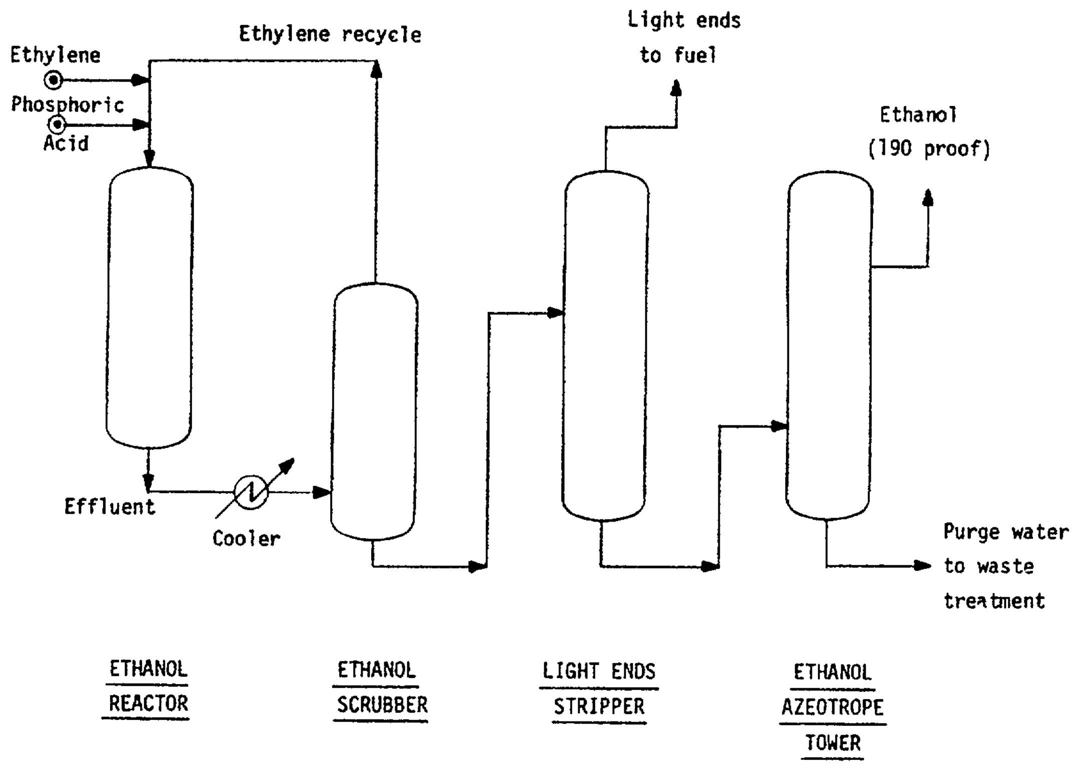
Process Description

The direct hydration process involves the catalytic addition of water to ethylene.

Phosphoric acid is commonly used as the catalyst. The reaction is exothermic operating at about 300^{0}C and 69 bar. Unconverted gases are separated from ethanol in the ethanol scrubber and recycled to the reactor feed stream. Dilute aqueous ethanol (15 to 20 weight percent) is then fed to the stripper where light by-products are removed. Stripper bottoms are passed to the ethanol azeotrope tower where 190 proof ethanol products are removed and sent to storage facilities. Overall process yield to ethanol is about 98.5 mol percent.

Uses

Industrial ethanol is one of the largest-volume organics chemicals used in industrial and consumer products. The main uses for ethanol are on an intermediate in the production of other chemicals and as a solvent.



The plot area requirement for a plant of 200 000 tonnes per year capacity is approximately 35 000 square metres. However, capcities as low as 40 000 tonnes per year are technically feasible.

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COST OF PRODUCTION ESTIMATE FOR ETHANOL(190 PROOF)
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - ETHYLENE HYDRATION

BASIS		CAPITAL COST	$ MILL
LOCATION-	BENELUX	BATTERY LIMITS	39.00
CAPACITY-	200 000 TONNES PER YEAR	OFFSITES	18.70
PRODUCTN-	200 000 TONNES PER YEAR		
YEAR -	1980	TOTAL FIXED INV.	57.70
STR.TIME-	8000 HOURS PER YEAR	WORKING	41.29

RAW MATERIALS	QUANTITY/TONNE	PRICE*	ANNUAL COST	UNIT* COST
ETHYLENE	.5880 TONNE	750.000	88 200 000	
CATALYST+CHEMS	4.0000 DOLLARS	1.000	800 000	
TOTAL RAW MATERIALS			89 000 000	445.00
UTILITIES				
POWER	.0970 MWH	61.500	1 193 100	
COOLING WATER	.1340 KTONNE	17.000	455 600	
L.P.STEAM	5.4000 TONNE	16.700	18 036 000	
PROCESS WATER	.0025 KTONNE	230.000	115 000	
FUEL	.6100 GCAL	18.100	2 208 200	
TOTAL UTILITIES COST			22 007 900	110.04
OPERATING COSTS				
LABOUR	32.00 MEN @ 17 700 $/YEAR		566 400	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR		29 200	
MAINTENANCE	@ .04×BLCC		1 560 000	
TOTAL OPERATING COST			2 155 600	10.78
OVERHEAD EXPENSES				
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION		238 240	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS		1 401 140	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP		865 500	
DEPRECIATION	@ .100× BLCC+ .050×OFFS		4 835 000	
INTEREST	@ .100× WORKING CAPITAL		4 128 950	
TOTAL OVERHEAD EXPENSES			11 468 830	57.34
BYPRODUCT CREDIT				
PURGE GAS	-.2110 GCAL	18.100	- 763 820	
TOTAL BYPRODUCT CREDIT			- 763 820	-3.82
NET COST OF PRODUCTION			123 868 510	619.34

VARIABLE COST OF PRODUCTION	551.22
CASH COST OF PRODUCTION	595.17
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	648.19
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	662.62
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV	677.04

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR ETHANOL(190 PROOF) ETHYLENE HYDRATION BENELUX LANG FACTOR 0.65

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	200000	200000	200000	200000	160000	120000	80000
PLANT OUTPUT	200000	170000	150000	120000	160000	120000	80000
CAPITAL COST — MILLION DOLLARS							
BLCC	39.0	39.0	39.0	39.0	33.7	28.0	21.5
OFFSITES	18.7	18.7	18.7	18.7	16.2	13.4	10.3
TOTAL FIXED	57.7	57.7	57.7	57.7	49.9	41.4	31.8
WORKING	41.3	35.6	31.8	26.1	33.3	25.3	17.2
DOLLARS PER TONNE PRODUCT - (BASED ON ETHYLENE AT $750/TONNE)							
RAW MATERIALS	445.0	445.0	445.0	445.0	445.0	445.0	445.0
UTILITIES	110.0	110.0	110.0	110.0	110.0	110.0	110.0
BYPROD. CREDIT	¯3.8	¯3.8	¯3.8	¯3.8	¯3.8	¯3.8	¯3.8
VARIABLE COST	551.2	551.2	551.2	551.2	551.2	551.2	551.2
OPERATION	10.8	12.7	14.4	18.0	12.2	14.3	18.2
OVERHEAD(EXCL.DEPN)	33.2	35.7	37.9	42.6	34.9	37.5	42.3
CASH COST	595.2	599.6	603.5	611.8	598.3	603.0	611.7
DEPRECIATION	24.2	28.4	32.2	40.3	26.1	28.9	33.3
NET COST OF PRODN	619.3	628.0	635.7	652.1	624.4	631.9	645.0
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	43.3	50.9	57.7	72.1	46.8	51.7	59.6
TRANSFER PRICE	662.6	678.9	693.4	724.2	671.2	683.7	704.6

EFFECT OF ETHYLENE PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	900.0	600.0	900.0	600.0	900.0	600.0	900.0	600.0	900.0	600.0	900.0	600.0	900.0	600.0
NET COST OF PRODN	707.5	531.1	716.2	539.8	723.9	547.5	740.3	563.9	712.6	536.2	720.1	543.7	733.2	556.8
TRANSFER PRICE	750.8	574.4	767.1	590.7	781.6	605.2	812.4	636.0	759.4	583.0	771.9	595.5	792.8	616.4

How to Start Manufacturing Industries

ETHYLBENZENE

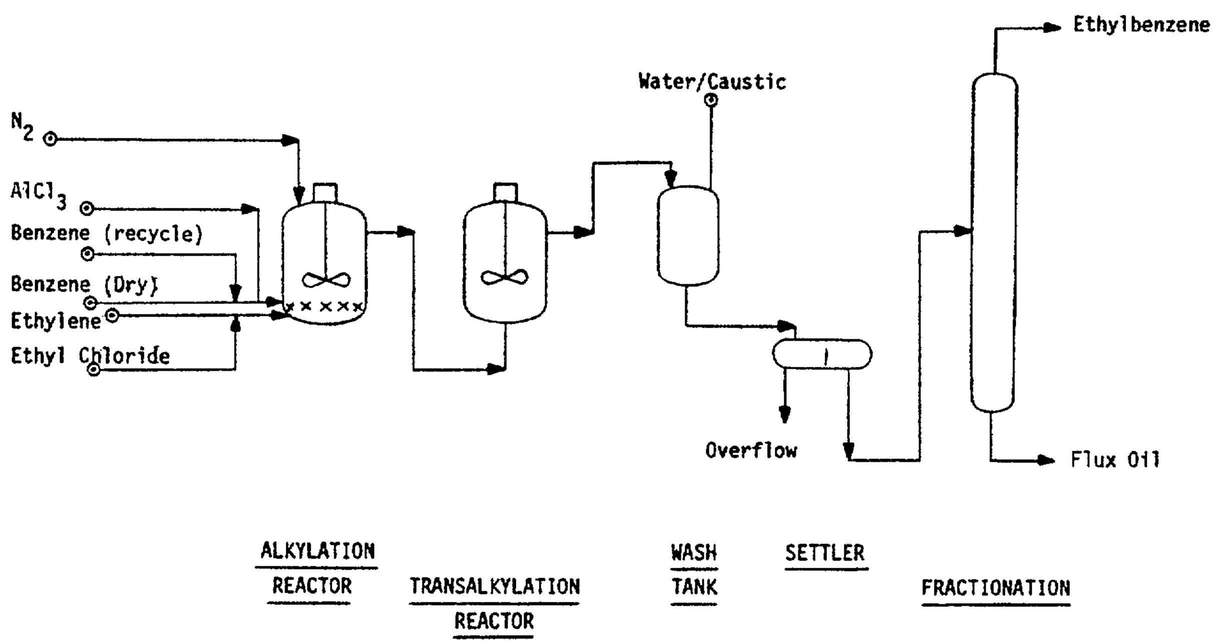
Process Description

Dry benzene, a catalyst slurry (of fresh aluminum chloride and ethylbenzene), and ethylene are charged to the alkylation reactor together with recycle polyethylbenzenes an a small quantity of ethyl chloride (catalyst promoter). Reaction is conducted in the liquid phase at 140-200^{0}C with residence times, of at least 15 minutes. The reaction products pass through a transalkylation reactor maintained at conditions similar to the alkylation reactor.

The alkylate is washed by water, caustic and again with water prior to fractionation.

Uses

Ethylbenzene is usually an intermediate produced for captive consumption within a complex manufacturing styrene.



Land area required for an actual 320 000 tonnes per year plant is approximately 6 000 square metres, which is a typical modern plant capacity. However plants as small as 60 000 tonnes per year are quite feasible from a technical point of view.

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COST OF PRODUCTION ESTIMATE FOR ETHYLBENZENE
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - BENZENE ALKYLATION

BASIS		CAPITAL COST	$ MILL
LOCATION-	BENELUX	BATTERY LIMITS	26.10
CAPACITY-	520 000 TONNES PER YEAR	OFFSITES	13.20
PRODUCTN-	520 000 TONNES PER YEAR		
YEAR -	1980	TOTAL FIXED INV.	39.30
STR.TIME-	8000 HOURS PER YEAR	WORKING	115.88

RAW MATERIALS	QUANTITY/TONNE		PRICE*	ANNUAL COST	UNIT* COST
ETHYLENE	.2670	TONNE	750.000	104 130 000	
BENZENE	.7420	TONNE	590.000	227 645 600	
ALUM.CHLORIDE	.0019	TONNE	1295.000	1 279 460	
CATALYST+CHEMS	.6058	DOLLARS	1.000	315 000	
TOTAL RAW MATERIALS				333 370 060	641.10
UTILITIES					
POWER	.0130	MWH	61.500	415 740	
COOLING WATER	.0170	KTONNE	17.000	150 280	
PROCESS WATER	.0008	KTONNE	230.000	99 268	
FUEL	.4930	GCAL	18.100	4 640 116	
TOTAL UTILITIES COST				5 305 404	10.20
OPERATING COSTS					
LABOUR	19.00 MEN @ 17 700 $/YEAR			336 300	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR			29 200	
MAINTENANCE	@ .04×BLCC			1 044 000	
TOTAL OPERATING COST				1 409 500	2.71
OVERHEAD EXPENSES					
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION			146 200	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS			916 175	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP			589 500	
DEPRECIATION	@ .100× BLCC+ .050×OFFS			3 270 000	
INTEREST	@ .100× WORKING CAPITAL			11 588 042	
TOTAL OVERHEAD EXPENSES				16 509 917	31.75
BYPRODUCT CREDIT					
ALCL3,25PC SOL	-.0017	TONNE	1295.000	-1 144 780	
LP.STEAM	-.7800	TONNE	16.700	-6 773 520	
FLUX OIL	-.1100	GCAL	18.100	-1 035 320	
TOTAL BYPRODUCT CREDIT				-8 953 620	-17.22
NET COST OF PRODUCTION				347 641 261	668.54

VARIABLE COST OF PRODUCTION	634.08
CASH COST OF PRODUCTION	662.25
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	676.10
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	679.88
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV	683.66

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR ETHYLBENZENE BENZENE ALKYLATION BENELUX LANG FACTOR 0.65

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	520000	520000	520000	520000	416000	312000	208000
PLANT OUTPUT	520000	442000	390000	312000	416000	312000	208000
CAPITAL COST MILLION DOLLARS							
BLCC	26.1	26.1	26.1	26.1	22.6	18.7	14.4
OFFSITES	13.2	13.2	13.2	13.2	11.4	9.5	7.3
TOTAL FIXED	39.3	39.3	39.3	39.3	34.0	28.2	21.7
WORKING	115.9	98.8	87.5	70.4	92.9	69.9	46.8
DOLLARS PER TONNE PRODUCT - (BASED ON ETHYLENE AT $750/TONNE)							
RAW MATERIALS	641.1	641.1	641.1	641.1	641.1	641.1	641.1
UTILITIES	10.2	10.2	10.2	10.2	10.2	10.2	10.2
BYPROD. CREDIT	¯17.2	¯17.2	¯17.2	¯17.2	¯17.2	¯17.2	¯17.2
VARIABLE COST	634.1	634.1	634.1	634.1	634.1	634.1	634.1
OPERATION	2.7	3.2	3.6	4.5	3.0	3.6	4.5
OVERHEAD(EXCL.DEPN)	25.5	26.1	26.7	27.9	25.9	26.5	27.7
CASH COST	662.3	663.4	664.4	666.5	663.0	664.2	666.3
DEPRECIATION	6.3	7.4	8.4	10.5	6.8	7.5	8.7
NET COST OF PRODN	668.5	670.8	672.7	676.9	669.8	671.7	675.0
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	11.3	13.3	15.1	18.9	12.3	13.6	15.6
TRANSFER PRICE	679.9	684.1	687.9	695.8	682.1	685.3	690.6

EFFECT OF ETHYLENE PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	900.0	600.0	900.0	600.0	900.0	600.0	900.0	600.0	900.0	600.0	900.0	600.0	900.0	600.0
NET COST OF PRODN	708.6	628.5	710.8	630.7	712.8	632.7	717.0	636.9	709.9	629.8	711.8	631.7	715.0	634.9
TRANSFER PRICE	719.9	639.8	724.2	644.1	727.9	647.8	735.9	655.8	722.1	642.0	725.3	645.2	730.6	650.5

How to Start Manufacturing Industries

ETHYLENE FROM ETHANE

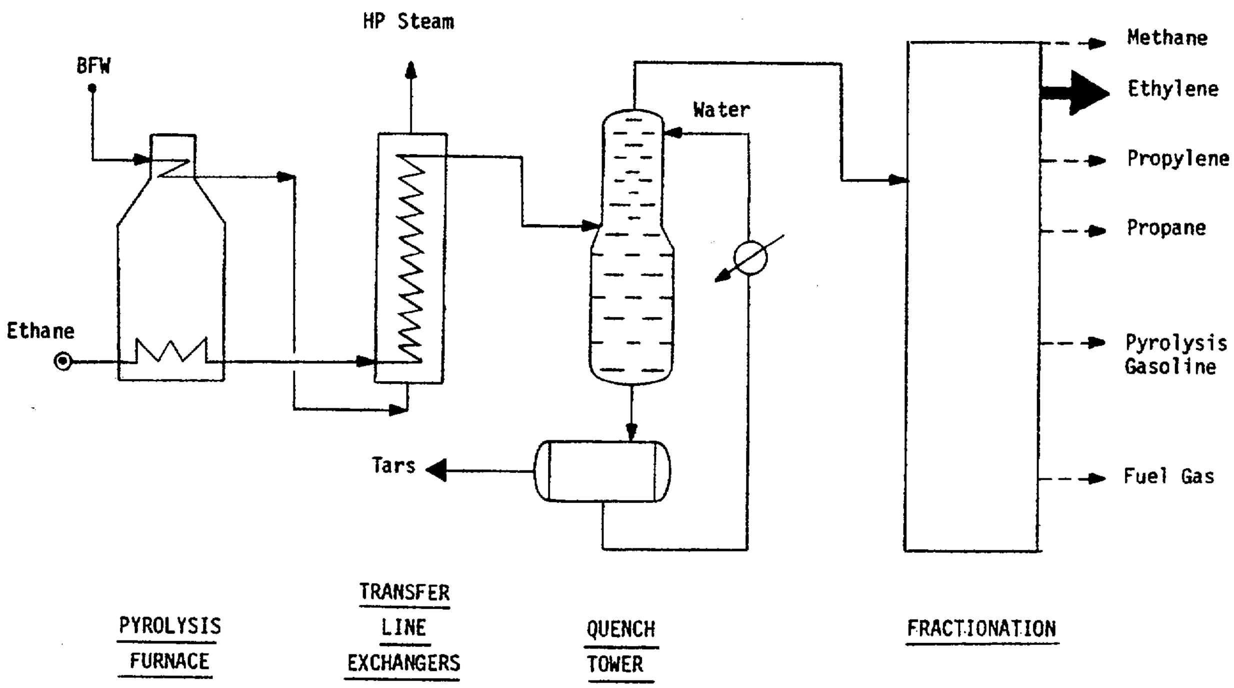
Process Description

Ethane vapour brought from outside battery limits is heated in stages and mixed with dilution steam, it therefore enters the convection section of the cracking furnaces where it is further heated. On leaving the convection section, the ethane/dilution steam mixture enters the radiant section where the cracking takes place. The hot gases are quickly cooled in horizontal heat exchangers where high pressure steam is generated.

A proper sequence of quenching 4-5 stage compression, separation, caustic and water washing is then performed, followed by the removal of methane, ethane and propane, until only ethylene remains.

Uses

Ethylene is the basic feedstock for other chemical manufacture, including polyethylene, PVC via vinyl chloride, polystyrene via ethylbenzene, and ethylene oxide to name but a few.



The cracker economics have been estimated for a 450 000 tonnes per year plant occupying an area of 50 000 square metres. This is a typical modern plant size. However ethane crackers of 100 000 tonnes per year have been constructed in Europe.

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COST OF PRODUCTION ESTIMATE FOR ETHYLENE
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - ETHANE

BASIS		CAPITAL COST	$ MILL
LOCATION-	BENELUX	BATTERY LIMITS	215.00
CAPACITY-	450 000 TONNES PER YEAR	OFFSITES	86.00
PRODUCTN-	450 000 TONNES PER YEAR		
YEAR -	1980	TOTAL FIXED INV.	301.00
STR.TIME-	8000 HOURS PER YEAR	WORKING	63.94

RAW MATERIALS	QUANTITY/TONNE	PRICE*	ANNUAL COST	UNIT* COST
ETHANE	1.2220 TONNE	222.000	122 077 800	
CATALYST+CHEMS	1.2222 DOLLARS	1.000	550 000	
TOTAL RAW MATERIALS			122 627 800	272.51
UTILITIES				
POWER	.0316 MWH	61.500	874 530	
COOLING WATER	.3330 KTONNE	17.000	2 547 450	
FUEL	5.6000 GCAL	18.100	45 612 000	
TOTAL UTILITIES COST			49 033 980	108.96
OPERATING COSTS				
LABOUR	36.00 MEN @ 17 700 $/YEAR		637 200	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR		29 200	
MAINTENANCE	@ .04×BLCC		8 600 000	
TOTAL OPERATING COST			9 266 400	20.59
OVERHEAD EXPENSES				
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION		266 560	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS		6 023 160	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP		4 515 000	
DEPRECIATION	@ .100× BLCC+ .050×OFFS		25 800 000	
INTEREST	@ .100× WORKING CAPITAL		6 393 840	
TOTAL OVERHEAD EXPENSES			42 998 560	95.55
BYPRODUCT CREDIT				
PYROL.GASOLINE	-.0150 TONNE	365.000	-2 463 750	
FUEL GAS	-3.6400 GCAL	18.100	-29 647 800	
TOTAL BYPRODUCT CREDIT			-32 111 550	-71.36
NET COST OF PRODUCTION			191 815 190	426.26

VARIABLE COST OF PRODUCTION	310.11
CASH COST OF PRODUCTION	368.92
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	493.14
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	526.59
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV	560.03

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR ETHYLENE ETHANE BENELUX LANG FACTOR 0.7

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	450000	450000	450000	450000	360000	270000	180000
PLANT OUTPUT	450000	382500	337500	270000	360000	270000	180000
CAPITAL COST MILLION DOLLARS							
BLCC	215.0	215.0	215.0	215.0	183.9	150.4	113.2
OFFSITES	86.0	86.0	86.0	86.0	73.6	60.1	45.3
TOTAL FIXED	301.0	301.0	301.0	301.0	257.5	210.5	158.5
WORKING	63.9	56.7	51.9	44.7	52.1	40.1	27.8
DOLLARS PER TONNE PRODUCT - (BASED ON ETHANE AT $222/TONNE)							
RAW MATERIALS	272.5	272.5	272.5	272.5	272.5	272.5	272.5
UTILITIES	109.0	109.0	109.0	109.0	109.0	109.0	109.0
BYPROD. CREDIT	¯71.4	¯71.4	¯71.4	¯71.4	¯71.4	¯71.4	¯71.4
VARIABLE COST	310.1	310.1	310.1	310.1	310.1	310.1	310.1
OPERATION	20.6	24.2	27.5	34.3	22.3	24.7	28.9
OVERHEAD(EXCL.DEPN)	38.2	43.1	47.4	56.6	40.4	43.6	48.9
CASH COST	368.9	377.4	385.0	401.0	372.8	378.5	387.9
DEPRECIATION	57.3	67.5	76.4	95.6	61.3	66.8	75.5
NET COST OF PRODN	426.3	444.9	461.4	496.6	434.1	445.3	463.3
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	100.3	118.0	133.8	167.2	107.3	116.9	132.1
TRANSFER PRICE	526.6	562.9	595.2	663.8	541.4	562.2	595.4

EFFECT OF ETHANE PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	266.4	177.6	266.4	177.6	266.4	177.6	266.4	177.6	266.4	177.6	266.4	177.6	266.4	177.6
NET COST OF PRODN	480.5	372.0	499.1	390.6	515.7	407.1	550.8	442.3	488.4	379.9	499.6	391.0	517.6	409.1
TRANSFER PRICE	580.8	472.3	617.2	508.6	649.4	540.9	718.0	609.5	595.7	487.1	616.5	508.0	649.7	541.2

How to Start Manufacturing Industries

ETHYLENE FROM LPG/PROPANE

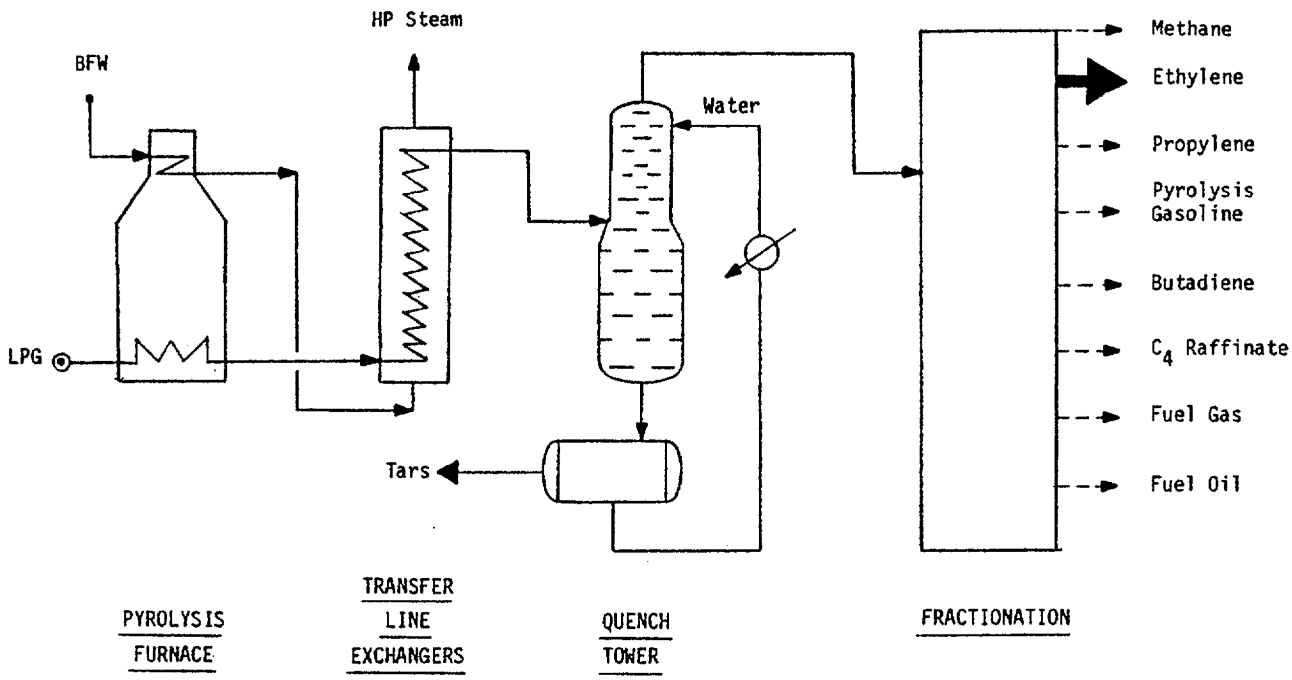
Process Description

A stream containing 0.3:1 ratio of steam to hydrocarbon is heated to 900^{o}C in a vertical tubular furnace Optimum yield pattern is obtained in less than 0.5 seconds. The reaction is halted by lowering the temperature in the transfer line exchangers. Heat recovery is by generation of high pressure steam which in turn is used to drive the process gas and refrigeration compressors.

The remaining steps are similar to ethane cracking with additional fractionation stages involved to separate the increased range of heavier-than-ethylene components.

Uses

Further uses of ethylene are in the manufacture of higher olefins used in detergent and plasticiser alcohol manufacture, and in synlube production.



The economics of the cracker have been calculated on the basis of a 450 000 tonnes per year plant, which would occupy an area of around 50 000 square metres. The minimum feasible size is 20 000 tonnes per year.

This information has been prepared for UNIDO by Chem Systems International Ltd., United Kingdom.

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COST OF PRODUCTION ESTIMATE FOR ETHYLENE
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - PROPANE CRACKING

BASIS		CAPITAL COST	$ MILL
LOCATION-	BENELUX	BATTERY LIMITS	265.00
CAPACITY-	450 000 TONNES PER YEAR	OFFSITES	105.00
PRODUCTN-	450 000 TONNES PER YEAR		
YEAR -	1980	TOTAL FIXED INV.	370.00
STR.TIME-	8000 HOURS PER YEAR	WORKING	188.44

RAW MATERIALS	QUANTITY/TONNE		PRICE*	ANNUAL COST	UNIT* COST
PROPANE	2.4070	TONNE	325.000	352 023 750	
CATALYST+CHEMS	1.4600	DOLLARS	1.000	657 000	
TOTAL RAW MATERIALS				352 680 750	783.73
UTILITIES					
POWER	.0450	MWH	61.500	1 245 375	
COOLING WATER	.3470	KTONNE	17.000	2 654 550	
FUEL	6.6200	GCAL	18.100	53 919 900	
TOTAL UTILITIES COST				57 819 825	128.49
OPERATING COSTS					
LABOUR	40.00 MEN @ 17 700 $/YEAR			708 000	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR			29 200	
MAINTENANCE	@ .04×BLCC			10 600 000	
TOTAL OPERATING COST				11 337 200	25.19
OVERHEAD EXPENSES					
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION			294 880	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS			7 369 180	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP			5 550 000	
DEPRECIATION	@ .100× BLCC+ .050×OFFS			31 750 000	
INTEREST	@ .100× WORKING CAPITAL			18 844 213	
TOTAL OVERHEAD EXPENSES				63 808 273	141.80
BYPRODUCT CREDIT					
PROPYLENE	-.4150	TONNE	480.000	-89 640 000	
PYROL.GASOLINE	-.1820	TONNE	365.000	-29 893 500	
RAW C4 STREAM	-.0690	TONNE	335.000	-10 401 750	
FUEL OIL	-.0380	TONNE	185.000	-3 163 500	
FUEL GAS	-8.5800	GCAL	18.100	-69 884 100	
TOTAL BYPRODUCT CREDIT				-202 982 850	-451.07
NET COST OF PRODUCTION				282 663 198	628.14

VARIABLE COST OF PRODUCTION	461.15
CASH COST OF PRODUCTION	557.58
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	710.36
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	751.47
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV	792.58

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR ETHYLENE PROPANE CRACKING BENELUX LANG FACTOR 0.7

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	450000	450000	450000	450000	360000	270000	180000
PLANT OUTPUT	450000	382500	337500	270000	360000	270000	180000
CAPITAL COST — MILLION DOLLARS							
BLCC	265.0	265.0	265.0	265.0	226.7	185.3	139.5
OFFSITES	105.0	105.0	105.0	105.0	89.8	73.4	55.3
TOTAL FIXED	370.0	370.0	370.0	370.0	316.5	258.8	194.8
WORKING	188.4	166.2	151.4	129.2	153.1	117.4	81.0
DOLLARS PER TONNE PRODUCT - (BASED ON PROPANE AT $325/TONNE)							
RAW MATERIALS	783.7	783.7	783.7	783.7	783.7	783.7	783.7
UTILITIES	128.5	128.5	128.5	128.5	128.5	128.5	128.5
BYPROD. CREDIT	¯451.1	¯451.1	¯451.1	¯451.1	¯451.1	¯451.1	¯451.1
VARIABLE COST	461.2	461.2	461.2	461.2	461.2	461.2	461.2
OPERATION	25.2	29.6	33.6	42.0	27.2	30.2	35.1
OVERHEAD(EXCL.DEPN)	71.2	78.0	84.0	96.8	74.2	78.6	85.7
CASH COST	557.6	568.8	578.7	599.9	562.6	569.9	581.9
DEPRECIATION	70.6	83.0	94.1	117.6	75.4	82.2	92.9
NET COST OF PRODN	628.1	651.8	672.8	717.5	638.1	652.1	674.8
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	123.3	145.1	164.4	205.6	131.9	143.8	162.4
TRANSFER PRICE	751.5	796.9	837.3	923.1	769.9	795.9	837.2

EFFECT OF PROPANE PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	390.0	260.0	390.0	260.0	390.0	260.0	390.0	260.0	390.0	260.0	390.0	260.0	390.0	260.0
NET COST OF PRODN	784.6	471.7	808.3	495.3	829.3	516.4	874.0	561.1	794.5	481.6	808.6	495.7	831.3	518.4
TRANSFER PRICE	907.9	595.0	953.3	640.4	993.7	680.8	1079.5	766.6	926.4	613.5	952.4	639.4	993.6	680.7

How to Start Manufacturing Industries

ETHYLENE FROM NAPHTHA

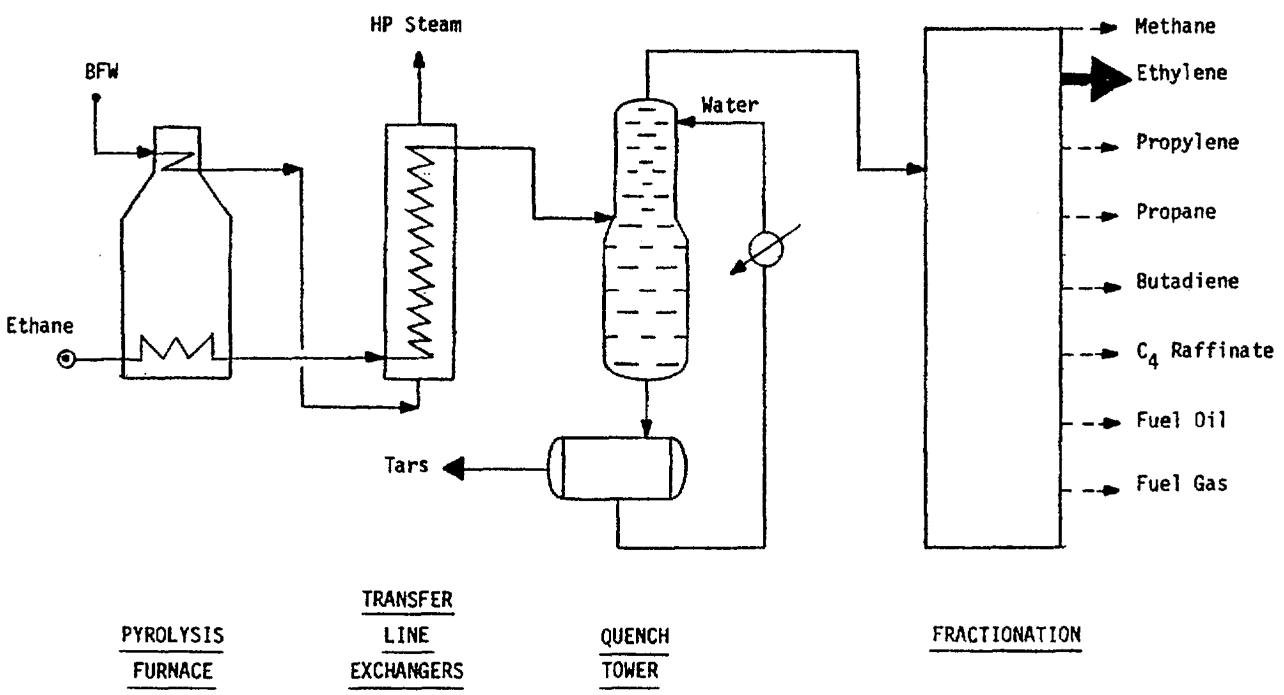
Process Description

Naphtha boils in the gasoline boiling range ie C_5-220^oC. A steam to hydrocarbon weight ratio used for cracking naphtha is about 0.5:1. Reaction is performed at a coil outlet temperature of 850^oC. Furnace design varies with feed type.

Fractionation is carried out with C_1 as being the first component, separated, followed by successively higher carbon numbers. The flow scheme is essentially identical to the previous description.

Uses

Ethylene is the basic feedstock for other chemical manufacture, including polyethylene, PVC via vinyl chloride, polystyrene via ethylbenzene, and ethylene oxide.



The economics of the cracker have been estimated on the basis of a 450 000 tonnes per year plant, which would occupy 50 000 square metres. The smallest size for the plant is considered to be 20 000 tonnes per year.

This information has been prepared for UNIDO by Chem Systems International Ltd., United Kingdom.

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COST OF PRODUCTION ESTIMATE FOR ETHYLENE
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - WIDE RANGE NAPHTHA

BASIS		CAPITAL COST	$ MILL
LOCATION-	BENELUX	BATTERY LIMITS	320.00
CAPACITY-	450 000 TONNES PER YEAR	OFFSITES	128.00
PRODUCTN-	450 000 TONNES PER YEAR		
YEAR	- 1980	TOTAL FIXED INV.	448.00
STR.TIME-	8000 HOURS PER YEAR	WORKING	202.03

RAW MATERIALS	QUANTITY/TONNE	PRICE*	ANNUAL COST	UNIT* COST
NAPHTHA	3.2000 TONNE	350.000	504 000 000	
CATALYST+CHEMS	1.9778 DOLLARS	1.000	890 000	
TOTAL RAW MATERIALS			504 890 000	1121.98
UTILITIES				
POWER	.0466 MWH	61.500	1 289 655	
COOLING WATER	.4310 KTONNE	17.000	3 297 150	
BLR.FEED WATER	.0003 KTONNE	450.000	60 750	
FUEL	8.4100 GCAL	18.100	68 499 450	
TOTAL UTILITIES COST			73 147 005	162.55
OPERATING COSTS				
LABOUR	44.00 MEN @ 17 700 $/YEAR		778 800	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR		29 200	
MAINTENANCE	@ .04×BLCC		12 800 000	
TOTAL OPERATING COST			13 608 000	30.24
OVERHEAD EXPENSES				
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION		323 200	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS		8 845 200	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP		6 720 000	
DEPRECIATION	@ .100× BLCC+ .050×OFFS		38 400 000	
INTEREST	@ .100× WORKING CAPITAL		20 202 768	
TOTAL OVERHEAD EXPENSES			74 491 168	165.54
BYPRODUCT CREDIT				
PROPYLENE	¯.5000 TONNE	480.000	¯108 000 000	
PYROL.GASOLINE	¯.6670 TONNE	365.000	¯109 554 750	
BUTADIENE	¯.1610 TONNE	690.000	¯49 990 500	
PROPANE/YLENE	¯.0550 TONNE	325.000	¯8 043 750	
C4 RAFFINATE	¯.1980 TONNE	335.000	¯29 848 500	
FUEL OIL	¯.0400 TONNE	185.000	¯3 330 000	
FUEL GAS	¯6.6700 GCAL	18.100	¯54 327 150	
TOTAL BYPRODUCT CREDIT			¯363 094 650	¯806.88
NET COST OF PRODUCTION			303 041 523	673.43

VARIABLE COST OF PRODUCTION	477.65
CASH COST OF PRODUCTION	588.09
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	772.98
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	822.76
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV	872.54

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR ETHYLENE WIDE RANGE NAPHTHA BENELUX LANG FACTOR 0.7

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	450000	450000	450000	450000	360000	270000	180000
PLANT OUTPUT	450000	382500	337500	270000	360000	270000	180000
CAPITAL COST — MILLION DOLLARS							
BLCC	320.0	320.0	320.0	320.0	273.7	223.8	168.5
OFFSITES	128.0	128.0	128.0	128.0	109.5	89.5	67.4
TOTAL FIXED	448.0	448.0	448.0	448.0	383.2	313.3	235.9
WORKING	202.0	179.0	163.6	140.6	164.5	126.4	87.5
DOLLARS PER TONNE PRODUCT - (BASED ON NAPHTHA AT $350/TONNE)							
RAW MATERIALS	1122.0	1122.0	1122.0	1122.0	1122.0	1122.0	1122.0
UTILITIES	162.5	162.5	162.5	162.5	162.5	162.5	162.5
BYPROD. CREDIT	¯806.9	¯806.9	¯806.9	¯806.9	¯806.9	¯806.9	¯806.9
VARIABLE COST	477.6	477.6	477.6	477.6	477.6	477.6	477.6
OPERATION	30.2	35.6	40.3	50.4	32.7	36.1	41.9
OVERHEAD(EXCL.DEPN)	80.2	88.3	95.6	110.9	83.8	88.9	97.3
CASH COST	588.1	601.6	613.5	639.0	594.1	602.7	616.9
DEPRECIATION	85.3	100.4	113.8	142.2	91.2	99.5	112.3
NET COST OF PRODN	673.4	702.0	727.3	781.2	685.3	702.2	729.2
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	149.3	175.7	199.1	248.9	159.7	174.1	196.6
TRANSFER PRICE	822.8	877.6	926.4	1030.1	845.0	876.2	925.8

EFFECT OF NAPHTHA PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	420.0	280.0	420.0	280.0	420.0	280.0	420.0	280.0	420.0	280.0	420.0	280.0	420.0	280.0
NET COST OF PRODN	897.4	449.4	926.0	478.0	951.3	503.3	1005.2	557.2	909.3	461.3	926.2	478.2	953.2	505.2
TRANSFER PRICE	1046.8	598.8	1101.6	653.6	1150.4	702.4	1254.1	806.1	1069.0	621.0	1100.2	652.2	1149.8	701.8

File: G39
ISIC 3511

How to Start Manufacturing Industries

ETHYLENE FROM GAS OIL

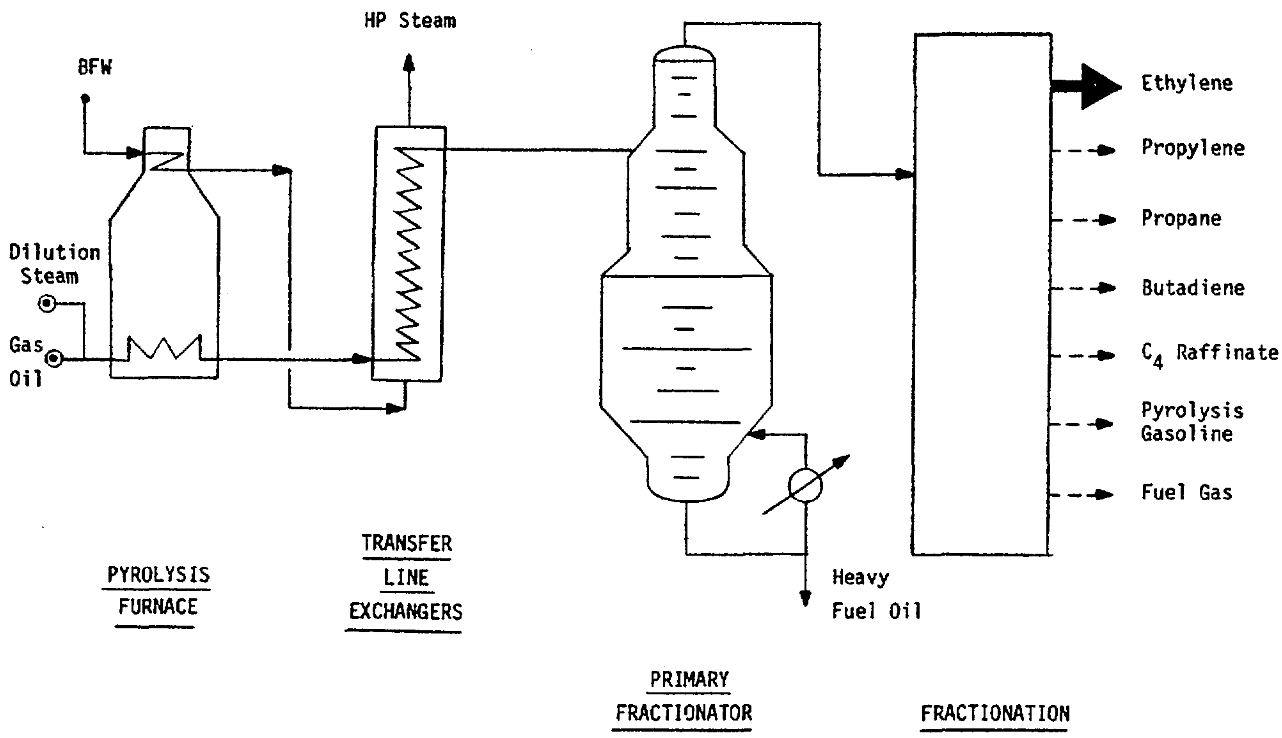
Process Description

Atmospheric gas oil boils in the range of 200-400°C. A dilution steam to hydrocarbon weight ratio of 0.8-1.0 is employed to give the appropriate hydrocarbon partial pressure at furnace cracking conditions.

Gas oil cracking yields a considerable amount of carbonaceous heavy fuel oil in addition to the usual range of products from cracking naphtha and lighter feeds. The primary fractionator is therefore much larger to allow for this.

Uses

Ethylene is the basic feedstock for other chemical manufacture, including polyethylene, PVC via vinyl chloride, polystyrene via ethylbenzene, and ethylene oxide.



All the cracker economics have been sized for 450 000 tonnes per year output, occupying an area in the region of 50 000 square metres. The minimum feasible capacity in this instance is approximately 120 000 tonnes per year.

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COST OF PRODUCTION ESTIMATE FOR ETHYLENE
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - ARABIAN ATM.GAS OIL

BASIS		CAPITAL COST	$ MILL
LOCATION-	BENELUX	BATTERY LIMITS	360.00
CAPACITY-	450 000 TONNES PER YEAR	OFFSITES	144.00
PRODUCTN-	450 000 TONNES PER YEAR		
YEAR -	1980	TOTAL FIXED INV.	504.00
STR.TIME-	8000 HOURS PER YEAR	WORKING	242.76

RAW MATERIALS	QUANTITY/TONNE		PRICE*	ANNUAL COST	UNIT* COST
ATM.GAS OIL	4.6200	TONNE	325.000	675 675 000	
CATALYST+CHEMS	2.2222	DOLLARS	1.000	1 000 000	
TOTAL RAW MATERIALS				676 675 000	1503.72

UTILITIES					
POWER	.0579	MWH	61.500	1 602 383	
COOLING WATER	.6660	KTONNE	17.000	5 094 900	
BLR.FEED WATER	.0005	KTONNE	450.000	101 250	
FUEL	11.6800	GCAL	18.100	95 133 600	
TOTAL UTILITIES COST				101 932 133	226.52

OPERATING COSTS			
LABOUR	49.00 MEN @ 17 700 $/YEAR	867 300	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR	29 200	
MAINTENANCE	@ .04×BLCC	14 400 000	
TOTAL OPERATING COST		15 296 500	33.99

OVERHEAD EXPENSES				
DIRECT OVERHEAD	@	.400× LAB+SUPERVISION	358 600	
GEN PLANT OVERHEAD	@	.650× OPERATING COSTS	9 942 725	
INSURANCE+PTY TAX	@	.015× TOTAL FIXED CAP	7 560 000	
DEPRECIATION	@	.100× BLCC+ .050×OFFS	43 200 000	
INTEREST	@	.100× WORKING CAPITAL	24 275 543	
TOTAL OVERHEAD EXPENSES			85 336 868	189.64

BYPRODUCT CREDIT					
PROPYLENE	¯.5000	TONNE	480.000	¯108 000 000	
PYROL.GASOLINE	¯.9330	TONNE	365.000	¯153 245 250	
BUTADIENE	¯.1780	TONNE	690.000	¯55 269 000	
PROPANE/YLENE	¯.1730	TONNE	325.000	¯25 301 250	
C4 RAFFINATE	¯.2440	TONNE	335.000	¯36 783 000	
FUEL OIL	¯1.0400	TONNE	185.000	¯86 580 000	
FUEL GAS	¯6.1300	GCAL	18.100	¯49 928 850	
TOTAL BYPRODUCT CREDIT				¯515 107 350	¯1144.68
NET COST OF PRODUCTION				364 133 151	809.18

VARIABLE COST OF PRODUCTION	585.56
CASH COST OF PRODUCTION	713.18
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	921.18
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	977.18
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV	1033.18

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR ETHYLENE ARABIAN ATM.GAS OIL BENELUX LANG FACTOR 0.7

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	450000	450000	450000	450000	360000	270000	180000
PLANT OUTPUT	450000	382500	337500	270000	360000	270000	180000
CAPITAL COST — MILLION DOLLARS							
BLCC	360.0	360.0	360.0	360.0	307.9	251.8	189.6
OFFSITES	144.0	144.0	144.0	144.0	123.2	100.7	75.8
TOTAL FIXED	504.0	504.0	504.0	504.0	431.1	352.5	265.4
WORKING	242.8	214.5	195.7	167.5	197.4	151.5	104.6
DOLLARS PER TONNE PRODUCT - (BASED ON ATM.GAS OIL AT $325/TONNE)							
RAW MATERIALS	1503.7	1503.7	1503.7	1503.7	1503.7	1503.7	1503.7
UTILITIES	226.5	226.5	226.5	226.5	226.5	226.5	226.5
BYPROD. CREDIT	¯1144.7	¯1144.7	¯1144.7	¯1144.7	¯1144.7	¯1144.7	¯1144.7
VARIABLE COST	505.6	585.6	585.6	585.6	585.6	585.6	585.6
OPERATION	34.0	40.0	45.3	56.7	36.7	40.6	47.1
OVERHEAD(EXCL.DEPN)	93.6	102.8	110.9	128.2	97.7	103.4	112.9
CASH COST	713.2	728.3	741.8	770.4	719.9	729.6	745.5
DEPRECIATION	96.0	112.9	128.0	160.0	102.6	111.9	126.4
NET COST OF PRODN	809.2	841.3	869.8	930.4	822.6	841.5	871.9
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	168.0	197.6	224.0	280.0	179.6	195.8	221.2
TRANSFER PRICE	977.2	1038.9	1093.8	1210.4	1002.2	1037.3	1093.0

EFFECT OF ATM.GAS OIL PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	390.0	260.0	390.0	260.0	390.0	260.0	390.0	260.0	390.0	260.0	390.0	260.0	390.0	260.0
NET COST OF PRODN	1109.5	508.9	1141.6	541.0	1170.1	569.5	1230.7	630.1	1122.9	522.3	1141.8	541.2	1172.2	571.6
TRANSFER PRICE	1277.5	676.9	1339.2	738.6	1394.1	793.5	1510.7	910.1	1302.5	701.9	1337.6	737.0	1393.3	792.7

File: G40
ISIC 3511

How to Start Manufacturing Industries

ETHYLENE DICHLORIDE - BALANCED OXYCHLORINATION

Process Description

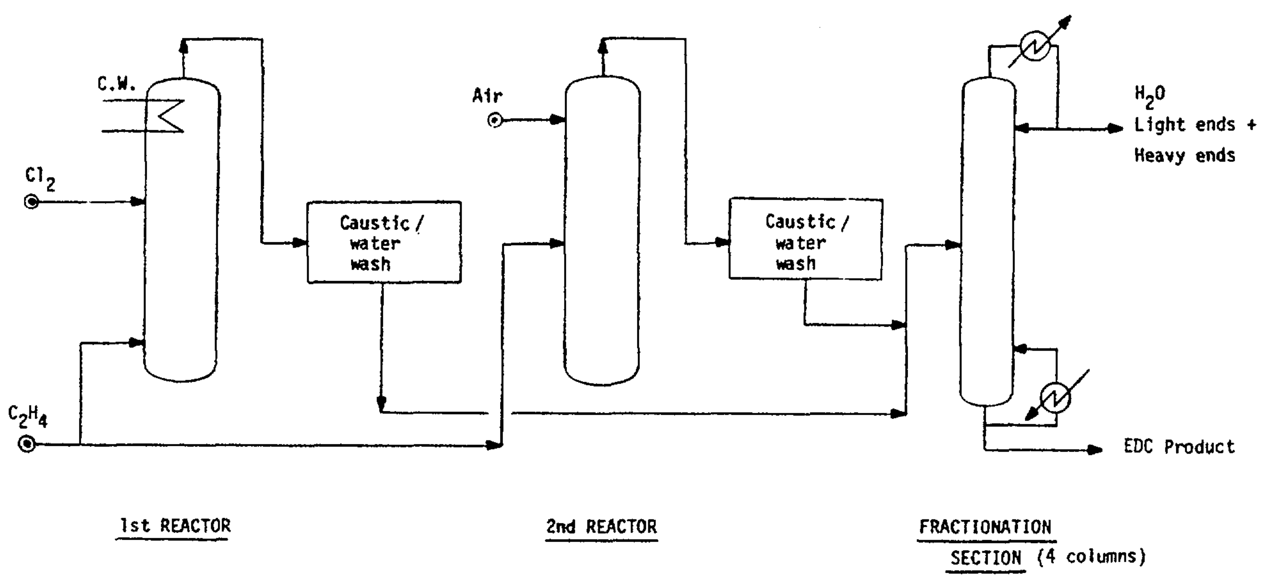
There are two reaction sections in this process. In the first section, high purity ethylene and chlorine (99+ percent) react in a liquid-phase, non catalytic reactor at about 11 bar and 50^{o}C.

In the second section, ethylene, air or oxygen, and HCl react in a vapour phase catalytic reactor at 260-310^{o}C and a pressure of 2-8 bar.

Reactor products from both sections are caustic and water washed separately. It is then passed through fractionation to separate water, other light ends and heavy ends to 99 percent purity EDC product.

Uses

It is mainly used for the production of vinyl chloride and as a solvent.



The land area required for a plant capacity of 800 000 tonnes per year would be 30 000 square metres, excluding the chlorine and VCM production sections. The minimum feasible capacity is 87 000 tonnes per year.

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COST OF PRODUCTION ESTIMATE FOR ETHYLENE DICHLORIDE
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - DIRECT CHLORINATION

BASIS		CAPITAL COST	$ MILL
LOCATION- BENELUX		BATTERY LIMITS	17.60
CAPACITY-	800 000 TONNES PER YEAR	OFFSITES	10.20
PRODUCTN-	800 000 TONNES PER YEAR		
YEAR	- 1980	TOTAL FIXED INV.	27.80
STR.TIME-	8000 HOURS PER YEAR	WORKING	107.25

RAW MATERIALS	QUANTITY/TONNE		PRICE*	ANNUAL COST	UNIT* COST
ETHYLENE	.2820	TONNE	750.000	169 200 000	
CHLORINE	.7410	TONNE	170.000	100 776 000	
SODIUM HYD.	.0100	TONNE	240.000	1 920 000	
CATALYST+CHEMS	.7500	DOLLARS	1.000	600 000	
TOTAL RAW MATERIALS				272 496 000	340.62
UTILITIES					
POWER	.0020	MWH	61.500	98 400	
COOLING WATER	.0397	KTONNE	17.000	539 920	
LP.STEAM	2.5100	TONNE	16.700	33 533 600	
PROCESS WATER	.0002	KTONNE	230.000	41 584	
TOTAL UTILITIES COST				34 213 504	42.77
OPERATING COSTS					
LABOUR	11.00 MEN @ 17 700 $/YEAR			194 700	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR			29 200	
MAINTENANCE	@ .04×BLCC			704 000	
TOTAL OPERATING COST				927 900	1.16
OVERHEAD EXPENSES					
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION			89 560	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS			603 135	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP			417 000	
DEPRECIATION	@ .100× BLCC+ .050×OFFS			2 270 000	
INTEREST	@ .100× WORKING CAPITAL			10 724 728	
TOTAL OVERHEAD EXPENSES				14 104 423	17.63
BYPRODUCT CREDIT					
TOTAL BYPRODUCT CREDIT				0	.00
NET COST OF PRODUCTION				321 741 827	402.18
VARIABLE COST OF PRODUCTION					383.39
CASH COST OF PRODUCTION					399.34
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV					405.65
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV					407.39
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV					409.13

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR ETHYLENE DICHLORIDE DIRECT CHLORINATION BENELUX LANG FACTOR 0.8

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	800000	800000	800000	800000	640000	480000	320000
PLANT OUTPUT	800000	680000	600000	480000	640000	480000	320000
CAPITAL COST — MILLION DOLLARS							
BLCC	17.6	17.6	17.6	17.6	14.7	11.7	8.5
OFFSITES	10.2	10.2	10.2	10.2	8.5	6.8	4.9
TOTAL FIXED	27.8	27.8	27.8	27.8	23.3	18.5	13.4
WORKING	107.2	91.4	80.8	64.9	85.9	64.5	43.1
DOLLARS PER TONNE PRODUCT - (BASED ON ETHYLENE AT $750/TONNE)							
RAW MATERIALS	340.6	340.6	340.6	340.6	340.6	340.6	340.6
UTILITIES	42.8	42.8	42.8	42.8	42.8	42.8	42.8
BYPROD. CREDIT	.0	.0	.0	.0	.0	.0	.0
VARIABLE COST	383.4	383.4	383.4	383.4	383.4	383.4	383.4
OPERATION	1.2	1.4	1.5	1.9	1.3	1.4	1.8
OVERHEAD(EXCL.DEPN)	14.8	15.1	15.3	15.8	14.9	15.1	15.5
CASH COST	399.3	399.8	400.3	401.2	399.6	400.0	400.7
DEPRECIATION	2.8	3.3	3.8	4.7	3.0	3.1	3.4
NET COST OF PRODN	402.2	403.2	404.0	405.9	402.6	403.1	404.1
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	5.2	6.1	7.0	8.7	5.5	5.8	6.3
TRANSFER PRICE	407.4	409.3	411.0	414.6	408.0	408.9	410.3

EFFECT OF ETHYLENE PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	900.0	600.0	900.0	600.0	900.0	600.0	900.0	600.0	900.0	600.0	900.0	600.0	900.0	600.0
NET COST OF PRODN	444.5	359.9	445.5	360.9	446.3	361.7	448.2	363.6	444.9	360.3	445.4	360.8	446.4	361.8
TRANSFER PRICE	449.7	365.1	451.6	367.0	453.3	368.7	456.9	372.3	450.3	365.7	451.2	366.6	452.6	368.0

How to Start Manufacturing Industries

ETHYLENE OXIDE

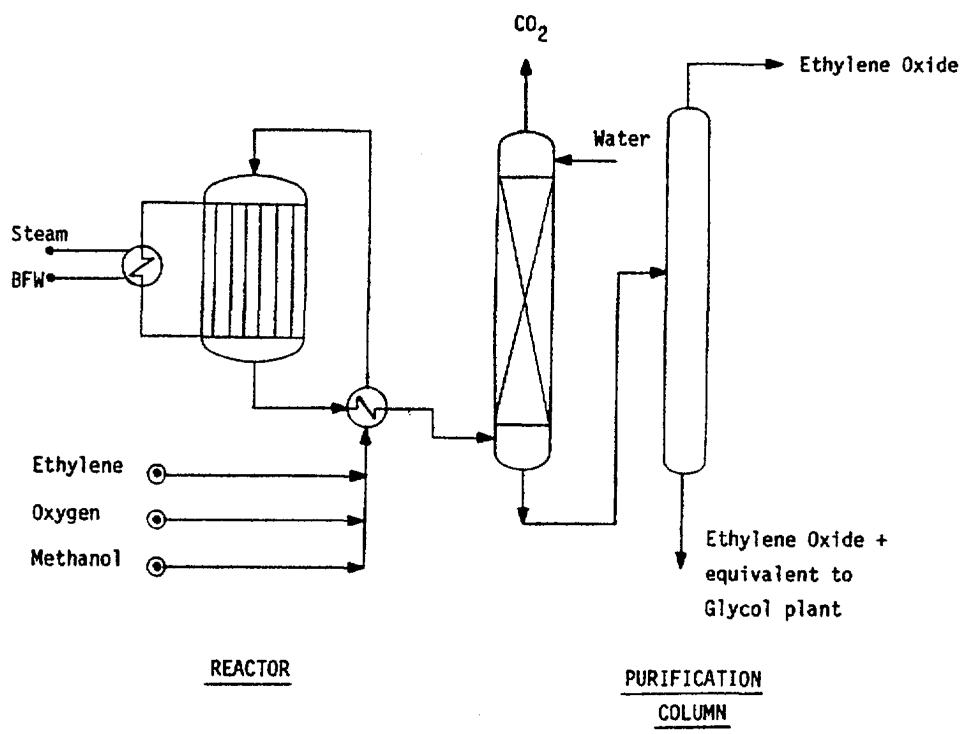
Process Description

Ethylene is combined with high purity oxygen with a molar ratio of ethylene to oxygen of 3.33. Methanol ballast is maintained at 45 percent concentration. This mixture at 220°C is fed to a tubular reactor at 17.2 bar pressure where it reacts. The selectivity to ethylene oxide is 77 mole percent. Ethylene conversion is 11 percent per pass.

Ethylene oxide is absorbed with lean cycle water in an absorber. It is later passed through a desorber, stripper, and an ethylene oxide purification column. The purified ethylene oxide either goes forward for sales or to an ethylene glycol synthesis plant.

Uses

Major use is in the manufacture of ethylene glycol (used as antifreeze or for polyester fibres). Other applications as a fumigant and as a sterilising agent.



Land area required for a typical plant of 150 000 tonnes per year capacity would be approximately 30 000 square metres. The minimum feasible capacity from a technical point of view could be as small as 10 000 tonnes per year.

This information has been prepared for UNIDO by Chem Systems International Ltd., United Kingdom.

Any inquiry about the information contained should be sent to: IO/COOP, Registry file No. ID/562/12, UNIDO, P.O. Box 300, A-1400, Vienna, Austria.

COST OF PRODUCTION ESTIMATE FOR ETHYLENE OXIDE
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - DIRECT OXIDATION

BASIS	CAPITAL COST	$ MILL
LOCATION- BENELUX	BATTERY LIMITS	48.89
CAPACITY- 150 000 TONNES PER YEAR	OFFSITES	19.56
PRODUCTN- 150 000 TONNES PER YEAR		
YEAR - 1980	TOTAL FIXED INV.	68.45
STR.TIME- 8000 HOURS PER YEAR	WORKING	43.41

RAW MATERIALS	QUANTITY/TONNE		PRICE*	ANNUAL COST	UNIT* COST
ETHYLENE	.8800	TONNE	750.000	99 000 000	
OXYGEN	1.1500	TONNE	87.000	15 007 500	
CATALYST+CHEMS	16.0000	DOLLARS	1.000	2 400 000	
TOTAL RAW MATERIALS				116 407 500	776.05
UTILITIES					
POWER	.0760	MWH	61.500	701 100	
COOLING WATER	.1550	KTONNE	17.000	395 250	
BLR.FEED WATER	.0050	KTONNE	450.000	337 500	
FUEL	.4000	GCAL	18.100	1 086 000	
TOTAL UTILITIES COST				2 519 850	16.80
OPERATING COSTS					
LABOUR	27.00 MEN @ 17 700 $/YEAR			477 900	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR			29 200	
MAINTENANCE	@ .04×BLCC			1 955 652	
TOTAL OPERATING COST				2 462 752	16.42
OVERHEAD EXPENSES					
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION			202 840	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS			1 600 789	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP			1 026 717	
DEPRECIATION	@ .100× BLCC+ .050×OFFS			5 866 957	
INTEREST	@ .100× WORKING CAPITAL			4 341 307	
TOTAL OVERHEAD EXPENSES				13 038 610	86.92
BYPRODUCT CREDIT					
STEAM	-1.4700	TONNE	19.000	-4 189 500	
TOTAL BYPRODUCT CREDIT				-4 189 500	-27.93
NET COST OF PRODUCTION				130 239 212	868.26

VARIABLE COST OF PRODUCTION	764.92
CASH COST OF PRODUCTION	829.15
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	913.89
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	936.71
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV	959.53

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR ETHYLENE OXIDE DIRECT OXIDATION BENELUX LANG FACTOR 0.65

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	150000	150000	150000	150000	120000	90000	60000
PLANT OUTPUT	150000	127500	112500	90000	120000	90000	60000
CAPITAL COST — MILLION DOLLARS							
BLCC	48.9	48.9	48.9	48.9	42.3	35.1	27.0
OFFSITES	19.6	19.6	19.6	19.6	16.9	14.0	10.8
TOTAL FIXED	68.4	68.4	68.4	68.4	59.2	49.1	37.7
WORKING	43.4	37.5	33.5	27.6	35.0	26.6	18.1
DOLLARS PER TONNE PRODUCT - (BASED ON ETHYLENE AT $750/TONNE)							
RAW MATERIALS	776.0	776.0	776.0	776.0	776.0	776.0	776.0
UTILITIES	16.8	16.8	16.8	16.8	16.8	16.8	16.8
BYPROD. CREDIT	¯27.9	¯27.9	¯27.9	¯27.9	¯27.9	¯27.9	¯27.9
VARIABLE COST	764.9	764.9	764.9	764.9	764.9	764.9	764.9
OPERATION	16.4	19.3	21.9	27.4	18.3	21.2	26.4
OVERHEAD(EXCL.DEPN)	47.8	51.6	55.0	62.1	50.2	53.8	60.2
CASH COST	829.1	835.8	841.8	854.4	833.4	839.9	851.5
DEPRECIATION	39.1	46.0	52.2	65.2	42.3	46.8	53.9
NET COST OF PRODN	868.3	881.8	893.9	919.6	875.7	886.7	905.4
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	68.4	80.5	91.3	114.1	74.0	81.8	94.3
TRANSFER PRICE	936.7	962.4	985.2	1033.7	949.7	968.6	999.7

EFFECT OF ETHYLENE PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	900.0	600.0	900.0	600.0	900.0	600.0	900.0	600.0	900.0	600.0	900.0	600.0	900.0	600.0
NET COST OF PRODN	1000.3	736.3	1013.8	749.8	1025.9	761.9	1051.6	787.6	1007.7	743.7	1018.7	754.7	1037.4	773.4
TRANSFER PRICE	1068.7	804.7	1094.4	830.4	1117.2	853.2	1165.7	901.7	1081.7	817.7	1100.6	836.6	1131.7	867.7

How to Start Manufacturing Industries

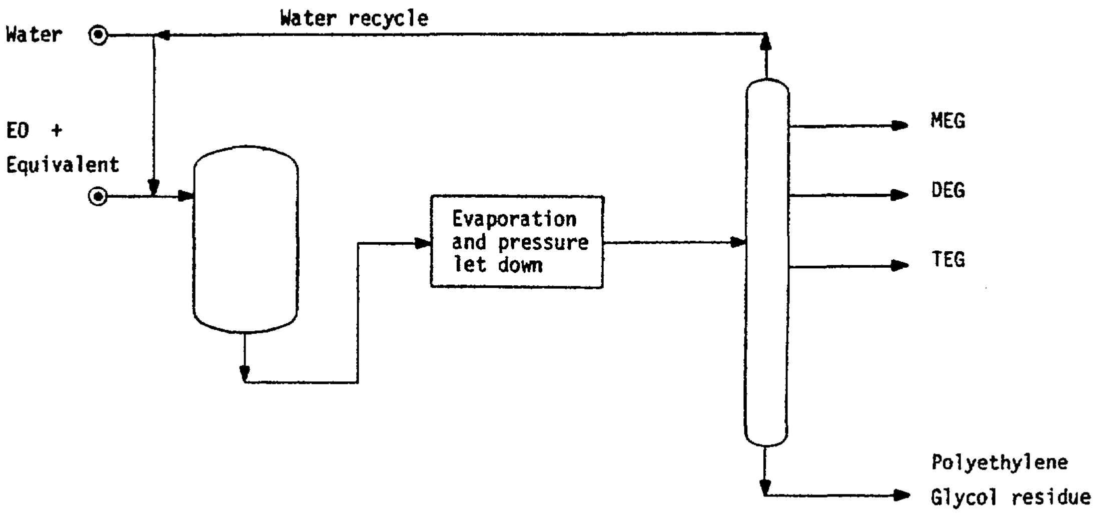
ETHYLENE GLYCOL

Process Description

Ethylene oxide plus equivalent in ethylene oxide solution is mixed with water to a ratio of 22:1 for optimum production. Heated to 150°C, the mixture enters the glycol reactor, where ethylene glycol (MEG) is produced at a selectivity of 88.4 percent, 10.3 percent to diethylene glycol (DEG), and 0.5 percent to triethylene glycol (TEG). Processing takes the form of a four stage evaporation system, with successive pressure letdowns and fractionation of the three components.

Uses

The major applications for ethylene glycol are in antifreeze and polyester fibre production. Other smaller uses of MEG are in polyester film and in PET barrier bottle resin production.



The land area required for a plant of 100 000 tonnes per year capacity is 6 000 square metres. The minimum feasible size for such a plant can be as low as 20 000 tonnes per year.

This information has been prepared for UNIDO by Chem Systems International Ltd., United Kingdom.

Any inquiry about the information contained should be sent to: IO/COOP, Registry file No. ID/562/12, UNIDO, P.O. Box 300, A-1400, Vienna, Austria.

COST OF PRODUCTION ESTIMATE FOR ETHYLENE GLYCOL
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - ETH.OX.HYDRATION

BASIS		CAPITAL COST	$ MILL
LOCATION-	BENELUX	BATTERY LIMITS	8.78
CAPACITY-	100 000 TONNES PER YEAR	OFFSITES	3.51
PRODUCTN-	100 000 TONNES PER YEAR		
YEAR -	1980	TOTAL FIXED INV.	12.29
STR.TIME-	8000 HOURS PER YEAR	WORKING	26.57

RAW MATERIALS	QUANTITY/TONNE	PRICE*	ANNUAL COST	UNIT* COST
ETHYLENE OXIDE	.8040 TONNE	935.000	75 174 000	
CATALYST+CHEMS	.3800 DOLLARS	1.000	38 000	
TOTAL RAW MATERIALS			75 212 000	752.12
UTILITIES				
POWER	.0263 MWH	61.500	161 745	
COOLING WATER	.5190 KTONNE	17.000	882 300	
HP.STEAM	5.2400 TONNE	20.200	10 584 800	
PROCESS WATER	.0053 KTONNE	230.000	121 900	
TOTAL UTILITIES COST			11 750 745	117.51
OPERATING COSTS				
LABOUR	20.00 MEN @ 17 700 $/YEAR		354 000	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR		29 200	
MAINTENANCE	@ .04×BLCC		351 014	
TOTAL OPERATING COST			734 214	7.34
OVERHEAD EXPENSES				
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION		153 280	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS		477 239	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP		184 283	
DEPRECIATION	@ .100× BLCC+ .050×OFFS		1 053 043	
INTEREST	@ .100× WORKING CAPITAL		2 656 535	
TOTAL OVERHEAD EXPENSES			4 524 381	45.24
BYPRODUCT CREDIT				
BLR.FEED WATER	-.0920 KTONNE	450.000	-4 140 000	
DIETHYLENE GLY	-.0998 TONNE	800.000	-7 984 000	
TRIETHYLENE GL	-.0046 TONNE	880.000	- 401 280	
TOTAL BYPRODUCT CREDIT			-12 525 280	-125.25
NET COST OF PRODUCTION			79 696 060	796.96

VARIABLE COST OF PRODUCTION	744.37
CASH COST OF PRODUCTION	786.43
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	809.25
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	815.39
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV	821.53

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR ETHYLENE GLYCOL ETH.OX.HYDRATION BENELUX LANG FACTOR 0.65

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	100000	100000	100000	100000	80000	60000	40000
PLANT OUTPUT	100000	85000	75000	60000	80000	60000	40000
CAPITAL COST — MILLION DOLLARS							
BLCC	8.8	8.8	8.8	8.8	7.6	6.3	4.8
OFFSITES	3.5	3.5	3.5	3.5	3.0	2.5	1.9
TOTAL FIXED	12.3	12.3	12.3	12.3	10.6	8.8	6.8
WORKING	26.6	22.7	20.1	16.3	21.3	16.1	10.9
DOLLARS PER TONNE PRODUCT - (BASED ON ETHYLENE OXIDE AT $935/TONNE)							
RAW MATERIALS	752.1	752.1	752.1	752.1	752.1	752.1	752.1
UTILITIES	117.5	117.5	117.5	117.5	117.5	117.5	117.5
BYPROD. CREDIT	-125.3	-125.3	-125.3	-125.3	-125.3	-125.3	125.3
VARIABLE COST	744.4	744.4	744.4	744.4	744.4	744.4	744.4
OPERATION	7.3	8.6	9.8	12.2	8.6	10.6	14.4
OVERHEAD(EXCL.DEPN)	34.7	36.3	37.7	40.7	36.2	38.5	43.0
CASH COST	786.4	789.3	791.9	797.4	789.1	793.5	801.7
DEPRECIATION	10.5	12.4	14.0	17.6	11.4	12.6	14.5
NET COST OF PRODN	797.0	801.7	805.9	814.9	800.5	806.1	816.3
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	18.4	21.7	24.6	30.7	19.9	22.0	25.4
TRANSFER PRICE	815.4	823.4	830.5	845.6	820.4	828.1	841.7

EFFECT OF ETHYLENE OXIDE PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	1122.0	748.0	1122.0	748.0	1122.0	748.0	1122.0	748.0	1122.0	748.0	1122.0	748.0	1122.0	748.0
NET COST OF PRODN	947.3	646.6	952.1	651.4	956.3	655.6	965.3	664.6	950.9	650.2	956.4	655.7	966.6	665.9
TRANSFER PRICE	965.7	665.0	973.7	673.0	980.9	680.2	996.0	695.3	970.8	670.1	978.4	677.7	992.0	691.3

FORMALDEHYDE

Process Description

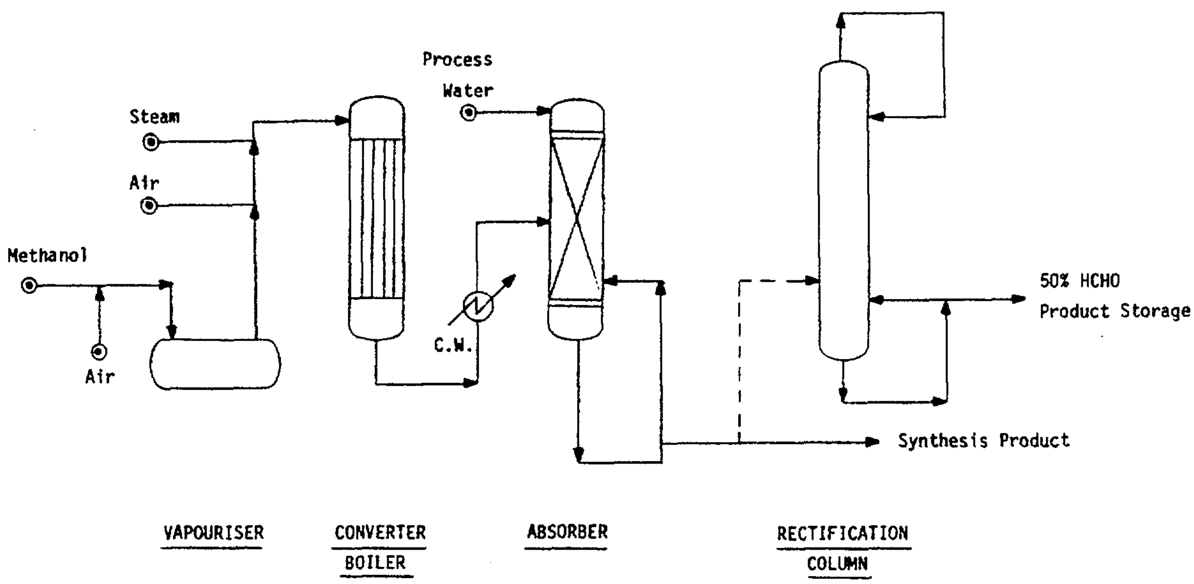
Recycle and fresh methanol are vapourised and mixed with air, and superheated to 100^{o}C-130^{o}C. Hot gases pass to the converter after mixing with by-pass air and steam. The converter contains granules of silver catalyst supported in a copper basket.

Partial condensation takes place in a gas cooler and the mixture of condensate and uncondensed gas is pumped to the bottom of an absorber. The remaining gas is finally scrubbed in the top tray section using the balance of process water required for the 'synthesis product'. This is the name given to the liquor removed from the base of the absorber.

For 37 percent HCHO/3 percent CH_5OH, the synthesis product is the final product. For a higher concentration however, of 50 percent HCHO/0.5 percent CH_3OH, the products need to be distilled.

Uses

The largest use of formaldehyde is in the manufacture of amino and phenolic resins. Other important uses include wood-industry products, moulding compounds, foundry resins and adhesives for insulation.



The plot area required for a plant of 50 000 tonnes per year capacity is 40 000 square metres. The minimum feasible capacity possible for this plant is 10 000 tonnes per year.

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COST OF PRODUCTION ESTIMATE FOR FORMALDEHYDE(50%)
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - VIA METHANOL

BASIS	CAPITAL COST	$ MILL
LOCATION- BENELUX	BATTERY LIMITS	6.80
CAPACITY- 50 000 TONNES PER YEAR	OFFSITES	2.70
PRODUCTN- 50 000 TONNES PER YEAR		
YEAR - 1980	TOTAL FIXED INV.	9.50
STR.TIME- 8000 HOURS PER YEAR	WORKING	3.52

RAW MATERIALS	QUANTITY/TONNE	PRICE*	ANNUAL COST	UNIT* COST
METHANOL	.4360 TONNE	270.000	5 886 000	
CATALYST+CHEMS	10.0000 DOLLARS	1.000	500 000	
TOTAL RAW MATERIALS			6 386 000	127.72
UTILITIES				
POWER	.0160 MWH	61.500	49 200	
COOLING WATER	.0670 KTONNE	17.000	56 950	
LP.STEAM	.4300 TONNE	16.700	359 050	
PROCESS WATER	.1250 KTONNE	230.000	1 437 500	
TOTAL UTILITIES COST			1 902 700	38.05
OPERATING COSTS				
LABOUR	12.00 MEN @ 17 700 $/YEAR		212 400	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR		29 200	
MAINTENANCE	@ .04×BLCC		272 000	
TOTAL OPERATING COST			513 600	10.27
OVERHEAD EXPENSES				
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION		96 640	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS		333 840	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP		142 500	
DEPRECIATION	@ .100× BLCC+ .050×OFFS		815 000	
INTEREST	@ .100× WORKING CAPITAL		351 979	
TOTAL OVERHEAD EXPENSES			1 739 959	34.80
BYPRODUCT CREDIT				
CONDENSATE	.0008 KTONNE	450.000	17 100	
TOTAL BYPRODUCT CREDIT			17 100	.34
NET COST OF PRODUCTION			10 559 359	211.19

VARIABLE COST OF PRODUCTION	166.12
CASH COST OF PRODUCTION	194.89
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	230.19
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	239.69
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV	249.19

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR FORMALDEHYDE(50%) VIA METHANOL BENELUX LANG FACTOR 0.65

CASE NO	1	2	3	4	5	6	7
	TONNES PER ANNUM						
PLANT CAPACITY	50000	50000	50000	50000	40000	30000	20000
PLANT OUTPUT	50000	42500	37500	30000	40000	30000	20000
CAPITAL COST	MILLION DOLLARS						
BLCC	6.8	6.8	6.8	6.8	5.9	4.9	3.7
OFFSITES	2.7	2.7	2.7	2.7	2.3	1.9	1.5
TOTAL FIXED	9.5	9.5	9.5	9.5	8.2	6.8	5.2
WORKING	3.5	3.1	2.8	2.4	2.9	2.2	1.6
	DOLLARS PER TONNE PRODUCT - (BASED ON METHANOL AT $270/TONNE)						
RAW MATERIALS	127.7	127.7	127.7	127.7	127.7	127.7	127.7
UTILITIES	38.1	38.1	38.1	38.1	38.1	38.1	38.1
BYPROD. CREDIT	.3	.3	.3	.3	.3	.3	.3
VARIABLE COST	166.1	166.1	166.1	166.1	166.1	166.1	166.1
OPERATION	10.3	12.1	13.7	17.1	11.9	14.6	19.6
OVERHEAD(EXCL.DEPN)	18.5	20.8	22.8	27.0	20.5	23.5	29.4
CASH COST	194.9	199.0	202.6	210.2	198.5	204.2	215.1
DEPRECIATION	16.3	19.2	21.7	27.2	17.6	19.5	22.5
NET COST OF PRODN	211.2	218.1	224.3	237.4	216.1	223.7	237.6
RETURN ON INVESTMENT	28.5	33.5	38.0	47.5	30.8	34.1	39.3
(AT 15% ON TOTAL FIXED INVESTMENT)							
TRANSFER PRICE	239.7	251.7	262.3	284.9	246.9	257.8	276.8

EFFECT OF METHANOL PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	324.0	216.0	324.0	216.0	324.0	216.0	324.0	216.0	324.0	216.0	324.0	216.0	324.0	216.0
NET COST OF PRODN	234.7	187.6	241.7	194.6	247.8	200.8	261.0	213.9	239.7	192.6	247.3	200.2	261.1	214.0
TRANSFER PRICE	263.2	216.1	275.2	228.1	285.8	238.8	308.5	261.4	270.5	223.4	281.3	234.3	300.4	253.3

File: G44
ISIC 3511

How to Start Manufacturing Industries

HYDROGEN FROM NATURAL GAS

Process Description

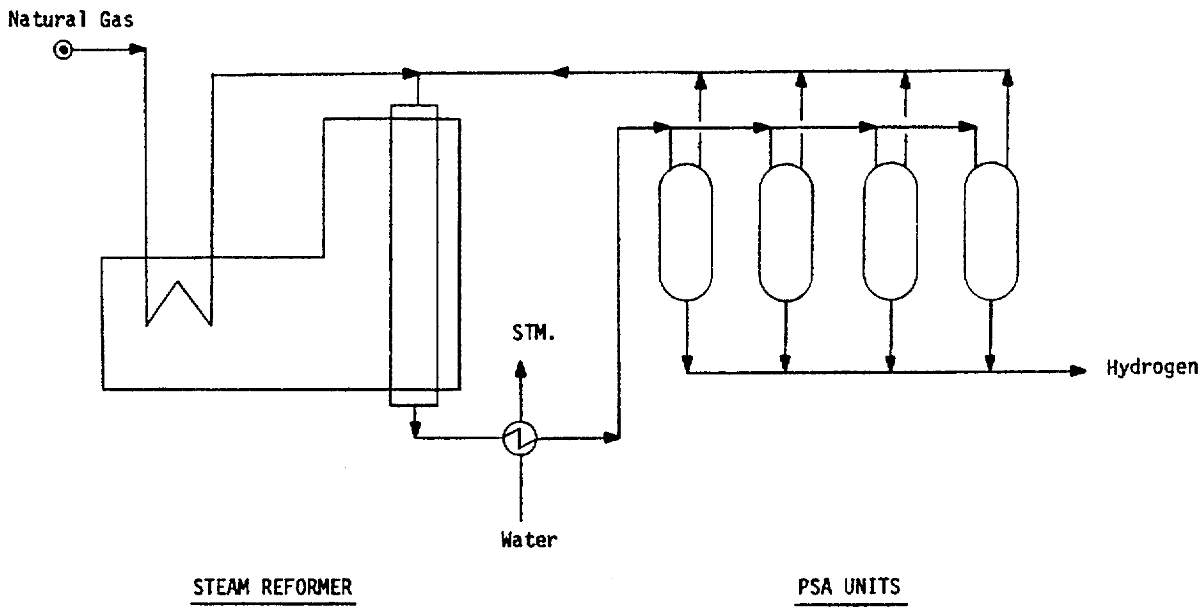
Desulphurised natural gas is mixed with steam to give a required steam to carbon molar ratio of 3 is steam-reformed. eaction is endothermic and takes place with a catalyst at 850-900^{o}C and 25 bar. Reaction scheme is:

$$CH_4 + H_2O \qquad CO + 3H_2$$
$$CO + H_2O \qquad CO_2 + 4H_2$$

After cooling, gas is passed through a pressure swing adsorption (PSA) unit which operates cyclically on a adsorption, depressurisation, purging, pressurisation cycle. Typical efficiencies are 75 percent.

Uses

This is a very important chemical in the synthesis of methanol and ammonia, also used in petroleum refining. Remainder in the manufacture of various chemicals eg cyclohexane, benzene, oxo-alcohols and aniline.



Plot area required for a hydrogen plant of 25 000 tonnes per year capacity is 1 000 square metres. Minimum feasible capacity of this plant can be as low as 2 500 tonnes per year.

This information has been prepared for UNIDO by Chem Systems International Ltd., United Kingdom.

Any inquiry about the information contained should be sent to: IO/COOP, Registry file No. ID/562/12, UNIDO, P.O. Box 300, A-1400, Vienna, Austria.

COST OF PRODUCTION ESTIMATE FOR HYDROGEN
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - NATURAL GAS VIA PSA

BASIS		CAPITAL COST	$ MILL
LOCATION-	BENELUX	BATTERY LIMITS	20.06
CAPACITY-	25 000 TONNES PER YEAR	OFFSITES	8.02
PRODUCTN-	25 000 TONNES PER YEAR		
YEAR -	1980	TOTAL FIXED INV.	28.08
STR.TIME-	8000 HOURS PER YEAR	WORKING	7.85

RAW MATERIALS	QUANTITY/TONNE	PRICE*	ANNUAL COST	UNIT* COST
NATURAL GAS	46.1000 GCAL	18.100	20 860 250	
CATALYST+CHEMS	2.5200 DOLLARS	1.000	63 000	
TOTAL RAW MATERIALS			20 923 250	836.93
UTILITIES				
POWER	.0160 MWH	61.500	24 600	
COOLING WATER	.0190 KTONNE	17.000	8 075	
BLR.FEED WATER	..0120 KTONNE	450.000	135 000	
TOTAL UTILITIES COST			167 675	6.71
OPERATING COSTS				
LABOUR	19.00 MEN @ 17 700 $/YEAR		336 300	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR		29 200	
MAINTENANCE	@ .04×BLCC		802 319	
TOTAL OPERATING COST			1 167 819	46.71
OVERHEAD EXPENSES				
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION		146 200	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS		759 082	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP		421 217	
DEPRECIATION	@ .100× BLCC+ .050×OFFS		2 406 957	
INTEREST	@ .100× WORKING CAPITAL		785 386	
TOTAL OVERHEAD EXPENSES			4 518 842	180.75
BYPRODUCT CREDIT				
MP.STEAM	-6.7000 TONNE	19.200	-3 216 000	
TOTAL BYPRODUCT CREDIT			-3 216 000	-128.64
NET COST OF PRODUCTION			23 561 586	942.46

VARIABLE COST OF PRODUCTION	715.00
CASH COST OF PRODUCTION	846.19
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	1054.79
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	1110.95
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV	1167.11

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR HYDROGEN NATURAL GAS VIA PSA BENELUX LANG FACTOR 0.65

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	25000	25000	25000	25000	20000	15000	10000
PLANT OUTPUT	25000	21250	18750	15000	20000	15000	10000
CAPITAL COST — MILLION DOLLARS							
BLCC	20.1	20.1	20.1	20.1	17.3	14.4	11.1
OFFSITES	8.0	8.0	8.0	8.0	6.9	5.8	4.4
TOTAL FIXED	28.1	28.1	28.1	28.1	24.3	20.1	15.5
WORKING	7.9	6.9	6.3	5.4	6.4	5.0	3.5
DOLLARS PER TONNE PRODUCT - (BASED ON NATURAL GAS AT $18.1/GCAL)							
RAW MATERIALS	836.9	836.9	836.9	836.9	836.9	836.9	836.9
UTILITIES	6.7	6.7	6.7	6.7	6.7	6.7	6.7
BYPROD. CREDIT	¯128.6	¯128.6	¯128.6	¯128.6	¯128.6	¯128.6	¯128.6
VARIABLE COST	715.0	715.0	715.0	715.0	715.0	715.0	715.0
OPERATION	46.7	55.0	62.3	77.9	53.0	62.7	80.8
OVERHEAD(EXCL.DEPN)	84.5	95.0	104.4	124.4	92.1	103.9	125.5
CASH COST	846.2	865.0	881.7	917.2	860.1	881.6	921.2
DEPRECIATION	96.3	113.3	128.4	160.5	104.1	115.1	132.7
NET COST OF PRODN	942.5	978.3	1010.1	1077.7	964.2	996.8	1053.9
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	168.5	198.2	224.6	280.8	182.2	201.5	232.2
TRANSFER PRICE	1111.0	1176.5	1234.7	1358.5	1146.3	1198.2	1286.1

EFFECT OF NATURAL GAS PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/GCAL	21.7	14.5	21.7	14.5	21.7	14.5	21.7	14.5	21.7	14.5	21.7	14.5	21.7	14.5
NET COST OF PRODN	1109.3	775.6	1145.1	811.4	1176.9	843.2	1244.6	910.8	1131.1	797.3	1163.6	829.9	1220.8	887.0
TRANSFER PRICE	1277.8	944.1	1343.4	1009.6	1401.6	1067.8	1525.4	1191.6	1313.2	979.5	1365.1	1031.4	1453.0	1119.2

How to Start Manufacturing Industries

ISOPROPANOL

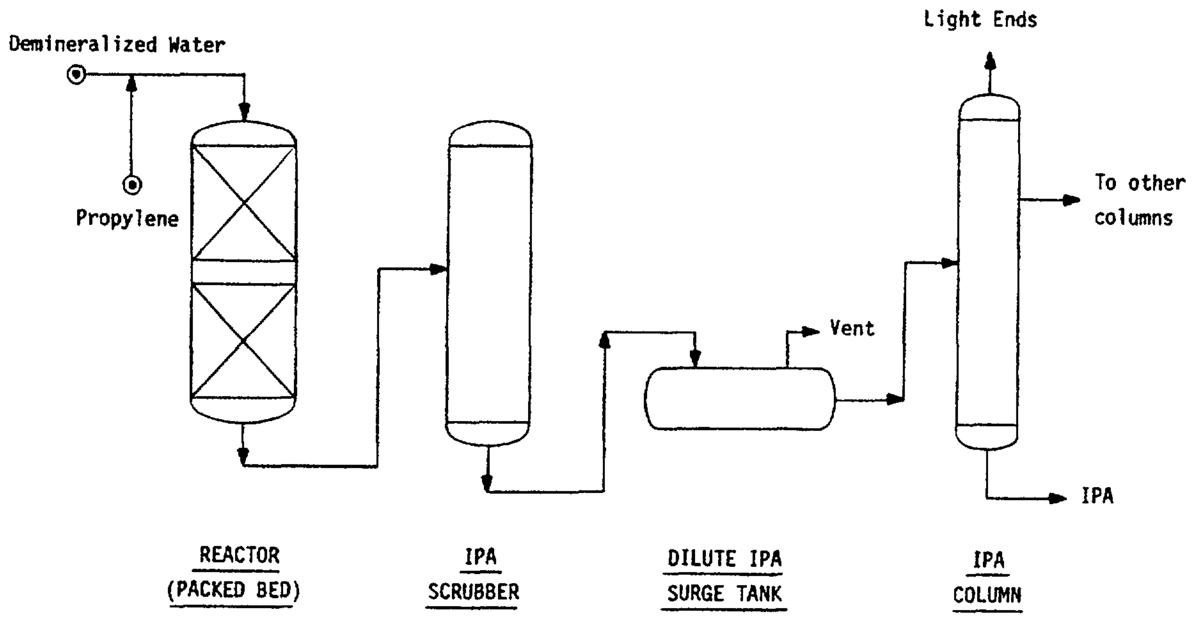
Process Description

Pure propylene is combined with demineralised water and recycle propylene (97 percent) and preheated by reactor effluent. The gaseous mixture of steam and propylene is then superheated to 180-220°C and 35-45 bar. The molar ratio of steam to propylene at the reactor inlet is about 1.0:1.0. Propylene hydration occurs in the vapour phase in the fixed bed catalytic reactor. There is approximately 5-6 percent conversion of propylene per pass.

Isopropanol (IPA) and by-products are recovered as a dilute aqueous solution in the isopropanol scrubber. The dilute IPA then proceeds to the storage tank where the pressure is further reduced and unreacted gas are purged and flared as tailgas. The dilute IPA neutralised and purified (99.9 wt percent IPA). Overall process yield based on real propylene is about 94.3 mole percent.

Uses

IPA is used for the manufacture of acetone and its derivatives, also the manufacture of glycerol and isopropyl acetate.



The land area required for a plant of 30 000 tonnes per year is 7 000 square metres. This also corresponds to the minimum feasible capacity for this plant.

This information has been prepared for UNIDO by Chem Systems International Ltd., United Kingdom.

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COST OF PRODUCTION ESTIMATE FOR ISOPROPANOL
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - PROPYLENE HYDRATION

BASIS	CAPITAL COST	$ MILL
LOCATION- BENELUX	BATTERY LIMITS	9.40
CAPACITY- 30 000 TONNES PER YEAR	OFFSITES	3.80
PRODUCTN- 30 000 TONNES PER YEAR		
YEAR - 1980	TOTAL FIXED INV.	13.20
STR.TIME- 8000 HOURS PER YEAR	WORKING	5.55

RAW MATERIALS	QUANTITY/TONNE	PRICE*	ANNUAL COST	UNIT* COST
PROPYLENE	.7800 TONNE	480.000	11 232 000	
CATALYST+CHEMS	1.6667 DOLLARS	1.000	50 000	
TOTAL RAW MATERIALS			11 282 000	376.07
UTILITIES				
POWER	.0600 MWH	61.500	110 700	
COOLING WATER	.1070 KTONNE	17.000	54 570	
MP.STEAM	3.6700 TONNE	19.200	2 113 920	
LP.STEAM	.5000 TONNE	16.700	250 500	
PROCESS WATER	.0030 KTONNE	230.000	20 700	
TOTAL UTILITIES COST			2 550 390	85.01
OPERATING COSTS				
LABOUR	18.00 MEN @ 17 700 $/YEAR		318 600	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR		29 200	
MAINTENANCE	@ .04×BLCC		376 000	
TOTAL OPERATING COST			723 800	24.13
OVERHEAD EXPENSES				
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION		139 120	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS		470 470	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP		198 000	
DEPRECIATION	@ .100× BLCC+ .050×OFFS		1 130 000	
INTEREST	@ .100× WORKING CAPITAL		554 539	
TOTAL OVERHEAD EXPENSES			2 492 129	83.07
BYPRODUCT CREDIT				
LIGHT ENDS	-.7590 GCAL	18.100	- 412 137	
TOTAL BYPRODUCT CREDIT			- 412 137	-13.74
NET COST OF PRODUCTION			16 636 182	554.54

VARIABLE COST OF PRODUCTION	447.34
CASH COST OF PRODUCTION	516.87
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	598.54
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	620.54
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV	642.54

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR ISOPROPANOL PROPYLENE HYDRATION BENELUX LANG FACTOR 0.65

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	30000	30000	30000	30000	24000	18000	12000
PLANT OUTPUT	30000	25500	22500	18000	24000	18000	12000
CAPITAL COST **MILLION DOLLARS**							
BLCC	9.4	9.4	9.4	9.4	8.1	6.7	5.2
OFFSITES	3.8	3.8	3.8	3.8	3.3	2.7	2.1
TOTAL FIXED	13.2	13.2	13.2	13.2	11.4	9.5	7.3
WORKING	5.5	4.9	4.4	3.7	4.5	3.5	2.5
DOLLARS PER TONNE PRODUCT - (BASED ON PROPYLENE AT $480/TONNE)							
RAW MATERIALS	376.1	376.1	376.1	376.1	376.1	376.1	376.1
UTILITIES	85.0	85.0	85.0	85.0	85.0	85.0	85.0
BYPROD. CREDIT	¯13.7	¯13.7	¯13.7	¯13.7	¯13.7	¯13.7	¯13.7
VARIABLE COST	447.3	447.3	447.3	447.3	447.3	447.3	447.3
OPERATION	24.1	28.4	32.2	40.2	28.0	34.3	46.3
OVERHEAD(EXCL.DEPN)	45.4	50.7	55.4	65.4	50.0	57.4	71.3
CASH COST	516.9	526.4	534.9	552.9	525.4	539.0	564.9
DEPRECIATION	37.7	44.3	50.2	62.8	40.7	45.0	51.9
NET COST OF PRODN	554.5	570.7	585.1	615.7	566.1	584.1	616.8
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	66.0	77.6	88.0	110.0	71.4	78.9	91.0
TRANSFER PRICE	620.5	648.4	673.1	725.7	637.5	663.0	707.8

EFFECT OF PROPYLENE PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	576.0	384.0	576.0	384.0	576.0	384.0	576.0	384.0	576.0	384.0	576.0	384.0	576.0	384.0
NET COST OF PRODN	629.4	479.7	645.6	495.9	660.0	510.3	690.6	540.8	641.0	491.3	659.0	509.2	691.7	541.9
TRANSFER PRICE	695.4	545.7	723.3	573.5	748.0	598.3	800.6	650.8	712.4	562.6	737.9	588.1	782.7	632.9

File: G46
ISIC 3511

How to Start Manufacturing Industries

METHANOL FROM NATURAL GAS

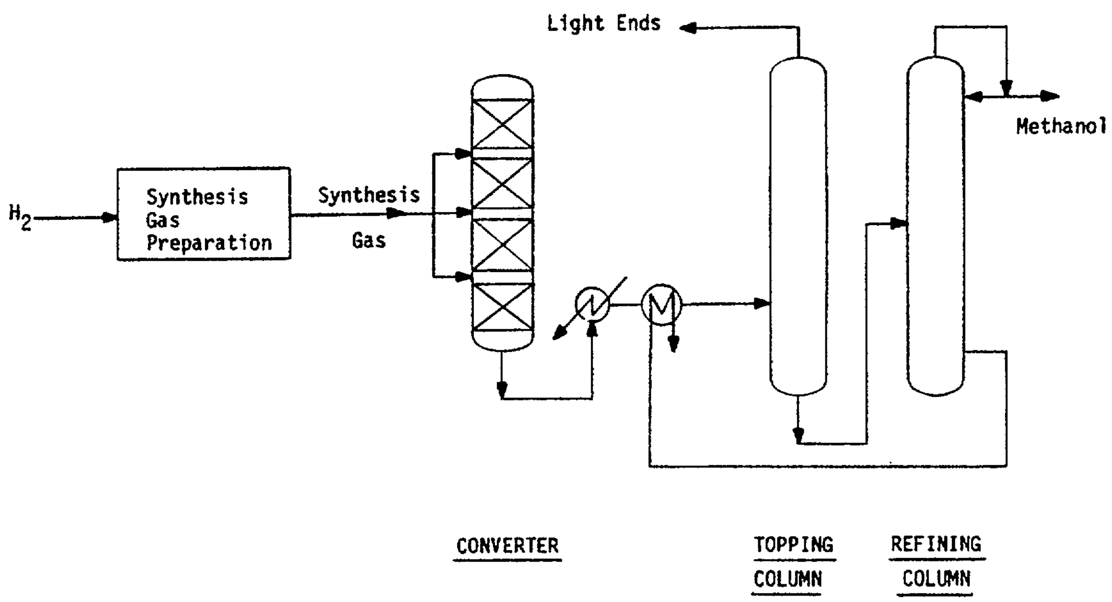
Process Description

Natural gas is desulphurised and mixed with steam and reformed over nickel at 20-22 bar and 850°C. Steam to carbon molar ratio is 2.5-3.0. The gas is cooled and compressed to the methanol loop pressure of 100 bar. The synthesis gas mixture is fed to the inlet of the individual converter catalyst beds at 270°C.

Hot effluent from the converter is cooled and condensed. Crude methanol is refined using two distillation stages ie a topping column to remove dimethyl ether, methyl formate and aldehydes, and a refining column for pure methanol to storage.

Uses

The greatest use is in the production of formaldehyde. Other applications are in the synthesis of methacrylates, methylamines and dimethyl terephthalate (DMT) for fibre manufacture.



Land area required for a typical methanol plant of 330 000 tonnes per year capacity using this process is 25 000 square metres. The minimum feasible capacity is 40 000 tonnes per year.

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COST OF PRODUCTION ESTIMATE FOR METHANOL
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - NATURAL GAS

BASIS	CAPITAL COST	$ MILL
LOCATION- BENELUX	BATTERY LIMITS	65.10
CAPACITY- 330 000 TONNES PER YEAR	OFFSITES	25.80
PRODUCTN- 330 000 TONNES PER YEAR		-------
YEAR - 1980	TOTAL FIXED INV.	90.90
STR.TIME- 8000 HOURS PER YEAR	WORKING	24.34

RAW MATERIALS	QUANTITY/TONNE	PRICE*	ANNUAL COST	UNIT* COST
NATURAL GAS	8.9300 GCAL	18.100	53 338 890	
CATALYST+CHEMS	1.9697 DOLLARS	1.000	650 000	
TOTAL RAW MATERIALS			53 988 890	163.60
UTILITIES				
POWER	.0550 MWH	61.500	1 116 225	
COOLING WATER	.1040 KTONNE	17.000	583 440	
BLR.FEED WATER	.0013 KTONNE	450.000	193 050	
TOTAL UTILITIES COST			1 892 715	5.74

OPERATING COSTS				
LABOUR	33.00 MEN	@ 17 700 $/YEAR	584 100	
SUPERVISION	1.00 MEN	@ 29 200 $/YEAR	29 200	
MAINTENANCE	@ .04 x BLCC		2 604 000	
TOTAL OPERATING COST			3 217 300	9.75

OVERHEAD EXPENSES				
DIRECT OVERHEAD	@	.400 x LAB+SUPERVISION	245 320	
GEN.PLANT OVERHEAD	@	.650 x OPERATING COSTS	2 091 245	
INSURANCE+PTY TAX	@	.015 x TOTAL FIXED CAP	1 363 500	
DEPRECIATION	@	.100 x BLCC+ .050 OFFS	7 800 000	
INTEREST	@	.100 x WORKING CAPITAL	2 434 447	
TOTAL OVERHEAD EXPENSES			13 934 512	42.23
BYPRODUCT CREDIT				
TOTAL BYPRODUCT CREDIT			0	.00
NET COST OF PRODUCTION			73 033 417	221.31

VARIABLE COST OF PRODUCTION	169.34
CASH COST OF PRODUCTION	197.68
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	248.86
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	262.63
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV	276.40

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR METHANOL NATURAL GAS BENELUX LANG FACTOR 0.7

CASE NO		1	2	3	4	5	6	7
	TONNES PER ANNUM							
PLANT CAPACITY		330000	333000	333000	333000	264000	198000	132000
PLANT OUTPUT		330000	280500	247500	198000	264000	198000	132000
CAPITAL COST	MILLION DOLLARS							
BLCC		65.1	65.1	65.1	65.1	55.7	45.5	34.3
OFFSITES		25.8	25.8	25.8	25.8	22.1	18.0	13.6
TOTAL FIXED		90.9	90.9	90.9	90.9	77.8	63.6	47.9
WORKING		24.3	21.5	19.5	16.6	19.8	15.2	10.6
	DOLLARS PER TONNE PRODUCT - (BASED ON NATURAL GAS AT $18.1/GCAL)							
RAW MATERIALS		163.6	163.6	163.6	163.6	163.6	163.6	163.6
UTILITIES		5.7	5.7	5.7	5.7	5.7	5.7	5.7
BYPROD. CREDIT		.0	.0	.0	.0	.0	.0	.0
VARIABLE COST		169.3	169.3	169.3	169.3	169.3	169.3	169.3
OPERATION		9.7	11.5	13.0	16.2	10.8	12.3	15.0
OVERHEAD (EXCL.DEPN.)		18.6	20.8	22.8	27.1	19.8	21.7	25.1
CASH COST		197.7	201.6	205.2	212.7	199.9	203.4	209.5
DEPRECIATION		23.6	27.8	31.5	39.4	25.3	27.6	31.1
NET COST OF PRODN.		221.3	229.5	236.7	252.1	225.2	230.9	240.6
RETURN ON INVESTMENT (at 15% ON TOTAL FIXED INVESTMENT)		41.3	48.6	55.1	68.9	44.2	48.2	54.4
TRANSFER PRICE		262.6	278.1	291.8	320.9	269.4	279.1	295.0

EFFECT OF NATURAL GAS PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/GCAL:	21.7	14.5	21.7	14.5	21.7	14.5	21.7	14.5	21.7	14.5	21.7	14.5	21.7	14.5
NET COST OF PRODN.	253.6	189.0	261.8	197.1	269.0	204.4	284.4	219.7	257.5	192.9	263.3	198.6	272.9	208.2
TRANSFER PRICE	295.0	230.3	310.4	245.7	324.1	259.5	353.3	288.6	301.7	237.1	311.4	246.8	327.3	262.6

How to Start Manufacturing Industries

METHYL METHACRYLATE VIA ACETONE CYANOHYDRIN

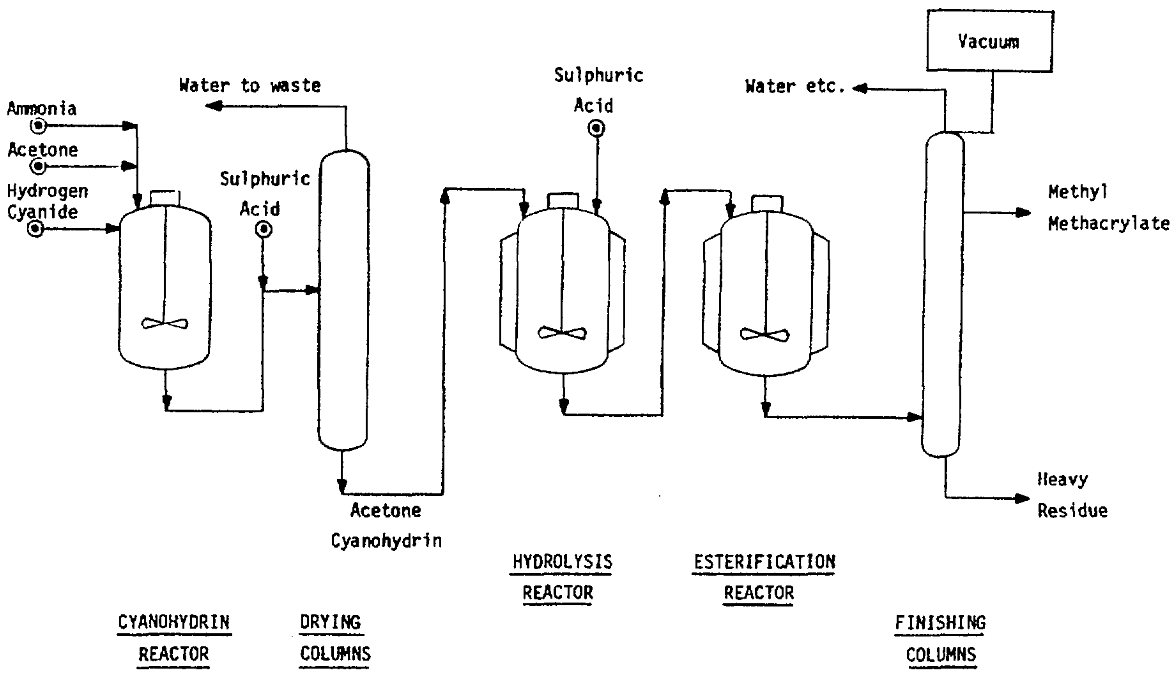
Process Description

Hydrogen cyanide and acetone are reacted wih an alkaline catalyst to form acetone cyanohydrin at 29-38^{o}C in the liquid phase with 91 percent yield. Excess catalyst is neutralised with sulphuric acid. The cyanohydrin is produced after filtration and two-stage distillation. Water-cooled hydrolysis reactors operating at 150^{o}C and 7 bar convert the cyanohydrin to methacrylic acid. Esterification with methanol produces methyl methacrylate.

Product recovery is performed by first removing the sulphuric acid. Thereafter azeotropic distillation removes much of the water, methanol recovery is undertaken. Finally a series of vacuum distillations yield the methacrylate to sufficient purity.

Uses

The methacrylate monomers are intermediate in the preparaion of polymers such as PMMA.



Land area required for a typical plant of 135 000 tonnes per year capacity is approximately 50 000 square metres. The minimum feasible capacity is in the region of 20 000 tonnes per year.

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COST OF PRODUCTION ESTIMATE FOR METHYL METHACRYLATE
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - ACETONE CYANOHYDRIN

BASIS		CAPITAL COST	$ MILL
LOCATION-	BENELUX	BATTERY LIMITS	86.50
CAPACITY-	135 000 TONNES PER YEAR	OFFSITES	41.37
PRODUCTN-	135 000 TONNES PER YEAR		
YEAR -	1980	TOTAL FIXED INV.	127.87
STR.TIME-	8000 HOURS PER YEAR	WORKING	48.08

RAW MATERIALS	QUANTITY/TONNE		PRICE*	ANNUAL COST	UNIT* COST
ACETONE	.6340	TONNE	625.000	53 493 750	
HYDROG.CYANIDE	.2870	TONNE	500.000	19 372 500	
METHANOL	.3450	TONNE	270.000	12 575 250	
SULPHURIC ACID	.1790	TONNE	120.000	2 899 800	
AMMONIA	.0070	TONNE	195.000	184 275	
CATALYST+CHEMS	.1115	DOLLARS	1.000	15 050	
TOTAL RAW MATERIALS				88 540 625	655.86
UTILITIES					
POWER	.5310	MWH	61.500	4 408 627	
COOLING WATER	.7170	KTONNE	17.000	1 645 515	
MP.STEAM	6.4000	TONNE	19.200	16 588 800	
PROCESS WATER	.0083	KTONNE	230.000	257 715	
FUEL	2.2200	GCAL	18.100	5 424 570	
TOTAL UTILITIES COST				28 325 227	209.82
OPERATING COSTS					
LABOUR	36.00 MEN @ 17 700 $/YEAR			637 200	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR			29 200	
MAINTENANCE	@ .06×BLCC			5 190 000	
TOTAL OPERATING COST				5 856 400	43.38
OVERHEAD EXPENSES					
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION			266 560	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS			3 806 660	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP			1 918 043	
DEPRECIATION	@ .100× BLCC+ .050×OFFS			10 718 478	
INTEREST	@ .100× WORKING CAPITAL			4 808 000	
TOTAL OVERHEAD EXPENSES				21 517 742	159.39
BYPRODUCT CREDIT					
TOTAL BYPRODUCT CREDIT				0	.00
NET COST OF PRODUCTION				144 239 994	1068.44

VARIABLE COST OF PRODUCTION	865.67
CASH COST OF PRODUCTION	989.05
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	1163.16
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	1210.52
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV	1257.88

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR METHYL METHACRYLATE ACETONE CYANOHYDRIN BENELUX LANG FACTOR 0.65

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	135000	135000	135000	135000	108000	81000	54000
PLANT OUTPUT	135000	114750	101250	81000	108000	81000	54000
CAPITAL COST — **MILLION DOLLARS**							
BLCC	86.5	86.5	86.5	86.5	74.8	62.1	47.7
OFFSITES	41.4	41.4	41.4	41.4	35.8	29.7	22.8
TOTAL FIXED	127.9	127.9	127.9	127.9	110.6	91.7	70.5
WORKING	48.1	42.0	38.0	32.0	39.0	29.9	20.6
DOLLARS PER TONNE PRODUCT - (BASED ON ACETONE AT $625/TONNE)							
RAW MATERIALS	655.9	655.9	655.9	655.9	655.9	655.9	655.9
UTILITIES	209.8	209.8	209.8	209.8	209.8	209.8	209.8
BYPROD. CREDIT	.0	.0	.0	.0	.0	.0	.0
VARIABLE COST	865.7	865.7	865.7	865.7	865.7	865.7	865.7
OPERATION	43.4	51.0	57.8	72.3	47.7	54.2	65.3
OVERHEAD(EXCL.DEPN)	80.0	88.8	96.7	113.4	85.0	92.4	105.2
CASH COST	989.0	1005.6	1020.2	1051.4	998.4	1012.3	1036.2
DEPRECIATION	79.4	93.4	105.9	132.3	85.8	94.9	109.4
NET COST OF PRODN	1068.4	1099.0	1126.1	1183.7	1084.3	1107.2	1145.6
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	142.1	167.1	189.4	236.8	153.6	169.9	195.8
TRANSFER PRICE	1210.5	1266.1	1315.5	1420.5	1237.9	1277.1	1341.4

EFFECT OF ACETONE PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	750.0	500.0	750.0	500.0	750.0	500.0	750.0	500.0	750.0	500.0	750.0	500.0	750.0	500.0
NET COST OF PRODN	1147.7	989.2	1178.2	1019.7	1205.3	1046.8	1263.0	1104.5	1163.5	1005.0	1186.5	1028.0	1224.8	1066.3
TRANSFER PRICE	1289.8	1131.3	1345.4	1186.9	1394.8	1236.3	1499.8	1341.3	1317.1	1158.6	1356.4	1197.9	1420.6	1262.1

File: G48
ISIC 3511

How to Start Manufacturing Industries

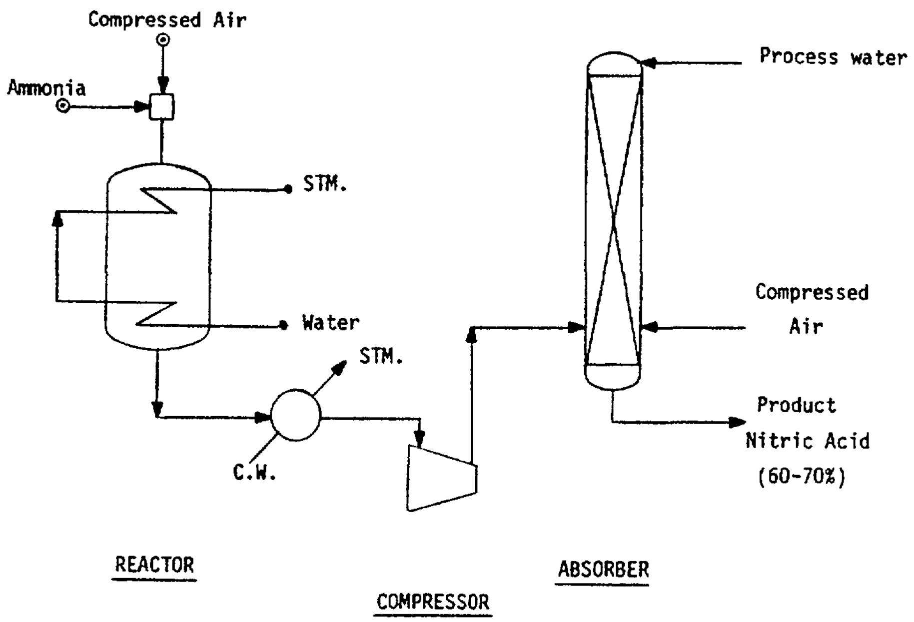
NITRIC ACID - WEAK

Process Description

Ammonia is oxidised over a Platinum/Rhodium catalyst to nitrous oxide, in an exothermic reaction at 900-950^{o}C. The exit gases pass over a steam boiler, and superheater surfaces raising steam at 30 bar and 350^{o}C. The wet gases are cooled to condense out the water, then compressed to 12 bar inlet to the absorber. Have, they contact compressed air and acid condensate to produce nitrogen dioxide which dissolves to form nitric acid. Any nitrous oxide is further oxidised to nitrogen dioxide in a bleaching column where it dissolves to form more acid.

Uses

The largest use is in the production of ammonium nitrate for use as a fertiliser. Nitric acid is also used in the manufacture of cyclohexane (and then to adipic acid) which in turn is a monomer for nylon-6,6.



Plot area required for a plant of 200 000 tonnes per year capacity is approximately 7 000 square metres, which is a typical modern capacity. The minimum feasible capacity of the plant from a technical viewpoint can be 40 000 tonnes per year.

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Any inquiry about the information contained should be sent to: IO/COOP, Registry file No. ID/562/12, UNIDO, P.O. Box 300, A-1400, Vienna, Austria.

COST OF PRODUCTION ESTIMATE FOR NITRIC ACID - 60%
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - MIXED PRESSURE

BASIS		CAPITAL COST	$ MILL
LOCATION- BENELUX		BATTERY LIMITS	13.16
CAPACITY-	200 000 TONNES PER YEAR	OFFSITES	5.27
PRODUCTN-	200 000 TONNES PER YEAR		
YEAR - 1980		TOTAL FIXED INV.	18.43
STR.TIME- 8000 HOURS PER YEAR		WORKING	5.07

RAW MATERIALS	QUANTITY/TONNE	PRICE*	ANNUAL COST	UNIT* COST
AMMONIA	.2830 TONNE	195.000	11 037 000	
CATALYST+CHEMS	.9700 DOLLARS	1.000	194 000	
TOTAL RAW MATERIALS			11 231 000	56.15
UTILITIES				
POWER	.0100 MWH	61.500	123 000	
COOLING WATER	.1200 KTONNE	17.000	408 000	
BLR.FEED WATER	.0001 KTONNE	450.000	9 000	
PROCESS WATER	.0003 KTONNE	230.000	13 800	
TOTAL UTILITIES COST			553 800	2.77
OPERATING COSTS				
LABOUR	14.00 MEN @ 17 700 $/YEAR		247 800	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR		29 200	
MAINTENANCE	@ .04×BLCC		526 522	
TOTAL OPERATING COST			803 522	4.02
OVERHEAD EXPENSES				
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION		110 800	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS		522 289	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP		276 424	
DEPRECIATION	@ .100× BLCC+ .050×OFFS		1 579 565	
INTEREST	@ .100× WORKING CAPITAL		506 669	
TOTAL OVERHEAD EXPENSES			2 995 747	14.98
BYPRODUCT CREDIT				
MP.STEAM	-.1000 TONNE	19.200	- 384 000	
TOTAL BYPRODUCT CREDIT			- 384 000	-1.92
NET COST OF PRODUCTION			15 200 069	76.00

VARIABLE COST OF PRODUCTION	57.00
CASH COST OF PRODUCTION	68.10
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	85.21
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	89.82
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV	94.43

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR NITRIC ACID - 60% MIXED PRESSURE BENELUX LANG FACTOR 0.65

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	200000	200000	200000	200000	160000	120000	80000
PLANT OUTPUT	200000	170000	150000	120000	160000	120000	80000
CAPITAL COST — MILLION DOLLARS							
BLCC	13.2	13.2	13.2	13.2	11.4	9.4	7.3
OFFSITES	5.3	5.3	5.3	5.3	4.6	3.8	2.9
TOTAL FIXED	18.4	18.4	18.4	18.4	15.9	13.2	10.2
WORKING	5.1	4.5	4.1	3.5	4.2	3.2	2.3
DOLLARS PER TONNE PRODUCT - (BASED ON AMMONIA AT $195/TONNE)							
RAW MATERIALS	56.2	56.2	56.2	56.2	56.2	56.2	56.2
UTILITIES	2.8	2.8	2.8	2.8	2.8	2.8	2.8
BYPROD. CREDIT	¯1.9	¯1.9	¯1.9	¯1.9	¯1.9	¯1.9	¯1.9
VARIABLE COST	57.0	57.0	57.0	57.0	57.0	57.0	57.0
OPERATION	4.0	4.7	5.4	6.7	4.6	5.5	7.1
OVERHEAD(EXCL.DEPN)	7.1	8.0	8.8	10.5	7.8	8.8	10.8
CASH COST	68.1	69.7	71.1	74.2	69.3	71.3	74.9
DEPRECIATION	7.9	9.3	10.5	13.2	8.5	9.4	10.9
NET COST OF PRODN	76.0	79.0	81.7	87.4	77.9	80.7	85.7
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	13.8	16.3	18.4	23.0	14.9	16.5	19.0
TRANSFER PRICE	89.8	95.3	100.1	110.4	92.8	97.2	104.8

EFFECT OF AMMONIA PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	234.0	156.0	234.0	156.0	234.0	156.0	234.0	156.0	234.0	156.0	234.0	156.0	234.0	156.0
NET COST OF PRODN	87.0	65.0	90.0	68.0	92.7	70.6	98.4	76.3	88.9	66.8	91.8	69.7	96.8	74.7
TRANSFER PRICE	100.9	78.8	106.3	84.2	111.1	89.1	121.4	99.4	103.9	81.8	108.3	86.2	115.8	93.7

File: G49
ISIC 3511

How to Start Manufacturing Industries

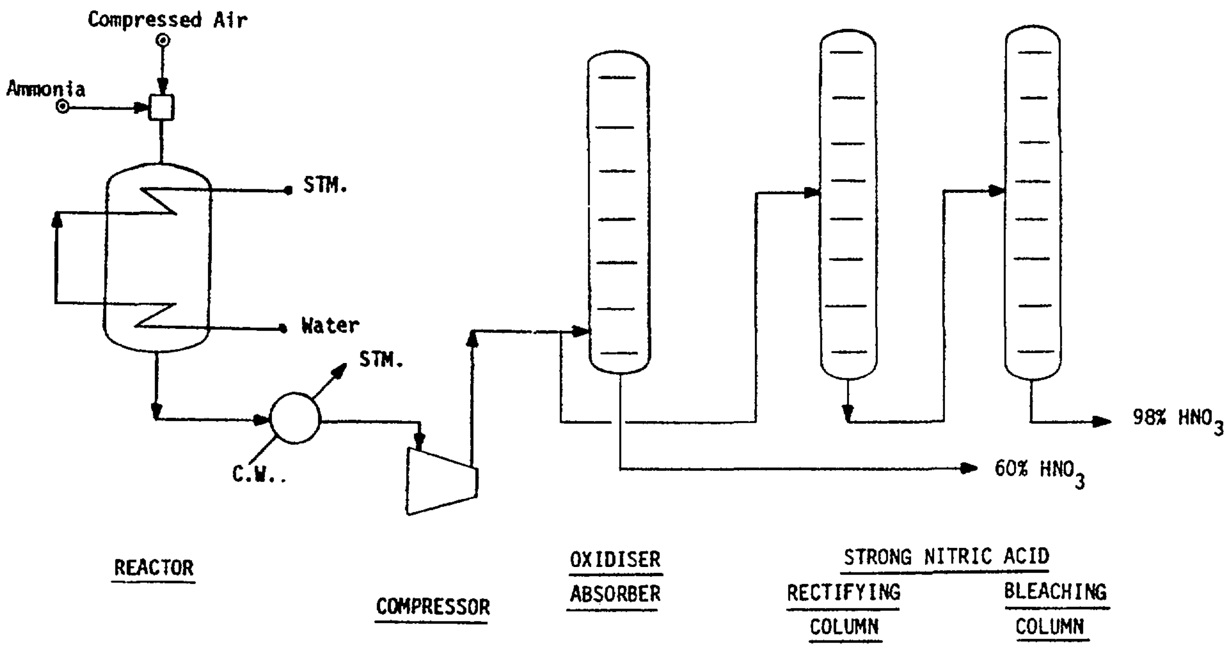
NITRIC ACID - CONCENTRATED

Process Description

Ammonia is first oxidised to nitric oxide using Platinum/Rhodium as catalyst. The reaction temperature is between 900 and 950°C. The nitric oxide is then oxidised to nitrogen dioxide. This reaction is carried out in the oxidiser/absorber, operated at sub ambient temperatures. The bottoms from the oxidiser/absorber is 60 percent nitric acid. The concentration process consists of two further absorption steps where weak acid is contacted with NOx streams of various concentration. The rectifying column downstream separates 98 percent nitric acid as overheads, it is bleached with air before being sent to storage.

Uses

The largest use of nitric acid is in the production of ammonium nitrate to be used as fertiliser. It is also used in the manufacture of cyclohexane.



Plot area required for a plant of 66 700 tonnes per year capacity is approximately 1 000 square metres, which would be in addition to that for a weak nitric acid plant. Minimum capacity can be 13 000 tonnes per year.

This information has been prepared for UNIDO by Chem Systems International Ltd., United Kingdom.

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COST OF PRODUCTION ESTIMATE FOR 98% NITRIC ACID
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - WEAK & STRONG INTGD

BASIS		CAPITAL COST	$ MILL
LOCATION-	BENELUX	BATTERY LIMITS	21.20
CAPACITY-	66 700 TONNES PER YEAR	OFFSITES	12.50
PRODUCTN-	66 700 TONNES PER YEAR		
YEAR	- 1980	TOTAL FIXED INV.	33.70
STR.TIME-	8000 HOURS PER YEAR	WORKING	2.57

RAW MATERIALS	QUANTITY/TONNE	PRICE*	ANNUAL COST	UNIT* COST
AMMONIA	.8640 TONNE	195.000	11 237 616	
CATALYST+CHEMS	3.4933 DOLLARS	1.000	233 000	
TOTAL RAW MATERIALS			11 470 616	171.97
UTILITIES				
POWER	.0570 MWH	61.500	233 817	
COOLING WATER	.5700 KTONNE	17.000	646 323	
BLR.FEED WATER	.0015 KTONNE	450.000	45 022	
PROCESS WATER	.0003 KTONNE	230.000	4 602	
FUEL	1.3600 GCAL	18.100	1 641 887	
TOTAL UTILITIES COST			2 571 652	38.56
OPERATING COSTS				
LABOUR	14.00 MEN @ 17 700 $/YEAR		247 800	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR		29 200	
MAINTENANCE	@ .04×BLCC		848 000	
TOTAL OPERATING COST			1 125 000	16.87
OVERHEAD EXPENSES				
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION		110 800	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS		731 250	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP		505 500	
DEPRECIATION	@ .100× BLCC+ .050×OFFS		2 745 000	
INTEREST	@ .100× WORKING CAPITAL		256 866	
TOTAL OVERHEAD EXPENSES			4 349 416	65.21
BYPRODUCT CREDIT				
MP.STEAM	-1.4100 TONNE	19.200	-1 805 702	
60% NITRIC AC.	-2.0000 TONNE	75.000	-10 005 000	
TOTAL BYPRODUCT CREDIT			-11 810 702	-177.07
NET COST OF PRODUCTION			7 705 981	115.53

VARIABLE COST OF PRODUCTION	33.46
CASH COST OF PRODUCTION	74.38
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	166.06
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	191.32
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV	216.58

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR 98% NITRIC ACID WEAK & STRONG INTGD BENELUX LANG FACTOR 0.65

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	66700	66700	66700	66700	53360	40020	26680
PLANT OUTPUT	66700	56695	50025	40020	53360	40020	26680
CAPITAL COST — **MILLION DOLLARS**							
BLCC	21.2	21.2	21.2	21.2	18.3	15.2	11.7
OFFSITES	12.5	12.5	12.5	12.5	10.8	9.0	6.9
TOTAL FIXED	33.7	33.7	33.7	33.7	29.1	24.2	18.6
WORKING	2.6	2.5	2.4	2.3	2.2	1.8	1.4
DOLLARS PER TONNE PRODUCT - (BASED ON AMMONIA AT $195/TONNE)							
RAW MATERIALS	172.0	172.0	172.0	172.0	172.0	172.0	172.0
UTILITIES	38.6	38.6	38.6	38.6	38.6	38.6	38.6
BYPROD. CREDIT	¯177.1	¯177.1	¯177.1	¯177.1	¯177.1	¯177.1	¯177.1
VARIABLE COST	33.5	33.5	33.5	33.5	33.5	33.5	33.5
OPERATION	16.9	19.8	22.5	28.1	18.9	22.1	27.9
OVERHEAD(EXCL.DEPN)	24.1	28.1	31.7	39.3	26.7	30.7	37.9
CASH COST	74.4	81.4	87.6	100.9	79.1	86.3	99.3
DEPRECIATION	41.2	48.4	54.9	68.6	44.5	49.2	56.7
NET COST OF PRODN	115.5	129.8	142.5	169.5	123.6	135.5	156.0
RETURN ON INVESTMENT	75.8	89.2	101.0	126.3	81.9	90.6	104.4
(AT 15% ON TOTAL FIXED INVESTMENT)							
TRANSFER PRICE	191.3	219.0	243.6	295.8	205.5	226.1	260.5

EFFECT OF AMMONIA PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	234.0	156.0	234.0	156.0	234.0	156.0	234.0	156.0	234.0	156.0	234.0	156.0	234.0	156.0
NET COST OF PRODN	149.2	81.8	163.5	96.1	176.2	108.8	203.2	135.8	157.3	89.9	169.2	101.8	189.7	122.3
TRANSFER PRICE	225.0	157.6	252.7	185.3	277.3	209.9	329.5	262.1	239.2	171.8	259.8	192.4	294.1	226.8

File: G50
ISIC 3513

How to Start Manufacturing Industries

NYLON-6

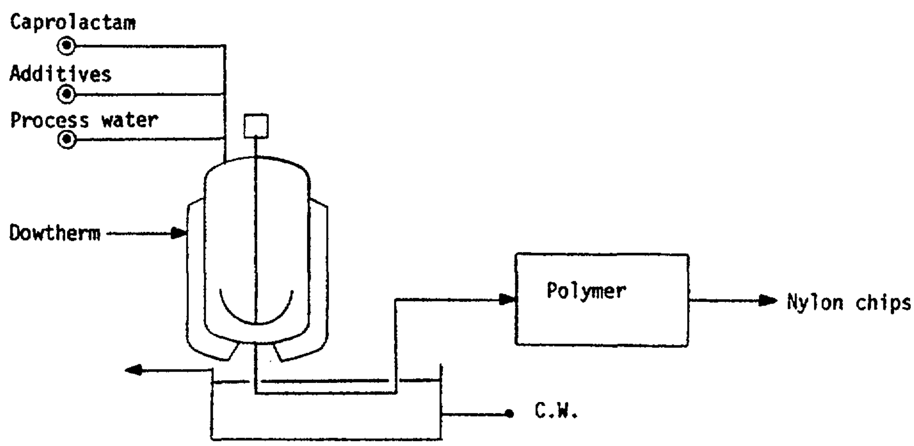
Process Description

Caprolactam and process water (up to 10 percent) are charged to an autoclave reactor. The vessel is purged with nitrogen, heated to 210°C and is pressurised to a maximum of 18 bar when polymerisation occurs. The pressure is maintained by bleeding steam. When the temperature rises to 270-280°C, the pressure is reduced to atmospheric after about 1 hour.

Pressure is reduced to below atmospheric (at the same temperature) when the unreacted monomers and oligomers (captrotriamide, cyclotriamide etc) are removed. The polymer product is finally removed by pressurising the vessel with nitrogen and extruding the polymer from the autoclave base. The polymer is quenched with water and cut into chips.

Uses

Major application is in fibre and film manufacture.



AUTOCLAVE
REACTOR

Plot area required for a 12 500 tonnes per year plant is around 1 000 square metres. Very small capacities are possible depending on the size and number of batches required.

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COST OF PRODUCTION ESTIMATE FOR NYLON-6
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - CAPROLACTAM

BASIS		CAPITAL COST	$ MILL
LOCATION-	BENELUX	BATTERY LIMITS	7.52
CAPACITY-	12 500 TONNES PER YEAR	OFFSITES	3.01
PRODUCTN-	12 500 TONNES PER YEAR		
YEAR -	1980	TOTAL FIXED INV.	10.53
STR.TIME-	8000 HOURS PER YEAR	WORKING	9.08

RAW MATERIALS	QUANTITY/TONNE		PRICE*	ANNUAL COST	UNIT* COST
CAPROLACTAM	1.1100	TONNE	1695.000	23 518 125	
TITANIUM DIOX	.0030	TONNE	1635.000	61 313	
CATALYST+CHEMS	10.0320	DOLLARS	1.000	125 400	
TOTAL RAW MATERIALS				23 704 837	1896.39
UTILITIES					
POWER	.1100	MWH	61.500	84 563	
COOLING WATER	.1400	KTONNE	17.000	29 750	
PROCESS WATER	.0020	KTONNE	230.000	5 750	
INERT GAS	13.0000	NM3	.085	13 813	
FUEL	2.3000	GCAL	18.100	520 375	
TOTAL UTILITIES COST				654 250	52.34
OPERATING COSTS					
LABOUR	10.00 MEN @ 17 700 $/YEAR			177 000	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR			29 200	
MAINTENANCE	@ .04×BLCC			300 870	
TOTAL OPERATING COST				507 070	40.57
OVERHEAD EXPENSES					
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION			82 480	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS			329 595	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP			157 957	
DEPRECIATION	@ .100× BLCC+ .050×OFFS			902 609	
INTEREST	@ .100× WORKING CAPITAL			908 234	
TOTAL OVERHEAD EXPENSES				2 380 875	190.47
BYPRODUCT CREDIT					
TOTAL BYPRODUCT CREDIT				0	.00
NET COST OF PRODUCTION				27 247 032	2179.76

VARIABLE COST OF PRODUCTION	1948.73
CASH COST OF PRODUCTION	2107.55
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	2264.01
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	2306.13
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV	2348.25

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR NYLON-6 CAPROLACTAM BENELUX LANG FACTOR 0.65

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	12500	12500	12500	12500	10000	7500	5000
PLANT OUTPUT	12500	10625	9375	7500	10000	7500	5000
CAPITAL COST — MILLION DOLLARS							
BLCC	7.5	7.5	7.5	7.5	6.5	5.4	4.1
OFFSITES	3.0	3.0	3.0	3.0	2.6	2.2	1.7
TOTAL FIXED	10.5	10.5	10.5	10.5	9.1	7.6	5.8
WORKING	9.1	7.8	7.0	5.7	7.3	5.6	3.8
DOLLARS PER TONNE PRODUCT - (BASED ON CAPROLACTAM AT $1695/TONNE)							
RAW MATERIALS	1896.4	1896.4	1896.4	1896.4	1896.4	1896.4	1896.4
UTILITIES	52.3	52.3	52.3	52.3	52.3	52.3	52.3
BYPROD. CREDIT	.0	.0	.0	.0	.0	.0	.0
VARIABLE COST	1948.7	1948.7	1948.7	1948.7	1948.7	1948.7	1948.7
OPERATION	40.6	47.7	54.1	67.6	46.6	56.3	74.4
OVERHEAD(EXCL.DEPN)	118.3	127.3	135.3	152.3	125.5	137.0	158.3
CASH COST	2107.6	2123.7	2138.1	2168.6	2120.9	2142.0	2181.4
DEPRECIATION	72.2	85.0	96.3	120.3	78.1	86.3	99.5
NET COST OF PRODN	2179.8	2208.7	2234.4	2289.0	2199.0	2228.3	2281.0
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	126.4	148.7	168.5	210.6	136.6	151.1	174.1
TRANSFER PRICE	2306.1	2357.3	2402.9	2499.6	2335.6	2379.4	2455.1

EFFECT OF CAPROLACTAM PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	2034.0	1356.0	2034.0	1356.0	2034.0	1356.0	2034.0	1356.0	2034.0	1356.0	2034.0	1356.0	2034.0	1356.0
NET COST OF PRODN	2556.1	1803.5	2585.0	1832.4	2610.7	1858.1	2665.3	1912.7	2575.3	1822.7	2604.6	1852.0	2657.2	1904.7
TRANSFER PRICE	2682.4	1929.8	2733.6	1981.1	2779.2	2026.6	2875.9	2123.3	2711.9	1959.3	2755.7	2003.1	2031.4	2078.8

How to Start Manufacturing Industries

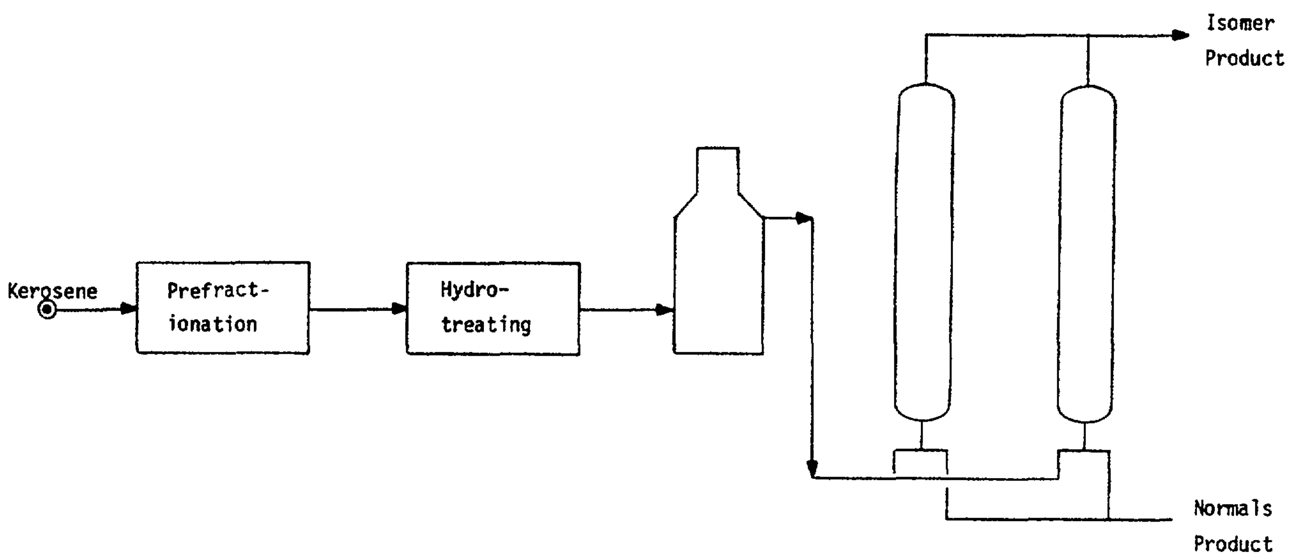
PARAFFINS RECOVERY

Process Description

This is a three stage process: prefractionation, hydrotreating, and separation of n-paraffins. Kerosene in the 160-285^{o}C boiling range is prefractionated to give a stream in the desired range of carbon numbers. This stream is passed through a hydrotreater to remove sulphur. Separation of n-paraffin is carried out in the vapour phase at 175^{o}C. At least three adsorbers are used, one adsorbing, one purifying and one desorbing using hexane as a desorbent.

Uses

Uses are as plasticisers in PVC (polyvinyl chloride) production, in polyethylene sealants. The other application is in LAB, SAS manufacture for use as detergents.



ISOSIV SECTION

Land area required for an actual plant processing 5 200 barrels per day of paraffins is approximately 3 000 square metres. Capacities as low as 10 000 tonnes per year are technically feasible.

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Any inquiry about the information contained should be sent to: IO/COOP, Registry file No. ID/562/12, UNIDO, P.O. Box 300, A-1400, Vienna, Austria.

COST OF PRODUCTION ESTIMATE FOR PARAFFINS RECOVERY
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - UCC PROCESS

BASIS	CAPITAL COST	$ MILL
LOCATION- BENELUX	BATTERY LIMITS	13.40
CAPACITY- 40 000 TONNES PER YEAR	OFFSITES	5.40
PRODUCTN- 40 000 TONNES PER YEAR		
YEAR - 1980	TOTAL FIXED INV.	18.80
STR.TIME- 8000 HOURS PER YEAR	WORKING	1.74

RAW MATERIALS	QUANTITY/TONNE	PRICE*	ANNUAL COST	UNIT* COST
PARAFFIN FEED	0000 TONNE	1.000	0	
TOTAL RAW MATERIALS			0	.00
UTILITIES				
POWER	.0388 MWH	61.500	95 448	
COOLING WATER	.7800 KTONNE	17.000	530 400	
L.P.STEAM	.7800 TONNE	16.700	521 040	
FUEL	1.1980 GCAL	18.100	867 352	
TOTAL UTILITIES COST			2 014 240	50.36
OPERATING COSTS				
LABOUR	5.00 MEN @ 17 700 $/YEAR		88 500	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR		29 200	
MAINTENANCE	@ .04×BLCC		536 000	
TOTAL OPERATING COST			653 700	16.34
OVERHEAD EXPENSES				
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION		47 080	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS		424 905	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP		282 000	
DEPRECIATION	@ .100× BLCC+ .050×OFFS		1 610 000	
INTEREST	@ .100× WORKING CAPITAL		173 515	
TOTAL OVERHEAD EXPENSES			2 537 500	63.44
BYPRODUCT CREDIT				
TOTAL BYPRODUCT CREDIT			0	.00
NET COST OF PRODUCTION			5 205 440	130.14

VARIABLE COST OF PRODUCTION	50.36
CASH COST OF PRODUCTION	89.89
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	177.14
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	200.64
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV	224.14

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR PARAFFINS RECOVERY UCC PROCESS BENELUX LANG FACTOR 0.65

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	40000	40000	40000	40000	32000	24000	16000
PLANT OUTPUT	40000	34000	30000	24000	32000	24000	16000
CAPITAL COST — MILLION DOLLARS							
BLCC	13.4	13.4	13.4	13.4	11.6	9.6	7.4
OFFSITES	5.4	5.4	5.4	5.4	4.7	3.9	3.0
TOTAL FIXED	18.8	18.8	18.8	18.8	16.3	13.5	10.4
WORKING	1.7	1.6	1.6	1.5	1.5	1.2	.9
DOLLARS PER TONNE PRODUCT - (BASED ON PARAFFIN FEED AT $1/TONNE)							
RAW MATERIALS	.0	.0	.0	.0	.0	.0	.0
UTILITIES	50.4	50.4	50.4	50.4	50.4	50.4	50.4
BYPROD. CREDIT	.0	.0	.0	.0	.0	.0	.0
VARIABLE COST	50.4	50.4	50.4	50.4	50.4	50.4	50.4
OPERATION	16.3	19.2	21.8	27.2	18.2	20.9	25.8
OVERHEAD(EXCL.DEPN)	23.2	27.0	30.3	37.5	25.5	28.9	35.0
CASH COST	89.9	96.6	102.5	115.1	94.0	100.2	111.2
DEPRECIATION	40.2	47.4	53.7	67.1	43.5	48.1	55.5
NET COST OF PRODN	130.1	143.9	156.2	182.2	137.5	148.4	166.6
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	70.5	82.9	94.0	117.5	76.2	84.3	97.2
TRANSFER PRICE	200.6	226.8	250.2	299.7	213.8	232.7	263.8

EFFECT OF PARAFFIN FEED PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	1.2	.8	1.2	.8	1.2	.8	1.2	.8	1.2	.8	1.2	.8	1.2	.8
NET COST OF PRODN	130.1	130.1	143.9	143.9	156.2	156.2	182.2	182.2	137.5	137.5	148.4	148.4	166.6	166.6
TRANSFER PRICE	200.6	200.6	226.8	226.8	250.2	250.2	299.7	299.7	213.8	213.8	232.7	232.7	263.8	263.8

PHENOL

Process Description

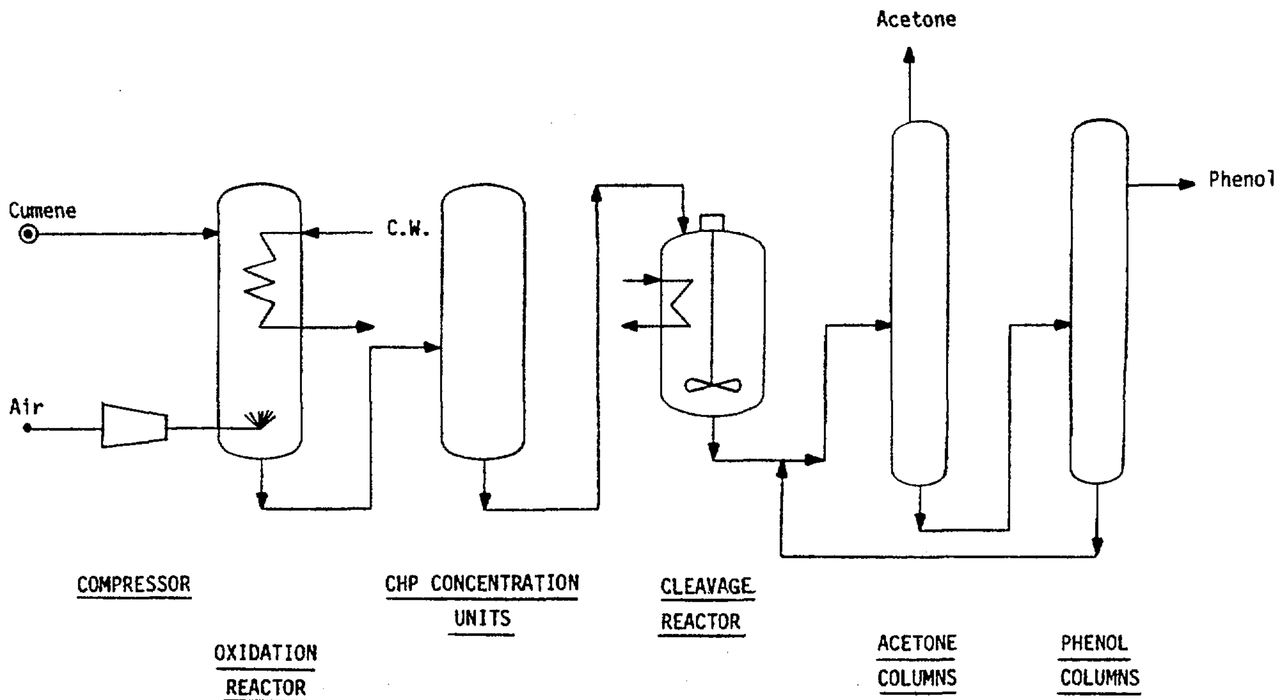
Cumene is first oxidised with air to form cumene hydroperoxide. The oxidation is carried out at 7 bar and at a temperature of 100°C. The cumene hydroperoxide is then concentrated to about 80 weight percent in a two stage fractionation. The concentrated product is cooled to 60°C and fed directly to the cleavage reactor where the cumene hydroperoxide is rapidly decomposed to yield phenol and acetone.

The cleavage mixture then passes through a three-column system where pure acetone is produced as the final overhead, and the bottoms stream containing α-methylstyrene, cumene and phenol is sent to the phenol recovery unit.

The process efficiencies are 95 percent for cumene oxidation to cumene hydroperoxide and 95 percent for cumene hydroperioxide cleavage to phenol.

Uses

The most important use of phenol is for phenolic resins. Other much smaller uses are in the manufacture of bisphenol-A, alkylphenols, and caprolactam.



An actual plot area for a 8 000 tonnes per year plant is 32 500 square metres, which is a typical modern capacity. However capacities as small as 25 000 tonnes per year are also in operation.

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COST OF PRODUCTION ESTIMATE FOR PHENOL
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - VIA CUMENE

BASIS		CAPITAL COST	$ MILL
LOCATION-	BENELUX	BATTERY LIMITS	85.00
CAPACITY-	200 000 TONNES PER YEAR	OFFSITES	40.80
PRODUCTN-	200 000 TONNES PER YEAR		
YEAR	- 1980	TOTAL FIXED INV.	125.80
STR.TIME-	8000 HOURS PER YEAR	WORKING	45.55

RAW MATERIALS	QUANTITY/TONNE	PRICE*	ANNUAL COST	UNIT* COST
PROPYLENE	.5773 TONNE	480.000	55 420 800	
BENZENE	.9334 TONNE	590.000	110 141 200	
CATALYST+CHEMS	18.0000 DOLLARS	1.000	3 600 000	
TOTAL RAW MATERIALS			169 162 000	845.81
UTILITIES				
POWER	.3270 MWH	61.500	4 022 100	
COOLING WATER	.2930 KTONNE	17.000	996 200	
L.P.STEAM	4.8000 TONNE	16.700	16 032 000	
FUEL	2.3300 GCAL	18.100	8 434 600	
TOTAL UTILITIES COST			29 484 900	147.42
OPERATING COSTS				
LABOUR	28.00 MEN @ 17 700 $/YEAR		495 600	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR		29 200	
MAINTENANCE	@ .04×BLCC		3 400 000	
TOTAL OPERATING COST			3 924 800	19.62
OVERHEAD EXPENSES				
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION		209 920	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS		2 551 120	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP		1 887 000	
DEPRECIATION	@ .100× BLCC+ .050×OFFS		10 540 000	
INTEREST	@ .100× WORKING CAPITAL		4 555 115	
TOTAL OVERHEAD EXPENSES			19 743 155	98.72
BYPRODUCT CREDIT				
ACETONE	¯.6210 TONNE	625.000	¯77 625 000	
FUEL	¯2.2200 GCAL	18.100	¯8 036 400	
TOTAL BYPRODUCT CREDIT			¯85 661 400	¯428.31
NET COST OF PRODUCTION			136 653 455	683.27

VARIABLE COST OF PRODUCTION	564.93
CASH COST OF PRODUCTION	630.57
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	746.17
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	777.62
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV	809.07

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR PHENOL VIA CUMENE BENELUX LANG FACTOR 0.65

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	200000	200000	200000	200000	160000	120000	80000
PLANT OUTPUT	200000	170000	150000	120000	160000	120000	80000
CAPITAL COST — MILLION DOLLARS							
BLCC	85.0	85.0	85.0	85.0	73.5	61.0	46.9
OFFSITES	40.8	40.8	40.8	40.8	35.3	29.3	22.5
TOTAL FIXED	125.8	125.8	125.8	125.8	108.8	90.3	69.3
WORKING	45.6	39.7	35.8	30.0	36.9	28.2	19.4
DOLLARS PER TONNE PRODUCT - (BASED ON PROPYLENE AT $480/TONNE)							
RAW MATERIALS	845.8	845.8	845.8	845.8	845.8	845.8	845.8
UTILITIES	147.4	147.4	147.4	147.4	147.4	147.4	147.4
BYPROD. CREDIT	¯428.3	¯428.3	¯428.3	¯428.3	¯428.3	¯428.3	¯428.3
VARIABLE COST	564.9	564.9	564.9	564.9	564.9	564.9	564.9
OPERATION	19.6	23.1	26.2	32.7	21.7	24.7	30.0
OVERHEAD(EXCL.DEPN)	46.0	50.7	54.9	63.7	48.7	52.6	59.3
CASH COST	630.6	638.7	646.0	661.3	635.3	642.2	654.3
DEPRECIATION	52.7	62.0	70.3	87.8	57.0	63.0	72.6
NET COST OF PRODN	683.3	700.7	716.2	749.2	692.2	705.2	726.9
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	94.3	111.0	125.8	157.3	102.0	112.8	130.0
TRANSFER PRICE	777.6	811.7	842.0	906.4	794.3	818.1	856.9

EFFECT OF PROPYLENE PRICE VARIATION

	1	1	2	2	3	3	4	4	5	5	6	6	7	7
PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	576.0	384.0	576.0	384.0	576.0	384.0	576.0	384.0	576.0	384.0	576.0	384.0	576.0	384.0
NET COST OF PRODN	738.7	627.8	756.1	645.3	771.6	660.8	804.6	693.8	747.7	636.8	760.7	649.8	782.3	671.5
TRANSFER PRICE	833.0	722.2	867.1	756.3	897.4	786.6	961.8	851.0	849.7	738.8	873.5	762.6	912.3	801.5

File: G53
ISIC 3511

How to Start Manufacturing Industries

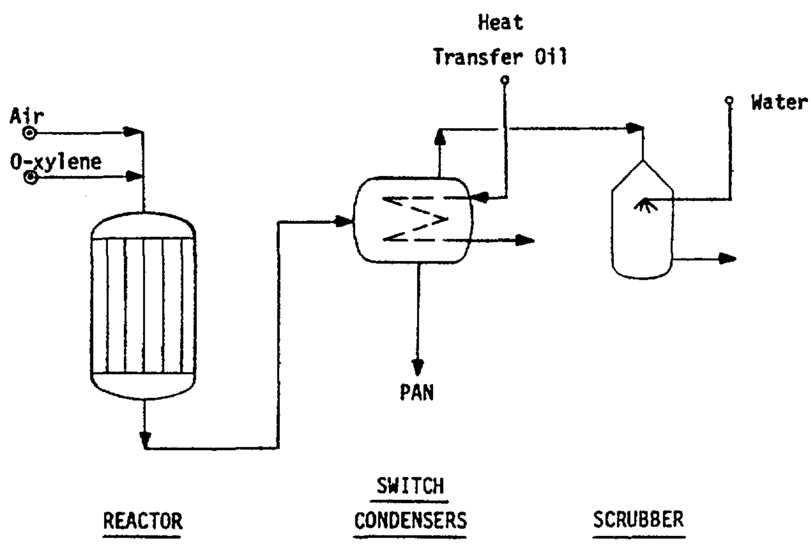
PHTHALIC ANHYDRIDE (XYLENE OXIDATION)

Process Description

Pressurised air at 3 bar is mixed with o-xylene vapour and is fed to a packed tube reactor. There are 32 tonnes of air per tonne of xylene. This keeps the mixture outside the upper explosive limit. The product gases are passed through switch condensers where the phthalic anhydride (PAN) product collected. When sufficient PAN has condensed, this condenser is isolated and the PAN is melted off.

Uses

These include plasticiser manufacture (dioctyl phthalate), alkyd resins (paints etc), unsaturated polyester resins. Other uses are in the preparation of dyes, pharmaceuticals and in the tanning industry.



Plot area for a plant having 90 000 tonnes per year capacity would be approximately 15 000 square metres. The smallest feasible capacity built in Europe is 5 000 tonnes per year.

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COST OF PRODUCTION ESTIMATE FOR PHTHALIC ANHYDRIDE
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - XYLENE OXIDATION

BASIS		CAPITAL COST	$ MILL
LOCATION-	BENELUX	BATTERY LIMITS	46.38
CAPACITY-	90 000 TONNES PER YEAR	OFFSITES	12.54
PRODUCTN-	90 000 TONNES PER YEAR		
YEAR -	1980	TOTAL FIXED INV.	58.92
STR.TIME-	8000 HOURS PER YEAR	WORKING	21.01

RAW MATERIALS	QUANTITY/TONNE	PRICE*	ANNUAL COST	UNIT* COST
O-XYLENE	.9700 TONNE	550.000	48 015 000	
CATALYST+CHEMS	34.4444 DOLLARS	1.000	3 100 000	
TOTAL RAW MATERIALS			51 115 000	567.94
UTILITIES				
POWER	1.0580 MWH	61.500	5 856 030	
COOLING WATER	.0500 KTONNE	17.000	76 500	
BLR.FEED WATER	.0070 KTONNE	450.000	283 500	
TOTAL UTILITIES COST			6 216 030	69.07
OPERATING COSTS				
LABOUR	23.00 MEN @ 17 700 $/YEAR		407 100	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR		29 200	
MAINTENANCE	@ .04×BLCC		1 855 362	
TOTAL OPERATING COST			2 291 662	25.46
OVERHEAD EXPENSES				
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION		174 520	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS		1 489 581	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP		883 804	
DEPRECIATION	@ .100× BLCC+ .050×OFFS		5 265 217	
INTEREST	@ .100× WORKING CAPITAL		2 101 304	
TOTAL OVERHEAD EXPENSES			9 914 426	110.16
BYPRODUCT CREDIT				
STEAM	-3.8000 TONNE	19.000	-6 498 000	
TOTAL BYPRODUCT CREDIT			-6 498 000	-72.20
NET COST OF PRODUCTION			63 039 119	700.43

VARIABLE COST OF PRODUCTION	564.81
CASH COST OF PRODUCTION	641.93
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	765.90
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	798.64
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV	831.37

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR PHTHALIC ANHYDRIDE XYLENE OXIDATION BENELUX LANG FACTOR 0.65

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	90000	90000	90000	90000	72000	54000	36000
PLANT OUTPUT	90000	76500	67500	54000	72000	54000	36000
CAPITAL COST — MILLION DOLLARS							
BLCC	46.4	46.4	46.4	46.4	40.1	33.3	25.6
OFFSITES	12.5	12.5	12.5	12.5	10.8	9.0	6.9
TOTAL FIXED	58.9	58.9	58.9	58.9	51.0	42.3	32.5
WORKING	21.0	18.4	16.6	14.0	17.1	13.1	9.1
DOLLARS PER TONNE PRODUCT - (BASED ON O-XYLENE AT $550/TONNE)							
RAW MATERIALS	567.9	567.9	567.9	567.9	567.9	567.9	567.9
UTILITIES	69.1	69.1	69.1	69.1	69.1	69.1	69.1
BYPROD. CREDIT	-72.2	-72.2	-72.2	-72.2	-72.2	-72.2	-72.2
VARIABLE COST	564.8	564.8	564.8	564.8	564.8	564.8	564.8
OPERATION	25.5	30.0	34.0	42.4	28.3	32.7	40.5
OVERHEAD(EXCL.DEPN)	51.7	57.3	62.4	73.1	55.2	60.5	69.9
CASH COST	641.9	652.1	661.1	680.4	648.3	658.1	675.3
DEPRECIATION	58.5	68.8	78.0	97.5	63.3	70.0	80.6
NET COST OF PRODN	700.4	720.9	739.2	777.9	711.6	728.0	755.9
RETURN ON INVESTMENT	98.2	115.5	130.9	163.7	106.2	117.4	135.3
(AT 15% ON TOTAL FIXED INVESTMENT)							
TRANSFER PRICE	798.6	836.5	870.1	941.5	817.8	845.4	891.2

EFFECT OF O-XYLENE PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	660.0	440.0	660.0	440.0	660.0	440.0	660.0	440.0	660.0	440.0	660.0	440.0	660.0	440.0
NET COST OF PRODN	807.1	593.7	827.6	614.2	845.9	632.5	884.6	671.2	818.3	604.9	834.7	621.3	862.6	649.2
TRANSFER PRICE	905.3	691.9	943.2	729.8	976.8	763.4	1048.2	834.8	924.5	711.1	952.1	738.7	997.9	784.5

How to Start Manufacturing Industries

POLYBUTADIENE RUBBER (BR)

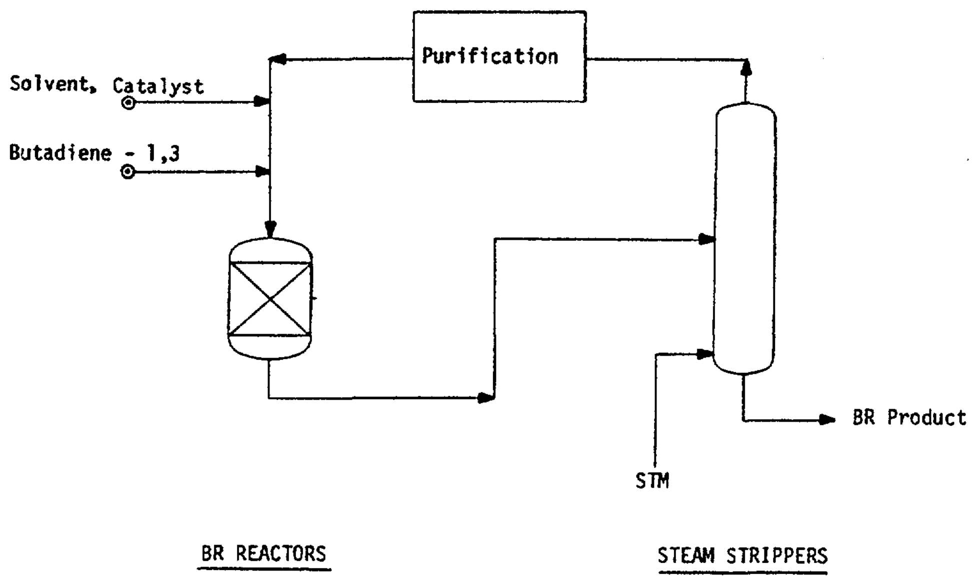
Process Description

Butadiene-1,3 together with solvent and catalyst are mixed and passed to the first of a series of polymerisation reactors, where the butadiene polymerises exothermically.

When oil extended types of BR are produced, oil is metered into the polymer cement and passed to steam strippers for converting the cement to a slurry. Vapours from the stripping are condensed and recycled for purification.

Uses

Both BR and SBR are used extensively in tyre manufacture. The use of BR in the manufacture of high impact polystyrene is also a growth area.



Land area for a 30 000 tonnes per year BR plant is approximately 3 000 square metres. Smallest size is 7 000 tonnes per year.

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COST OF PRODUCTION ESTIMATE FOR POLYBUTADIENE
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - HIGH-CIS

BASIS		CAPITAL COST	$ MILL
LOCATION-	BENELUX	BATTERY LIMITS	27.58
CAPACITY-	30 000 TONNES PER YEAR	OFFSITES	13.79
PRODUCTN-	30 000 TONNES PER YEAR		
YEAR	- 1980	TOTAL FIXED INV.	41.37
STR.TIME-	8000 HOURS PER YEAR	WORKING	13.91

RAW MATERIALS	QUANTITY/TONNE	PRICE*	ANNUAL COST	UNIT* COST
BUTADIENE	1.1300 TONNE	690.000	23 391 000	
CATALYST+CHEMS	125.3333 DOLLARS	1.000	3 760 000	
TOTAL RAW MATERIALS			27 151 000	905.03
UTILITIES				
POWER	.6500 MWH	61.500	1 199 250	
COOLING WATER	.0050 KTONNE	17.000	2 550	
MP.STEAM	8.3000 TONNE	19.200	4 780 800	
TOTAL UTILITIES COST			5 982 600	199.42
OPERATING COSTS				
LABOUR	35.00 MEN @ 17 700 $/YEAR		619 500	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR		29 200	
MAINTENANCE	@ .04×BLCC		1 103 188	
TOTAL OPERATING COST			1 751 888	58.40
OVERHEAD EXPENSES				
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION		259 480	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS		1 138 727	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP		620 543	
DEPRECIATION	@ .100× BLCC+ .050×OFFS		3 447 464	
INTEREST	@ .100× WORKING CAPITAL		1 391 438	
TOTAL OVERHEAD EXPENSES			6 857 653	228.59
BYPRODUCT CREDIT				
TOTAL BYPRODUCT CREDIT			0	.00
NET COST OF PRODUCTION			41 743 141	1391.44

VARIABLE COST OF PRODUCTION	1104.45
CASH COST OF PRODUCTION	1276.52
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	1529.34
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	1598.29
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV	1667.24

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR POLYBUTADIENE HIGH-CIS BENELUX LANG FACTOR 0.65

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	30000	30000	30000	30000	24000	18000	12000
PLANT OUTPUT	30000	25500	22500	18000	24000	18000	12000
CAPITAL COST — MILLION DOLLARS							
BLCC	27.6	27.6	27.6	27.6	23.9	19.8	15.2
OFFSITES	13.8	13.8	13.8	13.8	11.9	9.9	7.6
TOTAL FIXED	41.4	41.4	41.4	41.4	35.8	29.7	22.8
WORKING	13.9	12.2	11.1	9.3	11.4	8.8	6.1
DOLLARS PER TONNE PRODUCT - (BASED ON BUTADIENE AT $690/TONNE)							
RAW MATERIALS	905.0	905.0	905.0	905.0	905.0	905.0	905.0
UTILITIES	199.4	199.4	199.4	199.4	199.4	199.4	199.4
BYPROD. CREDIT	.0	.0	.0	.0	.0	.0	.0
VARIABLE COST	1104.5	1104.5	1104.5	1104.5	1104.5	1104.5	1104.5
OPERATION	58.4	68.7	77.9	97.3	66.8	80.0	104.7
OVERHEAD(EXCL.DEPN)	113.7	127.0	138.9	164.1	123.9	139.9	169.4
CASH COST	1276.5	1300.2	1321.2	1365.8	1295.1	1324.3	1378.6
DEPRECIATION	114.9	135.2	153.2	191.5	124.3	137.4	158.4
NET COST OF PRODN	1391.4	1435.4	1474.4	1557.4	1419.4	1461.8	1537.0
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	206.8	243.4	275.8	344.7	223.7	247.3	285.1
TRANSFER PRICE	1598.3	1678.7	1750.2	1902.1	1643.0	1709.1	1822.0

EFFECT OF BUTADIENE PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	828.0	552.0	828.0	552.0	828.0	552.0	828.0	552.0	828.0	552.0	828.0	552.0	828.0	552.0
NET COST OF PRODN	1547.4	1235.5	1591.3	1279.4	1630.3	1318.5	1713.3	1401.4	1575.3	1263.5	1617.7	1305.8	1692.9	1381.1
TRANSFER PRICE	1754.2	1442.3	1834.7	1522.8	1906.1	1594.3	2058.1	1746.2	1799.0	1487.1	1865.0	1553.2	1978.0	1666.1

How to Start Manufacturing Industries

POLYETHYLENE LOW DENSITY (LDPE) - TUBULAR REACTOR

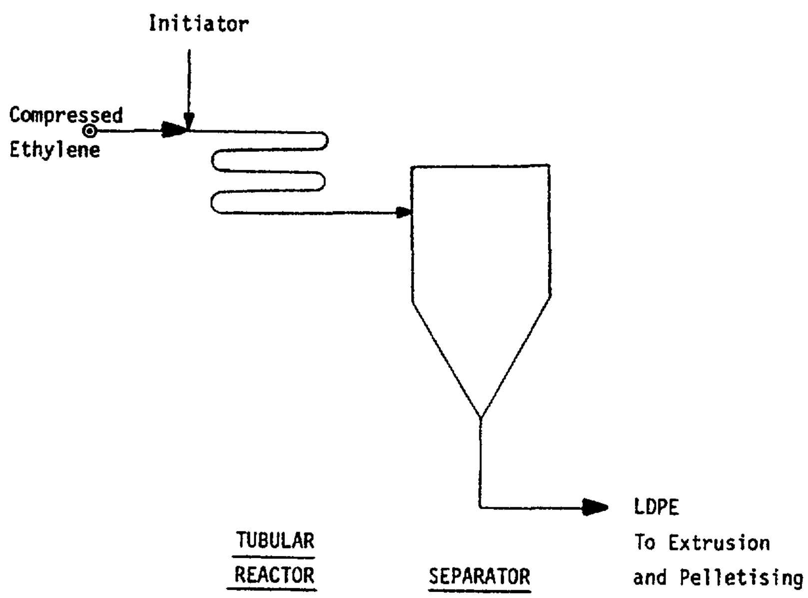
Process Description

Ethylene is compressed from up to 3 500 bar and combined with the oxygen or air as initiator (0.05-2.0 tonne initiator per tonne LDPE), then passed to a serpentine jacketed nickel/chromium tube, jacketed with carbon steel. Conversions of 20-25 percent per pass are obtained Plug flow gives a narrow molecular weight distribution of the polymer.

Polymer is separated from the ethylene at 340 bar where 90 percent of the ethylene is removed. The molten LDPE is extruded and pelletised.

Uses

Polyethylene is tough, has moisture resistance and is resistant to chemicals. It can be blow moulded or injection moulded. It is used in film and sheet manufacture, in wire and cable and in tube and pipe manufacture.



Plot area for a 100 000 tonnes per year is approximately 25 000 square metres. The smallest technically feasible capacity is 40 000 tonnes per year in Europe.

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COST OF PRODUCTION ESTIMATE FOR POLYETHYLENE - LDPE
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - TUBULAR SINGLE STR

BASIS	CAPITAL COST	$ MILL
LOCATION- BENELUX	BATTERY LIMITS	57.00
CAPACITY- 120 000 TONNES PER YEAR	OFFSITES	39.00
PRODUCTN- 120 000 TONNES PER YEAR		
YEAR - 1980	TOTAL FIXED INV.	96.00
STR.TIME- 8000 HOURS PER YEAR	WORKING	39.54

RAW MATERIALS	QUANTITY/TONNE		PRICE*	ANNUAL COST	UNIT* COST
ETHYLENE	1.0250	TONNE	750.000	92 250 000	
HYDROGEN	.0001	TONNE	1100.000	13 200	
CATALYST+CHEMS	5.0000	DOLLARS	1.000	600 000	
TOTAL RAW MATERIALS				92 863 200	773.86
UTILITIES					
POWER	.8000	MWH	61.500	5 904 000	
COOLING WATER	.2000	KTONNE	17.000	408 000	
MP.STEAM	.1000	TONNE	19.200	230 400	
LP.STEAM	.3000	TONNE	16.700	601 200	
PROCESS WATER	.0001	KTONNE	230.000	2 760	
TOTAL UTILITIES COST				7 146 360	59.55
OPERATING COSTS					
LABOUR	48.00 MEN @ 17 700 $/YEAR			849 600	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR			29 200	
MAINTENANCE	@ .04×BLCC			2 280 000	
TOTAL OPERATING COST				3 158 800	26.32
OVERHEAD EXPENSES					
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION			351 520	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS			2 053 220	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP			1 440 000	
DEPRECIATION	@ .100× BLCC+ .050×OFFS			7 650 000	
INTEREST	@ .100× WORKING CAPITAL			3 953 900	
TOTAL OVERHEAD EXPENSES				15 448 640	128.74
BYPRODUCT CREDIT					
TOTAL BYPRODUCT CREDIT				0	.00
NET COST OF PRODUCTION				118 617 000	988.47

VARIABLE COST OF PRODUCTION	833.41
CASH COST OF PRODUCTION	924.72
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	1068.47
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	1108.47
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV	1148.47

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR POLYETHYLENE - LDPE TUBULAR SINGLE STR BENELUX LANG FACTOR 0.65

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	120000	120000	120000	120000	96000	72000	48000
PLANT OUTPUT	120000	102000	90000	72000	96000	72000	48000
CAPITAL COST MILLION DOLLARS							
BLCC	57.0	57.0	57.0	57.0	49.3	40.9	31.4
OFFSITES	39.0	39.0	39.0	39.0	33.7	28.0	21.5
TOTAL FIXED	96.0	96.0	96.0	96.0	83.0	68.9	52.9
WORKING	39.5	34.4	30.9	25.7	32.0	24.5	16.9
DOLLARS PER TONNE PRODUCT - (BASED ON ETHYLENE AT $750/TONNE)							
RAW MATERIALS	773.9	773.9	773.9	773.9	773.9	773.9	773.9
UTILITIES	59.6	59.6	59.6	59.6	59.6	59.6	59.6
BYPROD. CREDIT	.0	.0	.0	.0	.0	.0	.0
VARIABLE COST	833.4	833.4	833.4	833.4	833.4	833.4	833.4
OPERATION	26.3	31.0	35.1	43.9	29.7	34.9	44.5
OVERHEAD(EXCL.DEPN)	65.0	71.4	77.1	89.2	69.3	76.0	87.9
CASH COST	924.7	935.8	945.6	966.4	932.4	944.3	965.8
DEPRECIATION	63.8	75.0	85.0	106.3	68.9	76.2	87.9
NET COST OF PRODN	988.5	1010.8	1030.6	1072.7	1001.4	1020.5	1053.7
RETURN ON INVESTMENT	120.0	141.2	160.0	200.0	129.7	143.5	165.4
(AT 15% ON TOTAL FIXED INVESTMENT)							
TRANSFER PRICE	1108.5	1151.9	1190.6	1272.7	1131.1	1164.0	1219.0

EFFECT OF ETHYLENE PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	900.0	600.0	900.0	600.0	900.0	600.0	900.0	600.0	900.0	600.0	900.0	600.0	900.0	600.0
NET COST OF PRODN	1142.2	834.7	1164.5	857.0	1184.3	876.8	1226.4	918.9	1155.1	847.6	1174.3	866.8	1207.4	899.9
TRANSFER PRICE	1262.2	954.7	1305.7	998.2	1344.3	1036.8	1426.4	1118.9	1284.9	977.4	1317.8	1010.3	1372.8	1065.3

How to Start Manufacturing Industries

POLYETHYLENE LOW DENSITY (LDPE) - AUTOCLAVE REACTOR

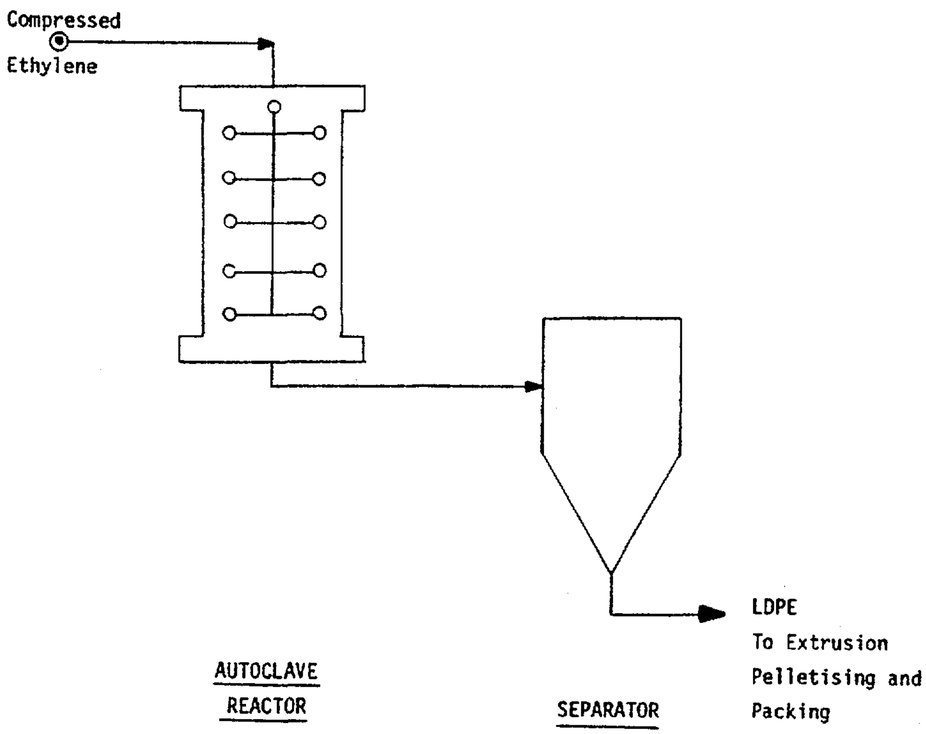
Process Description

Ethylene is compressed to a reaction pressure of 1 500 bar, initiated with air or oxygen and passed to an autoclave reactor. This has an L/D ratio of 10/1. Lower conversions of 15-20 percent per pass at residence terms of 30 seconds to 2 minutes. Molecular weight distributions tailored to specific needs are possible.

Separation sequence is similar to the tubular reactor apart from the difference that more ethylene is recycled due to the low conversion.

Uses

Polyethylene is tough, has moisture resistance and is resistant to chemicals. It can be blow moulded or injection moulded. It is used in film and sheet manufacture, in wire and cable and in tube and pipe manufacture.



Plot area for a 100 000 tonnes per year is approximately 25 000 square metres. The smallest technically feasible capacity is 40 000 tonnes per year in Europe.

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COST OF PRODUCTION ESTIMATE FOR POLYETHYLENE - LDPE
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - AUTOCLAVE SINGLE STR

BASIS	CAPITAL COST	$ MILL
LOCATION- BENELUX	BATTERY LIMITS	48.00
CAPACITY- 100 000 TONNES PER YEAR	OFFSITES	33.00
PRODUCTN- 100 000 TONNES PER YEAR		
YEAR - 1980	TOTAL FIXED INV.	81.00
STR.TIME- 8000 HOURS PER YEAR	WORKING	33.18

RAW MATERIALS	QUANTITY/TONNE		PRICE*	ANNUAL COST	UNIT* COST
ETHYLENE	1.0150	TONNE	750.000	76 125 000	
HYDROGEN	.0010	TONNE	1100.000	110 000	
CATALYST+CHEMS	11.0000	DOLLARS	1.000	1 100 000	
TOTAL RAW MATERIALS				77 335 000	773.35
UTILITIES					
POWER	.8500	MWH	61.500	5 227 500	
COOLING WATER	.2000	KTONNE	17.000	340 000	
MP.STEAM	.1000	TONNE	19.200	192 000	
LP.STEAM	.3000	TONNE	16.700	501 000	
PROCESS WATER	.0001	KTONNE	230.000	2 300	
TOTAL UTILITIES COST				6 262 800	62.63
OPERATING COSTS					
LABOUR	48.00 MEN @ 17 700 $/YEAR			849 600	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR			29 200	
MAINTENANCE	@ .04×BLCC			1 920 000	
TOTAL OPERATING COST				2 798 800	27.99
OVERHEAD EXPENSES					
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION			351 520	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS			1 819 220	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP			1 215 000	
DEPRECIATION	@ .100× BLCC+ .050×OFFS			6 450 000	
INTEREST	@ .100× WORKING CAPITAL			3 318 357	
TOTAL OVERHEAD EXPENSES				13 154 097	131.54
BYPRODUCT CREDIT					
TOTAL BYPRODUCT CREDIT				0	.00
NET COST OF PRODUCTION				99 550 697	995.51

VARIABLE COST OF PRODUCTION	835.98
CASH COST OF PRODUCTION	931.01
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	1076.51
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	1117.01
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV	1157.51

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR POLYETHYLENE - LDPE AUTOCLAVE SINGLE STRBENELUX LANG FACTOR 0.65

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	100000	100000	100000	100000	80000	60000	40000
PLANT OUTPUT	100000	85000	75000	60000	80000	60000	40000
CAPITAL COST — **MILLION DOLLARS**							
BLCC	48.0	48.0	48.0	48.0	41.5	34.4	26.5
OFFSITES	33.0	33.0	33.0	33.0	28.5	23.7	18.2
TOTAL FIXED	81.0	81.0	81.0	81.0	70.1	58.1	44.7
WORKING	33.2	28.9	26.0	21.7	26.9	20.6	14.2
DOLLARS PER TONNE PRODUCT - (BASED ON ETHYLENE AT $750/TONNE)							
RAW MATERIALS	773.3	773.3	773.3	773.3	773.3	773.3	773.3
UTILITIES	62.6	62.6	62.6	62.6	62.6	62.6	62.6
BYPROD. CREDIT	.0	.0	.0	.0	.0	.0	.0
VARIABLE COST	836.0	836.0	836.0	836.0	836.0	836.0	836.0
OPERATION	28.0	32.9	37.3	46.6	31.7	37.6	48.4
OVERHEAD(EXCL.DEPN)	67.0	73.8	79.8	92.5	71.8	79.2	92.5
CASH COST	931.0	942.7	953.1	975.1	939.5	952.7	976.9
DEPRECIATION	64.5	75.9	86.0	107.5	69.7	77.1	88.9
NET COST OF PRODN	995.5	1018.6	1039.1	1082.6	1009.3	1029.9	1065.8
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	121.5	142.9	162.0	202.5	131.4	145.3	167.4
TRANSFER PRICE	1117.0	1161.5	1201.1	1285.1	1140.6	1175.2	1233.3

EFFECT OF ETHYLENE PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	900.0	600.0	900.0	600.0	900.0	600.0	900.0	600.0	900.0	600.0	900.0	600.0	900.0	600.0
NET COST OF PRODN	1147.8	843.3	1170.8	866.3	1191.3	886.8	1234.9	930.4	1161.5	857.0	1182.1	877.6	1218.1	913.6
TRANSFER PRICE	1269.3	964.8	1313.8	1009.3	1353.3	1048.8	1437.4	1132.9	1292.9	988.4	1327.4	1022.9	1385.5	1081.0

How to Start Manufacturing Industries

POLYETHYLENE HIGH DENSITY (HDPE) - SLURRY PROCESS

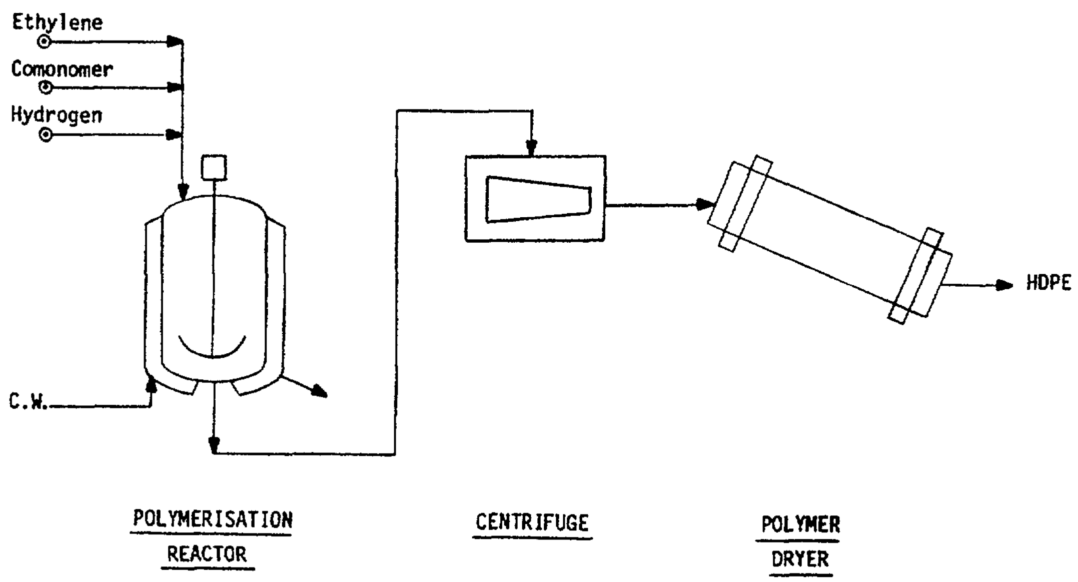
Process Description

Catalysts consisting of a mixture of alkylaluminium chlorides and alkyltitanium chlorides, plus ethylene, diluent (hexane or cyclohexane), and comonomer (when required), hydrogen (for molecular weight control) are charged to the reactor. Ethylene conversion is 40-50 percent at 60-80°C and 3-5 bar at a residence time of one-two hours.

The polymer slurry is flashed, and deactivated, by treating with alcohol and then with water. After catalyst removal, the polymer slurry is centrifuged, and washed. The effluent from the centrifuge is fractionated to recover the hexane or cyclohexane. The polymer cake is dried and pelletised.

Uses

Polyethylene is tough, has moisture resistance and is resistant to chemicals. It can be blow moulded or injection moulded. It is used in film and sheet manufacture, in wire and cable and in tube and pipe manufacture.



The land area occupied by a 60 000 tonnes per year plant is 12 000 square metres. The smallest capacity technically feasible is 30 000 tonnes per year.

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COST OF PRODUCTION ESTIMATE FOR POLYETHYLENE - HDPE
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - SLURRY

BASIS	CAPITAL COST	$ MILL
LOCATION- BENELUX	BATTERY LIMITS	38.86
CAPACITY- 60 000 TONNES PER YEAR	OFFSITES	15.54
PRODUCTN- 60 000 TONNES PER YEAR		
YEAR - 1980	TOTAL FIXED INV.	54.41
STR.TIME- 8000 HOURS PER YEAR	WORKING	21.69

RAW MATERIALS	QUANTITY/TONNE	PRICE*	ANNUAL COST	UNIT* COST
ETHYLENE	1.0400 TONNE	750.000	46 800 000	
CATALYST+CHEMS	38.3333 DOLLARS	1.000	2 300 000	
TOTAL RAW MATERIALS			49 100 000	818.33
UTILITIES				
POWER	.5000 MWH	61.500	1 845 000	
COOLING WATER	.1500 KTONNE	17.000	153 000	
HP.STEAM	1.1000 TONNE	20.200	1 333 200	
PROCESS WATER	.0011 KTONNE	230.000	15 180	
TOTAL UTILITIES COST			3 346 380	55.77
OPERATING COSTS				
LABOUR	65.00 MEN @ 17 700 $/YEAR		1 150 500	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR		29 200	
MAINTENANCE	@ .04×BLCC		1 554 493	
TOTAL OPERATING COST			2 734 193	45.57
OVERHEAD EXPENSES				
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION		471 880	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS		1 777 225	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP		816 109	
DEPRECIATION	@ .100× BLCC+ .050×OFFS		4 663 478	
INTEREST	@ .100× WORKING CAPITAL		2 169 285	
TOTAL OVERHEAD EXPENSES			9 897 977	164.97
BYPRODUCT CREDIT				
TOTAL BYPRODUCT CREDIT			0	.00
NET COST OF PRODUCTION			65 078 550	1084.64
VARIABLE COST OF PRODUCTION				874.11
CASH COST OF PRODUCTION				1006.92
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV				1175.32
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV				1220.66
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV				1266.00

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR POLYETHYLENE - HDPE SLURRY BENELUX LANG FACTOR 0.65

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	60000	60000	60000	60000	48000	36000	24000
PLANT OUTPUT	60000	51000	45000	36000	48000	36000	24000
CAPITAL COST MILLION DOLLARS							
BLCC	38.9	38.9	38.9	38.9	33.6	27.9	21.4
OFFSITES	15.5	15.5	15.5	15.5	13.4	11.2	8.6
TOTAL FIXED	54.4	54.4	54.4	54.4	47.1	39.0	30.0
WORKING	21.7	19.0	17.2	14.5	17.7	13.7	9.6
DOLLARS PER TONNE PRODUCT - (BASED ON ETHYLENE AT $750/TONNE)							
RAW MATERIALS	818.3	818.3	818.3	818.3	818.3	818.3	818.3
UTILITIES	55.8	55.8	55.8	55.8	55.8	55.8	55.8
BYPROD. CREDIT	.0	.0	.0	.0	.0	.0	.0
VARIABLE COST	874.1	874.1	874.1	874.1	874.1	874.1	874.1
OPERATION	45.6	53.6	60.8	75.9	52.6	63.7	84.9
OVERHEAD(EXCL.DEPN)	87.2	97.3	106.3	125.3	95.6	108.8	133.6
CASH COST	1006.9	1025.0	1041.1	1075.4	1022.3	1046.7	1092.5
DEPRECIATION	77.7	91.4	103.6	129.5	84.0	92.9	107.1
NET COST OF PRODN	1084.6	1116.5	1144.8	1204.9	1106.3	1139.6	1199.6
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	136.0	160.0	181.4	226.7	147.1	162.6	187.4
TRANSFER PRICE	1220.7	1276.5	1326.1	1431.6	1253.4	1302.2	1387.1

EFFECT OF ETHYLENE PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	900.0	600.0	900.0	600.0	900.0	600.0	900.0	600.0	900.0	600.0	900.0	600.0	900.0	600.0
NET COST OF PRODN	1240.6	928.6	1272.5	960.5	1300.8	988.8	1360.9	1048.9	1262.3	950.3	1295.6	983.6	1355.6	1043.6
TRANSFER PRICE	1376.7	1064.7	1432.5	1120.5	1482.1	1170.1	1507.6	1275.6	1409.4	1097.4	1458.2	1146.2	1543.1	1231.1

How to Start Manufacturing Industries

POLYETHYLENE HIGH DENSITY (HDPE) - GAS PHASE PROCESS

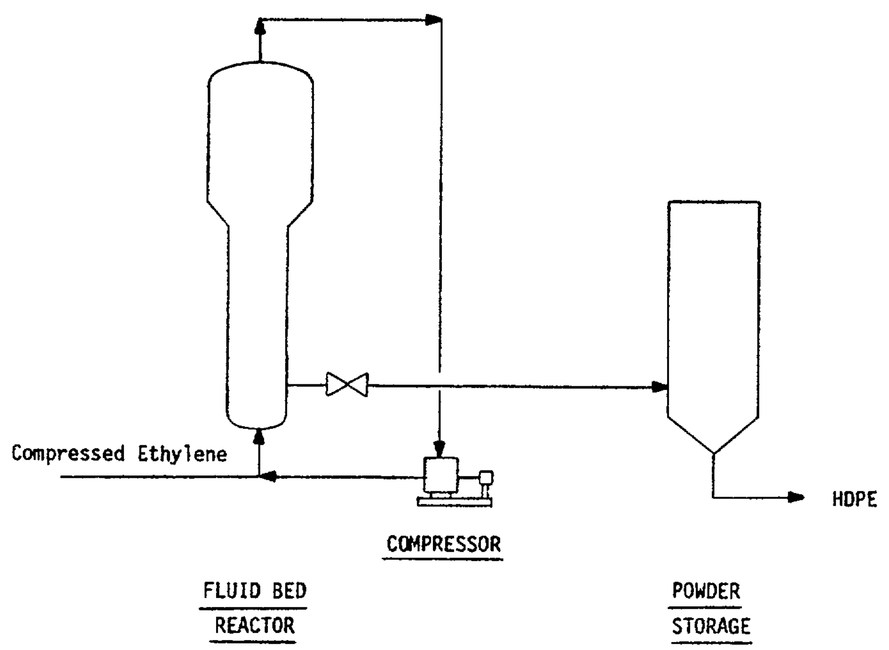
Process Description

Pure ethylene is fed to a fluidised bed of polymer particles maintained at 85-105^{o}C and 20 bar according to the polymer grade. Catalyst (chromium on silica) is injected continuously. Conversions of 2-3 percent with an average residence time of 3-5 hours.

Separation is carried out by successive pressure letdowns. The HDPE in the form of a powder is separated and blended with small amounts of stabiliser for storage.

Uses

Polyethylene is tough, has moisture resistance and is resistant to chemicals. It can be blow moulded or injection moulded. It is used in film and sheet manufacture, in wire and cable and in tube and pipe manufacture.



The land area occupied by a 60 000 tonnes per year plant is 12 000 square metres. The smallest capacity technically feasible is 30 000 tonnes per year.

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COST OF PRODUCTION ESTIMATE FOR POLYETHYLENE - HDPE
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - GAS PHASE

BASIS	CAPITAL COST	$ MILL
LOCATION- BENELUX	BATTERY LIMITS	29.08
CAPACITY- 60 000 TONNES PER YEAR	OFFSITES	11.66
PRODUCTN- 60 000 TONNES PER YEAR		
YEAR - 1980	TOTAL FIXED INV.	40.74
STR.TIME- 8000 HOURS PER YEAR	WORKING	20.01

RAW MATERIALS	QUANTITY/TONNE	PRICE*	ANNUAL COST	UNIT* COST
ETHYLENE	1.0200 TONNE	750.000	45 900 000	
CATALYST+CHEMS	15.0000 DOLLARS	1.000	900 000	
TOTAL RAW MATERIALS			46 800 000	780.00
UTILITIES				
POWER	.7000 MWH	61.500	2 583 000	
COOLING WATER	.1500 KTONNE	17.000	153 000	
MP.STEAM	.2000 TONNE	19.200	230 400	
NITROGEN	86.0000 NM3	.085	438 600	
TOTAL UTILITIES COST			3 405 000	56.75
OPERATING COSTS				
LABOUR	48.00 MEN @ 17 700 $/YEAR		849 600	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR		29 200	
MAINTENANCE	@ .04×BLCC		1 163 362	
TOTAL OPERATING COST			2 042 162	34.04
OVERHEAD EXPENSES				
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION		351 520	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS		1 327 406	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP		611 141	
DEPRECIATION	@ .100× BLCC+ .050×OFFS		3 491 341	
INTEREST	@ .100× WORKING CAPITAL		2 000 985	
TOTAL OVERHEAD EXPENSES			7 782 393	129.71
BYPRODUCT CREDIT				
TOTAL BYPRODUCT CREDIT			0	.00
NET COST OF PRODUCTION			60 029 555	1000.49
VARIABLE COST OF PRODUCTION				836.75
CASH COST OF PRODUCTION				942.30
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV				1068.40
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV				1102.35
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV				1136.30

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR POLYETHYLENE - HDPE GAS PHASE BENELUX LANG FACTOR 0.65

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	60000	60000	60000	60000	48000	36000	24000
PLANT OUTPUT	60000	51000	45000	36000	48000	36000	24000
CAPITAL COST — MILLION DOLLARS							
BLCC	29.1	29.1	29.1	29.1	25.2	20.9	16.0
OFFSITES	11.7	11.7	11.7	11.7	10.1	8.4	6.4
TOTAL FIXED	40.7	40.7	40.7	40.7	35.2	29.2	22.5
WORKING	20.0	17.4	15.7	13.1	16.3	12.5	8.7
DOLLARS PER TONNE PRODUCT - (BASED ON ETHYLENE AT $750/TONNE)							
RAW MATERIALS	780.0	780.0	780.0	780.0	780.0	780.0	780.0
UTILITIES	56.7	56.7	56.7	56.7	56.7	56.7	56.7
BYPROD. CREDIT	.0	.0	.0	.0	.0	.0	.0
VARIABLE COST	836.7	836.7	836.7	836.7	836.7	836.7	836.7
OPERATION	34.0	40.0	45.4	56.7	39.3	47.6	63.3
OVERHEAD(EXCL.DEPN)	71.5	79.0	85.7	100.0	77.8	87.6	106.1
CASH COST	942.3	955.8	967.9	993.4	953.8	971.9	1006.2
DEPRECIATION	58.2	68.5	77.6	97.0	62.9	69.6	80.2
NET COST OF PRODN	1000.5	1024.3	1045.5	1090.4	1016.7	1041.5	1086.3
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	101.9	119.8	135.8	169.8	110.1	121.8	140.4
TRANSFER PRICE	1102.3	1144.1	1181.3	1260.2	1126.8	1163.3	1226.7

EFFECT OF ETHYLENE PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	900.0	600.0	900.0	600.0	900.0	600.0	900.0	600.0	900.0	600.0	900.0	600.0	900.0	600.0
NET COST OF PRODN	1153.5	847.5	1177.3	871.3	1198.5	892.5	1243.4	937.4	1169.7	863.7	1194.5	888.5	1239.3	933.3
TRANSFER PRICE	1255.3	949.3	1297.1	991.1	1334.3	1028.3	1413.2	1107.2	1279.8	973.8	1316.3	1010.3	1379.7	1073.7

How to Start Manufacturing Industries

POLYPROPYLENE - LIQUID PHASE PROCESS

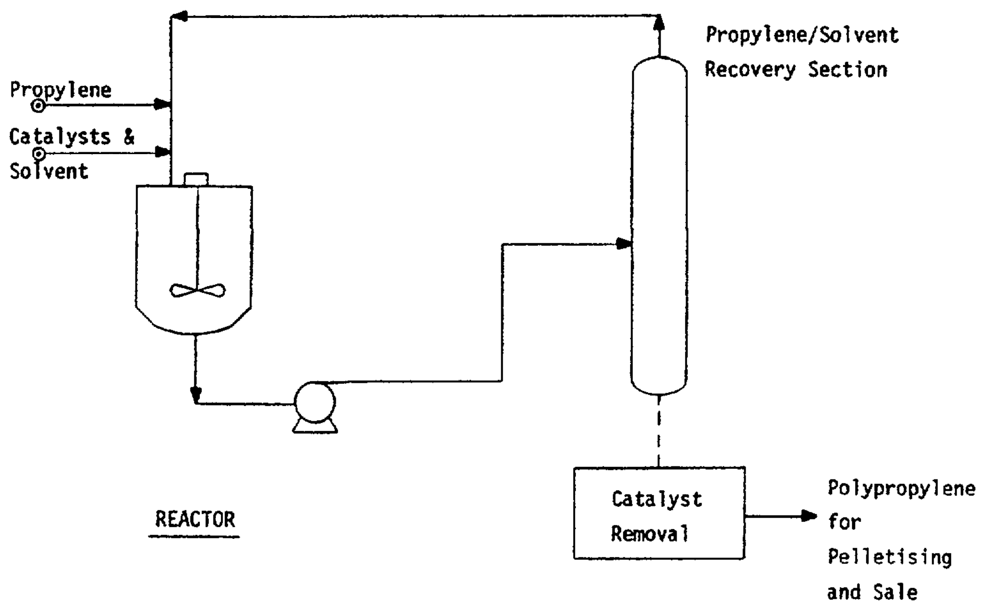
Process Description

Propylene gas of high purity (99.5 percent+) is fed to a reactor containing a solvent and catalyst, and polymerised in the liquid phase at 50-100°C and 1-10 atmospheres to form polypropylene.

The polypropylene is insoluble and precipitates as a fine granular solid. The polymer slurry is transferred to a stripping tank where unreacted propylene is flushed off and recycled. The catalyst is removed by dissolution in methanol and the resultant polypropylene is pelletised and packaged.

Uses

Polypropylene competes to some extent with high density polyethylene. It is used for a wide variety of mouldings, pipe and conduit, wire and cable insulation, fibre and filaments and film for packaging and bags.



Land area required for a typical plant of 90 000 ton per year capacity is approximately 20 000 square metres. This includes space for control room, intermediate powder storage, pellestising and final storage. The minimum feasible capacity of plant from a technical point of view could be as small as 5 000 tonnes per year. A typical modern capacity is however 90 000 ton per year.

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COST OF PRODUCTION ESTIMATE FOR POLYPROPYLENE
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - LIQ.PHASE,HI-YLD CAT

BASIS		CAPITAL COST	$ MILL
LOCATION-	BENELUX	BATTERY LIMITS	40.17
CAPACITY-	90 000 TONNES PER YEAR	OFFSITES	15.92
PRODUCTN-	90 000 TONNES PER YEAR		
YEAR -	1980	TOTAL FIXED INV.	56.09
STR.TIME-	8000 HOURS PER YEAR	WORKING	25.27

RAW MATERIALS	QUANTITY/TONNE	PRICE*	ANNUAL COST	UNIT* COST
PROPYLENE	1.0800 TONNE	480.000	46 656 000	
ADDITIVES	12.5000 DOLLARS	1.000	1 125 000	
CATALYST+CHEMS	50.0000 DOLLARS	1.000	4 500 000	
TOTAL RAW MATERIALS			52 281 000	580.90
UTILITIES				
POWER	.7300 MWH	61.500	4 040 550	
COOLING WATER	.2000 KTONNE	17.000	306 000	
MP.STEAM	3.3000 TONNE	19.200	5 702 400	
PROCESS WATER	.0290 KTONNE	230.000	600 300	
INERT GAS	32.0000 NM3	.085	244 800	
TOTAL UTILITIES COST			10 894 050	121.04
OPERATING COSTS				
LABOUR	48.00 MEN @ 17 700 $/YEAR		849 600	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR		29 200	
MAINTENANCE	@ .04×BLCC		1 606 800	
TOTAL OPERATING COST			2 485 600	27.62
OVERHEAD EXPENSES				
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION		351 520	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS		1 615 640	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP		841 350	
DEPRECIATION	@ .100× BLCC+ .050×OFFS		4 813 000	
INTEREST	@ .100× WORKING CAPITAL		2 526 971	
TOTAL OVERHEAD EXPENSES			10 148 481	112.76
BYPRODUCT CREDIT				
TOTAL BYPRODUCT CREDIT			0	.00
NET COST OF PRODUCTION			75 809 131	842.32

VARIABLE COST OF PRODUCTION	701.94
CASH COST OF PRODUCTION	788.85
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	904.65
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	935.81
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV	966.97

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR POLYPROPYLENE LIQ.PHASE,HI-YLD CATBENELUX LANG FACTOR 0.65

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	90000	90000	90000	90000	72000	54000	36000
PLANT OUTPUT	90000	76500	67500	54000	72000	54000	36000
CAPITAL COST — MILLION DOLLARS							
BLCC	40.2	40.2	40.2	40.2	34.7	28.8	22.1
OFFSITES	15.9	15.9	15.9	15.9	13.8	11.4	8.8
TOTAL FIXED	56.1	56.1	56.1	56.1	48.5	40.2	30.9
WORKING	25.3	22.0	19.8	16.6	20.5	15.7	10.9
DOLLARS PER TONNE PRODUCT - (BASED ON PROPYLENE AT $480/TONNE)							
RAW MATERIALS	580.9	580.9	580.9	580.9	580.9	580.9	580.9
UTILITIES	121.0	121.0	121.0	121.0	121.0	121.0	121.0
BYPROD. CREDIT	.0	.0	.0	.0	.0	.0	.0
VARIABLE COST	701.9	701.9	701.9	701.9	701.9	701.9	701.9
OPERATION	27.6	32.5	36.8	46.0	31.5	37.6	49.0
OVERHEAD(EXCL.DEPN)	59.3	65.5	71.0	82.7	64.0	71.3	84.8
CASH COST	788.8	799.9	809.7	830.6	797.4	810.9	835.8
DEPRECIATION	53.5	62.9	71.3	89.1	57.8	63.9	73.7
NET COST OF PRODN	842.3	862.8	881.0	919.8	855.3	874.8	909.5
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	93.5	110.0	124.6	155.8	101.1	111.8	128.8
TRANSFER PRICE	935.8	972.8	1005.7	1075.6	956.3	986.6	1038.3

EFFECT OF PROPYLENE PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	576.0	384.0	576.0	384.0	576.0	384.0	576.0	384.0	576.0	384.0	576.0	384.0	576.0	384.0
NET COST OF PRODN	946.0	738.6	966.5	759.1	984.7	777.4	1023.5	816.1	958.9	751.6	978.5	771.1	1013.2	805.8
TRANSFER PRICE	1039.5	832.1	1076.5	869.1	1109.4	902.0	1179.3	971.9	1060.0	852.7	1090.3	882.9	1142.0	934.6

How to Start Manufacturing Industries

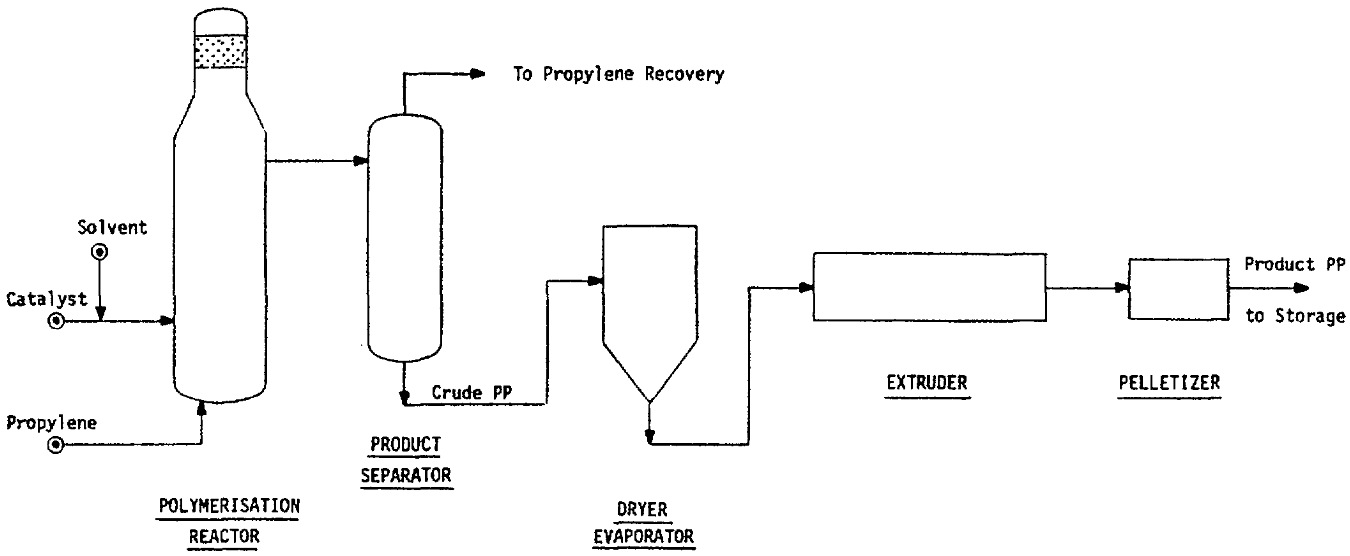
POLYPROPYLENE - VAPOUR PHASE POLYMERISATION (BASF)

Process Description

The basic catalyst, dry $TiCl_3$, $^1/_3$ $AlCl_3$ is blended and milled with triphenylphosphine oxide (10:1.67 molar ratio) to form a fixed particle size. Fresh and recycle propylene plus catalyst is fed to the first of the polymerisation reactors. These contain a bed of powdered polypropylene, kept in a fluidised state by vapourised propylene feed. Conditions for the reaction are 26.5 bar and 70^{0}C. The final step is the pellet manufacture. The crude polypropylene is separated from unreacted propylene then introduced into the extruder. Product polypropylene leaves the extruder and is pelletised and conveyed to the storage section. Unlike the liquid phase process, the solvents are not recovered or recycled.

Uses

Polypropylene competes to some extent with high density polyethylene. It is used for a wide variety of mouldings, pipe and conduit, wire and cable insulation, fibre and filaments and film for packaging and bags.



Land area required for a typical plant of 90 000 ton per year capacity is approximately 20 000 square metres. This includes space for control room, intermediate powder storage, pellestising and final storage. The minimum feasible capacity of plant from a technical point of view could be as small as 5 000 tonnes per year. A typical modern capacity is however 90 000 ton per year.

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COST OF PRODUCTION ESTIMATE FOR POLYPROPYLENE
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - VAPOUR PHASE

BASIS	CAPITAL COST	$ MILL
LOCATION- BENELUX	BATTERY LIMITS	41.88
CAPACITY- 90 000 TONNES PER YEAR	OFFSITES	18.86
PRODUCTN- 90 000 TONNES PER YEAR		
YEAR - 1980	TOTAL FIXED INV.	60.74
STR.TIME- 8000 HOURS PER YEAR	WORKING	23.33

RAW MATERIALS	QUANTITY/TONNE	PRICE*	ANNUAL COST	UNIT* COST
PROPYLENE	1.0960 TONNE	480.000	47 347 200	
ADDITIVES	12.5000 DOLLARS	1.000	1 125 000	
CATALYST+CHEMS	50.0000 DOLLARS	1.000	4 500 000	
TOTAL RAW MATERIALS			52 972 200	588.58
UTILITIES				
POWER	.5500 MWH	61.500	3 044 250	
COOLING WATER	.0960 KTONNE	17.000	146 880	
MP.STEAM	.6100 TONNE	19.200	1 054 080	
INERT GAS	21.0000 NM3	.085	160 650	
TOTAL UTILITIES COST			4 405 860	48.95
OPERATING COSTS				
LABOUR	39.00 MEN @ 17 700 $/YEAR		690 300	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR		29 200	
MAINTENANCE	@ .04×BLCC		1 675 200	
TOTAL OPERATING COST			2 394 700	26.61
OVERHEAD EXPENSES				
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION		287 800	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS		1 556 555	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP		911 100	
DEPRECIATION	@ .100× BLCC+ .050×OFFS		5 131 000	
INTEREST	@ .100× WORKING CAPITAL		2 333 076	
TOTAL OVERHEAD EXPENSES			10 219 531	113.55
BYPRODUCT CREDIT				
TOTAL BYPRODUCT CREDIT			0	.00
NET COST OF PRODUCTION			69 992 291	777.69
VARIABLE COST OF PRODUCTION				637.53
CASH COST OF PRODUCTION				720.68
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV				845.18
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV				878.93
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV				912.67

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR POLYPROPYLENE VAPOUR PHASE BENELUX LANG FACTOR 0.65

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	90000	90000	90000	90000	72000	54000	36000
PLANT OUTPUT	90000	76500	67500	54000	72000	54000	36000
CAPITAL COST — MILLION DOLLARS							
BLCC	41.9	41.9	41.9	41.9	36.2	30.0	23.1
OFFSITES	18.9	18.9	18.9	18.9	16.3	13.5	10.4
TOTAL FIXED	60.7	60.7	60.7	60.7	52.5	43.6	33.5
WORKING	23.3	20.4	18.4	15.4	19.0	14.6	10.1
DOLLARS PER TONNE PRODUCT - (BASED ON PROPYLENE AT $480/TONNE)							
RAW MATERIALS	588.6	588.6	588.6	588.6	588.6	588.6	588.6
UTILITIES	49.0	49.0	49.0	49.0	49.0	49.0	49.0
BYPROD. CREDIT	.0	.0	.0	.0	.0	.0	.0
VARIABLE COST	637.5	637.5	637.5	637.5	637.5	637.5	637.5
OPERATION	26.6	31.3	35.5	44.3	30.1	35.6	45.6
OVERHEAD(EXCL.DEPN)	56.5	62.6	68.1	79.6	60.9	67.5	79.7
CASH COST	720.7	731.5	741.1	761.5	728.5	740.6	762.8
DEPRECIATION	57.0	67.1	76.0	95.0	61.6	68.2	78.6
NET COST OF PRODN	777.7	798.5	817.1	856.5	790.2	808.8	841.4
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	101.2	119.1	135.0	168.7	109.5	121.1	139.5
TRANSFER PRICE	878.9	917.6	952.1	1025.2	899.6	929.9	980.9

EFFECT OF PROPYLENE PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	576.0	384.0	576.0	384.0	576.0	384.0	576.0	384.0	576.0	384.0	576.0	384.0	576.0	384.0
NET COST OF PRODN	882.9	672.5	903.8	693.3	922.3	711.9	961.7	751.3	895.4	684.9	914.0	703.6	946.6	736.2
TRANSFER PRICE	984.1	773.7	1022.9	812.4	1057.3	846.8	1130.4	920.0	1004.8	794.4	1035.1	824.6	1086.1	875.7

How to Start Manufacturing Industries

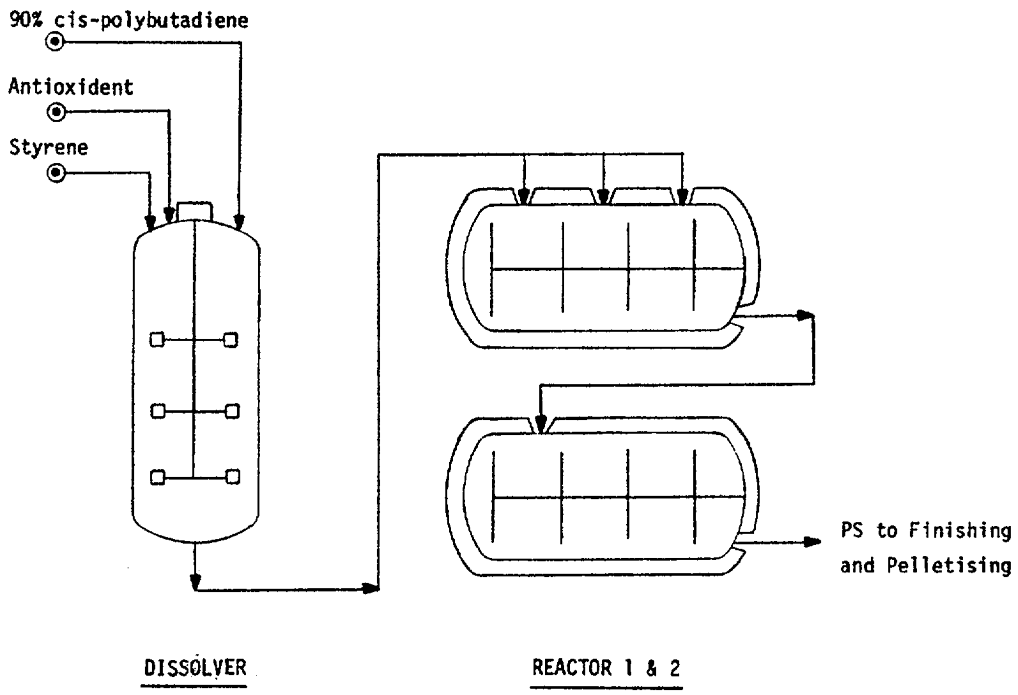
POLYSTYRENE

Styrene, ethylbenzene and cis-polybutadiene (for high impact grade) are added and kept in a dissolver for 6-8 hours to ensure a complete dissolution of the rubber. This mixture is filtered and fed to the first of two reactors maintained at 112°C where the conversion is 8.7 (maintaining the solution beyond the phase inversion point). In the second reactor, 95 percent of the styrene is converted by the end of the reaction, when the temperature has risen to about 165°C.

Polymerisation is completed in a finishing column held at 220°C for 1-2 hours followed by cooling, extrusion and pelletising.

Uses

Expanded foam polystyrene has excellent properties of heat insulation and buoyancy in water. High impact polystyrene is generally modified with rubber to provide greater shock resistance since the homopolymer is brittle.



Plot area of 20 000 square metres is required for a plant producing 100 000 tonnes per year of polystyrene. Plants as small as 20 000 tonnes per year are also technically feasible.

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COST OF PRODUCTION ESTIMATE FOR POLYSTYRENE
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - SOLUTION POLYMN

BASIS	CAPITAL COST	$ MILL
LOCATION- BENELUX	BATTERY LIMITS	40.12
CAPACITY- 100 000 TONNES PER YEAR	OFFSITES	16.05
PRODUCTN- 100 000 TONNES PER YEAR		
YEAR - 1980	TOTAL FIXED INV.	56.16
STR.TIME- 8000 HOURS PER YEAR	WORKING	33.31

RAW MATERIALS	QUANTITY/TONNE		PRICE*	ANNUAL COST	UNIT* COST
STYRENE	1.0500	TONNE	770.000	80 850 000	
CATALYST+CHEMS	12.5000	DOLLARS	1.000	1 250 000	
TOTAL RAW MATERIALS				82 100 000	821.00
UTILITIES					
POWER	.3330	MWH	61.500	2 047 950	
COOLING WATER	.0160	KTONNE	17.000	27 200	
HP.STEAM	1.3500	TONNE	20.200	2 727 000	
PROCESS WATER	.0080	KTONNE	230.000	184 000	
TOTAL UTILITIES COST				4 986 150	49.86
OPERATING COSTS					
LABOUR	32.00 MEN @ 17 700 $/YEAR			566 400	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR			29 200	
MAINTENANCE	@ .04×BLCC			1 604 638	
TOTAL OPERATING COST				2 200 238	22.00
OVERHEAD EXPENSES					
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION			238 240	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS			1 430 154	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP			842 435	
DEPRECIATION	@ .100× BLCC+ .050×OFFS			4 813 913	
INTEREST	@ .100× WORKING CAPITAL			3 331 418	
TOTAL OVERHEAD EXPENSES				10 656 161	106.56
BYPRODUCT CREDIT					
TOTAL BYPRODUCT CREDIT				0	.00
NET COST OF PRODUCTION				99 942 548	999.43

VARIABLE COST OF PRODUCTION	870.86
CASH COST OF PRODUCTION	951.29
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	1055.59
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	1083.67
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV	1111.75

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR POLYSTYRENE SOLUTION POLYMN BENELUX LANG FACTOR 0.65

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	100000	100000	100000	100000	80000	60000	40000
PLANT OUTPUT	100000	85000	75000	60000	80000	60000	40000
CAPITAL COST — MILLION DOLLARS							
BLCC	40.1	40.1	40.1	40.1	34.7	28.8	22.1
OFFSITES	16.0	16.0	16.0	16.0	13.9	11.5	8.8
TOTAL FIXED	56.2	56.2	56.2	56.2	48.6	40.3	31.0
WORKING	33.3	28.8	25.8	21.3	26.9	20.5	14.0
DOLLARS PER TONNE PRODUCT - (BASED ON STYRENE AT $770/TONNE)							
RAW MATERIALS	821.0	821.0	821.0	821.0	821.0	821.0	821.0
UTILITIES	49.9	49.9	49.9	49.9	49.9	49.9	49.9
BYPROD. CREDIT	.0	.0	.0	.0	.0	.0	.0
VARIABLE COST	870.9	870.9	870.9	870.9	870.9	870.9	870.9
OPERATION	22.0	25.9	29.3	36.7	24.8	29.1	37.0
OVERHEAD(EXCL.DEPN)	58.4	63.4	67.9	77.4	61.9	67.1	76.6
CASH COST	951.3	960.2	968.1	984.9	957.5	967.1	984.5
DEPRECIATION	48.1	56.6	64.2	80.2	52.0	57.6	66.3
NET COST OF PRODN	999.4	1016.8	1032.3	1065.1	1009.6	1024.7	1050.9
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	84.2	99.1	112.3	140.4	91.1	100.7	116.1
TRANSFER PRICE	1083.7	1115.9	1144.6	1205.5	1100.6	1125.4	1166.9

EFFECT OF STYRENE PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	924.0	616.0	924.0	616.0	924.0	616.0	924.0	616.0	924.0	616.0	924.0	616.0	924.0	616.0
NET COST OF PRODN	1161.1	837.7	1178.5	855.1	1194.0	870.6	1226.8	903.4	1171.3	847.9	1186.4	863.0	1212.6	889.2
TRANSFER PRICE	1245.4	922.0	1277.6	954.2	1306.3	982.9	1367.2	1043.8	1262.3	938.9	1287.1	963.7	1320.6	1005.2

How to Start Manufacturing Industries

PVC - SUSPENSION POLYMERISATION

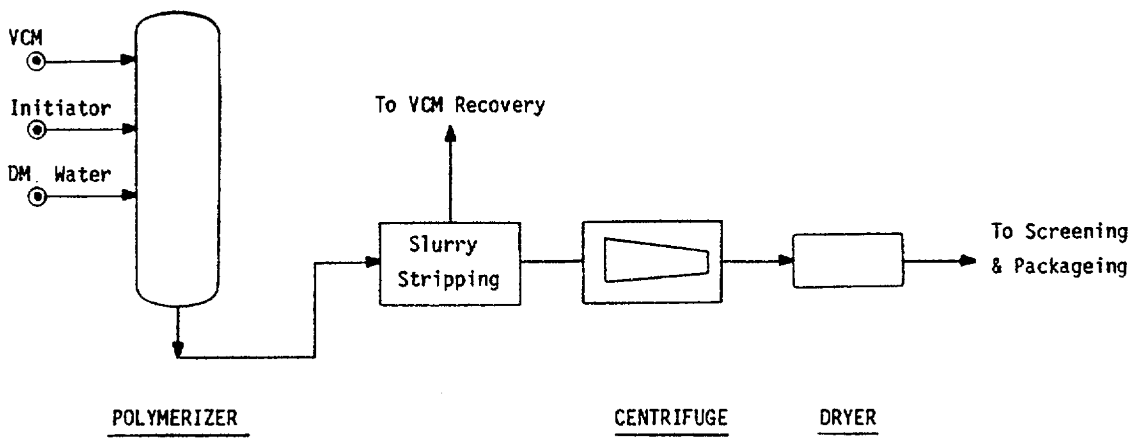
Process Description

Polyvinyl chloride is prepared commercially by the free-radical initiated polymerisation of vinyl chloride. In the suspension process; deionised water, suspending agents and vinyl chloride monomer (99 wt percent min) are charged into the polymeriser. The contents, are heated up to 56°C before adding the initiator emulsion.

A conversion of 90 percent is usually achieved after a reaction time of 6-8 hours. Unreacted monomer is stripped off and sent to the monomer recovery system. Stripped PVC slurry is dewatered by using a centrifuge. The PVC cake is dried and screened to remove oversize resin before packing.

Uses

It is the leading material for wire and cable insulation. Other applications are garden hose, gaskets, and welting for shoes, upholstery, and automobiles. Film and sheeting account for a substantial share of the vinyl resin produced.



Plot area required for a 90 000 tonnes per year plant is approximately 20 000 square metres. Capacities as low as 2 000 tonnes per year have been built in Europe. However, sizes much smaller than this are also feasible.

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COST OF PRODUCTION ESTIMATE FOR PIPE-GRADE PVC RESIN
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - SUSPENSION POLYMN.

BASIS		CAPITAL COST	$ MILL
LOCATION-	BENELUX	BATTERY LIMITS	35.10
CAPACITY-	90 000 TONNES PER YEAR	OFFSITES	15.20
PRODUCTN-	90 000 TONNES PER YEAR		
YEAR -	1980	TOTAL FIXED INV.	50.30
STR.TIME-	8000 HOURS PER YEAR	WORKING	25.17

RAW MATERIALS	QUANTITY/TONNE	PRICE*	ANNUAL COST	UNIT* COST
VINYL CHLORIDE	1.0250 TONNE	630.000	58 117 500	
CATALYST+CHEMS	13.3333 DOLLARS	1.000	1 200 000	
TOTAL RAW MATERIALS			59 317 500	659.08
UTILITIES				
POWER	.4000 MWH	61.500	2 214 000	
COOLING WATER	.0500 KTONNE	17.000	76 500	
LP.STEAM	1.3500 TONNE	16.700	2 029 050	
PROCESS WATER	.0270 KTONNE	230.000	558 900	
INERT GAS	12.0000 NM3	.085	91 800	
TOTAL UTILITIES COST			4 970 250	55.22
OPERATING COSTS				
LABOUR	36.00 MEN @ 17 700 $/YEAR		637 200	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR		29 200	
MAINTENANCE	@ .04×BLCC		1 404 000	
TOTAL OPERATING COST			2 070 400	23.00
OVERHEAD EXPENSES				
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION		266 560	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS		1 345 760	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP		754 500	
DEPRECIATION	@ .100× BLCC+ .050×OFFS		4 270 000	
INTEREST	@ .100× WORKING CAPITAL		2 517 068	
TOTAL OVERHEAD EXPENSES			9 153 888	101.71
BYPRODUCT CREDIT				
TOTAL BYPRODUCT CREDIT			0	.00
NET COST OF PRODUCTION			75 512 038	839.02
VARIABLE COST OF PRODUCTION				714.31
CASH COST OF PRODUCTION				791.58
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV				894.91
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV				922.86
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV				950.80

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR PIPE-GRADE PVC RESINSUSPENSION POLYMN. BENELUX LANG FACTOR 0.72

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	90000	90000	90000	90000	72000	54000	36000
PLANT OUTPUT	90000	76500	67500	54000	72000	54000	36000
CAPITAL COST — MILLION DOLLARS							
BLCC	35.1	35.1	35.1	35.1	29.9	24.3	18.1
OFFSITES	15.2	15.2	15.2	15.2	12.9	10.5	7.9
TOTAL FIXED	50.3	50.3	50.3	50.3	42.8	34.8	26.0
WORKING	25.2	21.8	19.6	16.3	20.4	15.5	10.6
DOLLARS PER TONNE PRODUCT - (BASED ON VINYL CHLORIDE AT $630/TONNE)							
RAW MATERIALS	659.1	659.1	659.1	659.1	659.1	659.1	659.1
UTILITIES	55.2	55.2	55.2	55.2	55.2	55.2	55.2
BYPROD. CREDIT	.0	.0	.0	.0	.0	.0	.0
VARIABLE COST	714.3	714.3	714.3	714.3	714.3	714.3	714.3
OPERATION	23.0	27.1	30.7	38.3	25:9	30.3	38.7
OVERHEAD(EXCL.DEPN)	54.3	59.5	64.1	74.0	57.7	63.1	73.0
CASH COST	791.6	800.9	809.1	826.7	797.9	807.7	825.9
DEPRECIATION	47.4	55.8	63.3	79.1	50.5	54.7	61.3
NET COST OF PRODN	839.0	856.7	872.4	905.7	848.4	862.5	887.3
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	83.8	98.6	111.8	139.7	89.2	96.7	108.4
TRANSFER PRICE	922.9	955.3	984.2	1045.5	937.6	959.2	995.6

EFFECT OF VINYL CHLORIDE PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	756.0	504.0	756.0	504.0	756.0	504.0	756.0	504.0	756.0	504.0	756.0	504.0	756.0	504.0
NET COST OF PRODN	968.2	709.9	985.8	727.5	1001.5	743.2	1034.9	776.6	977.5	719.2	991.6	733.3	1016.4	758.1
TRANSFER PRICE	1052.0	793.7	1084.5	826.2	1113.3	855.0	1174.6	916.3	1066.8	808.5	1088.3	830.0	1124.8	866.5

PROPYLENE OXIDE - CHLOROHYDRIN PROCESS

Process Description

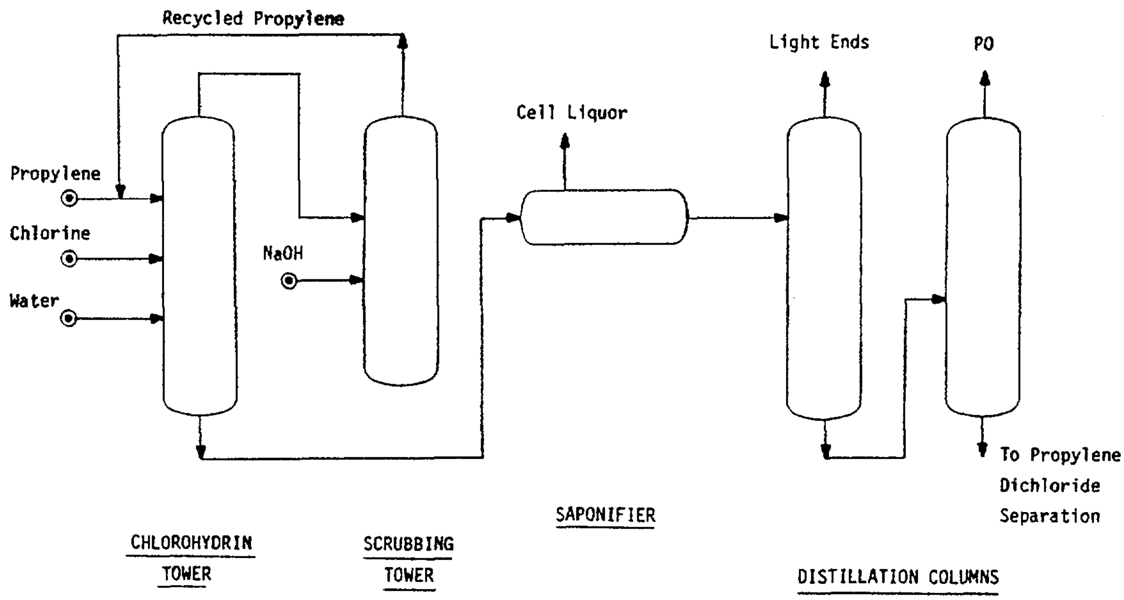
This description is for a chlorohydrin plant integrated with a caustic/chlorine plant.

Propylene chlorine and water are introduced into a reactor tower, which operates at slightly below atmospheric pressure and at a temperature of 38^{0}C, the molar ratio of the feeds is so chosen that the liquid effluent contains 3 to 4 percent propylene chlorohydrin. Unreacted propylene, on leaving the top of the tower, are scrubbed with a caustic soda solution to remove HCl and any residual Cl_2, before recycle.

The chlorohydrin solution is reacted with cell liquor directly from the diaphragm electrolysis cells to form propylene oxide. The overhead from the saponifier, predominantly propylene oxide, water and minor quantities of propylene dichloride, propionaldehyde and propylene chlorhydrin is purified by fractionation in multiple distillation columns.

Uses

All of the significant uses of propylene oxide are as a chemical intermediate, its largest single use is for the production of polyglycols which are in turn used for the manufacture of polyurethane foams and resins.



Plot area required for a 185 000 tonnes per year plant is approximately 25 000 square metres. Capacities as low as 7 000 tonnes per year are technically feasible.

This information has been prepared for UNIDO by Chem Systems International Ltd., United Kingdom.

Any inquiry about the information contained should be sent to: IO/COOP, Registry file No. ID/562/12, UNIDO, P.O. Box 300, A-1400, Vienna, Austria.

COST OF PRODUCTION ESTIMATE FOR PROPYLENE OXIDE
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - CHLOROHYDRIN

BASIS		CAPITAL COST	$ MILL
LOCATION-	BENELUX	BATTERY LIMITS	112.83
CAPACITY-	185 000 TONNES PER YEAR	OFFSITES	63.93
PRODUCTN-	185 000 TONNES PER YEAR		
YEAR -	1980	TOTAL FIXED INV.	176.76
STR.TIME-	8000 HOURS PER YEAR	WORKING	61.62

RAW MATERIALS	QUANTITY/TONNE	PRICE*	ANNUAL COST	UNIT* COST
PROPYLENE	.8740 TONNE	480.000	77 611 200	
SALT	.1460 TONNE	16.000	432 160	
CATALYST+CHEMS	20.3243 DOLLARS	1.000	3 760 000	
TOTAL RAW MATERIALS			81 803 360	442.18
UTILITIES				
POWER	4.4000 MWH	61.500	50 061 000	
COOLING WATER	.2220 KTONNE	17.000	698 190	
MP.STEAM	8.8000 TONNE	19.200	31 257 600	
PROCESS WATER	.0420 KTONNE	230.000	1 787 100	
TOTAL UTILITIES COST			83 803 890	452.99
OPERATING COSTS				
LABOUR	98.00 MEN @ 17 700 $/YEAR		1 734 600	
SUPERVISION	2.00 MEN @ 29 200 $/YEAR		58 400	
MAINTENANCE	@ .04×BLCC		4 513 043	
TOTAL OPERATING COST			6 306 043	34.09
OVERHEAD EXPENSES				
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION		717 200	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS		4 098 928	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP		2 651 413	
DEPRECIATION	@ .100× BLCC+ .050×OFFS		14 479 348	
INTEREST	@ .100× WORKING CAPITAL		6 161 565	
TOTAL OVERHEAD EXPENSES			28 108 454	151.94
BYPRODUCT CREDIT				
DICHLOROPROPAN	¯.1050 TONNE	150.000	¯2 913 750	
CHLOR.ETHER	¯.0220 TONNE	150.000	¯ 610 500	
HYDROGEN	¯1.3900 GCAL	38.400	¯9 874 560	
FUEL	¯1.2800 GCAL	7.500	¯1 776 000	
TOTAL BYPRODUCT CREDIT			¯15 174 810	¯82.03
NET COST OF PRODUCTION			184 846 937	999.17
VARIABLE COST OF PRODUCTION				813.15
CASH COST OF PRODUCTION				920.91
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV				1094.72
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV				1142.49
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV				1190.27

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR PROPYLENE OXIDE CHLOROHYDRIN BENELUX LANG FACTOR 0.65

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	185000	185000	185000	185000	148000	111000	74000
PLANT OUTPUT	185000	157250	138750	111000	148000	111000	74000
CAPITAL COST — MILLION DOLLARS							
BLCC	112.8	112.8	112.8	112.8	97.6	80.9	62.2
OFFSITES	63.9	63.9	63.9	63.9	55.3	45.9	35.2
TOTAL FIXED	176.8	176.8	176.8	176.8	152.9	126.8	97.4
WORKING	61.6	53.8	48.6	40.9	50.1	38.5	26.7
DOLLARS PER TONNE PRODUCT - (BASED ON PROPYLENE AT $480/TONNE)							
RAW MATERIALS	442.2	442.2	442.2	442.2	442.2	442.2	442.2
UTILITIES	453.0	453.0	453.0	453.0	453.0	453.0	453.0
BYPROD. CREDIT	¯82.0	¯82.0	¯82.0	¯82.0	¯82.0	¯82.0	¯82.0
VARIABLE COST	813.1	813.1	813.1	813.1	813.1	813.1	813.1
OPERATION	34.1	40.1	45.4	56.8	38.5	45.3	57.8
OVERHEAD(EXCL.DEPN)	73.7	81.7	88.9	104.1	79.2	87.7	103.1
CASH COST	920.9	935.0	947.5	974.1	930.9	946.2	974.1
DEPRECIATION	78.3	92.1	104.4	130.4	84.6	93.6	107.9
NET COST OF PRODN	999.2	1027.1	1051.8	1104.5	1015.5	1039.8	1082.0
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	143.3	168.6	191.1	238.9	155.0	171.4	197.5
TRANSFER PRICE	1142.5	1195.7	1242.9	1343.4	1170.4	1211.2	1279.5

EFFECT OF PROPYLENE PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	576.0	384.0	576.0	384.0	576.0	384.0	576.0	384.0	576.0	384.0	576.0	384.0	576.0	384.0
NET COST OF PRODN	1083.1	915.3	1111.0	943.1	1135.7	967.9	1188.4	1020.6	1099.4	931.6	1123.7	955.9	1165.9	998.1
TRANSFER PRICE	1226.4	1058.6	1279.6	1111.8	1326.8	1159.0	1427.3	1259.5	1254.3	1086.5	1295.1	1127.3	1363.4	1195.6

PROPYLENE OXIDE (CO-PRODUCT STYRENE)

Process Description

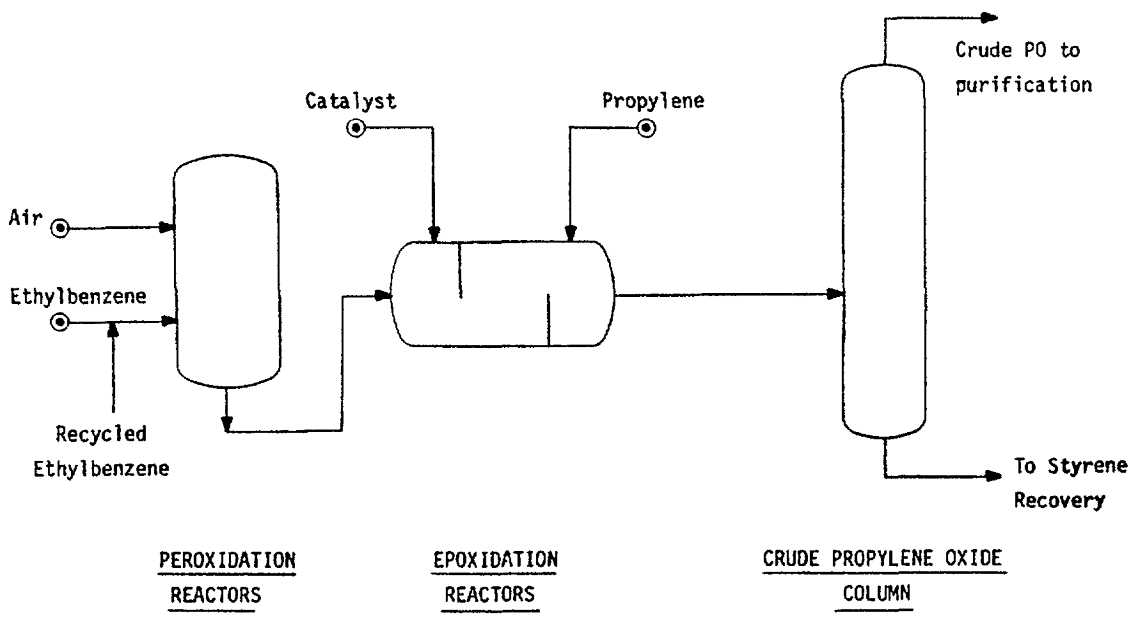
In this process the hydroperoxide intermediate is used to add an oxygen atom to the propylene. The hydroperoxide itself is made simply by direct oxidation of ethylbenzene with air. The reactors operate at about 3 bar and 140-150^{o}C.

The peroxide product passes to the epoxidation reactors where it reacts with propylene. The reacting pressure and temperature are kept at 23.5 to 25.5 bar and 115^{o}C respectively. The ratio of propylene to EBHP is 5.12 which gives a selectivity of propylene to propylene oxide of 91 percent at 14.5 percent conversion.

Separation of unreacted propylene from the epoxidate takes place in two distillation steps. Crude propylene oxide is distilled under vacuum at 0.5 bar from the depropanised epoxidate. It is further purified in a series of distillation columns.

Uses

All of the significant uses of propylene oxide are as a chemical intermediate, its largest single use is for the production of polyglycols which are in turn used for the manufacture of polyurethane foams and resins.



Plot area for a plant producing 180 000 tonnes per year PO is approximately 23 000 square metres, which is a typical capacity. Smallest capacity built to date is 30 000 tonnes per year.

This information has been prepared for UNIDO by Chem Systems International Ltd., United Kingdom.

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COST OF PRODUCTION ESTIMATE FOR PROPYLENE OXIDE
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - COPRODUCT STYRENE

BASIS		CAPITAL COST	$ MILL
LOCATION-	BENELUX	BATTERY LIMITS	225.65
CAPACITY-	180 000 TONNES PER YEAR	OFFSITES	90.26
PRODUCTN-	180 000 TONNES PER YEAR		
YEAR -	1980	TOTAL FIXED INV.	315.91
STR.TIME-	8000 HOURS PER YEAR	WORKING	85.04

RAW MATERIALS	QUANTITY/TONNE	PRICE*	ANNUAL COST	UNIT* COST
PROPYLENE	.8730 TONNE	480.000	75 427 200	
ETHYLBENZENE	3.0300 TONNE	700.000	381 780 000	
HYDROGEN	.0106 TONNE	1100.000	2 098 800	
CATALYST+CHEMS	41.7778 DOLLARS	1.000	7 520 000	
TOTAL RAW MATERIALS			466 826 000	2593.48
UTILITIES				
POWER	1.1790 MWH	61.500	13 051 530	
COOLING WATER	.6500 KTONNE	17.000	1 989 000	
HP.STEAM	21.0000 TONNE	20.200	76 356 000	
BLR.FEED WATER	.0025 KTONNE	450.000	202 500	
PROCESS WATER	.0001 KTONNE	230.000	3 312	
TOTAL UTILITIES COST			91 602 342	508.90
OPERATING COSTS				
LABOUR	54.00 MEN @ 17 700 $/YEAR		955 800	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR		29 200	
MAINTENANCE	@ .04×BLCC		9 026 087	
TOTAL OPERATING COST			10 011 087	55.62
OVERHEAD EXPENSES				
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION		394 000	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS		6 507 207	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP		4 738 696	
DEPRECIATION	@ .100× BLCC+ .050×OFFS		27 078 261	
INTEREST	@ .100× WORKING CAPITAL		8 503 622	
TOTAL OVERHEAD EXPENSES			47 221 785	262.34
BYPRODUCT CREDIT				
STYRENE	¯2.5400 TONNE	770.000	¯352 044 000	
PROPIONALDEHYD	¯.0380 TONNE	600.000	¯4 104 000	
ACETALDEHYDE	¯.0110 TONNE	765.000	¯1 514 700	
FUEL	¯.8870 GCAL	18.100	¯2 889 846	
TOTAL BYPRODUCT CREDIT			¯360 552 546	¯2003.07
NET COST OF PRODUCTION			255 108 668	1417.27

VARIABLE COST OF PRODUCTION	1099.31
CASH COST OF PRODUCTION	1266.84
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	1592.78
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	1680.53
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV	1768.28

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR PROPYLENE OXIDE COPRODUCT STYRENE BENELUX LANG FACTOR 0.65

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	180000	180000	180000	180000	144000	108000	72000
PLANT OUTPUT	180000	153000	135000	108000	144000	108000	72000
CAPITAL COST — MILLION DOLLARS							
BLCC	225.7	225.7	225.7	225.7	195.2	161.9	124.4
OFFSITES	90.3	90.3	90.3	90.3	78.1	64.8	49.8
TOTAL FIXED	315.9	315.9	315.9	315.9	273.3	226.7	174.1
WORKING	85.0	74.8	68.0	57.7	69.2	53.2	36.9
DOLLARS PER TONNE PRODUCT - (BASED ON PROPYLENE AT $480/TONNE)							
RAW MATERIALS	2593.5	2593.5	2593.5	2593.5	2593.5	2593.5	2593.5
UTILITIES	508.9	508.9	508.9	508.9	508.9	508.9	508.9
BYPROD. CREDIT	¯2003.1	¯2003.1	¯2003.1	¯2003.1	¯2003.1	¯2003.1	¯2003.1
VARIABLE COST	1099.3	1099.3	1099.3	1099.3	1099.3	1099.3	1099.3
OPERATION	55.6	65.4	74.2	92.7	61.1	69.1	82.8
OVERHEAD(EXCL.DEPN)	111.9	125.0	136.6	161.2	119.0	129.3	146.8
CASH COST	1266.8	1289.7	1310.0	1353.2	1279.3	1297.7	1328.9
DEPRECIATION	150.4	177.0	200.6	250.7	162.7	179.9	207.3
NET COST OF PRODN	1417.3	1466.7	1510.6	1604.0	1442.0	1477.6	1536.2
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	263.3	309.7	351.0	438.8	284.6	314.8	362.8
TRANSFER PRICE	1680.5	1776.4	1861.6	2042.7	1726.6	1792.4	1899.0

EFFECT OF PROPYLENE PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	576.0	384.0	576.0	384.0	576.0	384.0	576.0	384.0	576.0	384.0	576.0	384.0	576.0	384.0
NET COST OF PRODN	1501.1	1333.5	1550.5	1382.9	1594.4	1426.8	1687.8	1520.2	1525.8	1358.2	1561.4	1393.8	1620.0	1452.4
TRANSFER PRICE	1764.3	1596.7	1860.2	1692.6	1945.4	1777.8	2126.5	1958.9	1810.4	1642.8	1876.2	1708.6	1982.8	1815.2

File: G65
ISIC 3511

How to Start Manufacturing Industries

PROPYLENE OXIDE - CO-PRODUCT TBA

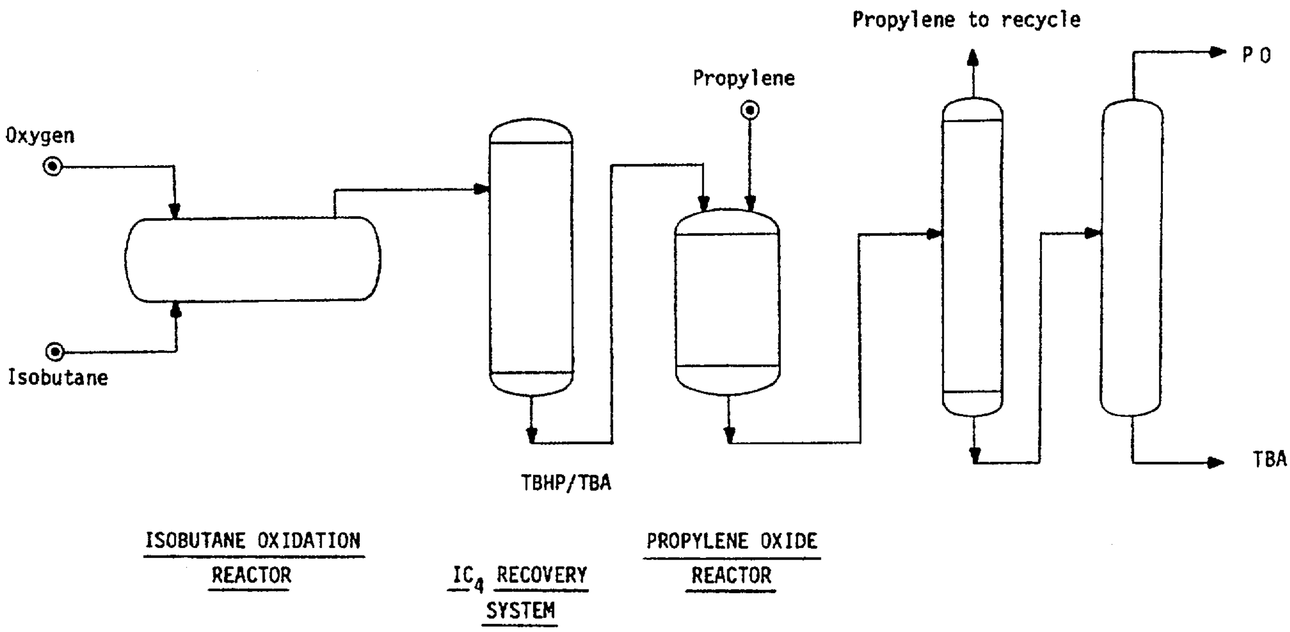
Process Description

Propylene oxide is produced by a two-step process in which isobutane is oxidised using oxygen to tert-butyl hydroperoxide (T HP` and the latter is used to oxidise propylene to propylene oxide.

Isobutane and oxygen are reacted at 90°C and 29 bar in the presence of a molybdenum naphthenate catalyst to form TBHP and tert- butyl alcohol (TBA). After separation, the TBHP is used to oxidise propylene to propylene oxide, peroxide selectivity to propylene oxide is 85 percent at a reaction time of 2-5 hours. Approximately 2.4 tonne of TBA are formed per tonne of propylene oxide produced.

Uses

All of the significant uses of propylene oxide are as a chemical intermediate, its largest single use is for the production of polyglycols which are in turn used for the manufacture of polyurethane foams and resins.



Land area for a 180 000 tonnes per year plant is approximately 23 000 square metres. The smallest size built to date in Europe is 155 000 tonnes per year. Smaller sizes are feasible, but a decision has to be made in respect to isobutane availability.

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COST OF PRODUCTION ESTIMATE FOR PROPYLENE OXIDE
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - COPRODUCT T-BUTANOL

BASIS		CAPITAL COST	$ MILL
LOCATION-	BENELUX	BATTERY LIMITS	122.86
CAPACITY-	180 000 TONNES PER YEAR	OFFSITES	73.96
PRODUCTN-	180 000 TONNES PER YEAR		
YEAR -	1980	TOTAL FIXED INV.	196.82
STR.TIME-	8000 HOURS PER YEAR	WORKING	34.69

RAW MATERIALS	QUANTITY/TONNE	PRICE*	ANNUAL COST	UNIT* COST
PROPYLENE	.9020 TONNE	480.000	77 932 800	
ISOBUTANE	2.3500 TONNE	370.000	156 510 000	
OXYGEN	.9700 TONNE	87.000	15 190 200	
CATALYST+CHEMS	19.1667 DOLLARS	1.000	3 450 000	
TOTAL RAW MATERIALS			253 083 000	1406.02
UTILITIES				
POWER	.3860 MWH	61.500	4 273 020	
COOLING WATER	.3660 KTONNE	17.000	1 119 960	
MP.STEAM	9.2000 TONNE	19.200	31 795 200	
TOTAL UTILITIES COST			37 188 180	206.60
OPERATING COSTS				
LABOUR	54.00 MEN @ 17 700 $/YEAR		955 800	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR		29 200	
MAINTENANCE	@ .04×BLCC		4 914 203	
TOTAL OPERATING COST			5 899 203	32.77
OVERHEAD EXPENSES				
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION		394 000	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS		3 834 482	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP		2 952 283	
DEPRECIATION	@ .100× BLCC+ .050×OFFS		15 983 696	
INTEREST	@ .100× WORKING CAPITAL		3 469 490	
TOTAL OVERHEAD EXPENSES			26 633 951	147.97
BYPRODUCT CREDIT				
TERT-BUTANOL	-2.4600 TONNE	450.000	-199 260 000	
50 PC ACETONE	-.2300 TONNE	400.000	-16 560 000	
PROPANE-BUTANE	-.8900 GCAL	18.100	-2 899 620	
TOTAL BYPRODUCT CREDIT			-218 719 620	-1215.11
NET COST OF PRODUCTION			104 084 713	578.25

VARIABLE COST OF PRODUCTION	397.51
CASH COST OF PRODUCTION	489.45
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	687.59
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	742.26
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV	796.94

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR PROPYLENE OXIDE COPRODUCT T-BUTANOL BENELUX LANG FACTOR 0.65

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	180000	180000	180000	180000	144000	108000	72000
PLANT OUTPUT	180000	153000	135000	108000	144000	108000	72000
CAPITAL COST — MILLION DOLLARS							
BLCC	122.9	122.9	122.9	122.9	106.3	88.1	67.7
OFFSITES	74.0	74.0	74.0	74.0	64.0	53.1	40.8
TOTAL FIXED	196.8	196.8	196.8	196.8	170.2	141.2	108.5
WORKING	34.7	31.0	28.5	24.8	28.5	22.2	15.7
DOLLARS PER TONNE PRODUCT - (BASED ON PROPYLENE AT $480/TONNE)							
RAW MATERIALS	1406.0	1406.0	1406.0	1406.0	1406.0	1406.0	1406.0
UTILITIES	206.6	206.6	206.6	206.6	206.6	206.6	206.6
BYPROD. CREDIT	¯1215.1	¯1215.1	¯1215.1	¯1215.1	¯1215.1	¯1215.1	¯1215.1
VARIABLE COST	397.5	397.5	397.5	397.5	397.5	397.5	397.5
OPERATION	32.8	38.6	43.7	54.6	36.4	41.8	51.3
OVERHEAD(EXCL.DEPN)	59.2	67.2	74.3	89.5	63.9	71.0	83.2
CASH COST	489.5	503.3	515.5	541.6	497.8	510.2	532.0
DEPRECIATION	88.8	104.5	118.4	148.0	96.0	106.2	122.4
NET COST OF PRODN	578.2	607.7	633.9	689.6	593.8	616.4	654.4
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	164.0	193.0	218.7	273.4	177.3	196.1	226.0
TRANSFER PRICE	742.3	800.7	852.6	963.0	771.1	812.5	880.5

EFFECT OF PROPYLENE PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	576.0	384.0	576.0	384.0	576.0	384.0	576.0	384.0	576.0	384.0	576.0	384.0	576.0	384.0
NET COST OF PRODN	664.8	491.7	694.3	521.1	720.5	547.3	776.2	603.0	680.4	507.2	703.0	529.8	741.0	567.8
TRANSFER PRICE	828.9	655.7	887.3	714.1	939.2	766.0	1049.6	876.4	857.7	684.5	899.1	725.9	967.0	793.9

File: G66
ISIC 3511

How to Start Manufacturing Industries

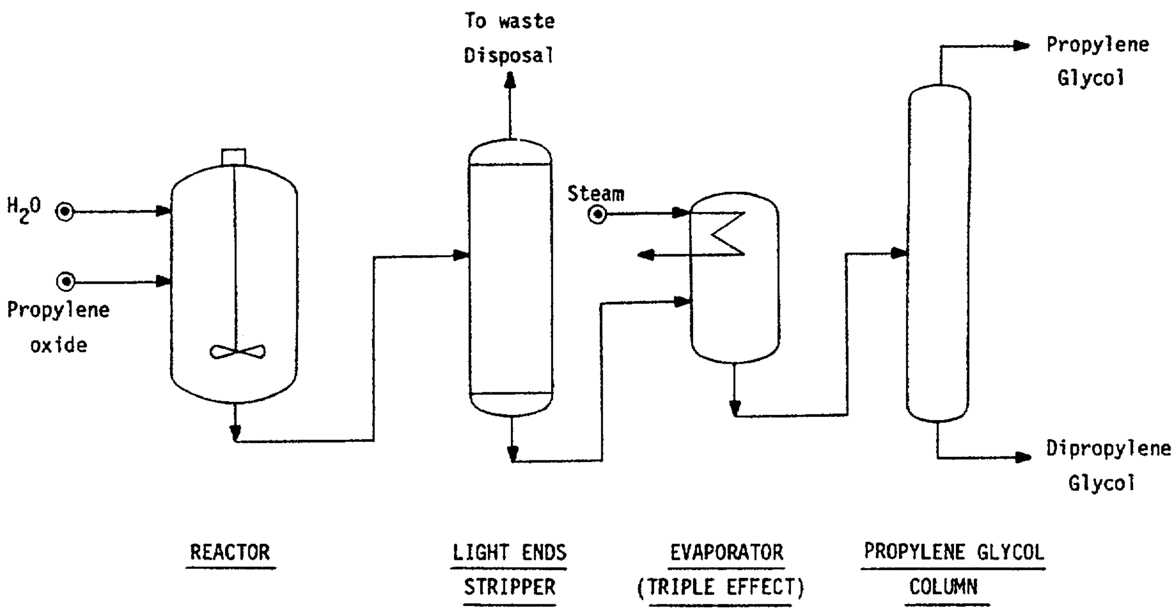
PROPYLENE GLYCOL BY OXIDE HYDRATION

Process Description

Propylene glycol plants are conventinally linked with partially captive propylene oxide. The hydrolysis takes place in two serially connected stirred reactors, operated under pressure. The molar ratio of water to propylene oxide in the feed to the first reactor is 15 to 1. Following the glycol formation, unreacted propylene oxide and bulk water are removed from the reaction mixture. The last traces of water are stripped under vacuum by the glycol drying column. The propylene glycol product is vacuum distilled overhead and then pumped to offsite storage tanks.

Uses

Propylene glycol is widely used in the food-chemical inustry. It is used as a solvent, preservative, softening agent, lubricant for food machinery, and as a heat transfer fluid for the processing of foods and drugs.



Land area required for a typical plant of 50 000 ton per year capacity is approximately 8 000 square metres. The minimum feasible capacity of plant could be as small as 12 000 tonnes per year. A typical modern capacity is however 90 000 tons per year.

This information has been prepared for UNIDO by Chem Systems International Ltd., United Kingdom.

Any inquiry about the information contained should be sent to: IO/COOP, Registry file No. ID/562/12, UNIDO, P.O. Box 300, A-1400, Vienna, Austria.

COST OF PRODUCTION ESTIMATE FOR PROPYLENE GLYCOL
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - P O HYDRATION

BASIS		CAPITAL COST	$ MILL
LOCATION- BENELUX		BATTERY LIMITS	8.40
CAPACITY-	50 000 TONNES PER YEAR	OFFSITES	3.38
PRODUCTN-	50 000 TONNES PER YEAR		
YEAR - 1980		TOTAL FIXED INV.	11.78
STR.TIME- 8000 HOURS PER YEAR		WORKING	13.77

RAW MATERIALS	QUANTITY/TONNE	PRICE*	ANNUAL COST	UNIT* COST
PROP. OXIDE	.8000 TONNE	820.000	32 800 000	
TOTAL RAW MATERIALS			32 800 000	656.00
UTILITIES				
POWER	.0970 MWH	61.500	298 275	
COOLING WATER	1.2500 KTONNE	17.000	1 062 500	
MP.STEAM	2.1000 TONNE	19.200	2 016 000	
PROCESS WATER	.0003 KTONNE	230.000	3 450	
FUEL	2.7800 GCAL	18.100	2 515 900	
TOTAL UTILITIES COST			5 896 125	117.92
OPERATING COSTS				
LABOUR	14.00 MEN @ 17 700 $/YEAR		247 800	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR		29 200	
MAINTENANCE	@ .04×BLCC		335 971	
TOTAL OPERATING COST			612 971	12.26
OVERHEAD EXPENSES				
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION		110 800	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS		398 431	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP		176 761	
DEPRECIATION	@ .100× BLCC+ .050×OFFS		1 009 167	
INTEREST	@ .100× WORKING CAPITAL		1 376 698	
TOTAL OVERHEAD EXPENSES			3 071 857	61.44
BYPRODUCT CREDIT				
DIPROP.GLYCOL	-.0300 TONNE	720.000	-1 080 000	
TOTAL BYPRODUCT CREDIT			-1 080 000	-21.60
NET COST OF PRODUCTION			41 300 953	826.02
VARIABLE COST OF PRODUCTION				752.32
CASH COST OF PRODUCTION				805.84
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV				849.59
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV				861.37
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV				873.16

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR PROPYLENE GLYCOL P O HYDRATION BENELUX LANG FACTOR 0.65

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	50000	50000	50000	50000	40000	30000	20000
PLANT OUTPUT	50000	42500	37500	30000	40000	30000	20000
CAPITAL COST — MILLION DOLLARS							
BLCC	8.4	8.4	8.4	8.4	7.3	6.0	4.6
OFFSITES	3.4	3.4	3.4	3.4	2.9	2.4	1.9
TOTAL FIXED	11.8	11.8	11.8	11.8	10.2	8.5	6.5
WORKING	13.8	11.8	10.5	8.6	11.1	8.4	5.7
DOLLARS PER TONNE PRODUCT - (BASED ON PROP OXIDE AT $820/TONNE)							
RAW MATERIALS	656.0	656.0	656.0	656.0	656.0	656.0	656.0
UTILITIES	117.9	117.9	117.9	117.9	117.9	117.9	117.9
BYPROD. CREDIT	¯21.6	¯21.6	¯21.6	¯21.6	¯21.6	¯21.6	21.6
VARIABLE COST	752.3	752.3	752.3	752.3	752.3	752.3	752.3
OPERATION	12.3	14.4	16.3	20.4	14.2	17.3	23.1
OVERHEAD(EXCL.DEPN)	41.3	44.0	46.4	51.5	43.5	47.2	54.0
CASH COST	805.8	810.7	815.0	824.2	810.1	816.8	829.4
DEPRECIATION	20.2	23.7	26.9	33.6	21.8	24.1	27.8
NET COST OF PRODN	826.0	834.4	841.9	857.9	831.9	840.9	857.3
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	35.4	41.6	47.1	58.9	38.2	42.3	48.7
TRANSFER PRICE	861.4	876.0	889.1	916.8	870.1	883.2	906.0

EFFECT OF PROP. OXIDE PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	984.0	656.0	984.0	656.0	984.0	656.0	984.0	656.0	984.0	656.0	984.0	656.0	984.0	656.0
NET COST OF PRODN	957.2	694.8	965.6	703.2	973.1	710.7	989.1	726.7	963.1	700.7	972.1	709.7	988.5	726.1
TRANSFER PRICE	992.6	730.2	1007.2	744.8	1020.3	757.9	1048.0	785.6	1001.3	738.9	1014.4	752.0	1037.2	774.8

-4-

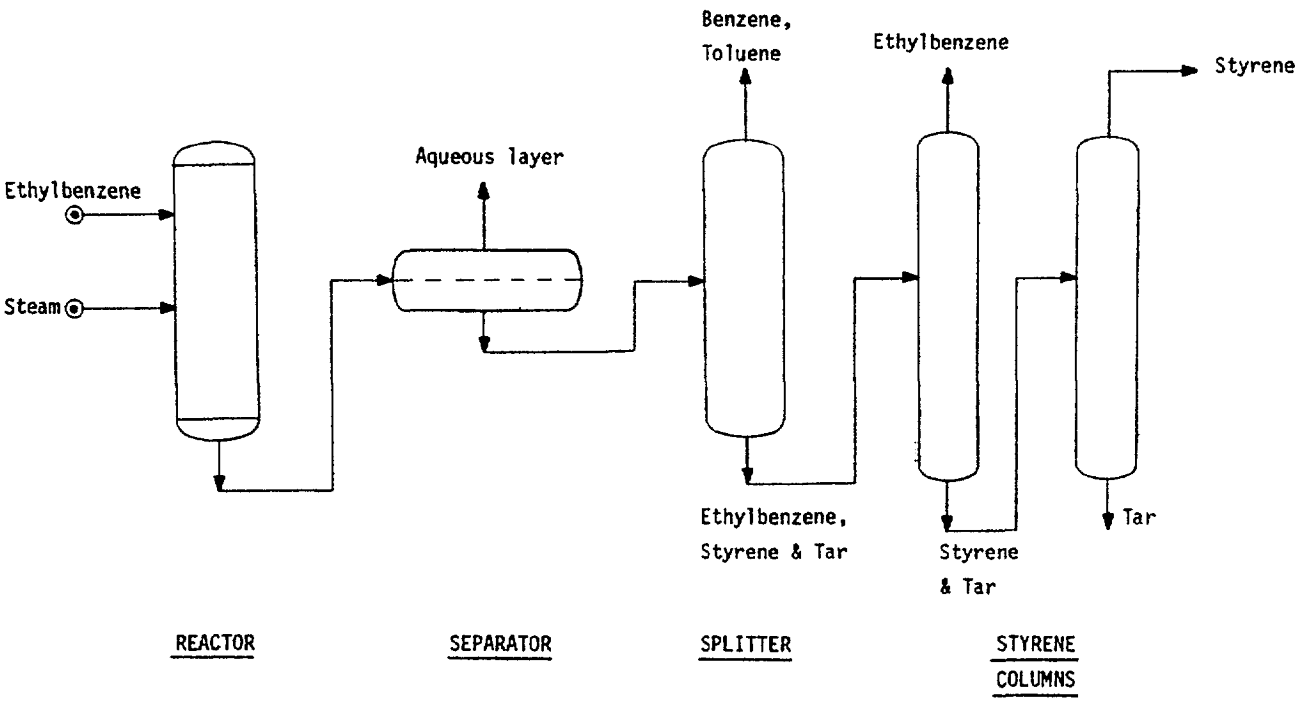
STYRENE

Process Description

Fresh and recycle ethylbenzene is preheated and fed with superheated steam to the reactor at a temperature of 600-620°C. Steam to ethylbenzene molar ratio is 12-15 to one. The reaction occurs adiabatically over a fixed catalyst bed, with 60 percent conversion, and 87-89 percent styrene into aqueous and organic phases. The organic phase, containing styrene, ethylbenzene, benzene, toluene and some higher boiling tar is first charged to the splitting column in which benzene, toluene and some ethylbenzene is taken overhead. The bottom is distilled under high vacuum to separate the unreacted ethylbenzene from the product styrene and tar. The final fractionation involves the recovery of polymer grade styrene. Benzene from the splitting column is further purified and recycled to the alkylation section of the plant.

Uses

Styrene was originally used principally for SBR synthetic rubber, styrene plastics are now the major outlet for monomer. These products, include polystyrene, rubber-modified polystyrene, styrene-butadiene copolymer and styrene-acrylonitrile copolymer (SAN).



The land area required for an actual 200 000 tonnes per year plant is 4 500 square metres which is also a typical modern capacity. The smallest technically feasible plant size is 45 000 tonnes per year.

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COST OF PRODUCTION ESTIMATE FOR STYRENE
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - EB DEHYDROGENATION

BASIS		CAPITAL COST	$ MILL
LOCATION-	BENELUX	BATTERY LIMITS	75.84
CAPACITY-	330 000 TONNES PER YEAR	OFFSITES	38.86
PRODUCTN-	330 000 TONNES PER YEAR		
YEAR -	1980	TOTAL FIXED INV.	114.71
STR.TIME-	8000 HOURS PER YEAR	WORKING	92.88

RAW MATERIALS	QUANTITY/TONNE		PRICE*	ANNUAL COST	UNIT* COST
BENZENE	.8200	TONNE	590.000	159 654 000	
ETHYLENE	.3070	TONNE	750.000	75 982 500	
ALUM.CHLORIDE	.0022	TONNE	1295.000	940 170	
CATALYST+CHEMS	6.0606	DOLLARS	1.000	2 000 000	
TOTAL RAW MATERIALS				238 576 670	722.96
UTILITIES					
POWER	.0660	MWH	61.500	1 339 470	
COOLING WATER	.0670	KTONNE	17.000	375 870	
MP.STEAM	1.7000	TONNE	19.200	10 771 200	
INERT GAS	6.0000	NM3	.000	0	
FUEL	1.5100	GCAL	18.100	9 019 230	
TOTAL UTILITIES COST				21 505 770	65.17
OPERATING COSTS					
LABOUR	26.00 MEN @ 17 700 $/YEAR			460 200	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR			29 200	
MAINTENANCE	@ .04×BLCC			3 033 768	
TOTAL OPERATING COST				3 523 168	10.68
OVERHEAD EXPENSES					
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION			195 760	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS			2 290 059	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP			1 720 598	
DEPRECIATION	@ .100× BLCC+ .050×OFFS			9 527 536	
INTEREST	@ .100× WORKING CAPITAL			9 288 407	
TOTAL OVERHEAD EXPENSES				23 022 360	69.76
BYPRODUCT CREDIT					
TOLUENE	-.0520	TONNE	410.000	-7 035 600	
ALUM.CHLORIDE	-.0022	TONNE	1295.000	- 940 170	
TOTAL BYPRODUCT CREDIT				-7 975 770	-24.17
NET COST OF PRODUCTION				278 652 198	844.40

VARIABLE COST OF PRODUCTION	763.96
CASH COST OF PRODUCTION	815.53
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	879.16
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	896.54
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV	913.92

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR STYRENE EB DEHYDROGENATION BENELUX LANG FACTOR 0.73

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	330000	330000	330000	330000	264000	198000	132000
PLANT OUTPUT	330000	280500	247500	198000	264000	198000	132000
CAPITAL COST MILLION DOLLARS							
BLCC	75.8	75.8	75.8	75.8	64.4	52.2	38.9
OFFSITES	38.9	38.9	38.9	38.9	33.0	26.8	19.9
TOTAL FIXED	114.7	114.7	114.7	114.7	97.5	79.0	58.8
WORKING	92.9	79.8	71.2	58.1	74.7	56.4	38.0
DOLLARS PER TONNE PRODUCT - (BASED ON BENZENE AT $590/TONNE)							
RAW MATERIALS	723.0	723.0	723.0	723.0	723.0	723.0	723.0
UTILITIES	65.2	65.2	65.2	65.2	65.2	65.2	65.2
BYPROD. CREDIT	¯24.2	¯24.2	¯24.2	¯24.2	¯24.2	¯24.2	¯24.2
VARIABLE COST	764.0	764.0	764.0	764.0	764.0	764.0	764.0
OPERATION	10.7	12.6	14.2	17.8	11.6	13.0	15.5
OVERHEAD(EXCL.DEPN)	40.9	43.5	45.7	50.6	42.1	43.9	47.0
CASH COST	815.5	820.0	823.9	832.3	817.7	820.9	826.4
DEPRECIATION	28.9	34.0	38.5	48.1	30.7	33.1	37.0
NET COST OF PRODN	844.4	853.9	862.4	880.5	848.4	854.0	863.4
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	52.1	61.3	69.5	86.9	55.4	59.9	66.8
TRANSFER PRICE	896.5	915.3	932.0	967.4	903.7	913.9	930.2

EFFECT OF BENZENE PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	708.0	472.0	708.0	472.0	708.0	472.0	708.0	472.0	708.0	472.0	708.0	472.0	708.0	472.0
NET COST OF PRODN	941.2	747.6	950.7	757.2	959.2	765.7	977.2	783.7	945.1	751.6	950.8	757.3	960.2	766.7
TRANSFER PRICE	993.3	799.8	1012.0	818.5	1028.7	835.2	1064.1	870.6	1000.5	807.0	1010.6	817.1	1027.0	833.4

How to Start Manufacturing Industries

SBR - COLD EMULSION PROCESS

Process Description

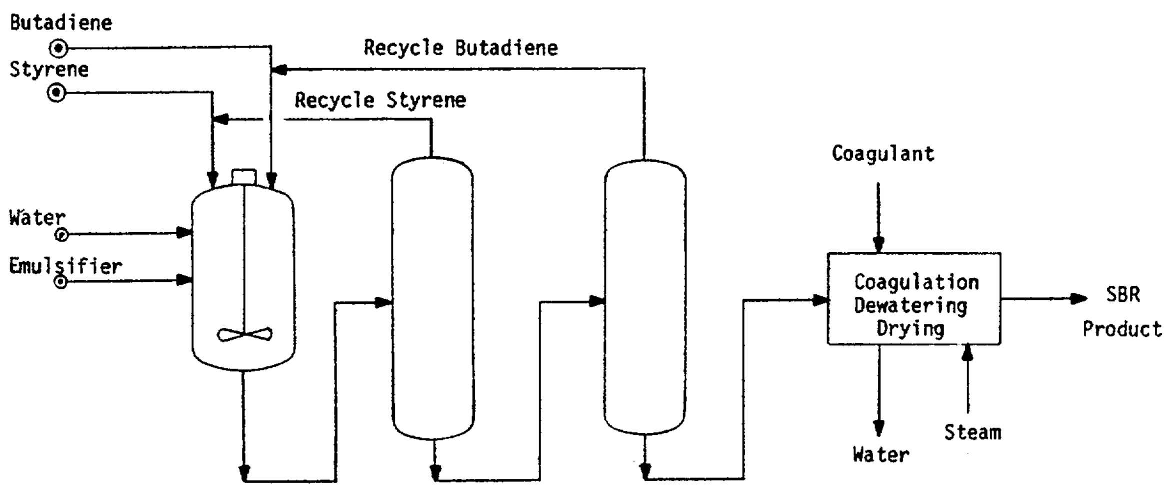
The styrene and butadiene monomers are mixed in an emulsion reactor with water, catalyst emulsifier (soap) and molecular weight modifier (eg tert-dodecyl mercaptan). The polymerisation temperature is low at 5°C. The conversion limit is 60 percent to prevent gel formation, this will typically be achieved in 12-15 hours.

Butadiene and styrene are removed from the latex by vacuum and steam stripping respectively and recycled after purification.

The product rubber is recovered by coagulating the latex, dewatered and dried.

Uses

Passenger tyres and tyre products account for the major portion of SBR consumption. Two expanding markets for SBR are adhesives and chewing gum.



Plot area for 100 000 tonnes per year of SBR plant is approximately 25 000 square metres. The minimum size technically feasible can be as small as 5 000 tonnes per year (or smaller).

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COST OF PRODUCTION ESTIMATE FOR SBR
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - COLD EMULSION

BASIS		CAPITAL COST	$ MILL
LOCATION-	BENELUX	BATTERY LIMITS	52.02
CAPACITY-	100 000 TONNES PER YEAR	OFFSITES	20.81
PRODUCTN-	100 000 TONNES PER YEAR		
YEAR -	1980	TOTAL FIXED INV.	72.83
STR.TIME-	8000 HOURS PER YEAR	WORKING	28.23

RAW MATERIALS	QUANTITY/TONNE		PRICE*	ANNUAL COST	UNIT* COST
BUTADIENE	.5100	TONNE	690.000	35 190 000	
STYRENE	.1600	TONNE	770.000	12 320 000	
EXTENDING OIL	.2800	TONNE	200.000	5 600 000	
FATTY ACIDS	.0450	TONNE	850.000	3 825 000	
CATALYST+CHEMS	45.0000	DOLLARS	1.000	4 500 000	
TOTAL RAW MATERIALS				61 435 000	614.35
UTILITIES					
POWER	.3000	MWH	61.500	1 845 000	
COOLING WATER	.2000	KTONNE	17.000	340 000	
MP.STEAM	3.0000	TONNE	19.200	5 760 000	
INERT GAS	30.0000	NM3	.085	255 000	
TOTAL UTILITIES COST				8 200 000	82.00

OPERATING COSTS		ANNUAL COST	UNIT* COST
LABOUR	39.00 MEN @ 17 700 $/YEAR	690 300	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR	29 200	
MAINTENANCE	@ .04×BLCC	2 081 000	
TOTAL OPERATING COST		2 800 500	28.00
OVERHEAD EXPENSES			
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION	287 800	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS	1 820 325	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP	1 092 525	
DEPRECIATION	@ .100× BLCC+ .050×OFFS	6 243 000	
INTEREST	@ .100× WORKING CAPITAL	2 823 419	
TOTAL OVERHEAD EXPENSES		12 267 069	122.67
BYPRODUCT CREDIT			
TOTAL BYPRODUCT CREDIT		0	.00
NET COST OF PRODUCTION		84 702 569	847.03

VARIABLE COST OF PRODUCTION	696.35
CASH COST OF PRODUCTION	784.60
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	919.86
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	956.28
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV	992.70

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR SBR COLD EMULSION BENELUX LANG FACTOR 0.65

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	100000	100000	100000	100000	80000	60000	40000
PLANT OUTPUT	100000	85000	75000	60000	80000	60000	40000
CAPITAL COST — MILLION DOLLARS							
BLCC	52.0	52.0	52.0	52.0	45.0	37.3	28.7
OFFSITES	20.8	20.8	20.8	20.8	18.0	14.9	11.5
TOTAL FIXED	72.8	72.8	72.8	72.8	63.0	52.3	40.1
WORKING	28.2	24.6	22.2	18.6	22.9	17.6	12.2
DOLLARS PER TONNE PRODUCT - (BASED ON BUTADIENE AT $690/TONNE)							
RAW MATERIALS	614.3	614.3	614.3	614.3	614.3	614.3	614.3
UTILITIES	82.0	82.0	82.0	82.0	82.0	82.0	82.0
BYPROD CREDIT	.0	.0	.0	.0	.0	.0	.0
VARIABLE COST	696.3	696.3	696.3	696.3	696.3	696.3	696.3
OPERATION	28.0	32.9	37.3	46.7	31.5	36.9	46.7
OVERHEAD(EXCL.DEPN)	60.2	66.6	72.3	84.4	64.5	71.1	83.0
CASH COST	784.6	795.9	806.0	827.4	792.4	804.4	826.0
DEPRECIATION	62.4	73.4	83.2	104.0	67.5	74.7	86.0
NET COST OF PRODN	847.0	869.4	889.2	931.5	859.9	879.0	912.0
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	109.3	128.5	145.7	182.1	118.1	130.6	150.6
TRANSFER PRICE	956.3	997.9	1034.9	1113.6	978.0	1009.6	1062.6

EFFECT OF BUTADIENE PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	828.0	552.0	828.0	552.0	828.0	552.0	828.0	552.0	828.0	552.0	828.0	552.0	828.0	552.0
NET COST OF PRODN	917.4	776.6	939.8	799.0	959.6	818.9	1001.8	861.1	930.3	789.5	949.4	808.6	982.4	841.7
TRANSFER PRICE	1026.7	885.9	1068.3	927.5	1105.3	964.5	1183.9	1043.2	1048.4	907.6	1080.0	939.3	1133.0	992.2

How to Start Manufacturing Industries

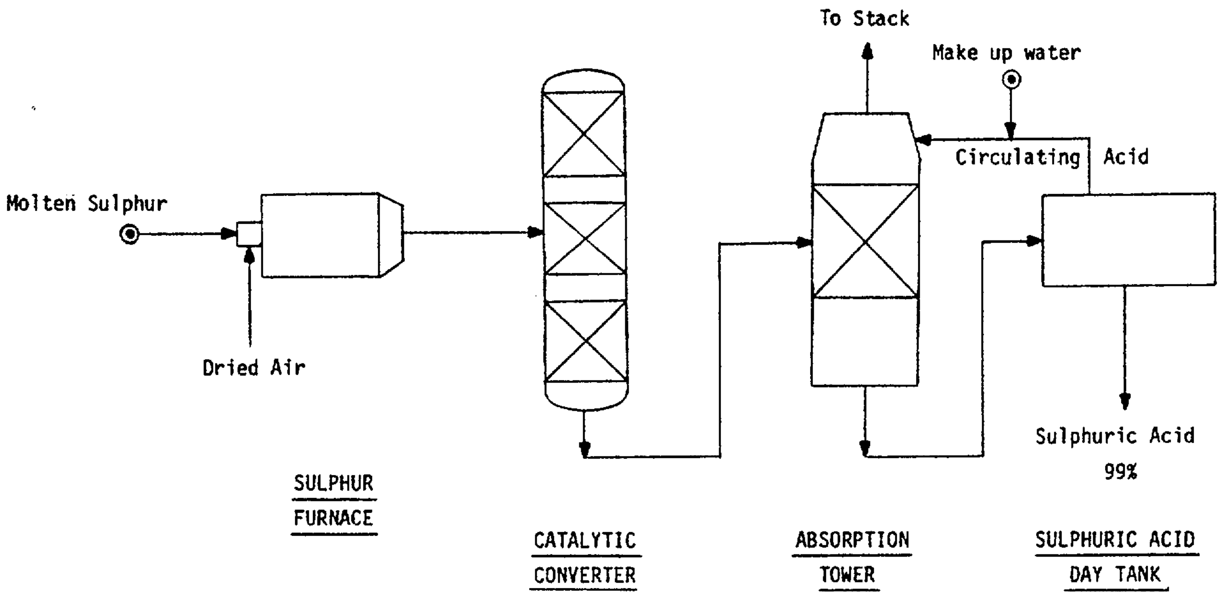
SULPHURIC ACID (SINGLE ABSORPTION PROCESS)

Process Description

All commercial sulphur sources containing more than 99.5 percent sulphur are suitable as raw materials. The sulphur is melted and burned with dried air to give a gas mixture containing 8 to 12 percent SO_2 by volume, the combustion temperature is held at about $800^{o}C$. After addition of more air, the SO_2 is oxidised to SO_3 over a vanadium catalyst. The SO_3 is absorbed in sulphuric acid of 98.3 percent H_2SO_4 and converted with its water content into H_2SO_4. Absorption and drying of the process air take place in packed towers where the gas are sprayed in counter-current with cooled concentrated sulphuric acid. The entire sulphuric acid plant operates with yields of more than 97.8 percent.

Uses

Sulphuric acid is mainly used in fertiliser, petroleum refining, iron and steel pickling and in ammonium sulphate manufacture.



Plot area required for 330 000 tonnes per year single absorption process would be approximately 15 000 square metres. The smallest size that would be technically feasible can be as small as 3 300 tonnes per year.

This information has been prepared for UNIDO by Chem Systems International Ltd., United Kingdom.

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COST OF PRODUCTION ESTIMATE FOR SULPHURIC ACID - 98%
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - SINGLE ABSORPTION

BASIS	CAPITAL COST	$ MILL
LOCATION- BENELUX	BATTERY LIMITS	15.80
CAPACITY- 330 000 TONNES PER YEAR	OFFSITES	4.76
PRODUCTN- 330 000 TONNES PER YEAR		
YEAR - 1980	TOTAL FIXED INV.	20.56
STR.TIME- 8000 HOURS PER YEAR	WORKING	3.11

RAW MATERIALS	QUANTITY/TONNE	PRICE*	ANNUAL COST	UNIT* COST
SULPHUR	.3350 TONNE	100.000	11 055 000	
TOTAL RAW MATERIALS			11 055 000	33.50
UTILITIES				
POWER	.0080 MWH	61.500	162 360	
COOLING WATER	.0300 KTONNE	17.000	168 300	
BLR.FEED WATER	.0010 KTONNE	450.000	148 500	
PROCESS WATER	.0020 KTONNE	230.000	151 800	
TOTAL UTILITIES COST			630 960	1.91
OPERATING COSTS				
LABOUR	14.00 MEN @ 17 700 $/YEAR		247 800	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR		29 200	
MAINTENANCE	@ .04×BLCC		631 826	
TOTAL OPERATING COST			908 826	2.75
OVERHEAD EXPENSES				
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION		110 800	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS		590 737	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP		308 391	
DEPRECIATION	@ .100× BLCC+ .050×OFFS		1 817 754	
INTEREST	@ .100× WORKING CAPITAL		310 923	
TOTAL OVERHEAD EXPENSES			3 138 605	9.51
BYPRODUCT CREDIT				
MP.STEAM	¯1.0110 TONNE	19.200	¯6 405 696	
TOTAL BYPRODUCT CREDIT			¯6 405 696	¯19.41
NET COST OF PRODUCTION			9 327 695	28.27

VARIABLE COST OF PRODUCTION	16.00
CASH COST OF PRODUCTION	22.76
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	34.50
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	37.61
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV	40.73

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR SULPHURIC ACID - 98%SINGLE ABSORPTION BENELUX LANG FACTOR 0.65

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	330000	330000	330000	330000	264000	198000	132000
PLANT OUTPUT	330000	280500	247500	198000	264000	198000	132000
CAPITAL COST MILLION DOLLARS							
BLCC	15.8	15.8	15.8	15.8	13.7	11.3	8.7
OFFSITES	4.8	4.8	4.8	4.8	4.1	3.4	2.6
TOTAL FIXED	20.6	20.6	20.6	20.6	17.8	14.8	11.3
WORKING	3.1	2.8	2.7	2.4	2.6	2.1	1.5
DOLLARS PER TONNE PRODUCT - (BASED ON SULPHUR AT $100/TONNE)							
RAW MATERIALS	33.5	33.5	33.5	33.5	33.5	33.5	33.5
UTILITIES	1.9	1.9	1.9	1.9	1.9	1.9	1.9
BYPROD. CREDIT	¯19.4	¯19.4	¯19.4	¯19.4	¯19.4	¯19.4	¯19.4
VARIABLE COST	16.0	16.0	16.0	16.0	16.0	16.0	16.0
OPERATION	2.8	3.2	3.7	4.6	3.1	3.7	4.7
OVERHEAD(EXCL.DEPN)	4.0	4.6	5.2	6.3	4.4	5.1	6.4
CASH COST	22.8	23.9	24.8	26.9	23.6	24.8	27.1
DEPRECIATION	5.5	6.5	7.3	9.2	6.0	6.6	7.6
NET COST OF PRODN	28.3	30.3	32.2	36.1	29.5	31.4	34.7
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	9.3	11.0	12.5	15.6	10.1	11.2	12.9
TRANSFER PRICE	37.6	41.3	44.6	51.6	39.6	42.6	47.6

EFFECT OF SULPHUR PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	120.0	80.0	120.0	80.0	120.0	80.0	120.0	80.0	120.0	80.0	120.0	80.0	120.0	80.0
NET COST OF PRODN	35.0	21.6	37.0	23.6	38.9	25.5	42.8	29.4	36.2	22.8	38.1	24.7	41.4	28.0
TRANSFER PRICE	44.3	30.9	48.0	34.6	51.3	37.9	58.3	44.9	46.3	32.9	49.3	35.9	54.3	40.9

How to Start Manufacturing Industries

SYNTHESIS GAS FROM PARTIAL OXIDATION OF FUEL OIL

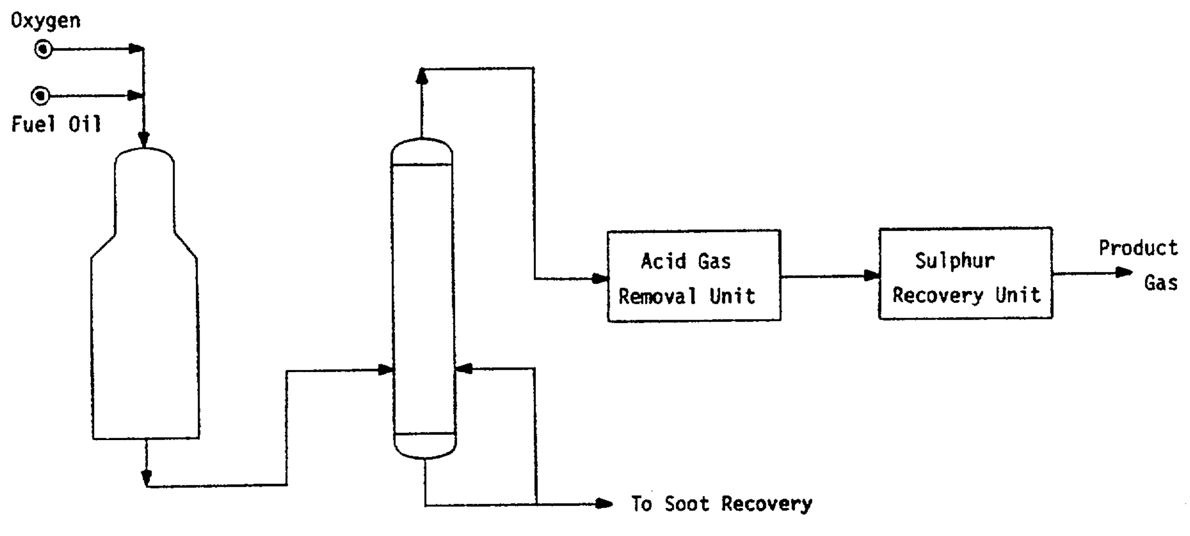
Process Description

The residual oil feedstock and process oxygen are preheated to 245°C and presurised to about 70 bar. Along with recycle soot, and steam diluent, the mixture is passed to the parallel partial oxidation reactors. Reactor residence time is 3.8 seconds at 59 bar and 1 430°C. Hot reactor effluent gas is rapidly quenched to about 180°C.

Crude synthesis gas passes to the quench/separator and crude gas scrubber system to remove residual soot and further cooling to 60-65°C. It then passes to the acid gas removal area and sulphur recovery for further upgrading.

Uses

For synthesizing a wide range of compounds both organic and inorganic especially ammonia. With transition-metal catalysts, synthesis gas yields alcohols, aldehydes, acrylic acid. It is the basis of the Oxo and Fischer-Tropsch reaction.



PARTIAL OXIDATION REACTORS

SCRUBBER COOLERS

Plot area required for a plant producing 300 000 tonnes per year of 1:1 (H_2:CO) syngas would occupy 75 000 square metres. Capacity as low as 30 000 tonnes per year of syngas is also feasible on a technical viewpoint.

This information has been prepared for UNIDO by Chem Systems International Ltd., United Kingdom.

Any inquiry about the information contained should be sent to: IO/COOP, Registry file No. ID/562/12, UNIDO, P.O. Box 300, A-1400, Vienna, Austria.

COST OF PRODUCTION ESTIMATE FOR SYNGAS(H2/CO=1/1)
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - PARTIAL OXIDN.

BASIS	CAPITAL COST	$ MILL
LOCATION- BENELUX	BATTERY LIMITS	46.18
CAPACITY- 300 000 TONNES PER YEAR	OFFSITES	20.35
PRODUCTN- 300 000 TONNES PER YEAR		
YEAR - 1980	TOTAL FIXED INV.	66.53
STR.TIME- 8000 HOURS PER YEAR	WORKING	15.45

RAW MATERIALS	QUANTITY/TONNE	PRICE*	ANNUAL COST	UNIT* COST
3.5%S FUEL OIL	.5510 TONNE	185.000	30 580 500	
CATALYST+CHEMS	.4433 DOLLARS	1.000	133 000	
TOTAL RAW MATERIALS			30 713 500	102.38
UTILITIES				
POWER	.0435 MWH	61.500	802 575	
COOLING WATER	.1057 KTONNE	17.000	539 070	
LP.STEAM	.0092 TONNE	16.700	46 092	
BLR.FEED WATER	.0004 KTONNE	450.000	54 000	
PROCESS WATER	.0038 KTONNE	230.000	262 200	
FUEL	.1780 GCAL	18.100	966 540	
TOTAL UTILITIES COST			2 670 477	8.90
OPERATING COSTS				
LABOUR	60.00 MEN @ 17 700 $/YEAR		1 062 000	
SUPERVISION	2.00 MEN @ 29 200 $/YEAR		58 400	
MAINTENANCE	@ .04×BLCC		1 847 200	
TOTAL OPERATING COST			2 967 600	9.89
OVERHEAD EXPENSES				
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION		448 160	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS		1 928 940	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP		997 950	
DEPRECIATION	@ .100× BLCC+ .050×OFFS		5 635 500	
INTEREST	@ .100× WORKING CAPITAL		1 544 556	
TOTAL OVERHEAD EXPENSES			10 555 106	35.18
BYPRODUCT CREDIT				
SULPHUR	-.0190 TONNE	100.000	- 570 000	
TOTAL BYPRODUCT CREDIT			-570 000	-1.90
NET COST OF PRODUCTION			46 336 683	154.46

VARIABLE COST OF PRODUCTION	109.38
CASH COST OF PRODUCTION	135.67
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	176.63
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	187.72
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV	198.81

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR SYNGAS(H2/CO=1/1) PARTIAL OXIDN. BENELUX LANG FACTOR 0.7

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	300000	300000	300000	300000	240000	180000	120000
PLANT OUTPUT	300000	255000	225000	180000	240000	180000	120000
CAPITAL COST — MILLION DOLLARS							
BLCC	46.2	46.2	46.2	46.2	39.5	32.3	24.3
OFFSITES	20.4	20.4	20.4	20.4	17.4	14.2	10.7
TOTAL FIXED	66.5	66.5	66.5	66.5	56.9	46.5	35.0
WORKING	15.4	13.7	12.6	10.9	12.7	9.9	7.1
DOLLARS PER TONNE PRODUCT - (BASED ON 3.5%S FUEL OIL AT $185/TONNE)							
RAW MATERIALS	102.4	102.4	102.4	102.4	102.4	102.4	102.4
UTILITIES	8.9	8.9	8.9	8.9	8.9	8.9	8.9
BYPROD. CREDIT	¯1.9	¯1.9	¯1.9	¯1.9	¯1.9	¯1.9	¯1.9
VARIABLE COST	109.4	109.4	109.4	109.4	109.4	109.4	109.4
OPERATION	9.9	11.6	13.2	16.5	11.3	13.4	17.4
OVERHEAD(EXCL.DEPN)	16.4	18.6	20.6	24.8	18.0	20.6	25.3
CASH COST	135.7	139.6	143.2	150.7	138.7	143.4	152.2
DEPRECIATION	18.8	22.1	25.0	31.3	20.1	21.9	24.7
NET COST OF PRODN	154.5	161.7	168.2	182.0	158.7	165.3	176.9
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	33.3	39.1	44.4	55.4	35.6	38.8	43.8
TRANSFER PRICE	187.7	200.9	212.6	237.4	194.3	204.0	220.7

EFFECT OF 3.5%S FUEL OIL PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	222.0	148.0	222.0	148.0	222.0	148.0	222.0	148.0	222.0	148.0	222.0	148.0	222.0	148.0
NET COST OF PRODN	174.8	134.1	182.1	141.4	188.6	147.8	202.4	161.6	179.1	138.4	185.7	144.9	197.3	156.5
TRANSFER PRICE	208.1	167.3	221.3	180.5	233.0	192.2	257.8	217.0	214.7	173.9	224.4	183.7	241.1	200.3

File: G71
ISIC 3511

How to Start Manufacturing Industries

TEREPHTHALIC ACID (TPA) - FIBRE GRADE

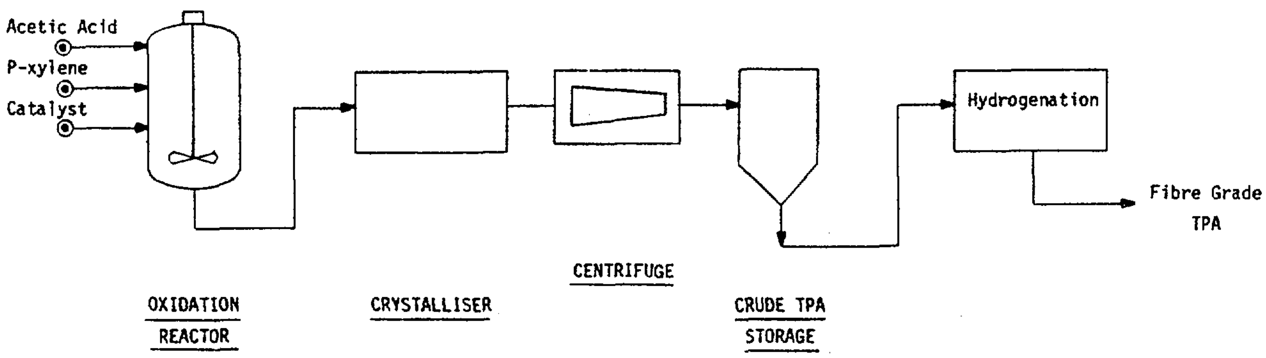
Process Description

Para-xylene and fresh acetic acid are mixed with catalyst and recycled acetic acid. The feed stream is pumped to the top of the oxidation reactor while the air enters through the bottom of the reactor. Temperature and pressure in the reactor are held at 200^{o}C and 14 bar respectively. Reaction time is half to one hour.

The reactor products are continuously discharged as a hot slurry into a crystalliser where cooling takes places by flashing off part of acetic acid, unreacted p-xylene and water of reaction. The slurry is then sent to a centrifuge. The crude TPA is dried and further purified to fibre grade TPA by means of hydrogenation. The liquid from the centrifuge is sent to acetic acid recovery for recycle.

Uses

Nearly all the TPA produced is used to make polyethylene terephthalate (PET), a polymer used for making fibres and films, and the larger of these two uses is in fibre production. The film is used for magnetic tapes, electrical insulation and packaging.



Land area required for a plant of 185 000 tonnes per year capacity is 6 000 square metres. However, a capacity as small as 40 000 tonnes per year is also feasible.

This information has been prepared for UNIDO by Chem Systems International Ltd., United Kingdom.

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COST OF PRODUCTION ESTIMATE FOR TPA (FIBRE GRADE)
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - PARA-XYLENE

BASIS		CAPITAL COST	$ MILL
LOCATION-	BENELUX	BATTERY LIMITS	114.21
CAPACITY-	185 000 TONNES PER YEAR	OFFSITES	54.78
PRODUCTN-	185 000 TONNES PER YEAR		
YEAR	- 1980	TOTAL FIXED INV.	168.99
STR.TIME-	8000 HOURS PER YEAR	WORKING	44.17

RAW MATERIALS	QUANTITY/TONNE	PRICE*	ANNUAL COST	UNIT* COST
PARA-XYLENE	.6750 TONNE	690.000	86 163 750	
CATALYST+CHEMS	30.0000 DOLLARS	1.000	5 550 000	
TOTAL RAW MATERIALS			91 713 750	495.75
UTILITIES				
POWER	.6800 MWH	61.500	7 736 700	
COOLING WATER	.1000 KTONNE	17.000	314 500	
BLR.FEED WATER	.0030 KTONNE	450.000	249 750	
INERT GAS	15.0000 NM3	.085	235 875	
FUEL	.8600 GCAL	18.100	2 879 710	
TOTAL UTILITIES COST			11 416 535	61.71
OPERATING COSTS				
LABOUR	38.00 MEN @ 17 700 $/YEAR		672 600	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR		29 200	
MAINTENANCE	@ .04×BLCC		4 568 400	
TOTAL OPERATING COST			5 270 200	28.49
OVERHEAD EXPENSES				
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION		280 720	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS		3 425 630	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP		2 534 895	
DEPRECIATION	@ .100× BLCC+ .050×OFFS		14 160 150	
INTEREST	@ .100× WORKING CAPITAL		4 416 948	
TOTAL OVERHEAD EXPENSES			24 818 343	134.15
BYPRODUCT CREDIT				
MP.STEAM	-.2000 TONNE	19.200	- 710 400	
TOTAL BYPRODUCT CREDIT			-710 400	-3.84
NET COST OF PRODUCTION			132 508 428	716.26

VARIABLE COST OF PRODUCTION	553.62
CASH COST OF PRODUCTION	639.72
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	807.61
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	853.28
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV	898.96

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR TPA (FIBRE GRADE) PARA-XYLENE BENELUX LANG FACTOR 0.7

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	185000	185000	185000	185000	148000	111000	74000
PLANT OUTPUT	185000	157250	138750	111000	148000	111000	74000
CAPITAL COST — MILLION DOLLARS							
BLCC	114.2	114.2	114.2	114.2	97.7	79.9	60.1
OFFSITES	54.8	54.8	54.8	54.8	46.9	38.3	28.8
TOTAL FIXED	169.0	169.0	169.0	169.0	144.6	118.2	89.0
WORKING	44.2	38.9	35.3	30.0	35.9	27.5	19.0
DOLLARS PER TONNE PRODUCT - (BASED ON PARA-XYLENE AT $690/TONNE)							
RAW MATERIALS	495.8	495.7	495.7	495.7	495.7	495.7	495.7
UTILITIES	61.7	61.7	61.7	61.7	61.7	61.7	61.7
BYPROD. CREDIT	¯3.8	¯3.8	¯3.8	¯3.8	¯3.8	¯3.8	¯3.8
VARIABLE COST	553.6	553.6	553.6	553.6	553.6	553.6	553.6
OPERATION	28.5	33.5	38.0	47.5	31.1	35.1	42.0
OVERHEAD(EXCL.DEPN)	57.6	64.4	70.5	83.3	61.0	66.1	74.8
CASH COST	639.7	651.5	662.1	684.4	645.8	654.8	670.4
DEPRECIATION	76.5	90.0	102.1	127.6	81.8	89.2	100.8
NET COST OF PRODN	716.3	741.6	764.1	812.0	727.7	744.1	771.2
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	137.0	161.2	182.7	228.4	146.5	159.7	180.4
TRANSFER PRICE	853.3	902.8	946.8	1040.3	874.2	903.8	951.6

EFFECT OF PARA-XYLENE PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	828.0	552.0	828.0	552.0	828.0	552.0	828.0	552.0	828.0	552.0	828.0	552.0	828.0	552.0
NET COST OF PRODN	809.4	623.1	834.7	648.4	857.3	671.0	905.1	718.8	820.8	634.5	837.2	650.9	864.4	678.1
TRANSFER PRICE	946.4	760.1	995.9	809.6	1040.0	853.7	1133.5	947.2	967.3	781.0	996.9	810.6	1044.7	858.4

UNSATURATED POLYESTERS

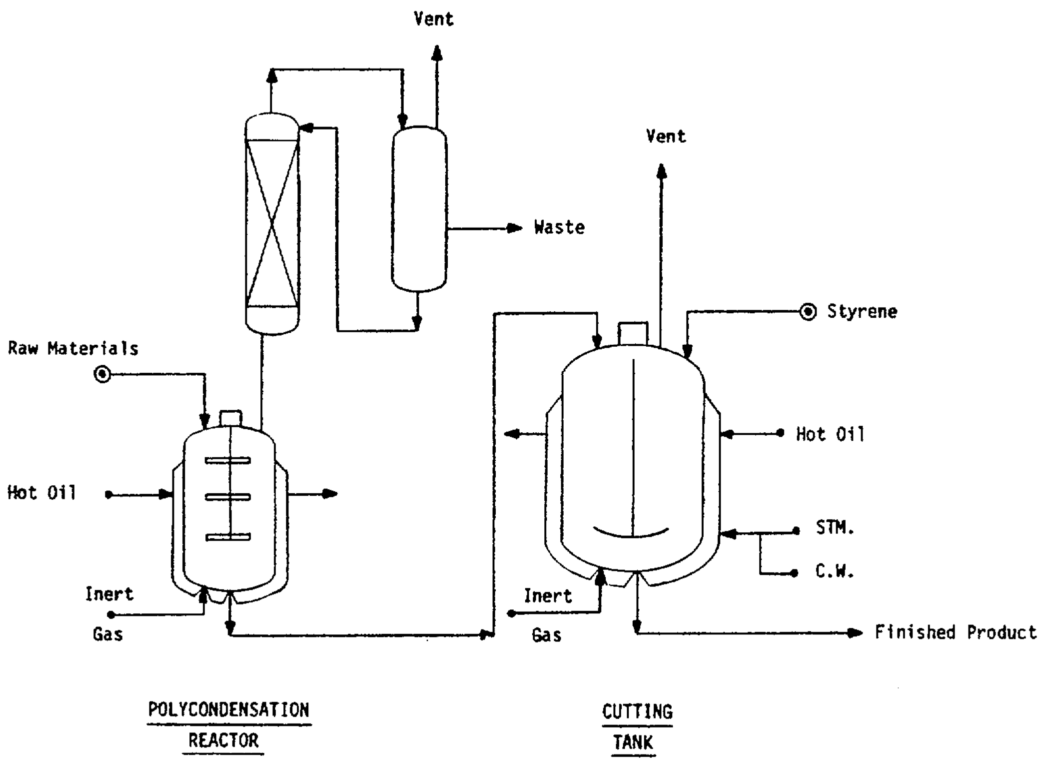
Process Description

Unsaturated polyester resins have traditionally been manufactured in batch operations, and reactor design is an important factor. Typical polyester reactors are constructed at a length/diameter ratio of approaching unity, and are equipped with a single pitched (axial flow) turbine whose diameter is about 40 percent of that of the tank. Reactor cooling capability is the single most critical factor determining the plant's capacity, because the polymerisation is highly exothermic. Polyester reactors usually contain spiral-wound, water-filled cooling coils for this purpose.

To promote a steady reaction rate and to help maintain a homogenous product, some of the reactants may be introduced continuously or in discrete additions, as the reaction proceeds. The reaction time varies between six and thirty hours, being strongly dependent upon the nature of the raw materials.

Uses

Main applications are as plasticisers in PVC production.



Land area required for a 65 000 tonnes per year plant is in the region of 4 000 square metres. However, since this is a batch process very small capacities are feasible. The smallest reported in Europe for example, is 1 000 tonnes per year.

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COST OF PRODUCTION ESTIMATE FOR UNSAT'D POLYESTERS
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - BATCH

BASIS		CAPITAL COST	$ MILL
LOCATION- BENELUX		BATTERY LIMITS	8.20
CAPACITY-	65 000 TONNES PER YEAR	OFFSITES	3.30
PRODUCTN-	65 000 TONNES PER YEAR		
YEAR	- 1980	TOTAL FIXED INV.	11.50
STR.TIME-	8000 HOURS PER YEAR	WORKING	20.53

RAW MATERIALS	QUANTITY/TONNE	PRICE*	ANNUAL COST	UNIT* COST
MALEIC ANHYD	.1720 TONNE	1050.000	11 739 000	
PHTHALIC ANHYD	.2610 TONNE	780.000	13 232 700	
PROP. GLYCOL	.2930 TONNE	710.000	13 521 950	
STYRENE	.3540 TONNE	770.000	17 717 700	
CATALYST+CHEMS	8.0154 DOLLARS	1.000	521 000	
TOTAL RAW MATERIALS			56 732 350	872.81
UTILITIES				
POWER	.0550 MWH	61.500	219 863	
COOLING WATER	.0125 KTONNE	17.000	13 812	
MP.STEAM	.0500 TONNE	19.200	62 400	
INERT GAS	3.5400 NM3	.085	19 559	
HOT OIL	.0544 GCAL	18.100	64 002	
TOTAL UTILITIES COST			379 635	5.84
OPERATING COSTS				
LABOUR	18.00 MEN @ 17 700 $/YEAR		318 600	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR		29 200	
MAINTENANCE	@ .04×BLCC		328 000	
TOTAL OPERATING COST			675 800	10.40
OVERHEAD EXPENSES				
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION		139 120	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS		439 270	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP		172 500	
DEPRECIATION	@ .100× BLCC+ .050×OFFS		985 000	
INTEREST	@ .100× WORKING CAPITAL		2 052 541	
TOTAL OVERHEAD EXPENSES			3 788 431	58.28
BYPRODUCT CREDIT				
TOTAL BYPRODUCT CREDIT			0	.00
NET COST OF PRODUCTION			61 576 216	947.33

VARIABLE COST OF PRODUCTION	878.65
CASH COST OF PRODUCTION	932.17
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	965.02
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	973.86
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV	982.71

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR UNSAT'D POLYESTERS BATCH BENELUX LANG FACTOR 0.65

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	65000	65000	65000	65000	52000	39000	26000
PLANT OUTPUT	65000	55250	48750	39000	52000	39000	26000
CAPITAL COST — MILLION DOLLARS							
BLCC	8.2	8.2	8.2	8.2	7.1	5.9	4.5
OFFSITES	3.3	3.3	3.3	3.3	2.9	2.4	1.8
TOTAL FIXED	11.5	11.5	11.5	11.5	9.9	8.3	6.3
WORKING	20.5	17.6	15.6	12.6	16.5	12.5	8.4
DOLLARS PER TONNE PRODUCT - (BASED ON MALEIC ANHYD AT $1050/TONNE)							
RAW MATERIALS	872.8	872.8	872.8	872.8	872.8	872.8	872.8
UTILITIES	5.8	5.8	5.8	5.8	5.8	5.8	5.8
BYPROD. CREDIT	.0	.0	.0	.0	.0	.0	.0
VARIABLE COST	878.6	878.6	878.6	878.6	878.6	878.6	878.6
OPERATION	10.4	12.2	13.9	17.3	12.1	15.0	20.3
OVERHEAD(EXCL.DEPN)	43.1	45.4	47.4	51.7	45.2	48.5	54.7
CASH COST	932.2	936.3	939.9	947.7	936.0	942.1	953.7
DEPRECIATION	15.2	17.8	20.2	25.3	16.4	18.1	20.9
NET COST OF PRODN	947.3	954.1	960.1	972.9	952.4	960.2	974.6
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	26.5	31.2	35.4	44.2	28.7	31.7	36.6
TRANSFER PRICE	973.9	985.3	995.5	1017.1	981.1	991.9	1011.1

EFFECT OF MALEIC ANHYD PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	1260.0	840.0	1260.0	840.0	1260.0	840.0	1260.0	840.0	1260.0	840.0	1260.0	840.0	1260.0	840.0
NET COST OF PRODN	983.4	911.2	990.2	918.0	996.2	924.0	1009.0	936.8	988.5	916.2	996.3	924.1	1010.7	938.4
TRANSFER PRICE	1010.0	937.7	1021.4	949.2	1031.6	959.4	1053.3	981.0	1017.2	944.9	1028.0	955.8	1047.3	975.0

How to Start Manufacturing Industries

UREA

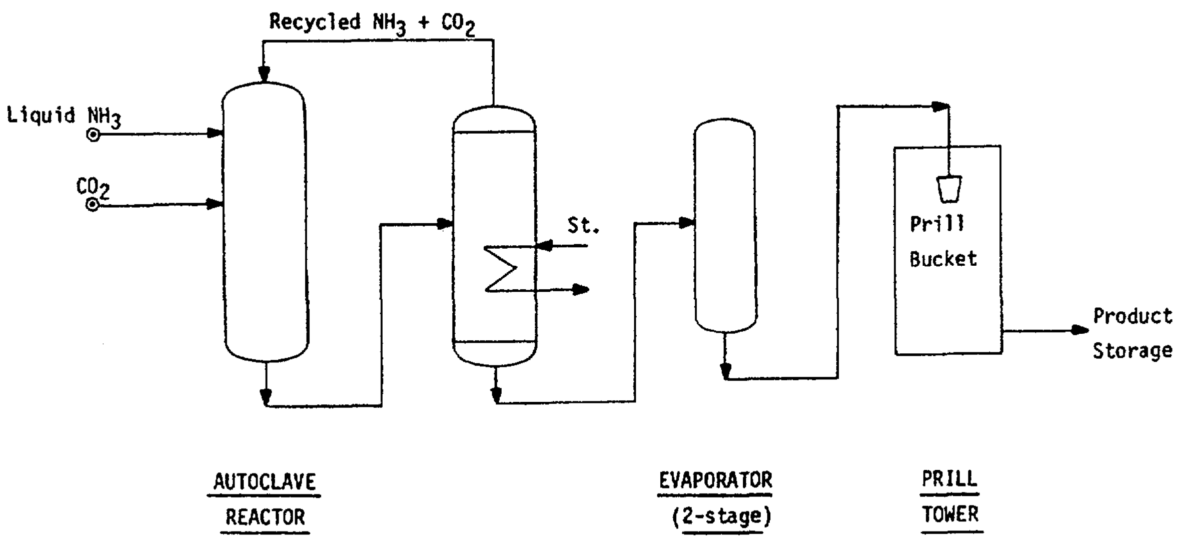
Process Description

Ammonia and carbon dioxide are compressed to a pressure in the range of 150-220 bar and a temperature of 180-220^{o}C, an exothermic reaction occurs to form carbonate which is then dehydrated to urea.

The unconverted carbonate and excess reactants are removed in the solution purification stages and returned to the reaction system. The urea solution is evaporated to achieve required concentration for fertiliser or technical grade urea. If a low biuret content is required, the product is concentrated by crystallisation. The final shaping of the product is almost always done by prilling.

Uses

Urea is used mainly as a fertiliser. In recent years, the demand for urea as a supplement in cattle feed has been steadily growing. Another important use is in formaldehyde resins.



Land area for 500 000 tonnes per year of urea would be approximately 8 000 square metres. Capacities as low as 7 000 tonnes per year are technically feasible.

This information has been prepared for UNIDO by Chem Systems International Ltd., United Kingdom.

Any inquiry about the information contained should be sent to: IO/COOP, Registry file No. ID/562/12, UNIDO, P.O. Box 300, A-1400, Vienna, Austria.

COST OF PRODUCTION ESTIMATE FOR UREA
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - STRIPPING PROCESS

BASIS		CAPITAL COST	$ MILL
LOCATION-	BENELUX	BATTERY LIMITS	41.37
CAPACITY-	500 000 TONNES PER YEAR	OFFSITES	28.83
PRODUCTN-	500 000 TONNES PER YEAR		
YEAR -	1980	TOTAL FIXED INV.	70.20
STR.TIME-	8000 HOURS PER YEAR	WORKING	54.97

RAW MATERIALS	QUANTITY/TONNE		PRICE*	ANNUAL COST	UNIT* COST
AMMONIA	.6000	TONNE	195.000	58 500 000	
CARBON DIOXIDE	.7600	TONNE	205.000	77 900 000	
CATALYST+CHEMS	.1254	DOLLARS	1.000	62 700	
TOTAL RAW MATERIALS				136 462 700	272.93
UTILITIES					
POWER	.1250	MWH	61.500	3 843 750	
COOLING WATER	.0550	KTONNE	17.000	467 500	
MP.STEAM	1.0000	TONNE	19.200	9 600 000	
TOTAL UTILITIES COST				13 911 250	27.82
OPERATING COSTS					
LABOUR	24.00 MEN @ 17 700 $/YEAR			424 800	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR			29 200	
MAINTENANCE	@ .04×BLCC			1 654 783	
TOTAL OPERATING COST				2 108 783	4.22
OVERHEAD EXPENSES					
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION			181 600	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS			1 370 709	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP			1 053 043	
DEPRECIATION	@ .100× BLCC+ .050×OFFS			5 578 623	
INTEREST	@ .100× WORKING CAPITAL			5 497 042	
TOTAL OVERHEAD EXPENSES				13 681 017	27.36
BYPRODUCT CREDIT					
L.P.STEAM	¯.1500	TONNE	16.700	¯1 252 500	
TOTAL BYPRODUCT CREDIT				¯1 252 500	¯2.50
NET COST OF PRODUCTION				164 911 250	329.82

VARIABLE COST OF PRODUCTION	298.24
CASH COST OF PRODUCTION	318.67
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	343.86
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	350.88
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV	357.90

VARIATION ANALYSIS FOR UREA STRIPPING PROCESS BENELUX LANG FACTOR 0.65

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	500000	500000	500000	500000	400000	300000	200000
PLANT OUTPUT	500000	425000	375000	300000	400000	300000	200000
CAPITAL COST MILLION DOLLARS							
BLCC	41.4	41.4	41.4	41.4	35.8	29.7	22.8
OFFSITES	28.8	28.8	28.8	28.8	24.9	20.7	15.9
TOTAL FIXED	70.2	70.2	70.2	70.2	60.7	50.4	38.7
WORKING	55.0	47.3	42.1	34.4	44.3	33.5	22.7
DOLLARS PER TONNE PRODUCT - (BASED ON AMMONIA AT $195/TONNE)							
RAW MATERIALS	272.9	272.9	272.9	272.9	272.9	272.9	272.9
UTILITIES	27.8	27.8	27.8	27.8	27.8	27.8	27.8
BYPROD. CREDIT	-2.5	-2.5	-2.5	-2.5	-2.5	-2.5	-2.5
VARIABLE COST	298.2	298.2	298.2	298.2	298.2	298.2	298.2
OPERATION	4.2	5.0	5.6	7.0	4.7	5.5	6.8
OVERHEAD(EXCL.DEPN)	16.2	17.2	18.2	20.2	16.9	17.8	19.6
CASH COST	318.7	320.5	322.0	325.4	319.8	321.6	324.7
DEPRECIATION	11.2	13.1	14.9	18.6	12.1	13.3	15.4
NET COST OF PRODN	329.8	333.6	336.9	344.0	331.9	334.9	340.0
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	21.1	24.8	28.1	35.1	22.8	25.2	29.0
TRANSFER PRICE	350.9	358.4	365.0	379.1	354.6	360.1	369.1

EFFECT OF AMMONIA PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	234.0	156.0	234.0	156.0	234.0	156.0	234.0	156.0	234.0	156.0	234.0	156.0	234.0	156.0
NET COST OF PRODN	353.2	306.4	357.0	310.2	360.3	313.5	367.4	320.6	355.3	308.5	358.3	311.5	363.4	316.6
TRANSFER PRICE	374.3	327.5	381.8	335.0	388.4	341.6	402.5	355.7	378.0	331.2	383.5	336.7	392.5	345.7

VINYL ACETATE - ETHYLENE VAPOUR PHASE OXIDATION

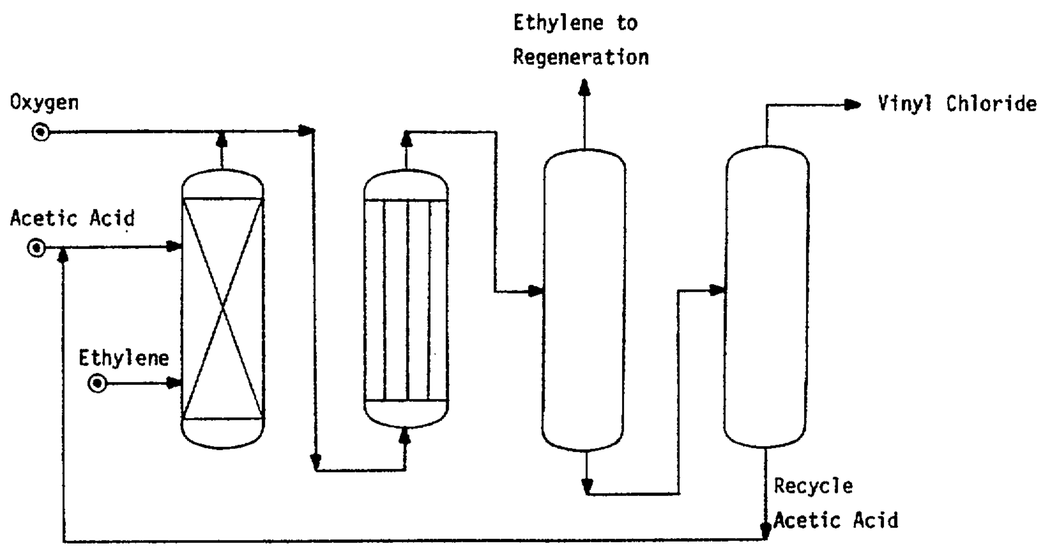
Process Description

Fresh and recycle acetic acid is vapourised, and continuously fed to the acetic vapouriser where it is contacted with gaseous ethylene. Pure oxygen is now introduced into the vapourised acetic acid/ethylene feed stream. Vinyl acetate, water and carbon dioxide are formed in the catalytic multi-tube reactors. The reactors are operated near to 8 bar and 175^{o}C. Major yields across the synthesis section, based upon ethylene are about 92 percent vinyl acetate, 7.5 percent carbon dioxide.

Reactor effluent then enters a series of separators and a scrubber to recover crude vinyl acetate and acetic acid. Crude vinyl acetate is then fed to the recovery section which consists of five fractionation columns.

Uses

Polymerisation is the only major use for vinyl acetate. More than 50 percent is used for polyvinyl acetate, the other polymerisation products are polyvinyl alcohol, polyvinyl acetate and vinyl chloride copolymers.



Plot area for 150 000 tonnes per year of vinyl acetate is approximately 15 000 square metres. Sizes as low as 7 000 tonnes per year have successfully operated in Western Europe.

This information has been prepared for UNIDO by Chem Systems International Ltd., United Kingdom.

Any inquiry about the information contained should be sent to: IO/COOP, Registry file No. ID/562/12, UNIDO, P.O. Box 300, A-1400, Vienna, Austria.

COST OF PRODUCTION ESTIMATE FOR VINYL ACETATE
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - ETHYLENE OXIDATION

BASIS	CAPITAL COST	$ MILL
LOCATION- BENELUX	BATTERY LIMITS	72.71
CAPACITY- 150 000 TONNES PER YEAR	OFFSITES	28.83
PRODUCTN- 150 000 TONNES PER YEAR		
YEAR - 1980	TOTAL FIXED INV.	101.54
STR.TIME- 8000 HOURS PER YEAR	WORKING	40.77

RAW MATERIALS	QUANTITY/TONNE	PRICE*	ANNUAL COST	UNIT* COST
ETHYLENE	.3700 TONNE	750.000	41 625 000	
OXYGEN	.2800 TONNE	87.000	3 654 000	
ACETIC ACID	.7200 TONNE	380.000	41 040 000	
CATALYST+CHEMS	16.7333 DOLLARS	1.000	2 510 000	
TOTAL RAW MATERIALS			88 829 000	592.19
UTILITIES				
POWER	.3420 MWH	61.500	3 154 950	
COOLING WATER	.2200 KTONNE	17.000	561 000	
HP.STEAM	.4600 TONNE	20.200	1 393 800	
LP.STEAM	3.1600 TONNE	16.700	7 915 800	
INERT GAS	46.0000 NM3	.085	586 500	
TOTAL UTILITIES COST			13 612 050	90.75
OPERATING COSTS				
LABOUR	19.00 MEN @ 17 700 $/YEAR		336 300	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR		29 200	
MAINTENANCE	@ .04×BLCC		2 908 406	
TOTAL OPERATING COST			3 273 906	21.83
OVERHEAD EXPENSES				
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION		146 200	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS		2 128 039	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP		1 523 152	
DEPRECIATION	@ .100× BLCC+ .050×OFFS		8 712 681	
INTEREST	@ .100× WORKING CAPITAL		4 076 725	
TOTAL OVERHEAD EXPENSES			16 586 797	110.58
BYPRODUCT CREDIT				
TOTAL BYPRODUCT CREDIT			0	.00
NET COST OF PRODUCTION			122 301 753	815.35

VARIABLE COST OF PRODUCTION	682.94
CASH COST OF PRODUCTION	757.26
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	883.04
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	916.89
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV	950.74

* $/UNIT. TONNE=METRIC TON=2204.6 LB.

VARIATION ANALYSIS FOR VINYL ACETATE ETHYLENE OXIDATION BENELUX

CASE NO	1	2	3	4	
TONNES PER ANNUM					
PLANT CAPACITY	150000	150000	150000	150000	1200
PLANT OUTPUT	150000	127500	112500	90000	1200
CAPITAL COST – **MILLION DOLLARS**					
BLCC	72.7	72.7	72.7	72.7	62
OFFSITES	28.8	28.8	28.8	28.8	24
TOTAL FIXED	101.5	101.5	101.5	101.5	87
WORKING	40.8	35.5	31.9	26.6	33
DOLLARS PER TONNE PRODUCT – (BASED ON ETHYLENE AT $750/TONNE)					
RAW MATERIALS	592.2	592.2	592.2	592.2	592
UTILITIES	90.7	90.7	90.7	90.7	90
BYPROD. CREDIT	.0	.0	.0	.0	
VARIABLE COST	682.9	682.9	682.9	682.9	682
OPERATION	21.8	25.7	29.1	36.4	24
OVERHEAD(EXCL.DEPN)	52.5	57.6	62.1	71.8	55
CASH COST	757.3	766.2	774.2	791.1	762
DEPRECIATION	58.1	68.3	77.4	96.8	62
NET COST OF PRODN	815.3	834.6	851.6	887.9	825
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	101.5	119.5	135.4	169.2	109
TRANSFER PRICE	916.9	954.0	987.0	1057.2	934

EFFECT OF ETHYLENE PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-2
RM PRICE $/TONNE	900.0	600.0	900.0	600.0	900.0	600.0	900.0	600.0	900.0	600
NET COST OF PRODN	870.8	759.8	890.1	779.1	907.1	796.1	943.4	832.4	880.6	769
TRANSFER PRICE	972.4	861.4	1009.5	898.5	1042.5	931.5	1112.7	1001.7	990.4	879

File: G75
ISIC 3511

How to Start Manufacturing Industries

VINYL CHLORIDE

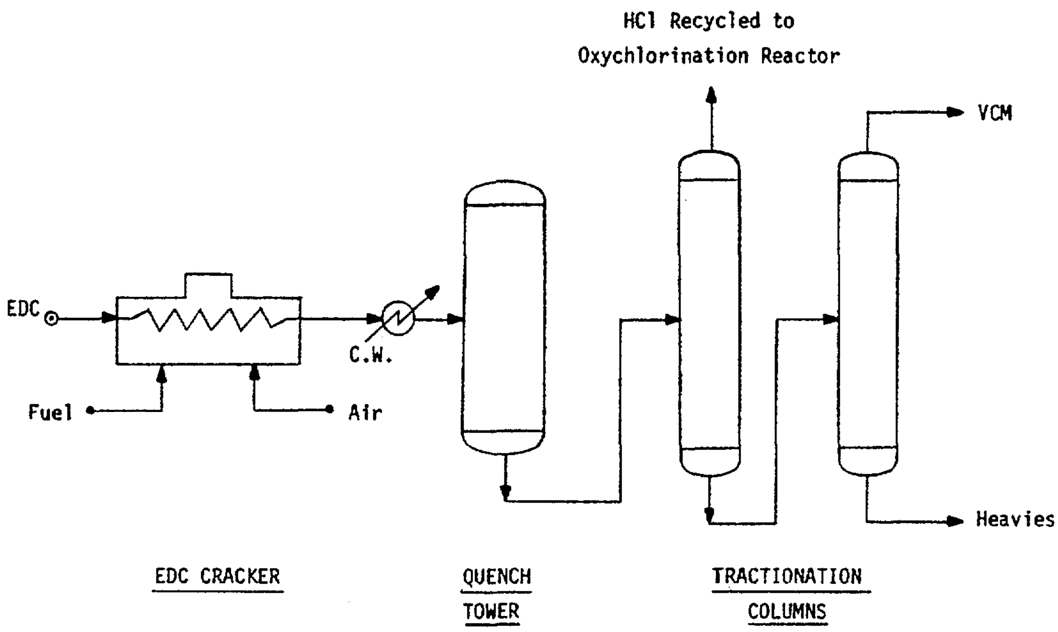
Process Description

Ethylene dichloride (EDC) is formed via the balanced oxychlorination route (see ethylene dichloride description). Pure EDC (99 percent) from the fractionation facilities is feed to the pyrolysis section where it is thermally cracked to VCM and HCl.

Operating conditions are in the region of 11 bar and 480°C. Conversion is about 50-60 percent per pass. Furnace effluent is cooled in a quench tower prior to being fed to VCM fractionation facilities.

Uses

It is mainly used for polyvinyl chloride and copolymers and as adhesive for plastics.



The plot area for a 300 000 tonnes per year plant is approximately 50 000 square metres. The smallest size built in Europe to date is 15 000 tonnes per year.

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COST OF PRODUCTION ESTIMATE FOR VINYL CHLORIDE
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - BALANCED OXYCHLORN

BASIS	CAPITAL COST	$ MILL
LOCATION- BENELUX	BATTERY LIMITS	94.40
CAPACITY- 450 000 TONNES PER YEAR	OFFSITES	53.80
PRODUCTN- 450 000 TONNES PER YEAR		
YEAR - 1980	TOTAL FIXED INV.	148.20
STR.TIME- 8000 HOURS PER YEAR	WORKING	86.81

RAW MATERIALS	QUANTITY/TONNE	PRICE*	ANNUAL COST	UNIT* COST
ETHYLENE	.4800 TONNE	750.000	162 000 000	
CHLORINE	.6100 TONNE	170.000	46 665 000	
CATALYST+CHEMS	5.1333 DOLLARS	1.000	2 310 000	
TOTAL RAW MATERIALS			210 975 000	468.83
UTILITIES				
POWER	.2200 MWH	61.500	6 088 500	
COOLING WATER	.1000 KTONNE	17.000	765 000	
MP.STEAM	.9000 TONNE	19.200	7 776 000	
PROCESS WATER	.0009 KTONNE	230.000	93 150	
FUEL	.4995 GCAL	18.100	4 068 428	
TOTAL UTILITIES COST			18 791 077	41.76
OPERATING COSTS				
LABOUR	37.00 MEN @ 17 700 $/YEAR		654 900	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR		29 200	
MAINTENANCE	@ .04×BLCC		3 776 000	
TOTAL OPERATING COST			4 460 100	9.91
OVERHEAD EXPENSES				
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION		273 640	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS		2 899 065	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP		2 223 000	
DEPRECIATION	@ .100× BLCC+ .050×OFFS		12 130 000	
INTEREST	@ .100× WORKING CAPITAL		8 681 099	
TOTAL OVERHEAD EXPENSES			26 206 804	58.24
BYPRODUCT CREDIT				
TOTAL BYPRODUCT CREDIT			0	.00
NET COST OF PRODUCTION			260 432 982	578.74

VARIABLE COST OF PRODUCTION	510.59
CASH COST OF PRODUCTION	551.78
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	611.67
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	628.14

VARIATION ANALYSIS FOR VINYL CHLORIDE BALANCED OXYCHLORN BENELUX LANG FACTOR 0.65

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	450000	450000	450000	450000	360000	270000	180000
PLANT OUTPUT	450000	382500	337500	270000	360000	270000	180000
CAPITAL COST — MILLION DOLLARS							
BLCC	94.4	94.4	94.4	94.4	81.7	67.7	52.0
OFFSITES	53.8	53.8	53.8	53.8	46.5	38.6	29.7
TOTAL FIXED	148.2	148.2	148.2	148.2	128.2	106.3	81.7
WORKING	86.8	74.9	67.0	55.1	70.0	53.1	36.1
DOLLARS PER TONNE PRODUCT - (BASED ON ETHYLENE AT $750/TONNE)							
RAW MATERIALS	468.8	468.8	468.8	468.8	468.8	468.8	468.8
UTILITIES	41.8	41.8	41.8	41.8	41.8	41.8	41.8
BYPROD. CREDIT	.0	.0	.0	.0	.0	.0	.0
VARIABLE COST	510.6	510.6	510.6	510.6	510.6	510.6	510.6
OPERATION	9.9	11.7	13.2	16.5	11.0	12.6	15.4
OVERHEAD(EXCL.DEPN)	31.3	33.7	35.8	40.4	32.7	34.8	38.4
CASH COST	551.8	555.9	559.6	567.5	554.2	557.9	564.3
DEPRECIATION	27.0	31.7	35.9	44.9	29.1	32.2	37.1
NET COST OF PRODN	578.7	587.7	595.6	612.4	583.4	590.2	601.5
RETURN ON INVESTMENT (AT 15% ON TOTAL FIXED INVESTMENT)	49.4	58.1	65.9	82.3	53.4	59.1	68.1
TRANSFER PRICE	628.1	645.8	661.5	694.8	636.8	649.2	669.5

EFFECT OF ETHYLENE PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	900.0	600.0	900.0	600.0	900.0	600.0	900.0	600.0	900.0	600.0	900.0	600.0	900.0	600.0
NET COST OF PRODN	650.7	506.7	659.7	515.7	667.6	523.6	684.4	540.4	655.4	511.4	662.2	518.2	673.5	529.5
TRANSFER PRICE	700.1	556.1	717.8	573.8	733.5	589.5	766.8	622.8	708.8	564.8	721.2	577.2	741.5	597.5

How to Start Manufacturing Industries

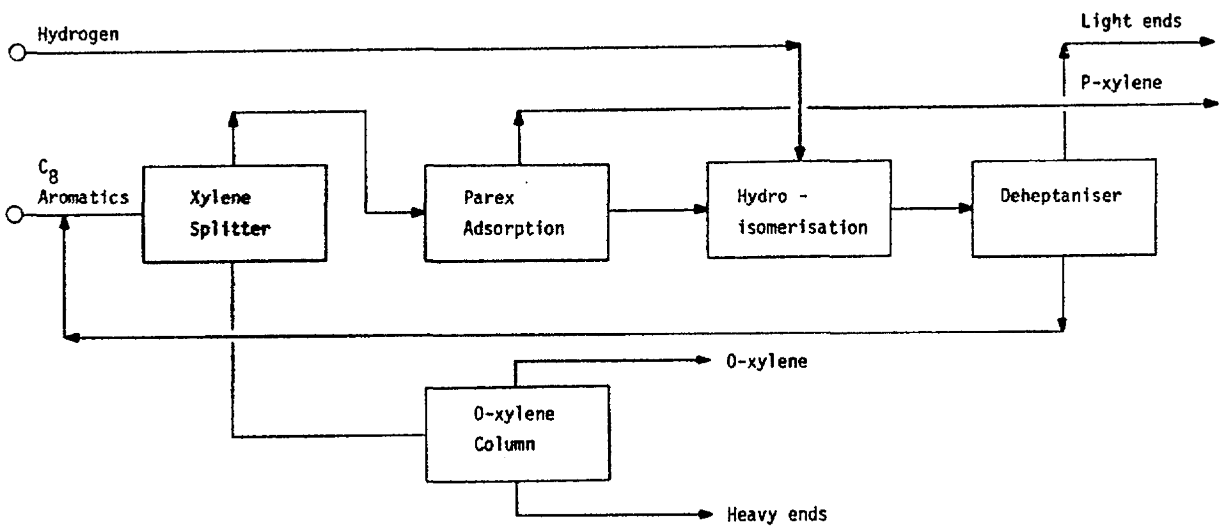
p-XYLENE - RECOVERY BY ADSORPTION

Process Description

The UOP Parex process was the first commercial process. It is a continuous process using a fixed bed of adsorbent. All process streams are in the liquid phase at constant temperature in the bed. Feed is introduced and p-xylene is selectively adsorbed. The adsorbed p-xylene is recovered from the pores of the adsorbent by displacement with another liquid hydrocarbon. The stream leaves the adsorbent bed with both the p-xylene product and the rejected raffinate streams. The desorbent is recovered from these two streams by fractionation and is recycled to the adsorbent bed. A rotary valve is employed in the process to stimulate countercurrent flow of solid and liquid without actual movement of the solid adsorbent.

Uses

p-xylene is mainly used as the raw material for terephthalic acid and dimethyl terephthalate production. The other major uses are as a high quality octane-blending agent into motor fuels and as a solvent.



A para-xylene recovery unit of 2 000 barrels per day capacity can occupy 1 500 square metres where as 20 000 barrels per day plant can occupy 10 000 square metres. There is no linear relationship between capacity and plot area. The smallest plant in Europe has a capacity of 20 000 tonnes per year. However smaller sizes are also feasible.

This information has been prepared for UNIDO by Chem Systems International Ltd., United Kingdom.

COST OF PRODUCTION ESTIMATE FOR P-XYLENE
(EXPRESSED IN CONSTANT 1980 US DOLLARS)
PROCESS - XYLENES ADSORPTION

BASIS		CAPITAL COST	$ MILL
LOCATION-	BENELUX	BATTERY LIMITS	43.88
CAPACITY-	100 000 TONNES PER YEAR	OFFSITES	15.04
PRODUCTN-	100 000 TONNES PER YEAR		
YEAR -	1980	TOTAL FIXED INV.	58.92
STR.TIME-	8000 HOURS PER YEAR	WORKING	19.37

RAW MATERIALS	QUANTITY/TONNE	PRICE*	ANNUAL COST	UNIT* COST
XYLENES	1.6100 TONNE	420.000	67 620 000	
HYDROGEN	.0120 TONNE	1100.000	1 320 000	
CATALYST+CHEMS	4.4000 DOLLARS	1.000	440 000	
TOTAL RAW MATERIALS			69 380 000	693.80
UTILITIES				
POWER	.2000 MWH	61.500	1 230 000	
COOLING WATER	.1200 KTONNE	17.000	204 000	
FUEL	3.7000 GCAL	18.100	6 697 000	
TOTAL UTILITIES COST			8 131 000	81.31
OPERATING COSTS				
LABOUR	13.00 MEN @ 17 700 $/YEAR		230 100	
SUPERVISION	1.00 MEN @ 29 200 $/YEAR		29 200	
MAINTENANCE	@ .04×BLCC		1 755 072	
TOTAL OPERATING COST			2 014 372	20.14
OVERHEAD EXPENSES				
DIRECT OVERHEAD	@ .400× LAB+SUPERVISION		103 720	
GEN PLANT OVERHEAD	@ .650× OPERATING COSTS		1 309 342	
INSURANCE+PTY TAX	@ .015× TOTAL FIXED CAP		883 804	
DEPRECIATION	@ .100× BLCC+ .050×OFFS		5 139 855	
INTEREST	@ .100× WORKING CAPITAL		1 937 331	
TOTAL OVERHEAD EXPENSES			9 374 052	93.74
BYPRODUCT CREDIT				
O-XYLENE	-.5000 TONNE	550.000	-27 500 000	
MP.STEAM	-.3600 TONNE	19.200	- 691 200	
LIGHT ENDS	-1.2600 GCAL	18.100	-2 280 600	
HEAVY ENDS	-.1700 GCAL	18.100	- 307 700	
TOTAL BYPRODUCT CREDIT			-30 779 500	-307.79
NET COST OF PRODUCTION			58 119 925	581.20

VARIABLE COST OF PRODUCTION	467.31
CASH COST OF PRODUCTION	529.80
TRANSFER PRICE @ 10.0PC RETURN ON FIXED INV	640.12
TRANSFER PRICE @ 15.0PC RETURN ON FIXED INV	669.58
TRANSFER PRICE @ 20.0PC RETURN ON FIXED INV	699.04

VARIATION ANALYSIS FOR P-XYLENE XYLENES ADSORPTION BENELUX LANG FACTOR 0.65

CASE NO	1	2	3	4	5	6	7
TONNES PER ANNUM							
PLANT CAPACITY	100000	100000	100000	100000	80000	60000	40000
PLANT OUTPUT	100000	85000	75000	60000	80000	60000	40000
CAPITAL COST — MILLION DOLLARS							
BLCC	43.9	43.9	43.9	43.9	38.0	31.5	24.2
OFFSITES	15.0	15.0	15.0	15.0	13.0	10.8	8.3
TOTAL FIXED	58.9	58.9	58.9	58.9	51.0	42.3	32.5
WORKING	19.4	17.0	15.3	12.9	15.7	12.1	8.3
DOLLARS PER TONNE PRODUCT - (BASED ON XYLENES AT $420/TONNE)							
RAW MATERIALS	693.8	693.8	693.8	693.8	693.8	693.8	693.8
UTILITIES	81.3	81.3	81.3	81.3	81.3	81.3	81.3
BYPROD. CREDIT	-307.8	-307.8	-307.8	-307.8	-307.8	-307.8	-307.8
VARIABLE COST	467.3	467.3	467.3	467.3	467.3	467.3	467.3
OPERATION	20.1	23.7	26.9	33.6	22.2	25.3	30.7
OVERHEAD(EXCL.DEPN)	42.3	47.0	51.1	59.8	45.0	48.8	55.5
CASH COST	529.8	538.0	545.3	560.7	534.5	541.5	553.5
DEPRECIATION	51.4	60.5	68.5	85.7	55.6	61.5	70.8
NET COST OF PRODN	581.2	598.5	613.8	646.4	590.1	602.9	624.3
RETURN ON INVESTMENT	88.4	104.0	117.8	147.3	95.6	105.7	121.8
(AT 15% ON TOTAL FIXED INVESTMENT)							
TRANSFER PRICE	669.6	702.4	731.6	793.7	685.6	708.6	746.1

EFFECT OF XYLENES PRICE VARIATION

PRICE CHANGE	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%	+20%	-20%
RM PRICE $/TONNE	504.0	336.0	504.0	336.0	504.0	336.0	504.0	336.0	504.0	336.0	504.0	336.0	504.0	336.0
NET COST OF PRODN	716.4	446.0	733.7	463.2	749.0	478.5	781.6	511.1	725.3	454.8	738.2	467.7	759.6	489.1
TRANSFER PRICE	804.8	534.3	837.7	567.2	866.9	596.4	928.9	658.4	820.9	550.4	843.9	573.4	881.4	610.9

OXALIC ACID*/

(As a Downstream Industry for a Mini Sugar Plant)

Introduction

Oxalix acid is the simplest dicarboxylic acid. It occurs naturally in many plants (wood sorrel, rhubarb, spinach). Oxalic acid is an important organic chemical having wide application in various industries such as texitle industry, dye-stuff industry, pharmaceuticals and others. Its use in textile industry centres upon its calcium-iron removal and reducing properties and as such it is widely used as a bleach for removing iron stains from vairety of materials. Oxalic acid also finds application in automobile radiator cleanser. In dye-stuff industry it is mainly used as an intermediates. It is a starting raw material for the manufacture of diethyl oxalate which in turn is being used as the starting raw material for the manufacture of sulphamethaxazole which the latest sulpha drug used in combination with trimethoprim in various formulations and has broad spectrum antibacterial range. Oxalic acid also finds use as a purifying agent, as a catalyst, as a stripping agent for permanent press resins and also in the processing of rate earths. Its use pattern is given below:

Consumption pattern:	Per cent
Metal and equipment cleaning	27
Chemical intermediates	25
Textile finishing and cleaning	23
Leather tanning	4
Miscellaneous (as a purifying agent, as a catalyst, stripping agent for permanent press resins and rate earth processing etc.)	21
	100

Production process

Oxalic acid is prepared by the oxidation of carbohydrates such as glucos, sucrose (sugar), starch, dextrin and cellulose by nitric acid. The alkali (potassium and sodium hydroxides) fusion of carbohydrates also yields oxalic acid. The fusion method is particularly applicable in the utilization of waste cellulosic materials, such as sawdust, corn cobs, cornstalks, and oat halls.

The method described herein uses sugar/molasses/jaggery and nitric-sulphuric acid mixture as the basic raw materials. Mother liquor (consisting of residual oxalic acid, sulphuric acid, nitritic acid and catalyst) of previous batch, is taken into reactor. To this, sulphuric acid is added. The quantum of sulphuric acid to be added depends upon the specific gravity of the mother liquor. Addition of sulphuric acid increases the temperature of reactor (30-35° C) which is brought down with chilled water circulation through the cooling coils. At 20-25° C nitric acid is added into the reactor from the feed tank at slow rate.

After the addition of nitric acid, sugar addition is started. Addition of sugar in the initial stages is done at slow rate to avoid rapid increase in the temperature. After 4-5 hours of additions of sugar at low rate controlled by screw conveyor, addition of sugar is done at an increased rate.

The temperature of the reactor is maintained below 60° C during reaction. Oxides of nitric acid generated during reaction are absorbed in series of three absorbers, using counter current principle. Mother liquor of previous batch is circulated in the columns via heat exchangers. The unabsorbed oxide and air mixture is fed to the bottom of next absorber again running on mother liquor. In the third absorber water is used. The scrubbed acid is recirculated through absorber via chilled water tanker so as to obtain nitric acid of higher concentration. When required concentration of nitric acid is obtained it is used in the reaction mixture. After completion of reaction in the reactors, the product of reaction is cooled, centrifuged to separate oxalic acid crystals. Mother liquor is used for the next batch for absorption. Oxalic acid obtained after centrifuging is then further purified by recrystallization using water as solvent. The recrystalized material is again centrifuged and dried.

Properties

Oxalic acid crystallizes from water as dihydrate (HOOCCOOH $2H_2O$) in the form of colourless, monoclinic prisms with the following properties:

Mol. Wt.	126.07	M.P.	101.5° C
Sp. gr.	1.9	B.P.	losses $2H_2O$ at 100° C

Soluble in water (10 g. per 100 ml. at 20° C, 120 g. per 100 ml. at 100° C.)

Absolute alcohol (24 g.per 100 g. at 15° C) and ether (1.3 g. per 100 g. at 15° C)

Grades - Technical (99.8 per cent as crystals and powder) and chemically pure (C.P.) Both grades are the dihydrates (containing 2 molecules of water).

Profile

For the plant of the size of 300 M.T. per annum the basic requirements are as under:

No. of working days	300
Land	4000 sq.m.
Plant and machinery	$ US 1.2 million

Basic equipments required:

1. Storage tanks
2. Mother liquor tanks
3. Pumps
4. Feed vessels
5. Reactors
6. Absorption columns
7. Centrifuges
8. Dissolving tanks
9. Crystallizers

Requirements of raw materials

1. Nitric acid	320 M.T.
2. Sulphoric acid	100 M.T.
3. Sugar	225 M.T.
4. Catalyst	30 Kg

When molasses or jaggery is used instead of sugar, the consumption of nitric acid/sulphuric acid is on the higher side. However, the difference of cost between sugar and jaggery/molasses more than compensates for the higher consumption of other raw materials.

Manpower requirements (3-shift basis)

Skilled	35
Unskilled	10
Supervisory	10
Power	200 KVA.

Polystyrene Resin Making Plant

The family of styrene resins generally breaks down into polymer styrene and copolymers AS and ABS. All these are thermoplastic resins manufactured with styrene, one of the petrochemicals, as main feedstock.

Such styrene resins were initially discovered in 1836 but was not until 1925 that the commercial production was started. With the development of injection molding and other processing machines, the styrene resins are now one of the most widely used plastic raw materials together with polyvinylchloride, polyethylene and polypropyrene.

Among the styrene resins, polystyrene has the largest share in its production volume. A colorless, tasteless and non-toxic resin, this product is excellent in electric insulation and can be easily processed, facilitating various types of molding including the injection molding, extrusion molding and vacuum molding. Besides, exact in molded dimensions and excellent in coloring, uses of this resin are on the increase, with its demand rapidly increasing. The polystyrene resin is used in manufacturing not only household products but also various industrial products. Its main uses are as follows:

- Parts for electric appliances
  Television, radio, electric refrigerator, electric washing machine, cassette recorder, stereo, air conditioner, room cooler, electric fan, ventilator, telephone, humidifier, hair dryer, insulated rice cooker, mixer, recopy machine, calculator, illuminator, etc.
- Sundry goods
  Household goods, leisure articles, office supplies, cosmetics container, pharmaceutical container, foodstuff container, typewriter, stationery, toy, sporting goods, musical instrument, decorative article, wall clock, desk clock, sign board, thermos, display case, etc.
- Packing
  Foodstuff, synthetic paper, cup, etc.
- Others
  Industrial parts, light electric appliance parts (components), car parts, printing machine, knitting machine, spinning machine, optical instrument, sewing machine, farm machine, measuring instrument, medical instrument, building material, etc.

The polystyrene resin manufacturing plant introduces molding characteristics. With full consideration on the foodstuff sanitation, it conforms to FDA standards of the United States. The plant can also produce the polystyrene fully matching American UL specifications.

The process is so arranged as to minimize the investment for plant facilities and reduce the energy consumption, resulting in reduced production costs. In other words, it is characterized by its economical plant construction and operation.

Products and specifications

Polystyrene resins, which can be produced in this plant, largely break down into the general-purpose resin (GP), high impact resin (HI) and medium impact resin (MI). The GP includes the following types of product excellent in temperature, coloring, electric characteristics, mechanical characteristics, waterproofness, resistance to chemicals, non-toxicity and mold-processing.

GP-100 High fluid (thin thickness molding)/ injection molding, compression molding, blow molding, etc.

GP-125 Standard fluid/extrusion molding, compression molding, blow molding,etc.

GP-150 High heat resistance, high rigidity /injection molding, extrusion molding, compression molding, blow molding, etc.

GP-165 (H-C) Super-high heat resistance, super-high rigidity/extrusion molding, injection molding, compression molding, blow molding, etc.

The HI resin is produced by the graft polymerization of styrene monomer and synthetic rubber and excellent in impact resistance, heat resistance and luster, with the following types:

HI-425 Excellent fluid, impact resistance/extrusion molding, injection molding, etc.

HI-425E High impact resistance, high cold resistance/injection molding, extrusion molding, blow molding, etc.

HI-425 High impact resistance, high heat resist-

HI-945 Super-high impact resistance/injection molding

HFH-400 Self-extinguishing, high heat resistance, molding stability/injection molding

MIB High fluid (thin thickness molding)/ injection molding, injection blow molding

The MI resin is a product with intermediary characteristics between the general-purpose resin and high impact resin. It is a product excellent in fluid, heat resistance and bend strength, with the following types:

MI-225 High fluid (thin thickness molding)/ injection molding

MI-230S Excellent fluid (thin thickness molding)/ extrusion molding

MI-250 High heat resistance/injection molding

MI-310 Heat resistance, high rigidity/extrusion molding, vacuum molding, blow molding, etc.

Contents of Technology

1) Process description

The polymerization process for the manufacture of polystyrene generally breaks down into the bulk polimerization, solution polymerization, emulsion polymerization and suspension polymerization. This plant introduced here adopts the continuous bulk polymerization process.

In this process, products conforming to various standards on the basis of adjustment of reaction conditions in the reactor and the variation in additives. In particular, the addition of synthetic rubber can produce high impact resins. The process in this plant largely breaks down into the reaction process and recovery process.

Reaction process

Styrene monomer is stored in a small feedstock supply tank and mixed with an appropriate amount of recycle feed, solvent and additives. The mixture is then filtered, preheated and pumped to the prepolymerizer. The temperature, pressure and supply ratio are so adjusted as to conform to the molecular weight of a polymer and the final product.

In the case of high impact products, the rubber is crushed first and dissolved in styrene monomer. The solution is transferred to the first feedstock supply tank, and the rubber concentration is controlled by either recycle or adding pure styrene monomer as

Table 1. Specifications of Polystyrene Resin

Test item	Unit	General purpose GP				Middle impact MI			High impact HI			
		100	125	150	165	225	250	310	425	425E	425TV	HFH -400
Tensile strength	kg/cm^2	390	450	530	550	220	320	300	230	280	300	255
Tensile modulus	kg/cm^2	23,000	25,000	25,000	25,000	20,000	16,000	21,000	17,000	21,000	21,000	18,000
Tensile elongation	%	–	–	–	8	30	20	30	50	55	35	40
Flexural strength	kg/cm^2	700	690	1,030	1,000	390	630	540	370	460	550	450
Flexural modulus	kg/cm^2	27,000	27,000	30,000	30,000	25,000	25,000	20,000	21,000	21,000	21,000	18,000
Izod impact strength	$kg{\cdot}cm^2/cm$	–	–	–	2.3	5.4	6.5	6.5	8.0	9.0	9.0	10
H.D.T. unannealed	°C	75	82	85	88	73	80	78	72	78	82	75
H.D.T. annealed	°C	82	88	94	95	77	91	90	85	90	92	90
Vicat softening point	°C	91	93	104	104	89	102	99	93	99	101	95
Rockwell hardness	L	94	92	90	100	84	85	80	65	68	72	60
	M	75	65	60	80	35	45	40	10	20	25	20
Melt flow index	g/10 min	11.0	8.0	2.5	3.5	19.0	3.0	4.0	5.5	3.0	4.0	4.0
Specific gravity		1.05	1.05	1.05	1.05	1.04	1.04	1.04	1.04	1.04	1.04	1.16

required.

After that, solvent and additives are mixed, filtered, preheated and pumped to the prepolymerizer as in the case of general-purpose polystyrene but operation conditions are adjusted to suit the production of high impact resins. The partially-polymerized solution from the prepolymerization is continuously transferred to the succeeding reactor with controlled reaction conditions.

Recovery process

The viscous polymer from the final reactor, in which the polymerization has already been completed, is heated by the preheater and pumped to the devolatilizer. The devolatilizer is operated under vacuum to remove solvent and unreacted styrene monomer, and the recovered styrene monomer is recycled to the prepolymerization.

The devolatilized polymer passes through the strander and is cooled in the water tank, and then moisture is eliminated from the polymer by an air wiper. It is cut into uniform pellets by a slicer. Polymer pellets are transported by air conveying to the storage silo for packing as the finished product.

2) Equipment and Machinery

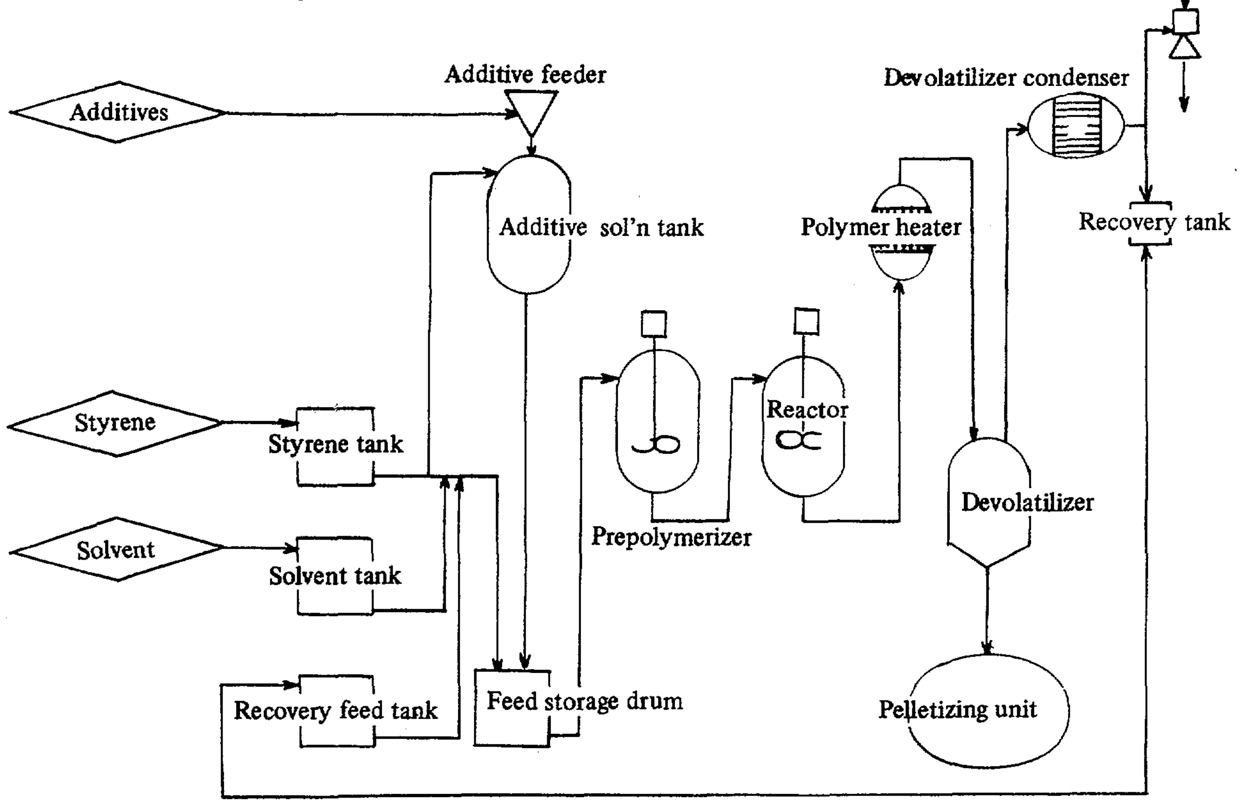
Styrene tank
Solvent tank
Recovery feed tank
Additive feeder
Additive solution tank
Feed storage drum
Prepolymerizer
Reactor
Polymer heater
Devolatilizer
Pelletizing unit
Devolatizer condenser
Recovery tank

3) Raw materials and Utilities

○ General purpose polystyrene

Raw materials and utilities	Requirement (per ton of product)
Styrene monomer	1,040 kg
Plasticizer	10 kg
Electric power	110 kwh
Fuel	0.03 kl
Water	40 m^3

Polystyrene Resin Manufacturing Process Flow Sheet



○ High impact polystyrene

Raw materials and utilities	Requirement (per ton of product)
Styrene monomer	1,010 kg
Lubricant	2 kg
Plasticizer	130 kg
PBL	70 kg
Electric power	110 kwh
Fuel	0.03 kl
Water	40 m^3

Example of Plant Capacity and Construction Cost

1) Plant capacity: 100,000 m/t/year

* Basis : 330 days/year

2) Example of estimated construction cost(as of 1982)

○ Equipment and machinery	:	US$13,100,000
○ Material cost	:	US$ 2,600,000
○ Installation cost	:	US$ 400,000
Total	:	US$16,100,000

* Plant site : Korea

3) Required space

○ Site area	:	15,000 m^2
○ Building area	:	10,000 m^2

4) Personnel requirement

○ Plant manager	:	1 person
○ Engineer	:	3 persons
○ Operator	:	60 persons
Total	:	64 persons

Nitrobenzene Making Plant

Nitrobenzene was first manufactured in England in 1856 and thus became available quite early as a basic industrial chemical. This early manufacture may reflect the relative ease of nitration of aromatic hydrocarbons, whereas aliphatic nitro compounds were not manufactured on a large scale until 1940. The present industrial application of nitrobenzene stems largely from the impetus provided by this ease of manufacture.

The most important application of nitrobenzene is the manufacture of aniline. The large amount of nitrobenzene manufactured is being used by the dye industry in the preparation of azo dye intermediates. Also this product is extensively used as a solvent and as a raw material for the manufacture of rubber chemicals, photographic chemicals and drugs.

So the market demand of nitrobenzene mainly depends upon the level of fine chemical industries and can be sharply increased according to the development of above mentioned industry.

Also this nitration plant can be constructed on a comparatively small-batch scale since the ratio of the labor cost to raw material cost is low. It has been estimated that 85% of the cost of manufacture may be attributed to raw material.

Thus this nitrobenzene plant seems to be a necessary one for the developing and underdeveloped country, in view of the fact that this plant can initiate the development of organic chemical industry with relatively low investment cost.

Products and Specifications

Technical grade of product can be produced in this plant and the detail specification of this product is shown in table 1.

Table 1. Specification of Mononitrobenzene

Test items	Specification
Purity	>99.5%
Colour	Light greenish yellow
Density	1.207 – 1.213
Solidifying point	< 5.5°C
Distillation range (95% min., vol/vol)	209 – 212°C
Acidity, as HNO_3	< 0.0005%
Water content	< 0.05%

Contents of Technology

1) Process Description

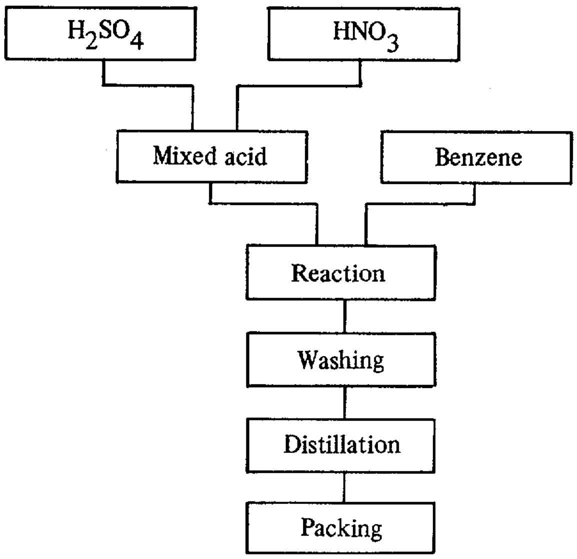
Mixed acid preparation

Following extraction, several batches of spent acid are transferred to a storage tank until a sufficient amount accumulates for the preparation of full storage tank of mixed acid. Spent acid in the storage tank is then cooled by circulation through a cooler using chilled water. Correct amount of 98% H_2SO_4 and 98% HNO_3 is then slowly added while the temperature of the mixed acid is controlled. While mixed acid is prepared in one storage tank, mixed acid from a second storage tank is used for nitration.

Reaction

Correct amounts of benzene and the mixed acid are transferred to measuring head tanks. Mixed acid is then drained into the nitrator. Benzene is fed into the nitrator according to the curve showing the temperature profile of nitration. Following nitration, the spent acid is drained into extractor and MNB into crude MNB tank. Correct amount of benzene is added to the spent acid in the extractor. The mixture is agitated and kept at low temperature. Following extraction, purified spent acid is transferred to the

Nitrobenzene Manufacturing Process Block Diagram



mixed acid storage tank and extracted benzene and nitrobenzene is transferred to the benzene head tank for use in next nitration batch.

Washing

Crude MNB receives three water washes, two caustic washes and three or more post caustic washes in the washer.

Distillation

Water is removed from MNB in the dryer. Finished product is drained into MNB product storage tank. All process vessel vents are connected to a fume scrubbing system where organic materials are absorbed in MNB which is replaced once in a while and reprocessed.

2) Equipment and Machinery

Tanks
Reactor
Separators
Washer
Preheater
Distillation tower
Absorption tower
Boiler
Condensers
Receivers
Separate pump
Washing pump
Vacuum pump

3) Raw Materials

Raw materials and utilities	Requirement (per ton of product)
Benzene	0.67 ton
Sulfuric acid	0.57 ton
Nitric acid	0.56 ton
Caustic soda	0.008 ton

Example of Plant Capacity and Construction Cost

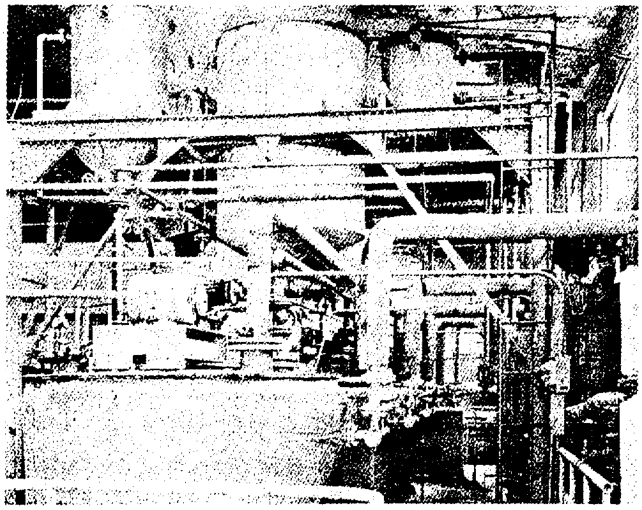
1) Plant capacity : 6 tons/day
   * Basis : 8 hrs/working day

2) Example of estimated equipment cost and engineering cost. (as of 1983)
   - o Equipment : US$380,000
   - o Engineering : US$ 95,000
   - o Know-how fee : US$120,000

   Total : US$595,000

3) Personnel requirement: 8 persons

Pentaerythritol Making Plant



View of Pentaerythritol Reactor

Pentaerythritol was initially developed as a raw material to make explosive. But, later, this was mainly used in the manufacture of alkyd resins. The production of pentaerythritol showed rapid growth due to the tremendous increase of alkyd resin production.

Pentaerythritol is one of predominant polyhydric alcohols used in alkyd resins. And the high functionality of pentaerythritol attracted wide interest because it gives many advantages. Alkyd resins containing Pentaerythritol tend to have higher viscosities and molecular weights, dry more rapidly, and give coatings of greater hardness with lower flexibility, better gloss and gloss retention, better heat and yellowing resistance, better chemical resistance, better water resistance, and better exterior durability than other polyhydric alcohol alkyds. In paints, pentaerythritol type also show greater antisagging at equal brushability and flow.

So, in Korea, large amount (about 80% of total production) is used in alkyd resin and resin ester, which are mainly used in paint industry. The remainder is used in the manufacture of polyether, polyesters, plasticizer, stabilizers, synthetic dry oil, PETN, penton resin, synthetic lubricant, etc.

Di-pentaerythritol, which is obtained as a by-product of the pentaerythritol synthesis reaction, is used in the preparation of drying oil, rosin esters and alkyd resins. Surface-coating compositions derived from form coatings that have improved hardness, gloss and durability. This is also used in the manufacture of plasticizers, lubricants, waxes and fire-retardant compositions.

Tri-pentaerythritol is another by-product and is principally used in the preparation of surface-coating materials. It is particularly useful in the manufacture of fire-retardant surface coating.

The pentaerythritol manufacturing plant which is to be introduced here has some characteristics as follows:

- High yield and low molar ratio of formaldehyde.
- Monomer, dimer and trimer can be manufactured simultaneously.
- Easy control of the purity of mono-pentaerythritol.
- Low plant construction cost.
- Can produce sodium formate and formic acid as by-products.

Products and Specifications

In this plant, di-pentaerythritol and tri-pentaerythritol are produced in addition to mono-pentaerythritol. ›no-pentaerythritol with the purity of more than 98% is also being produced.

Specifications of current products are as shown in table 1, but other varied specifications are also possible.

Table 1. Specifications of Pentaerythritols

Product \ Item	Momo(%)	OH(%)	Ash(%)	Moisture (%)	Color (Phthalate)	Melting point(°C)
Pure grade mono-pentaerythritol	98 min.	49 min.	0.02 max.	0.2 max.	No. 1	250 min.
Technical grade mono-pentaerythritol	95 min.	48 min.	0.05 max.	0.3 max.	No. 1	200 min.
Di-pentaerythritol	--	38 min.	0.2 max.	1.0 max.	No. 1	210 min.
Tri-pentaerythritol	--	35 min.	0.5 max.	1.5 max.	Ivory white	210 min.

* Other specification is available by order.

Contents of Technology

1) Process Description

This pentaerythritol plant consists of the process simultaneously producing main products of mono-, di-and tri-pentaerythritol, recovery process for sodium formate as by-product and process manufacturing formic acid making use of sodium formate.

This process description relates to explanations on the production of pentaerythritol, recovery of sodium formate and manufacture of formic acid based on sodium formate.

(a)Pentaerythritol manufacturing and sodium formate recovery process

Pentaerythritol is basically produced in accordance with the following reaction formula:

$$CH_3CHO + 4HCHO + NaOH \rightarrow C(C_2OH)_4 + HCOONa$$

In this process, the molar ratio of formaldehyde is adjusted low for the simultaneous production of monomer and polymer and caustic soda is used as catalyst to enhance the value of by-product utilization.

The mixture of acetaldehyde, formaldehyde and caustic soda adjusted in constant purities in a feed tank is pumped to the reactor containing caustic soda in a fixed mole ratio. Pentaerythritol is synthesized in the reactor with the control of pertinent temperature, pressure and reaction time, and the residual caustic soda in the reaction product is neutralized by formic acid.

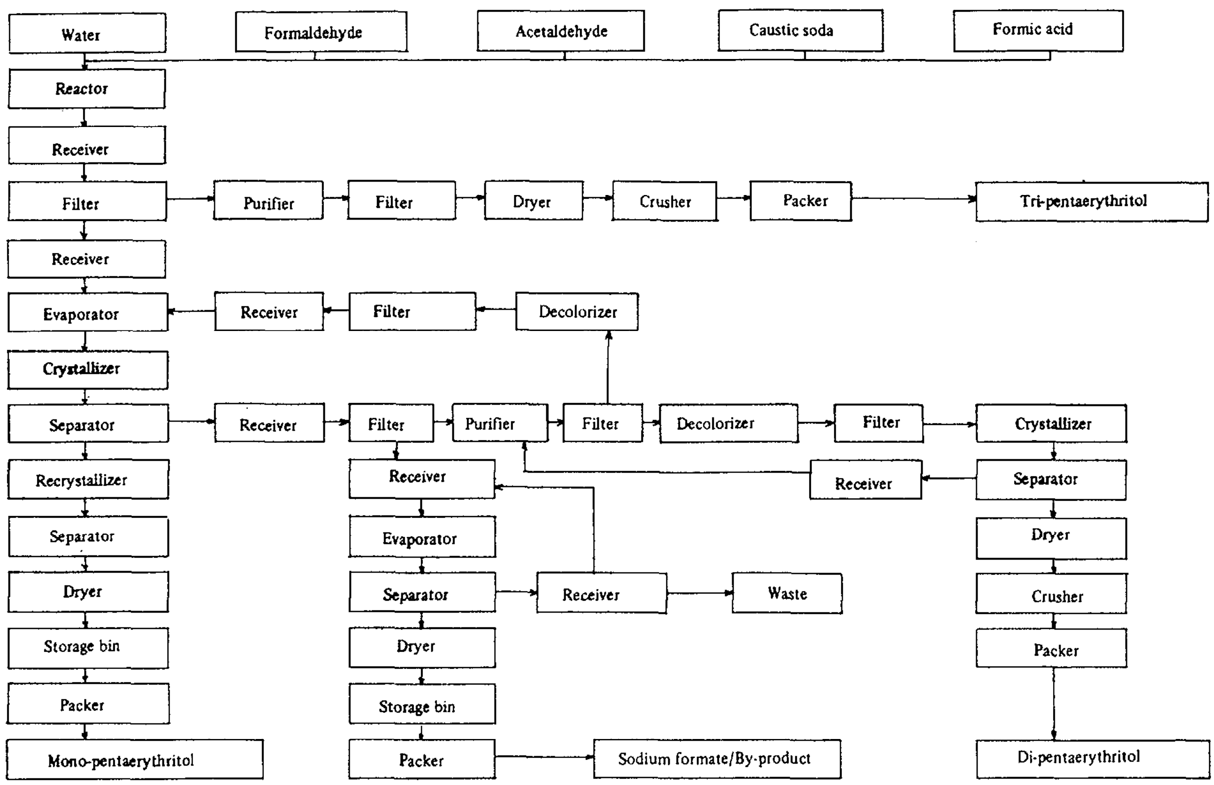
The neutralized reaction product is filtered and then solution is sent to the pentaerythritol evaporator. The recovered solid matter is refined, filtered, dried and crushed as tri-pentaerythritol product.

The reaction product transferred to the evaporator is evaporated,. concentrated and crystallized in the crystallizer by cooling. It is then separated in the separator into filtrate and solid matter.

The separated solid matter is dried and packed as mono-pentaerythritol product. The solution from separator is filtered, and the recovered solid matter is decolorized, filtered, crystallized, separated, dried and crushed into di-pentaerythritol as product.

The filtrate from the di-pentaerythritol recovery process is evaporated in the sodium formate evaporator

Pentaerythritol Manufacturing Process Block Diagram



for concentration and also separated in the separator. The separated solid matter is packed as sodium formate product.

(b)Formic acid manufacturing process

The production of formic acid from sodium formate proceeds in accordance with the following reaction:

$$HCOONa+1/2\ H_2SO_4 \rightarrow HCOOH+1/2\ Na_2SO_4$$

Formic acid with the purity desired to be produced is filled in the formic acid reactor and mixed with sodium formate. After recovering an appropriate quantity of formic acid by vacuum distillation, concentrated sulfuric acid is added for reaction. The formic acid recovered from the reaction product by vacuum distillation is collected in the product storage tank for delivery.

After distillation, small amount of water is added to the reaction product to filter and recover crude sodium sulfate. The remainder is discharged as waste liquid.

2) Equipment and Machinery

Tanks and crystallizers
- Raw material mixing tank
- Intermediate receiving tank
- Evaporator feed tank
- Recovered formaldehyde receiving tank
- Mother lye receivers
- Filtrate receiver
- Mono-penta. crystallizer
- Di-penta. crystallizer
- Mono-penta. recrystallizer

Reactor and others
- Reactor
- Filtrate decolorizer
- Di-penta. decolorizer
- Tri-penta. purifier
- Di-penta. purifier

Separators and dryers
- Filter for intermediate
- Tri-penta. filter
- Mother lye filter
- Di-penta. filter
- Mono-penta. separator
- Di-penta. separator
- Sodium formate separator
- Mono-penta. dryer
- Tri-penta. dryer
- Di-penta. dryer
- Sodium formate dryer

Evaporator and cooler
- Evaporator for intermediate
- Sodium formate evaporator
- Recovered formaldehyde cooler

Pumps
- Raw material transfer pump
- Raw material feed pump
- Intermediate pump
- Recovered formaldehyde transfer pump
- Tri-penta. pump
- Di-penta. pump
- Mother lye pump
- Filtrate pump

Others
- Mono-penta. conveyors
- Sodium formate conveyors
- Sodium formate storage bin
- Mono-penta. storage bin
- Packer
- Tri-penta. crusher
- Di-penta. crusher
- Others

3) Raw Materials and Utilities

o Pentaerythritol plant

Raw materials and utilities	Requirement (per ton of product)
Formaldehyde (37%)	3.15 tons
Acetaldehyde (100%)	0.41 ton
Caustic soda (100%)	0.425 ton
Formic acid (100%)	0.045 ton
Activated carbon	0.003 ton
Electric power	*400 kwh
Process water	* 20 m^3
Steam (4kg/cm^2G)	*19.4 tons
Cold water	*3,279 m^3

* Utilities for sodium formate are included.

o Formic acid plant

Raw materials and utilities	Requirement (per ton of product)
Sodium formate(100%)	1.940 tons
Sulfuric acid (98%)	1.360 tons
Steam (4kg/cm^2G)	8 tons
Electric power	1.376 kwh
Process water	3 m^3
Cold water	4,896 m^3

Example of Plant Capacity and Construction Cost

1) Plant capacity

o Pentaerythritol plant

Pentaerythritol	:	3,000m/t/year
Sodium formate	:	1,200m/t/year

o Formic acid plant	:	200m/t/year
* Basis	:	330 days/year

2) Example of estimated plant cost (as of 1981)

o Pentaerythritol plant	:	US$4,410,000
o Formic acid plant	:	US$ 180,000
Total	:	US$4,590,000

* Plant site: Korea

3) Personnel requirement

o Pentaerythritol plant

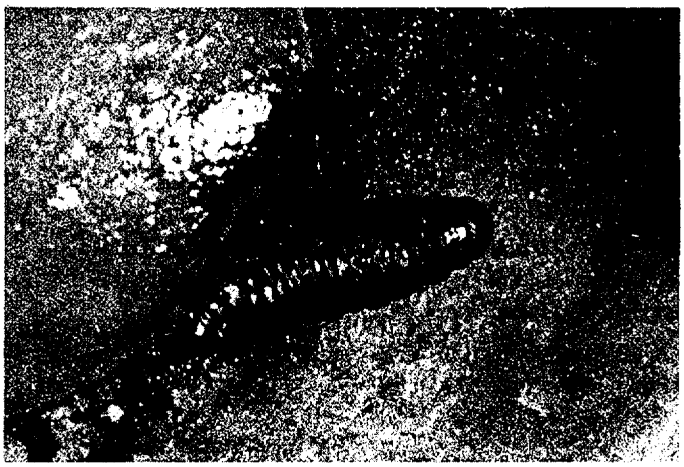
Supervisor	:	3 persons
Operator	:	42 persons
Total	:	45 persons

o Formic acid plant

Supervisor	:	1 person
Operator	:	3 persons
Total	:	4 persons

EPN Making Plant

Leaf Roller



Persimmon Fruit Worm

Organophosphorous insecticide is a synthetic farm chemical which has been continuously developed since 1937 when Bayer of Germany first developed it.

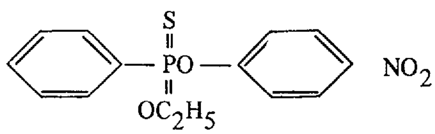
This insecticide has outstanding properties and performance; strong power of killing harmful insects, a wide variety of applications, contact, stomach and gas poisoning effect, and excellent permeability and osmosis. It thus has an unparalleled effect against insects harmful to rice, fruits and other agricultural crops which insects can hardly be destroyed by other insecticides, thereby contributing greatly to farm production increases.

EPN is a variety of organophosphorous insecticide first developed in the United States in 1949. It is the most widely used agricultural chemical, only next to parathion, in the world today. Its direct insect killing effect is somewhat weaker than parathion, but its remaining effect is longer because of its relative stability against hydrolysis. Thus its actual killing effect on insects is almost similar to that of parathion, though its osmosis in a plant is relatively weak.

EPN's uses are similar to parathion's. It can be used against insects harmful to rice, fruits and vegetables.

Products and Specifications

EPN is the abbreviation of ethyl-p-nitrophenyl thiono-benzene phosphonate, and its structural formula is as follows:



EPN has the following features :

- General insect killing effect is somewhat weaker

Table 1. Specifications and Available Formulations

○ **Technical grade**

Active ingredient	90% min.
Appearance	A dark ambercolored liquid
Odor	Odorless
Density	$D_4^{25} = 1.27$
Melting point	35°C
Boiling point	100°C/0.03 mmHg
Solubility	Soluble in most organic solvents and insoluble in water

○ **Formulations available**

EPN 60 EC	60% Emulsifiable concentrate
EPN 50 EC	50% Emulsifiable concentrate
EPN 25 WP	25% Wettable powder
EPN D	Dusts
EPN G	Granules

than parathion's, but the effect on the specific insect harmful to rice is almost equal to parathion's effect.

- Sustaining effect is longer than parathion's and methyl parathion's.
- Stronger effect on the specific insect harmful to rice stem.
- Against some insects it can destroy eggs and larvae.
- Lower osmosis than parathion.
- Longer remaining effect than parathion. When applied to rice leaves, EPN is effective for six days in preventing the specific insect from eating up the leaves, and parathion is effective for only four days.

EPN is available in three forms, 60% emulsifiable concentrate, 50% emulsifiable concentrate and 25% wettable powder.

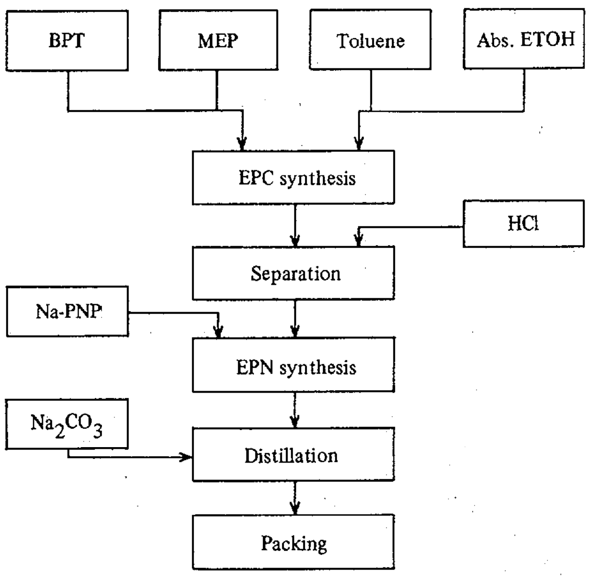
EPN's specifications and available formulations are shown in the following table 1.

Contents of Technology

1) Process Description

BPT is mixed with toluene, as a solvent, and MEP which absorbs HCl. The mixture is then stirred at the normal temperature, while adding absolute alcohol for synthesizing EPC (ethyl-thionobenzene-phosphonyl-monochloride). The HC1 is added to separate the excess MEP in the form of MEP· HCl.

EPN Manufacturing Process
Block Diagram



The separated EPC is mixed with Na–PNP for chemical reaction at 100°C for about three hours and the mixture is neutralized by adding Na_2Co_3. The neutralized solution is distilled at a reduced pressure for recovering toluene and producing EPN. The separated MEP·HCl. is also neutralized by adding NaOH and distilled to recover MEP.

2) Equipment and Machinery

SUS reactor	Condenser (carbon)
Vacuum pump	Condenser (SUS 304)
Centrifuge	Receiver (SS+GL)
Vacuum dehydrator	Receiver (SUS 304)
Dryer	Filter SS-Teflon
Reactor (glass)	Steam ejector
Condenser (glass)	Purification equipment

3) Raw Materials and Utilities

Raw materials and utilities	Requirement (per ton of product)
BPT	0.74 ton
Na-PNP	0.65 ton
Abs. ETOH	0.19 ton
Electric power	700 kwh
Fuel oil	350 ℓ
Water	10 tons

Example of Plant Capacity and Construction Cost

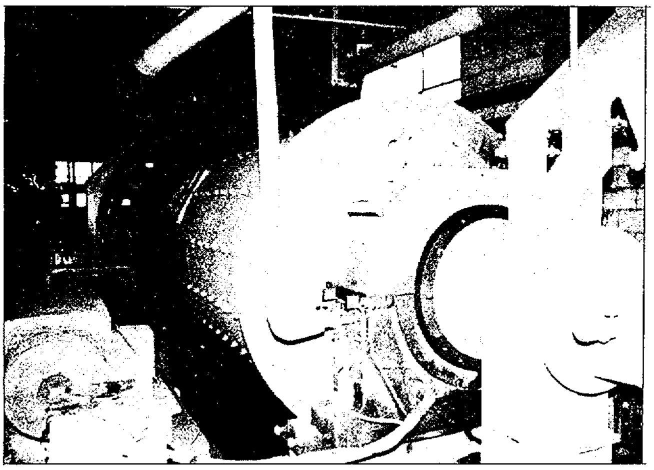
1) Plant capacity : 1.5m/t/day
   * Basis : 8 hrs/working day

2) Example of estimated plant cost (as of 1983):
   Total : US$1,700,000

Any inquiry about the information contained should be sent to:
IO/COOP, Registry file No. ID/562/12, UNIDO, P.O. Box 300, A-1400 Vienna, Austria

FILE: G82
ISIC 3511

Titanium Dioxide Making Plant



View of Rotary Kiln

Titanium dioxide is the most widely used white pigment. Its predominance is due to the high refractive index, lack of colour and chemical inertness. High refractive index in the visual portion of spectrum results in strong scattering of visible radiation of particles in the correct size range. This provides the opportunity for producing film with high opacity. Among those substances that are available in quantities sufficient to meet the requirements of industry, no other material has the high refractive index and other desired pigmentary properties possessed by titanium dioxide.

The manufacture of titanium dioxide pigments results in the production of either the anatase or rutile crystal structure, depending upon the processing. Rutile pigments have the greater hiding power and also an improved durability -or less chalking -in paint medium. Compared with anatase pigment, they have the disadvantages of costing rather more to produce and a slight inferiority in color.

This titanium dioxide pigment is used in various industries, such as paint, plastics, paper, textiles, rubber and other various industries. And the major outlet for titanium dioxide is the paint industry, in which titanium dioxide is by far the most effective white pigment in terms of hiding power. While pigment research is extensive no equally effective substitute has been found in paint industry. In plastics and rubbers, titanium dioxide offers the best combination of white pigment coat, dispersion and resistance to discolouration. And in other product application areas, no substitute product represents serious threat to titanium dioxides established position, except in only one market segment-paper. In paper industry, titanium dioxide enjoys the advantage of being an efficient opacifier, but it is at a cost disadvantage to aluminum and silica clays, some of which offer adequate brightness in particular paper application.

The production of titanium dioxide showed a rapid growth over past 10 years in Korea and is anticipated to increase more rapidly in the future, due to the above-mentioned various application fields and it's leading position in this field.

Products and Specifications

Titanium dioxide breaks down into anatase type and rutile type depending upon its crystal structure. Generally, the anatase type is excellent in color (whiteness) but the rutile type is better in its hiding power and tinting strength, being superb in stability against light and heat as well as in durability.

Characteristics by type and uses of such titanium dioxides this plant can produce at present are as follows:

Table 1. Specifications of Titanium Dioxides

Item / Type	TiO_2%	Specific gravity	Particle size (micron)	Spatula oil absorption (cc/100g)	Tinting strength	Residue (325M)%	PH	Moisture %	Water dispersibility	Weather resistance
Anatase	98.5	3.9	0.3-0.5	22-24	1,250-1,280	0.008	6.0-8.0	0.3	disperse	poor

Anatase type

Characteristics:

- Fine particle and particle size distribution
- Excellent white pigment with touch of blue color
- Low cohesion.as powder
- Excellent dispersion in water
- Excellent and safe dispersion over wide range of pH

Uses:

Household paint, ink, rubber, plastics goods, paper, enamel, cosmetics and etc.

Rutile type

Characteristics

- Superbly weather-proof, light-fast and resistant to heat when treated with Si-Al
- Fine particle and particle size distribution
- Excellent in whiteness, tinting strength and hiding power
- High dispersion in oil

Uses:

Paints for building, industrial paint, printing ink, plastics goods, rubber and etc.

Specifications of titanium dioxides with the above characteristics are as shown in table 1.

Contents of Technology

1) Process Description

Digestion

Dried and crushed ilmenite of 50-54% titanium dioxide content is mixed with 80-95% sulfuric acid (1.5-2.0 times of mineral) for an explosive reaction, producing a porous reaction product.

With the addition of water, it is leached to form titanium sulfate solution and then clarified in the settling vessel.

$$FeO \cdot TiO_2 + 2H_2SO_4 \longrightarrow TiOSO_4 + FeSO_4 + 2H_2O$$

Separation by crystallization

Titanium sulfate solution containing ferrous sulfate ($Fe_2SO_4 \cdot 7H_2O$) in quantities is separated by a centrifuge and the solution is further clarified.

Concentration

In order to adjust conditions of hydrolysis, clarified titanium sulfate solution is concentrated.

Hydrolysis

The concentrated titanium sulfate is heated and hydrolized into precipitated titanium hydroxide (meta titanic acid).

$$TiOSO_4 + 2H_2O \longrightarrow TiO(OH)_2 + H_2SO_4$$

Filtration and washing

Sulfuric acid and soluble impurities (iron and others) contained in the titanium hydroxide slurry are separated by means of various types of filters.

Calcination

Following water-washing, titanium hydroxide is added with several kinds of inorganic matters (to adjust the optimum conditions of calcination) and supplied to the rotary kiln. The calcination proceeds for 12 hours at temperatures of 800-1,000°C, producing crystalline titanium dioxide (TiO_2).

Such basic properties of pigment as crystal forms of anatase and rutile types, whiteness and particle size are determined in the calcination process.

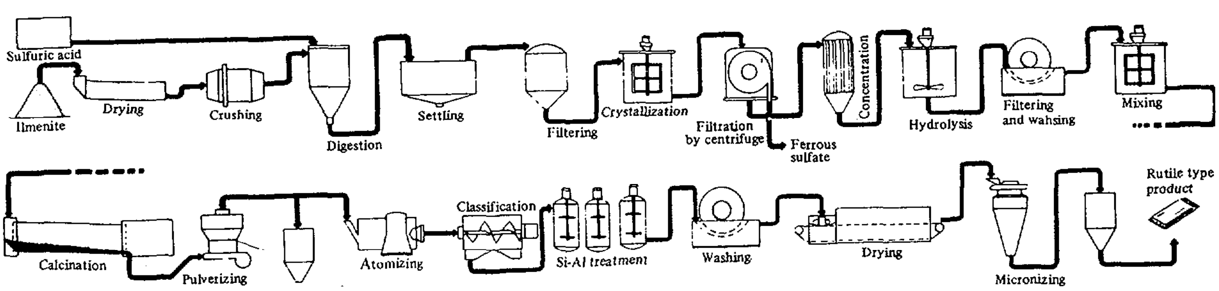
$$TiO(OH)_2 \longrightarrow TiO_2 + H_2O$$

Pulverizing and after-treatment

The sintered titanium dioxide after calcination is pulverized to provide the anatase-type titanium dioxide as product at this stage.

The rutile-type titanium dioxide is produced

Titanium Dioxide Manufacturing Process Flow Sheet



through succeeding surface coating process. The pulverized titanium dioxide is atomized again by weck atomizer and classified by particle size to be followed by surface coating, filtration and washing, drying and micronizing to produce the final product. The surface property of titanium dioxide is altered to a great extent by the surface coating process.

2) Equipment and Machinery

Mills and atomizer
- Ball mill
- Roller mill
- Micronizer
- Weck atomizer

Tanks and thickner
- Digestion tank
- Settling tank
- Crystallization tank
- Vacuum concentrator
- Hydrolysis tank
- Dorr-thickener

Centrifuge and filters
- Centrifuge
- Drum filter
- Ceramic filter
- Leaf filter
- Filter press

Pumps and compressor
- Vacuum pump
- Slurry pump
- Compressor

Kiln and dryer
- Rotary kiln
- Rotary cooler
- Air dryei

Elevator and conveyer
- Bucket elevator
- Belt conveyer
- Flow conveyer

Others
- Refrigerator
- Electro-precipitator
- Sulfuric acid recovery unit
- Sulfuric acid plant
- Cooling tower
- Electric generator
- Boiler

3) Raw Materials and Utilities

Raw materials and utilities	Requirement (per ton of product)
Ilmenite	2.828 tons
Sulfuric acid	4.566 tons
Fe scrap	0.192 ton
Caustic soda	11.342 kg
Himoloc 200	4.863 kg
Himoloc 600	2.627 kg
Diatonaceous earth(#300)	5.566 kg
Diatonaceous earth(#250)	5.255 kg
Fluoric acid	1.453 kg
Bunker–C oil	1,038 ℓ
Electric power	988 kwh
Water	48.6 tons

Example of Plant Capacity and Construction Cost

1) Plant capacity : 1,300 m/t/month
   * Basis : 330 days/year, 24 hrs/day

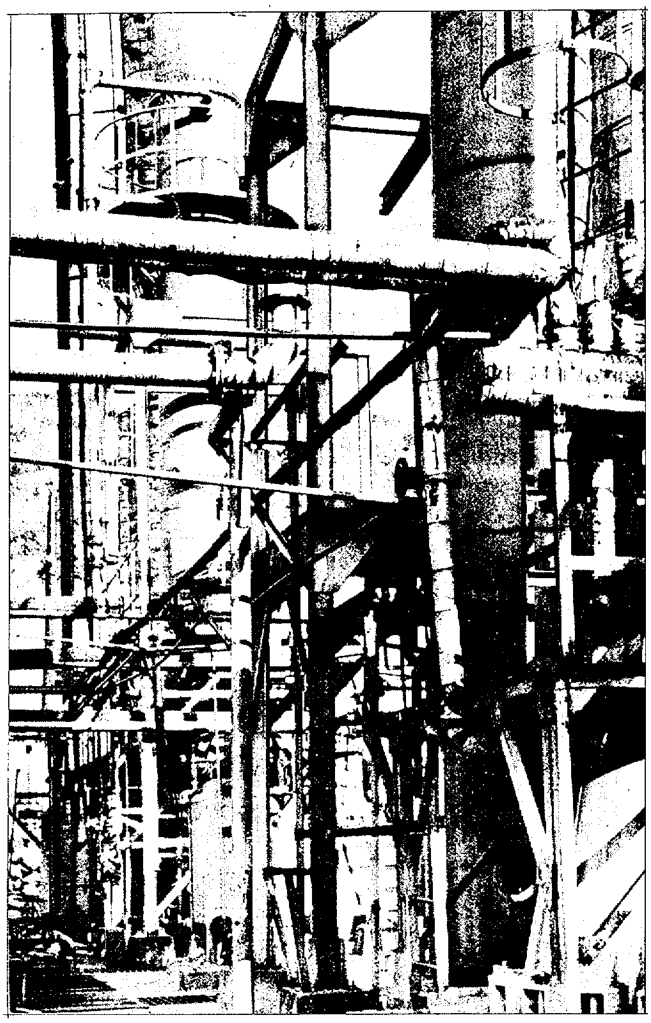
2) Example of estimated construction cost (as of 1981)
   - o Equipment and machinery : US$8,820,000
   - o Installation cost : US$ 870,000
   - Total : US$9,690,000

   * Plant site : Korea

3) Required space
   - o Site area : 66,000 m^2
   - o Building area : 19,800 m^2

4) Personnel requirement
   - o Technical manager : 6 persons
   - o Engineer : 24 persons
   - o Operater : 150 persons
   - Total : 180 persons

Formaldehyde Making Plant



View of Formaldehyde Plant

Formaldehyde is the unique first member of a series of aliphatic aldehydes. And formaldehyde became an outstanding industrial product because of its high reactivity, colorlessness, stability, purity in commercial forms and low cost.

A practical method of manufacturing formaldehyde was developed by Loew in 1886 and thereafter, a number of production were initiated in many countries but this production was on a limited scale before the commercial production of phenolic resin in 1910.

Thereafter, the production of formaldehyde rapidly increased due to the large production of resins, such as phenolic resin, urea resin, oil-soluble resins, acetal major outlet of formaldehyde.

In addition, formaldehyde is employed in the manufacture of various products, including pentaerythritol, hexamethylene-diamine, ethylene glycol, fertilizer, textile, paper, leather and other chemical products.

Formaldehyde is generally manufactured in large part from methanol, even though a portion is produced by the partial oxidation of the lower petroleum hydrocarbons, because the former gives essentially pure formaldehyde. Therefore, the plant introduced here also adopts the methanol process with its specific merits as follows:

- High yield
- Energy conservative
- High quality product

Products and Specifications

The standard formaldehyde of only 37% solution is produced now in this plant, but products of other specifications are also possible on order. The specification of 37% aldehyde is as follows:

Formaldehyde	:	37.2 ±0.2%
Free acid	:	50ppm max.
Chlorides	:	25ppm max.
Sulfate	:	clear
Ash	:	100ppm max.

Contents of Technology

1) Process description

Formaldehyde is formed by two gas phase reactions involving the dehydrogenation and oxidation of methanol.

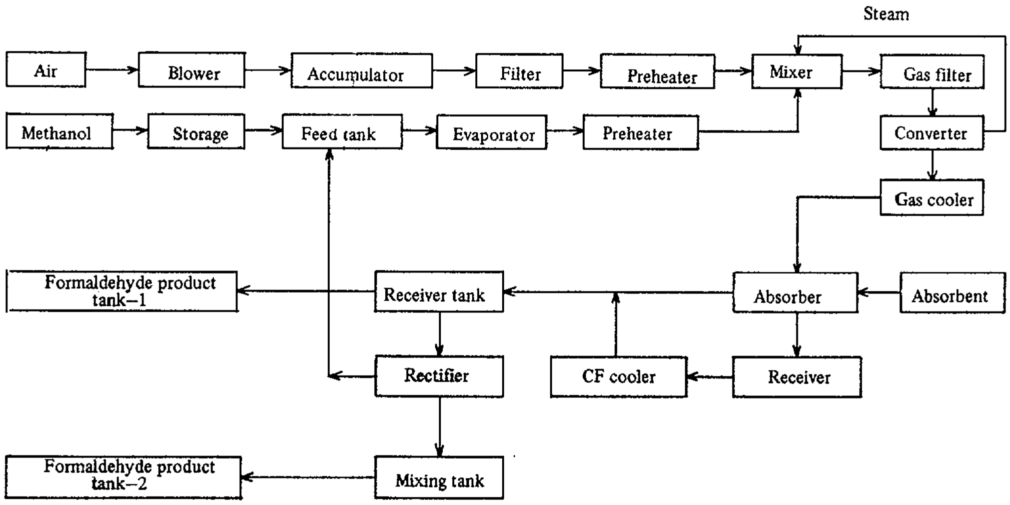
$$CH_3OH \longrightarrow HCHO + H_2$$

$$CH_3OH + \tfrac{1}{2}O_2 \longrightarrow HCHO + H_2O$$

Raw materials employed are chemically pure synthetic methanol, air and water. The air is filtered and may be washed, if necessary, to remove contaminants including sulfur dioxide, which is injurious.

The first manufacturing step is the production of a methanol-air vapor mixture, which is fed to the catalytic converters. This is carried out by evaporation of

Formaldehyde Manufacturing Process Block Diagram



controlled condition. For safety, explosive mixture of methanol and air must be avoided, and flame arresters, explosion discs and the like must be used whenever there is danger of accidantal fires or explosions.

The feed vapor, usually preheated, is passed into the converter which consists of jacketed vessel containing a bed of prepared silver catalyst. The temperature for a silver catalyst reactor is 600-650°C and the pressure is less than $1 kg/m^2G$.

This process is designed to recover waste heat by using waste heat boiler. The low-pressure steam from the waste heat boiler is supplied in part to the raw material gas mixer. The remainder steam is used in other processes. The temperature of reactor is then controlled within 670-700°C.

Product vapor from the reactor passes through a series of gas coolers and absorbers which cool the gas and absorb the formaldehyde. The primary product solution, which contains some methanol, must be adjusted to meet customer's requirements with respect to its methanol and formaldehyde contents. Excess methanol is removed by fractionation, so that a substantially methanol-free solution can be obtained.

2) Equipment and Machinery

Tanks
- Process water tank
- BFW tank
- Methanol storage tank
- Formaldehyde storage tank
- CF receiver

Separators
- Air filter
- Gas filter
- Vapor/Water separator
- Absorber

Heaters and evaporator
- Air preheater
- Methanol vapor preheater
- Methanol evaporator

Pumps and blower
- Blower
- Air accumulator
- Methanol feed pump
- Process water feed pump
- BFW feed pump
- Absorbent pump
- CF circulation pump

Others
- Gas mixer
- Reactor
- Rectifier
- Ion exchanger
- Others

3) Raw Materials and Utilities

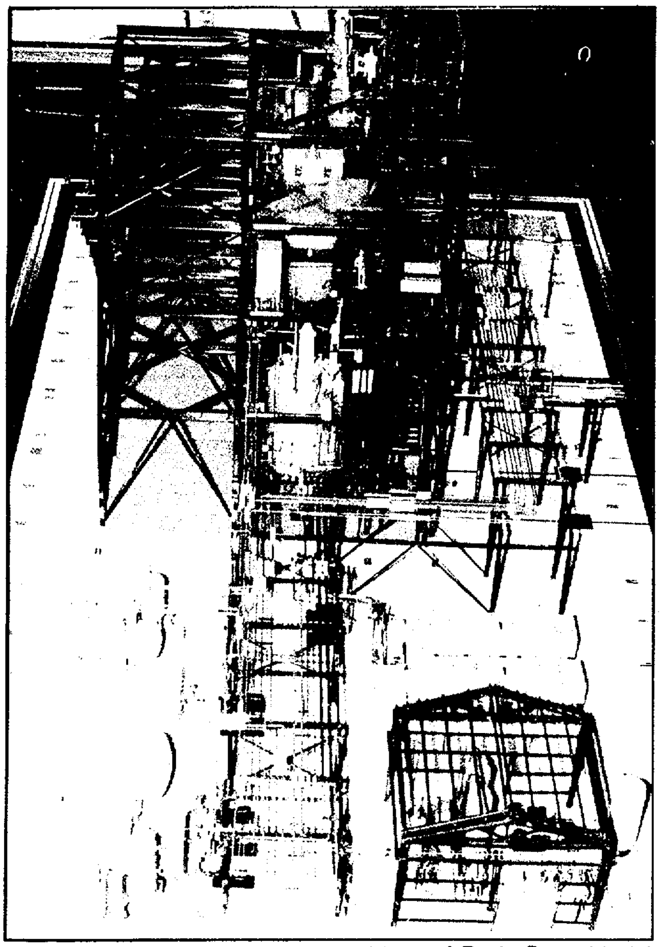
Raw materials and utilities	Requirement (per ton of product)
Methanol (99.8%)	465 kg
Electric power	30 kwh
Steam	–
Process water	500 kg
Cooling water	60 m^3

Example of Plant Capacity and Construction Cost

1) Plant capacity : 15,000m/t/year
   * Basis : 330 days/year
2) Example of estimated total plant cost (as of 1981)
   Total : US$590,000
   * Plant site : Korea
3) Personnel requirement
   - Supervisor : 1 person
   - Operator : 6 persons

   Total : 7 persons

Unsaturated Polyester Resin Plant



View of Resin Plant Model

The first commercial production of unsaturated polyester resins came about the 1940s. Thereafter these resins were used in a variety of applications which can be classified under the category of molding, casting and coating, due to its excellent properties.

The main properties of these resins which characterize them and are the chief factors in their success are:

- Ease of handling in liquid form
- Rapid cure
- Excellent dimensional stability
- Good electrical properties
- Good general physical properties
- Ease of coloring and modifying for special characteristics

Especially, the combination of unsaturated polyester resins with glass fiber produced the first FRP and opened up a new field in the plastic industry. Now, the bulk amount of these resins are used for FRP and make up over 90% of the resins used in reinforced plastics.

FRP growth is expected to rise sharply next decade. Because the corrosion resistance property and high strength-to-weight ratio that are achievable in products make FRP competitive with a number of structural materials such as steel, cast iron and aluminum.

And FRP products offer significant energy savings, including all the energies consumed in manufacturing, transportation, installation, operation, maintenance and fuel value of the product itself.

Also the continuous developments in the field of casting and coating of unsaturated polyester resins show promise of even larger volumes of resins going into these fields.

So the market demand of unsaturated polyester resins is anticipated to increase more rapidly in the future than before, due to sharp growth of FRP industry and other above-mentioned related industries.

As a result, the relatively small investment required and the future large market can attract a flood of enthusiasm in unsaturated polyester resin plant and this plant can be one of those attractive plastic making plants, especially in developing countries.

Products and Specifications

The unsaturated polyester resins which can be made in this plant are based on macromolecules with polyester backbone in which both phthalic anhydride and maleic anhydride are condensed with a propylene glycol. And these resins are dissolved in and later crosslinked to thermosetting copolymers with styrene.

These resins are clear, pigment and dyes can be added for desired colors and these resins have excellent resistance to many acids, alkalies and other various chemicals.

Also these resins provide excellent electrical insulating properties and, when combined with glass fiber, provide good thermal and shock resistance.

The detail specifications of typical unsaturated polyester resins are shown in table 1.

Table 1. Specifications of Unsaturated Polyester Resin

Test items \ Product number	7130 MCX	7130	7200
Acid value	18.5	20.6	10 ± 2
Hydroxyl value	–	19.1	20 ± 5
Gardner color	-2	+ 1	2 max.
Viscosity, stokes @25°C	10.2	10.9	9-12.5
Brookfield viscosity, CPS	1,224	–	1,300 ± 200
Cup gel			
RT gel, minutes	6.7	7.0	–
GPE, minutes	8.2	10.5	–
PE, °C	205	187	–
SPI gel -180°F			
SPIG, minutes	4.6–4.7	6.5–7.0	3.0 ± 1.0
PET, minutes	6.3–6.4	8.5–8.75	4.0 ± 1.0
PE, °F	482–488	468–470	445 ± 15
% Monomer	40.4	39.5	

Contents of Technology

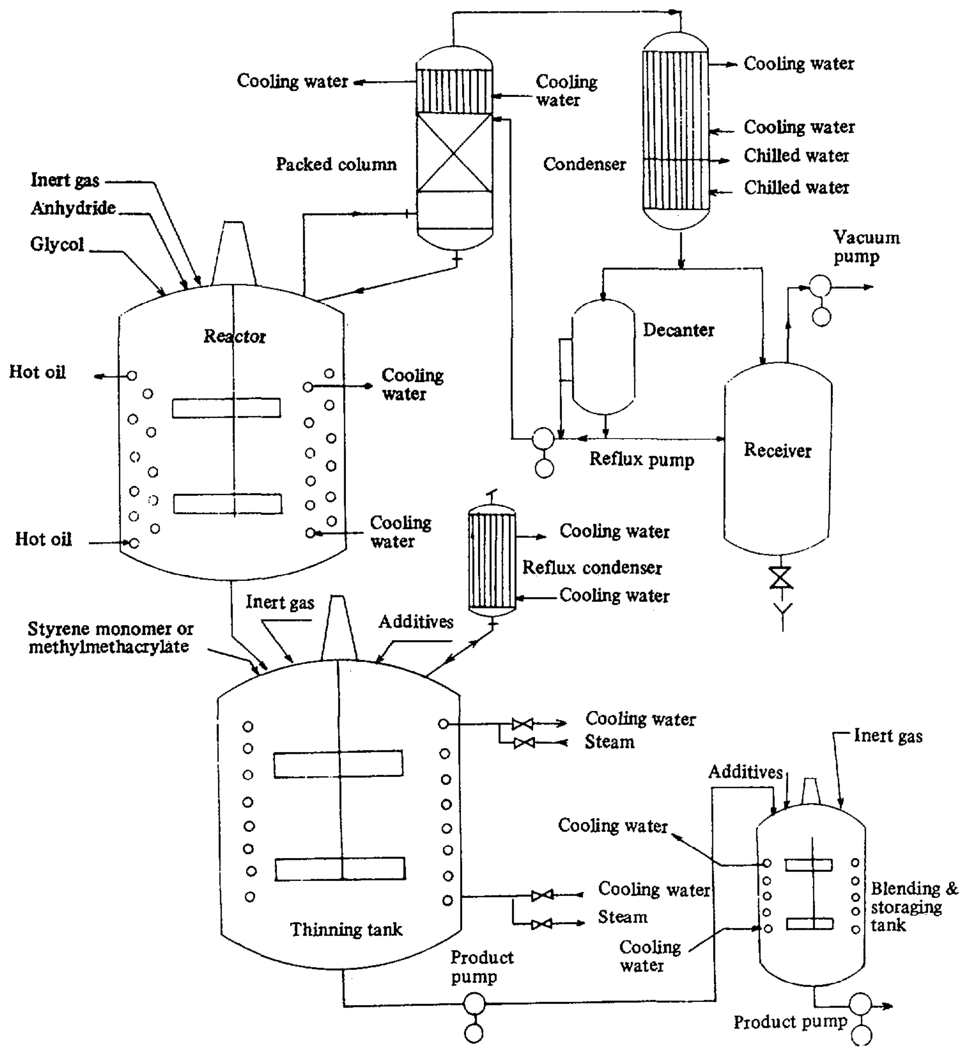
1) Process description

Diethylene glycol and propylene glycol will be charged to the reactor, and phthalic (or isophthalic) anhydride and maleic anhydride will be charged to the reactor.

The reactor will be heated for esterification reaction between glycol and anhydride. The packed column and condenser will be used for rectification. Water, which is produced in the course of reaction and has to be removed, is stripped off by means of continuous inert gas purging and vacuum pump for further reaction to shorten the reaction time.

The reacted polyester resin will be cooled and transfered to thinning tank and mixed with styrene

Unsaturated Polyester Resin Manufacturing Process Flow Sheet



monomer or methyl methacrylate in the presence of inhibitor.

The thinned polyester resin will be blended with additional quantity of styrene and other additives.

2) Equipment and machinery

Reactor
Packed column & condenser
Thinning tank
Blending tanks
Receivers
Boilers
Hot oil heater
Inert gas generator
Air compressor
Pump (centrifugal, rotary, vacuum)
Others (filter, bins, blower, ventilator, hoist conveyor & etc.)

3) Raw materials and Utilities

Raw materials and utilities	Requirement (per ton of product)
Maleic anhydride	0.190 ton
Phthalic anhydride	0.286 ton
Propylene glycol	0.308 ton
Styrene monomer	0.300 ton
Other chemicals	0.200 kg
Electric power	340 kwh
Water	0.3 ton
Fuel oil	0.06 kl
LPG	9 kg

Example of Plant Capacity and Construction Cost

1) Plant capacity : 10,000m/t/year
   * Basis : 330 days/year

2) Example of equipment cost and installation cost (as of 1977)

- Equipment and machinery : US$3,000,000
- Material cost : US$ 850,000
  (For erection and installation)
- Installation cost : US$1,800,000

Total : US$5,650,000

3) Required space

- Site area : 6,000 m^2
- Building area : 2,100 m^2

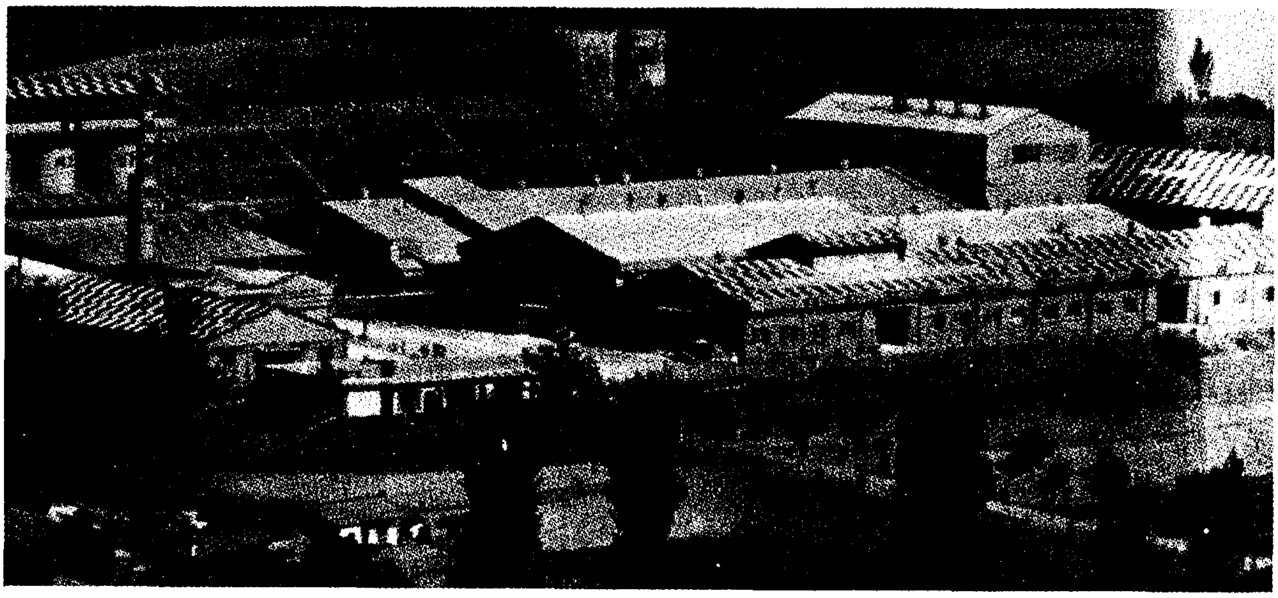
4) Personnel requirement

- General manager : 1 person
- Financing manager : 1 person
- Production manager : 1 person
- Site manager : 1 person
- Sales manager : 1 person
- Operating dept.
  - Shift supervisor : 3 persons
  - Operator : 12 persons
  - Labor : 10 persons
- Laboratory staff : 2 persons
- Maintenance : 5 persons
- Clerk and secretary : 3 persons

Total : 40 persons

FILE: G85
ISIC 3511

Calcium Carbonate Making Plant



View of Calcium Carbonate Plant

Limestone is one of the most abundantly available natural resources on earth. Composed mainly of calcium carbonate, limestones are divided into the weathered marine shell, white soft earthy limestone, sugar calcite and compact limestone depending upon respective types of formation.

These raw materials are ground as they are for use as the shell powder, chalk and whiting, or chemically processed into pure calcium carbonate for various uses.

The plant introduced here relates to the production of high-purity quality calcium carbonate in accordance with the carbonation process using the compact limestone with the highest hardness among the calcium carbonate raw materials mentioned above.

The products of this plant generally have both the characteristic as the filler and the function of reinforcing materials, with a wide range of uses for rubber and plastics products. In addition, the high-purity product is used as a filler in paper making, blender for tooth paste and food additive. In recent years, it is also used in agriculture.

Due to such extensive uses, the demand for calcium carbonate is rapidly increasing, and at the same time, it is required to further uprgade and produce in diverse grades for the improvement of related products. The calcium carbonate is based on the utilization of cheap limestones currently available in quantities in most countries. It is now one of the basic inorganic chemical products which has high added values and also capable of maximizing the efficiency of natural resources with no particular need of importing raw materials.

Accordingly, this calcium carbonate manufacturing plant is also one of the most essential plants for fostering the import-substitution industry as well as the basic chemical industry in developing countries.

Products and Specifications

The plant introduced here has been engaged in the manufacture of various kinds of precipitated calcium carbonates. The main products are OKYUMHWA-TC & OKYUMHWA-TL.

OKYUMHWA-TC consists of ultra-fine particles, 0.04 microns in size. This product is surface-treated with an organic material to improve its dispersibility and is extensively used as white reinforcing fillers for rubber, plastics and others.

OKYUMHWA-TL (Light precipitated culcium carbonate) is a highly pure calcium carbonate produced by reacting carbon dioxide with an aqueous suspension of culcium hydroxide. This product is not surface coated and is offered in particle sizes ranging from 0.8 to 3 microns, rated at 325 mesh. Because of its relatively large particle size, TL is inferior to its sister product, TC, as a reinforcing agent, but finds an extensive use as a filler to cut material costs in a wide range of products. It is also used as food additives, and finds an application in the manufacture of agricultural fertilizers.

Table 1. Physical and Chemical Properties of Calcium Carbonate

○ Physical properties

Test item	TC	TL
Whiteness and brilliance	up 90	up 92
Specific gravity	2.57	2.60
Moisture	less 0.6	less 1.0
Average particle size (μ)	0.04	0.8 - 3
pH	8.0 - 8.5	8.5-11.0
Apparent volume (mℓ/g)	–	1.6-2.2

○ Chemical properties

Test item	TC	TL
Calcium oxide(%)	up 54	up 55
Magnesium oxide (%)	less 0.2	less 0.3
Silicon dioxide (%)	less 0.2	less 0.2
Iron oxide and aluminium oxide (%)	less 0.2	less 0.2
Ignition loss (%)	45	43

Contents of Technology

1) Process Description

The manufacturing process of precipitated calcium carbonate largely breaks down to two different methods. One is the carbonation process and the other is the lime-soda process.

The latter is a process in which calcium carbonate is produced by reacting milk of lime or calcium chloride with soda ash (sodium carbonate). It is the process mainly used in Europe and the United States.

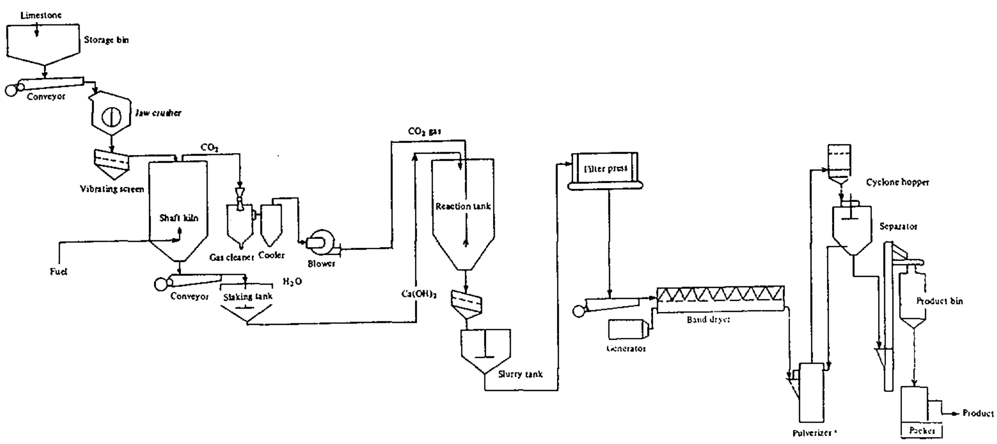
As can be seen in the process flow sheet, the plant introduced here adopts the carbonation process based on the use of refined milk of lime, with the description briefly focused on the light precipitated calcium carbonate (TL) process.

The raw material limestone in a storage bin is fed into the jaw crusher by the conveyor system for crushing and then further fed into the calcium kiln after passing through a vibrating screen.

The raw material fed into the kiln is calcined by using coal, heavy oil or fuel gas to first produce quicklime, and then it is reacted with water to become calcium hydroxide. The produced calcium hydroxide is contacted for reaction with carbon dioxide gas evolved from the carbonation of limestone to obtain precipitated calcium carbonate. Hereby its reaction conditions can be diversely changed for the adjustment of particle sizes and forms in obtaining various types of calcium carbonate.

On completion of the reaction, it is dehydrated, dried and pulverized as the final product.

Precipitated Calcium Carbonate Manufacturing Process Flow Sheet



2) Equipment and Machinery

Raw ore crushing section
- Jaw crusher
- Vibrating screen

Raw ore weighing section
- Hopper scale

Calcining section
- Shaft kiln

Lime slaking section
- Slaking machine
- Hydro & multi-separator
- Milk storage tank & water tank
- Milk feed pump

Gas refining process
- Washing & cooling tower
- Oil & mist separator
- Air compressor

Reaction section
- Carbonation tank

Filtering section
- Sedimentation tank
- Slurry tank & pump
- Filter press or centrifuge

Drying section
- Roll granulator
- Band dryer
- Hot air generator

Crushing & packing section
- Pulverizer
- Separator
- Bin vent filter
- Automatic packer

Water treating section

3) Raw Materials and Utilities

Raw materials and utilities	Requirement (per ton of product)
Limestone	1.43 ton
Fuel (for calcining) Bunker-C oil	663 kcal/$CaCo_3$ 1kg 0.5 drum

Example of Plant Capacity and Construction Cost

1) Plant capacity : 20 m/t/day
   * Basis 24 hrs/day, 330 days/year

2) Estimated equipment cost
   - o Equipment cost : US$ 980,000
     (Excluding installation cost)

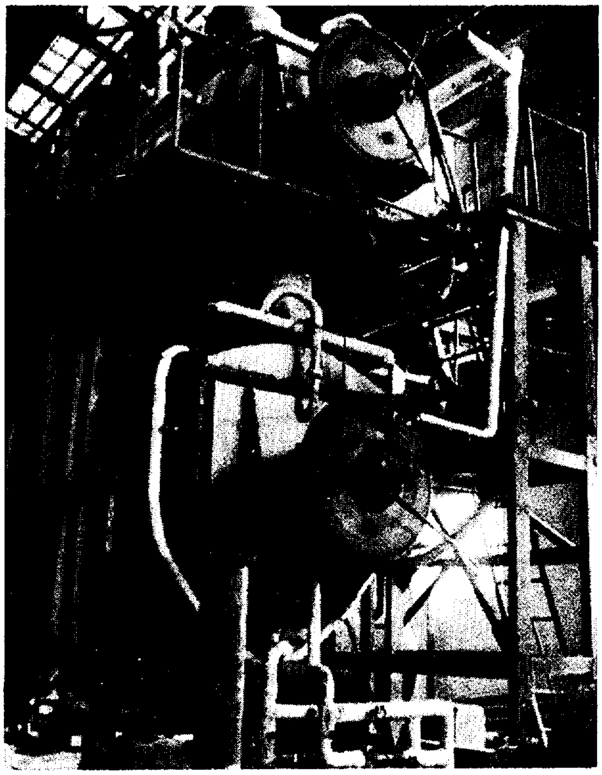
3) Required space
   - o Site area : 30,000 m^2
   - o Building area : 7,000 m^2
   - o Others : 1,000 m^2

4) Personnel requirement
   - o Manager : 3 persons
   - o Engineer : 3 persons
   - o Operator : 20 persons
   - o Others : 4 persons

   Total : 30 persons

FILE: G86
ISIC 3513

CMC Making Plant


View of CMC Reactor

Carboxymethyl cellulose (CMC), a kind of cellulose ether, is a white powdery sizing agent made from pulp cellulose. Since its discovery by Jansen of Germany in 1918, it has rapidly expanded in advanced western countries.

In Korea, it was produced for the first time in 1967 to attain significant growth since then. In particular, since it has a wide range of applications in various industries including the textile industry, foodstuff industry, detergent industry and ceramic industry, its market has gradually expanded on a great scale with the growth of these industries (see table 1).

Owing to such an extensive scope of applications, specifications of CMC also require a variety of products, with consequent requirements for much experiences and know-hows in its manufacturing industry.

Currently available in Korea are not only the CMC manufacturing technology based on conventional water solvent process but also the technology based on the solvent process requiring the latest technology. The production of a high-purity item with special specifications is also possible on the basis of experiences and technology accumulation over the years.

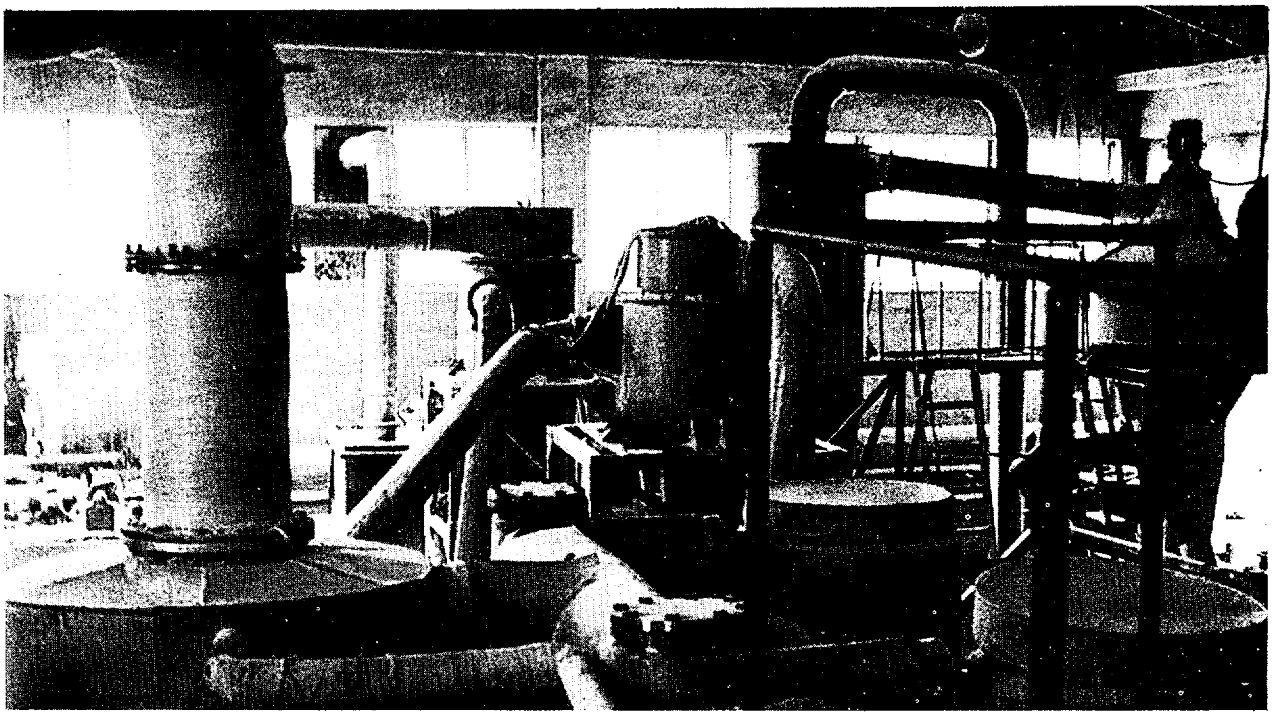

View of Product Pulverizer

Table 1. Product Types and Characteristics

Field of application	Types	Viscosity (cps, 1% solution at 25°C)	Characteristics
Textile industry	PBH KC–200	20 ~ 40 200 ~ 400	Good ability for uniform printing, penetration and easy removability on washing (after drying) Applicable to stencil paper, screen, and special printing.
	KWS–100 KWS–200	20 ~ 100 100 ~ 300	Excellent flexibility, elongation, twist and intensity application for warp-sizing of silk, cotton and synthetic fiber.
Foodstuff	KFG–400	300 ~ 500	General use: Applicable to increase viscosity and stability of food stuffs.
	KFA–100 KFA–200 KFA–300	10 ~ 50 50 ~ 150 150 ~ 250	Acid resisting : Applicable to increas viscosity and stability of foodstuffs that needs to be acid-resistant.
Pharmaceutical	Ca-CMC		Applicable to ointment, eczema coating, dyeing agent, tablet binder, emulsifying agent for liver oil, and stabilizer by the virtue of the functions of forming protective colloid and of stabilizing.
Paint	KC–800 KC–400 KC–200	750 ~ 850 300 ~ 500 200 ~ 300	With the properties of film forming action, stabilizing ability, forming protective colloid and viscous body forming action, suitable for uniform coating dispersing, stabilizing and viscous thickner forming agent.
Ceramics & refractories	KCR–200	100 ~ 200	Use as glaze additives that have properties such as dissolving glue-like things, penetration, and developing of glaze.
Drilling mud additive	KP–100 KP–300 KP–800	20 ~ 60 200 ~ 500 700 ~ 900	In rotary drilling of wells, form a thin, impermeable film on the wall of bored well.
Detergent use	KD–100 KD–200	20 ~ 30 100 ~ 200	Improving detergency on synthetic detergent.
Construction material use	KCC–100 KCC–800	40 ~ 150 750 ~ 850	Used with the mixture of bentonite in construction.
Paper sizing	KPS–100 KPS–300 KPS–600	20 ~ 100 100 ~ 300 300 ~ 600	Film forming action, increasing tensile strength and oil resistance enable it to be used in paper industry.

Products and Specifications

CMC, water soluble polymer derived from cellulose, has the following functions and properties.

- Acts as viscous thickener, binder and suspending agent
- Surface active agent
- Physiologically inert
- Forms protective films that are resistant to water and flavour to be evaporated.

This plant produces the most widely used types, from a D.S. of 0.5 to 0.9, and types KM, blended or denatured CMC, and applicable to various uses in accordance with consumer's demand.

The types of products, characteristics, uses and general physical properties are shown in table 1 and table 2.

Table 2. Physical Properties of CMC

Powder Phase	
Sodium carboxymethylcellulose, dry basis %	99.5%
Moisture content, max. %	7% max.
Browning temperature	180~225°C
Charring temperature	210~250°C
Bulk density	0.65~0.75
BOD	10,000~ 18,000ppm
Solution phase	
PH, 2% solution	6.5~7.5
Films	
Specific gravity, g/ml.	1.52~1.59

Contents of Technology

1) Process Description

Sodium carboxymethyl cellulose is produced by reacting alkalicellulose with sodium monochloro acetate. In this reaction, some of the hydrogens in anhydroglucose are substituted by carboxymethyl groups. The solution characteristics are dependent upon the degree of substitution and the degree of polymerization. Having a D.S. of above 0.4, The product becomes water-soluble and showes good compatibilities with other natural gums.

The rough process description of this plant is as follows:

Raw material feeding
Pulp, caustic soda and MCA (monochloroacetate) are weighed and fed in.

Mixing
The raw material is uniformly mixed in a mixer with agitation.

Reaction
The mixture is reacted at constant temperature.

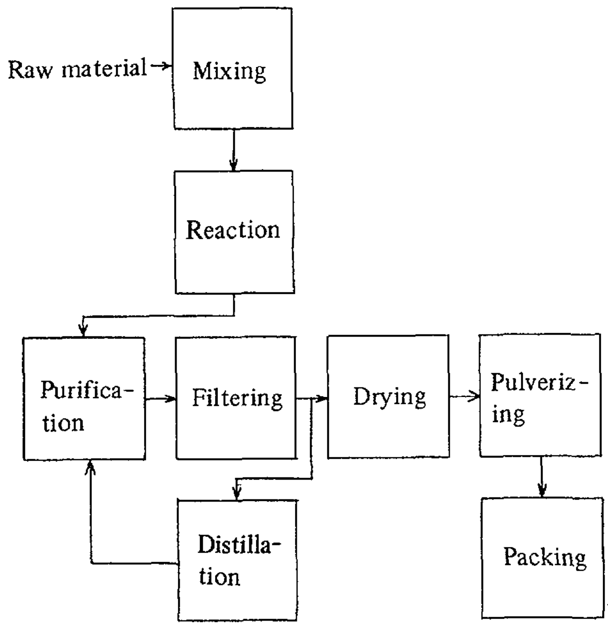
Purification
The by-product is removed in this process.

Dehydration
The reaction product is separated to further increase its purity.

Drying
After drying, it is fed to a crusher.

Crushing
It is crushed to fixed particle size for packing.

CMC Manufacturing Process Block Diagram



2) Equipment and Machinery

Mixer
Reactor
Roller conveyer
Crusher
Washing tank
Filter press
Screw conveyer
Dryer
Pulverizer
Shifting machine
Refrigerator
Rectification tower
Agitator

3) Raw Materials and Utilities

Raw materials and utilities	Requirement (per ton of product)
Pulp	800 kg
Monochloroacetate	600 kg
Caustic soda	1,000 kg
Hydrochloric acid	50 kg
Methanol	600 kg
Bunker-C oil	1,000 ℓ
Electric power	3,000 kw
Industrial water	50 tons

Example of Plant Capacity and Construction Cost

1) Plant capacity : 4 tons/day

* Basis : 24 hrs/day

2) Estimated construction cost (as of 1983)

- Manufacturing equipment : US$1,013,000
- Utility facility : US$ 127,000
- Installation cost : US$ 253,000

Total : US$1,393,000

3) Required space

- Site area : 5,000 m^2
- Building area : 2,000 m^2

4) Personnel requirement

- Manager : 2 persons
- Engineer : 4 persons
- Operator : 20 persons

Total : 26 persons

Any inquiry about the information contained should be sent to:

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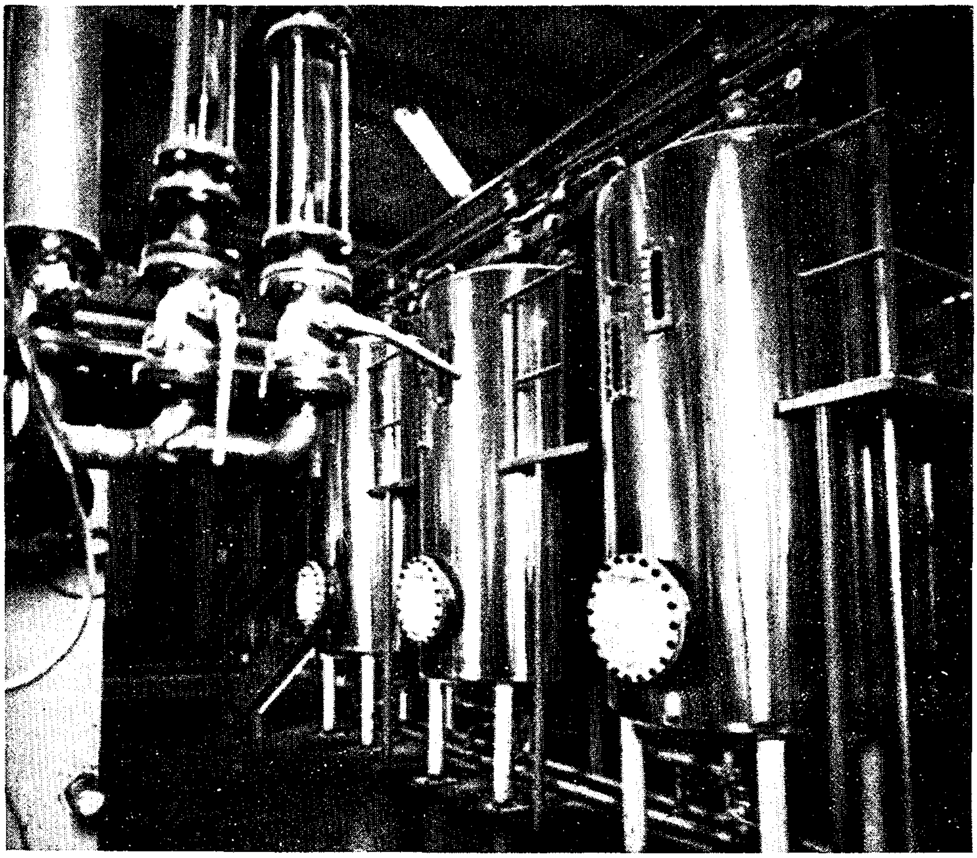
Starch Hydrolysis Products Plant



View of Isomerization Column

The products which can be produced through saccharification of starch are glucose syrup, dextrose syrup or crystal dextrose, 42% fructose syrup and 55% fructose syrup.

These products can also be selectively produced according to needs. Especially, fructose syrups are very good products and can partially replace the sucrose being imported by many countries. 55% Fructose syrup which was developed in the 1970s all over the world can be supplied at lower prices and with better sweetness than surcose as new product. In general, these products are used in foods confectionery, beverages, etc.

The plant introduced here is the same as those in America and Japan in the aspect of yield, consumption of secondary raw meterials and energy, while its equipment for production can be supplied at lower and information and advice relating to the operation and management of their plant can also be supplied.

The services and information which can be supplied is for the purpose of helping to reduce costs of production, improve the efficiency and operation of the plant as well as the quality of the products.

Products and Specifications

The products currently produced by this plant include glucose syrup, dextrose syrup or crystal dextrose, 42% high fructose syrup and 55% high fructose syrup based on the saccharification of starch.

Detailed specifications of typical products are as

Table 1. Specifications of Glucose Syrup, Dextrose, High Fructose Syrup

○ Dextrose

Classification	Item	Package	Specification		Special feature	Use
			Common	Item		
Refined powder dextrose	Special A 1A 1B	20 kg Paper bag	DE 96 ↑ Mo. 9% ↓	Particle size + 60 mesh↓ Particle size + 30 mesh↓ Particle size + 20 mesh ↓	◦ sanitary products of spray dried. ◦ restraint of microorganism's growth is superior due to high osmotic pressure. ◦ change of particle size is possible by order.	confectionary, bakery, dairy products, beverage, canning, ice cream, leather etc.
Dextrose monohydrate	Regular	20 kg Paper bag	DE99.5 ↑ Mo. 9% ↓	Particle size + 30 mesh ↓ Particle size + 80 mesh ↓	◦ pure crystal of monohydrate ◦ mouth feeling is good due to quick solubility. ◦ price is cheaper than crystal products.	confectionary, beverage, cosmetic, ice cream nutrient agent for medicine, brewing industry etc.
Dextrose anhydrous	Regular Powder	20 kg Paper bag	DE99.5% ↑ Mo. 0.5% ↓	Particle size + 24 mesh ↓ Particle size + 80 mesh ↓	◦ crystalline without hydration. ◦ Stable to heat than dextrose monohydrate.	antibiotics, injection, cosmetic, tea binder high grade liquor etc.
Liquid dextrose	G-60	Tank lorry	Mo. 40%↓	DE 96.0 ↑	◦ Price is cheap ◦ easy handling because of liquid phase. ◦ adjustable D E and Moisture content by order	confectionary, bakery, canning, leather, dyestuff, beverage, fermentation.

○ Glucose syrup

Classification	Package	Specification	Special feature	Use
Medium D.E. glucose syrup	24 kg can, tank lorry	Mo. 18-25% DE 90-95	◦ stable to long period storage and hardly colored with high temperature.	candy, confectionary, dairy products, bakery, meat processing, canning, ice cream, cooking for home etc.
High D.E. glucose syrup		Mo. 18% ↓ DE 50↑	◦ adjustable DE and moisture content by order.	
Malto dextrin syrup	23 kg can, tank lorry	Mo. 29.5% ↓ DE 20-35	◦ can reduce retrogradation of starch in food. ◦ High viscosity and coagulating power	coffee cream, canning, candy, confectionary, dairy products, ice cream.
Maltose syrup	5 kg, 24kg can, tank lorry	Mo. 18% ↓ Maltose 40-50%	◦ glossness is good and hard to coloring and moisturing of processed food. ◦ have mild sweetness and good application in surface coating of food.	candy, confectionary, caramel, meat processing, canning, beer, preservative improver for fast type food.

○ High Fructose Corn Syrup

Classification	Package	Specification	Special feature	Use
42% High fructose syrup	25 kg can, 1000kg container tank lorry	Mo. 25% ↓ Fructose 42% ↑ Glucose 50% ↑	◦ have good fluidity ◦ similar sweetness with sucrose by dry basis. ◦ good resistance of microorganism's growth.	beverage including coke, confectionary, bakery, ice cream, canning, fish processing, medicine, substitution for sugar and treacle (or molasses)
55% High fructose syrup		Mo. 23% ↓ Fructose 55% ↑ Glucose 39% ↑	◦ have same or more sweetness with sucrose by dry base. ◦ can store long period in relatively low temp. (no crystal formed)	

Contents of Technology

1) Process Description

Liquefaction section

PH and concentration of the refined starch slurry are adjusted at room temperature, and then enzyme co-factor is added. The starch slurry is passed through a high temperature holding cell. The slurry is fed into reactors for proper retention. In the reactors the product is fully liquefied and transferred to the saccharification section.

Saccharification section

The hydrolysate coming from the liquefaction reactors is cooled by means of heat exchanger. The hydrolysate pH is adjusted and enzyme is automatically and continuously dosed into the hydrolysate. The saccharification takes place in the saccharifying tank and after proper retention time the final DE is obtained.

Decolorization and filtration section

After saccharification the color bodies are removed and then non-soluble part of the protein and fats are separated from the hydrolysate in this section.

1st Refining section

The clear and decolored hydrolysate is led to the 1st refining section consisting of cation, anion and mixed bed exchangers. In the cation exchangers, sodium, calcium, iron, copper, etc. are removed. Some amino acids are also removed. The anion exchangers remove chlorides, sulphates, phosphate and most of the remaining soluble amino acids. The mixed bed tower also reduces dissolved solids to maximum extent.

Isomerization section

By continuous enzymatic conversion, part of the liquid dextrose is made into fructose syrup and then isomerized fructose syrup is obtained.

2nd Refining section

After the isomerization the syrup is led to the 2nd refining section where the syrup is subjected to a second demineralization.

Evaporation section

The evaporation takes place in a double-stage evaporator according to the falling-film principle where the product flows from the top to the bottom of the inside wall of vertical heating tubes as a thin boiling film. After the evaporation, part of the product is pumped into F/G separation system.

F/G Separation section

The purpose of this system is to obtain higher fructose syrup by the chromatographic separation technique. After the F/G separation the high fructose syrup is demineralized again in a mixed bed ion exchanger.

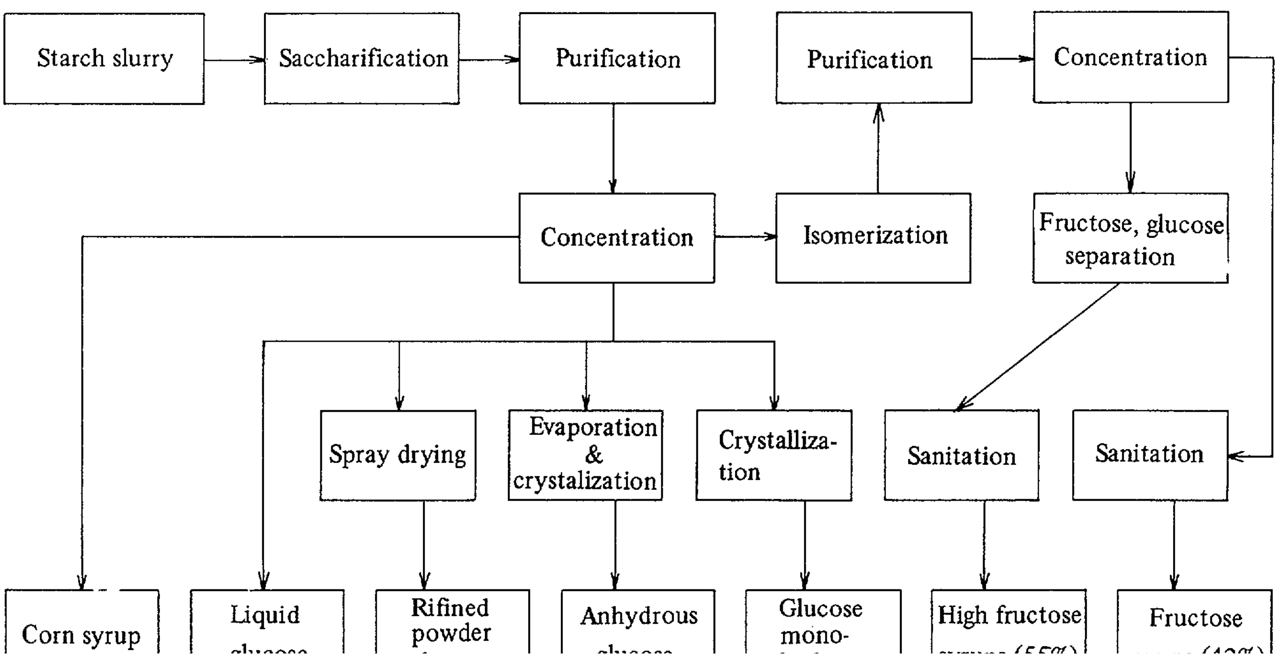
Sanitation section

Produced high fructose syrup is filtered to remove micro-organisms and fine insoluble impurities and then sterilized and cooled by plate type heat-exchanger.

Final product

Final product is thus produced by these processes.

Dextrose and High Fructose Syrup Manufacturing Process Block Diagram



2) Equipment and Machinery

Liquefaction and saccharification section
- Starch slurry tank
- Control tank
- Service tank
- Reactor
- PH control tank
- Enzyme tank
- Saccharifying tank

Decolorization and filtration section
- Decolorization tank
- 1st Activated carbon tank
- 2nd Activated carbon tank
- Carbon injection pump
- Feed pump

Refining section
- Receive tank
- Feed pump
- Plate heat exchanger
- Ion exchange resin tower
- Refined hydrolysate storage tank
- Refined hydrolysate pump

Isomerization section
- Dextrose storage tank
- Dextrose feed pump
- Vacuum pump
- Plate heat exchanger
- Syrup receive tank
- Syrup pump

Evaporation Section
- Feed tank
- Feed pump
- Evaporator

Fructose, Glucose Separation Section
- HFS storage tank
- HFS pump
- HFS control tank
- F/G separation column
- Fructose rich receive tank
- Fructose rich pump
- Glucose rich pump

3) Raw Materials and Utilities

Raw materials and utilities	Requirement (per ton of product)	
	Dextrose monohydrate	55% HFS
Corn starch Tapioca starch	1.1 m/t-D.S	0.965 m/t-D.S
Calcium chloride (70% $CaCl_2$)	0.3 kg	0.3 kg
Sodium hydroxide (40% NaOH)	12 kg	18 kg
Hydrochloric acid (35%-Hcl)	12 kg	20 kg
Activated carbon	1.5 kg	2 kg
Steam	2.3 m/t	1.3 m/t
Electric power	120 kwh	90 kwh
Water	8 m^3	12 m^3

Example of Plant Capacity and Construction Cost

1) Plant capacity : 70 m/t/day
   * Basis : 10 hrs/day

2) Example of construction cost (as of 1983)
   - o Equipment and machinery : US$4,500,000
   - o Material cost : US$1,500,000
   - o Installation cost : US$1,200,000

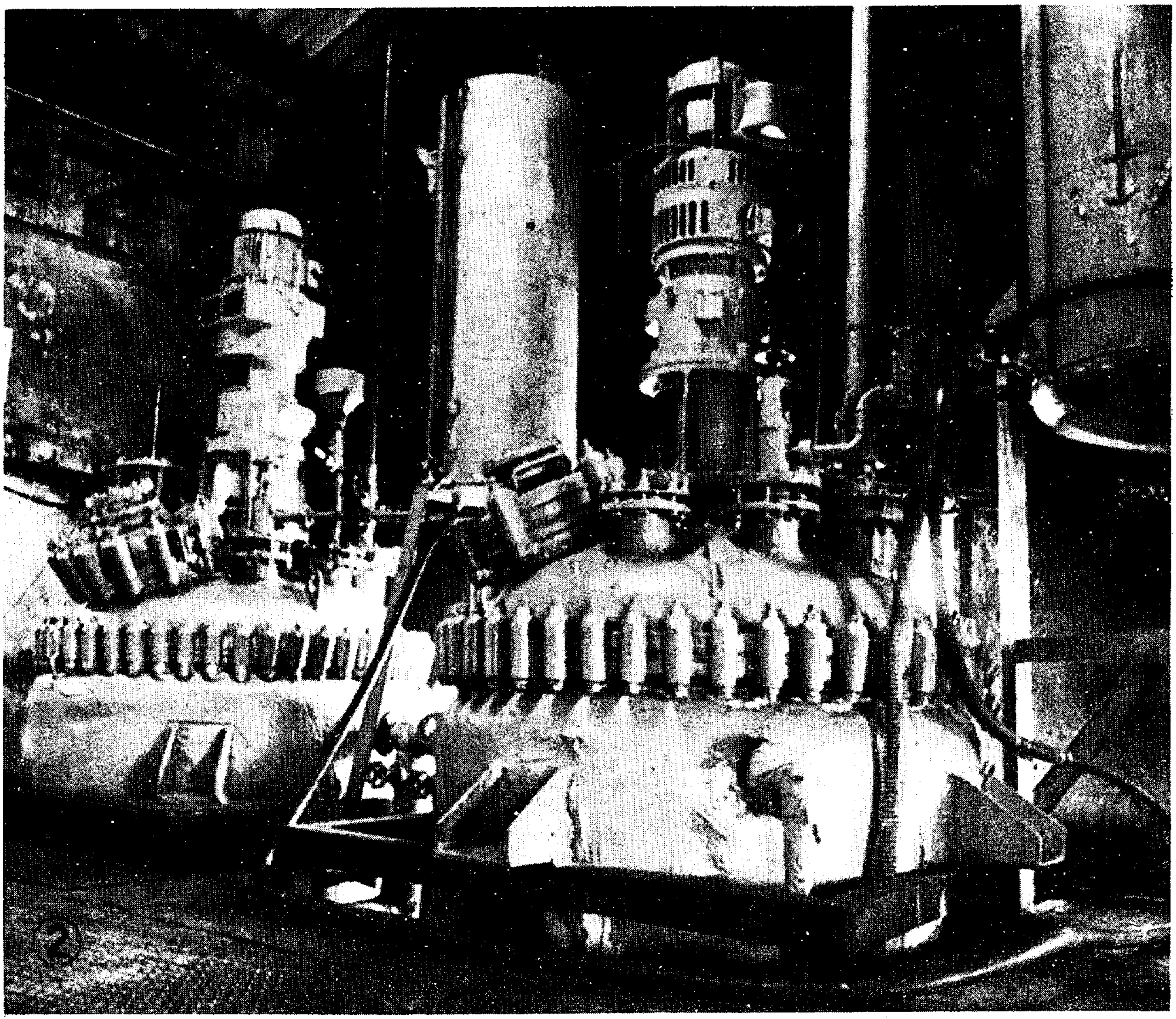
   Total : US$7,200,000

3) Required space
   - o Site area : 15,000 m^2
   - o Building area : 3,000 m^2

4) Personnel requirement
   - o Manager : 10 persons
   - o Engineer : 10 persons
   - o Operator : 40 persons
   - o Others : 20 persons

   Total : 80 persons

Lauryl Sulfate Making Plant



View of Sulfation Reactor

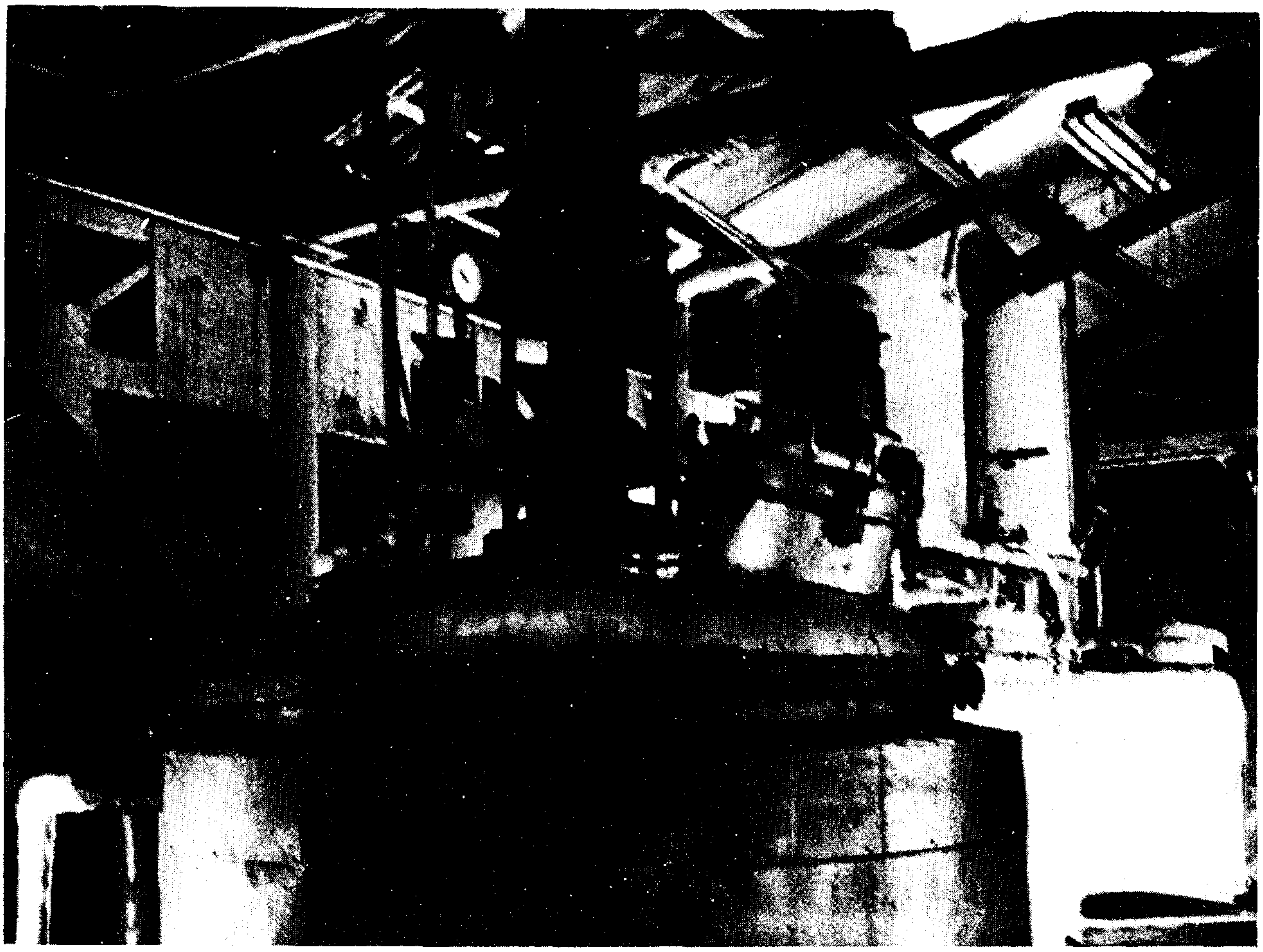
Since this product is based on batch operations, its production can be readily converted depending upon desired products. The time required for switching over to the production of a specific product required by customers, is relatively short, with a small quantity production also possible.

Accordingly, the plant construction costs are relatively low while not many operators are required because of its being basically an equipment industry.

Since its raw material is derived from natural substances in high purity, it can be safely used for any purposes including cosmetics, pharmaceuticals, household and industrial uses.

This product is superior to ordinary detergents in its biodegradation, not causing much public nuisance including water pollution.

Highly foaming, this product is excellent in washing, penetrating and emulsifying capacities with no particular damages to the skin, hair and textile. Bright in color, nice smelling and good tasting, this product can use any of soft water or hard water.



View of Neutralization reactor

Products Name & Formula From Lauryl Alcohol Origin

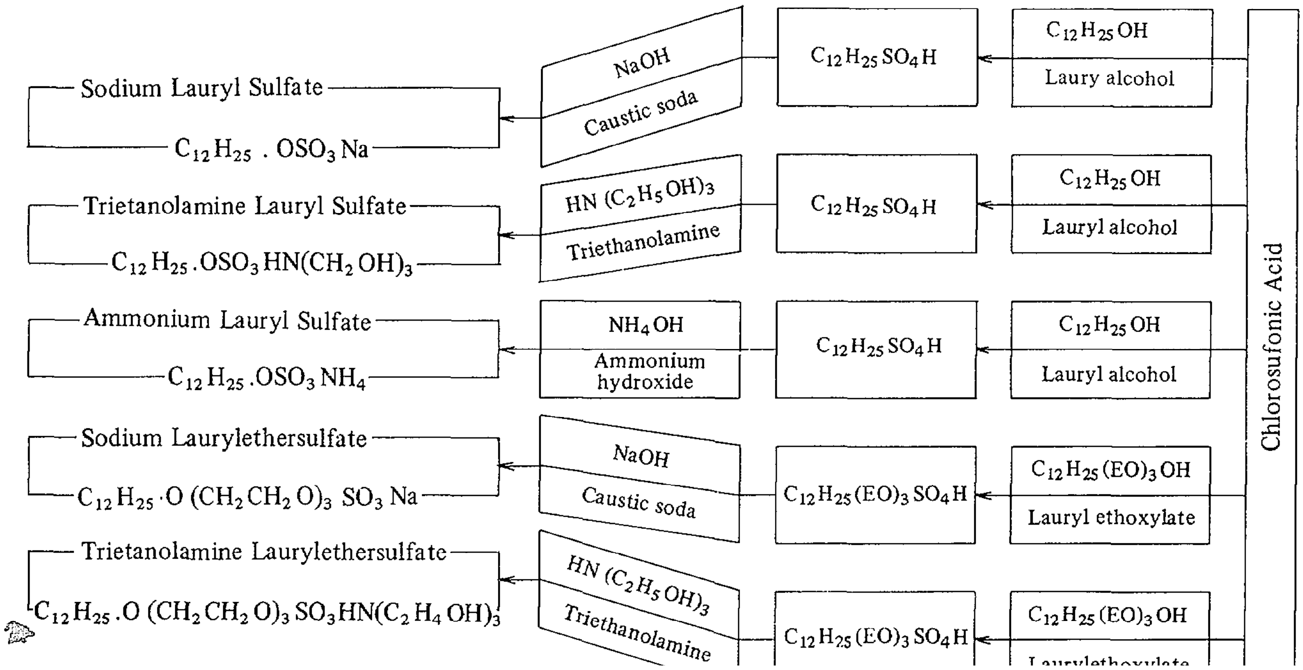


Table 1. Products and Specifications

Product	General Characteristics	Specifications	Uses
Sunfom-A (Ammonium lauryl sulfate)	Classification : Anionic surfactant. Appearance : Clear amber viscous liquid at 20°C Solubility : Soluble in hard and soft water.	Active component : 30 ± 1%. norganic salts : 2% max. Unsulfated matter : 1% max. PH (1% soln.) : 7.0 ± 1.0	Base for shampoos, cleaning agents and liquid detergents
Sunform-T (Tri-ethanol amine lauryl sulfate)	Classification : Anionic surfactant. Appearance : Almost colourless clear liquid. Solubility : Soluble in hard and soft water.	Active component : 30 ~ 45 ± 1%. Inorganic salts : 2% max. Unsulfated matter : 1% max. PH (1% soln.) : 7.0 ± 1.0	Base for liquid shampoos and foam baths, fine foam structure for shampoos.
Sunfom-S (Sodium laury1 l sulfate)	Classification : Anionic surfactant. Appearance : Nearly water white viscous liquid Solubilty : Souble in hard and soft water.	Active component : 30 ~ 60 ± 1% Inorganic salts : 2% max. Unsulfated matter : 1% max. PH (1% soln.) : 7.0 ± 1.0	Base for shampoos and bubble bath, light duty and other liquid detergents. Foaming agent for tooth pastes, mouth washes, emulsifier, hand cleaner and other cosmetics.
Sunfom-E (Sodium lauryl ether sulfate)	Classification : Anionic Surfactant Appearance : Clear amber viscous liquid. Solubility : Soluble in hard and soft water.	Active component : 30 ± 1% ~ 70 ± 1% Inorganic salts : 20% max. Unsulfated matter : 1% max. PH (1% soln) : 7.0 ± 1.0	Base for manufacture of liquid shampoos and bubble bath, high quality dishwashing agents, hand cleaner and other cosmetics. cosmetics.

Products and Specifications

The products produced in this plant are ammonium lauryl sulfate, tri-ethanolamine lauryl sulfate, sodium lauryl sulfate and sodium lauryl ether sulfate.

These products are widely used as hase for shampoo, liquid detergent, foaming agent for tooth paste and mouth washes and emulsifier for cosmetics.

The specifications of these products are as shown in table 1.

Contents of Technology

1) Process Description

Sulfation

reacted with cholorosulfonic acid in a reactor at 30°C. Hydrogen chloride gas generated in this reaction is led off the system. After reaction, the sulfation product is transferred to a neutralization vessel through pile lines.

Neutralization

The sulfation product is neutralized at the temperature below 45°C by using triethanol amine, ammonia or sodium hydroxide together with water for adjusting its active component.

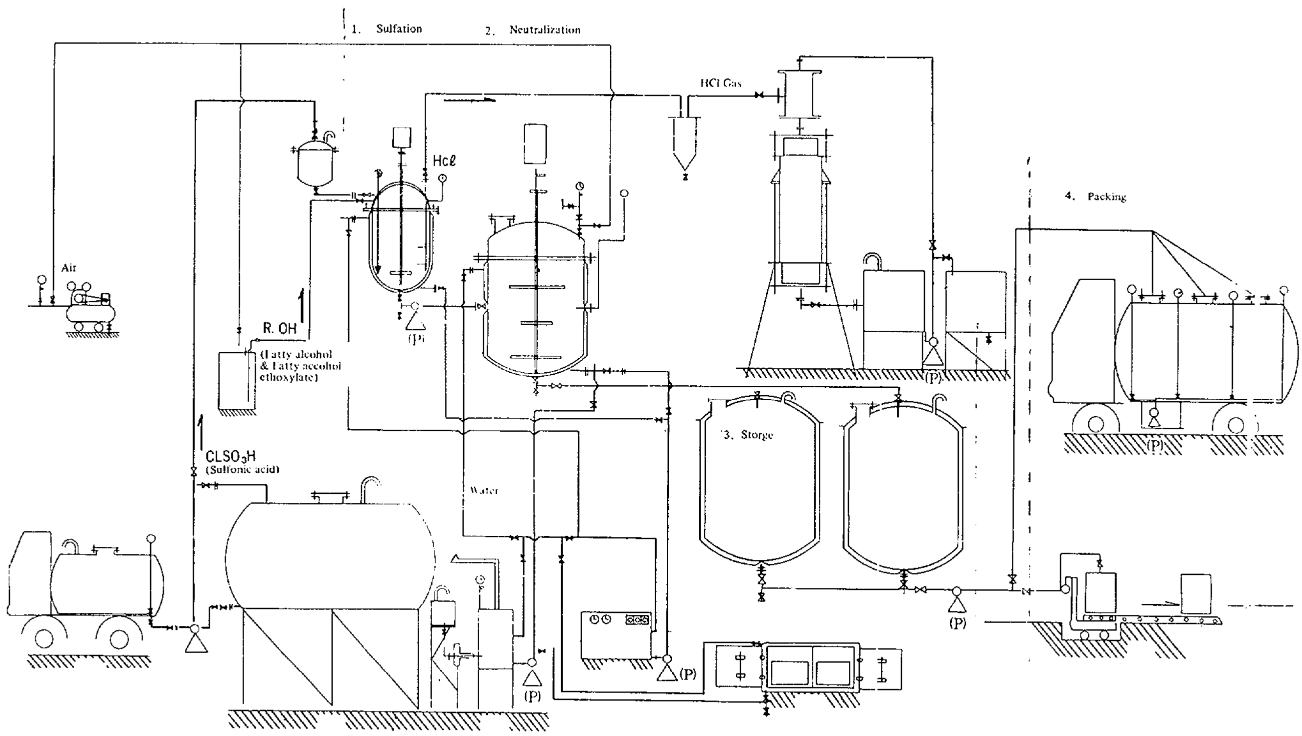
Storage

On completion of the neutralization and formation of active components, the surfactants are transferred to respective tanks for storage as products.

Packing

The products are delivered in drums or tank lorries

Equipments & Process Flow Sheet



2) Equipment and Machinery

Equipment	Quantity	Volume	Raw material
Chlorosulfonic acid tanklorry	1	3,000 ℓ	SUS 304 or 316
Chlorosulfonic acid & caustic soda tank	2	10,000 ℓ	SUS 304 or 316
Hot water boiler	1	100,000 Kcal/hr	Steel
Fatty alcohol melting chamber	1	H x W x L 1.1x2.3x3.9m	Steel
Sulfation reactor	1	1,500 ℓ	Glass lining & Steel
Neutralization reator	1	3,500 ℓ	SUS 316L
Hydrochloric acid cooling condenser	1	ϕ x H 0.4x2.2m	Carbon & PVC
Products storage tank	2	20,000 ℓ	FRP
Products measuring scale	1	300Kg	Steel
Products tanklorry	1	10,000 ℓ	SUS 304
Cooling water producing compressor	1	20HP	Steel & copper
Air compressor	1	7.5HP	Steel
Pump	8	31HP	SUS 304 or 316

* Basis = 250 m/t/month

3) Raw Materials

○ Unit consumption by product

Products / Raw materials	E	S	A	T
LA		0.20739	0.20000	0.14606
AE	0.24219			
CS	0.09183	0.12516	0.12056	0.08814
NaOH	0.10014	0.10782		
TEA				0.13712
NH_4OH			0.09583	
H_2O	0.56584	0.55963	0.58361	0.62868
Total	1	1	1	1

* E : Sodium lauryl ether sulfate
S : Sodium lauryl sulfate
A : Ammonium lauryl sulfate
T : Triethanol amine lauryl sulfate

Example of Plant Capacity and Construction Cost

1) Plant capacity : 250 m/t/month
   * Basis : 16 hours/day, 300 days/year

2) Estimated construction cost (as of 1982)

o Equipment and machinery	:	US$ 100,000
o Utilities	:	US$ 15,000
o Installation cost	:	US$ 25,000
Total	:	US$ 140,000

3) Required space

- o Site area : 1,300m²
- o Building area : 300m²

4) Personnel requirement

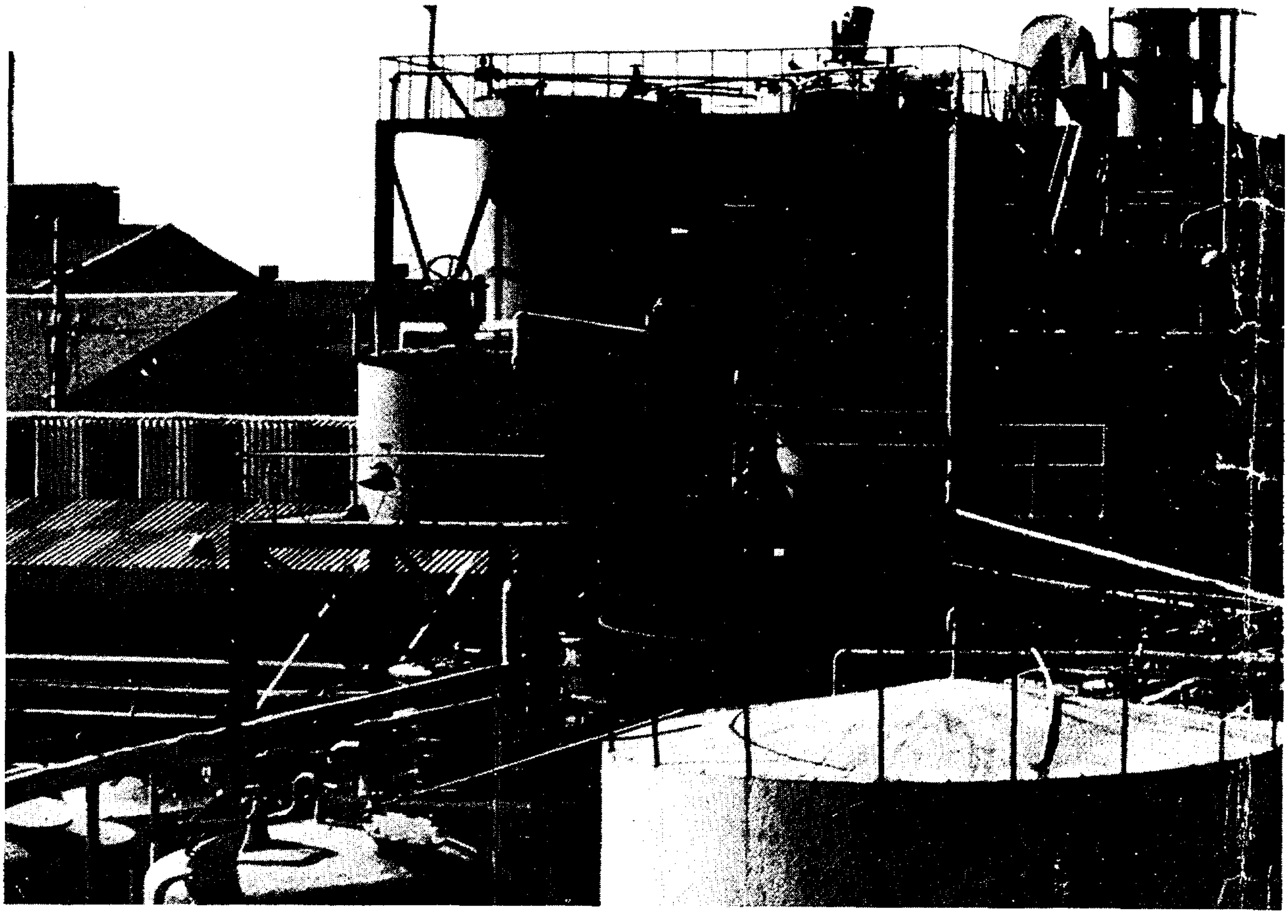
o Plant manager	:	3 persons
o Engineer	:	2 persons
o Operator	:	8 persons
o Others	:	4 persons
Total	:	17 persons

Any inquiry about the information contained should be sent to:

IO/COOP, Registry file No. ID/562/12, UNIDO, P.O. Box 300, A-1400 Vienna, Austria

FILE: G89
ISIC 3511

Caustic Soda Making Plant



View of Caustic Soda Concentrator

Caustic soda is one of the basic chemical products produced in the largest quantity along with sulfuric acid, ammonia and ethylene. Moreover, because of its large production scale, caustic soda is generally classified as one of the heavy chemicals.

This product is mainly used for the synthesis of various organic and inorganic chemical compounds, production of soap, pulp, paper and rayon as well as neutralization in a wide range of industies.

By-product chlorine is simultaneously obtained in its production because the raw material of caustic soda is common salt. This chlorine is also much used in the synthesis of vinylchloride monomer and production of solvent, chloromethane, inorganic chemicals, paper and pulp.

The caustic soda plant introduced here is designed in particular to suit market conditions of developing countries. It is the plant having the system capable of producing not only on a small scale in small markets but also simultaneously such basic inorganic products as hydrochloric acid and sodium hypochlorite, with the possibility of maximizing its economy.

Products and Specifications

In this plant, such by-products as 99.4% liquid chlorine, 35% hydrochloric acid and sodium hypochlorite besides 40% main product sodium hydroxide are produced.

In addition to general-use product with 8-12% active chlorine, sodium hypochlorite having 4-7% active chlorine for foodstuff processing is also produced.

Contents of Technology

1) Process Description

Hydrochloric acid is synthesized with chlorine and hydrogen generated by the electrolysis of raw salt, while part of chlorine is liquefied to produce liquid chlorine. The electrolyzed solution is prepared as 40% liquid caustic soda by concentration, while the produced caustic soda is reacted again with chlorine to produce sodium hypochlorite.

Raw salt dissolving and refining

After dissolving natural salt as a raw material in water, solutions of Na_2CO_3, NaOH and $BaCl_2$ are fed into the brine refining vessel for reaction with and removal of such impurities as SO_4^{--}, Ca^{++} and Mg^{++} contained in the raw salt by precipitation, whereby 1-2 ppm of organic high polymer coagulant is added.

Clear solution in the settling vessel is filtered by the sand filter for the removal of suspending $CaCO_3$ and $Mg(OH)_2$, with excess sodium carbonate and sodium hydroxide also neutralized with hydrochloric acid.

Electrolysis process

The refined brine is electrolyzed in diaphragm-type electrolysis cells to produce hydrogen and chlorine gases as well as electrolytic dilute caustic soda solution.

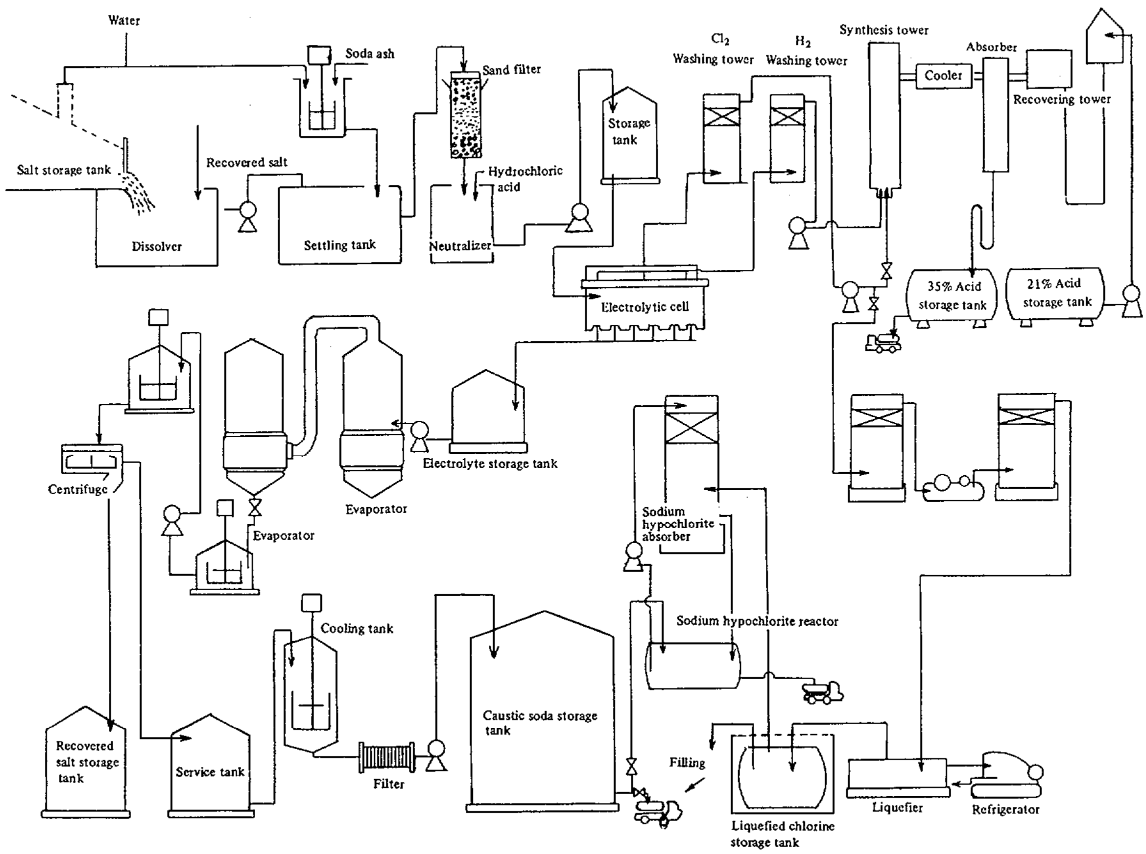
Concentration process

On completion of the electrolysis, the electrolytic solution contains 10-13% of caustic soda and 15-18% of salt. The salt is separated after concentrating the

Table 1. Chemical and Physical Properties of Products

Chemical name	Purity	Descriptions
Liquid chlorine	Not less than 99.4%	Yellow, oily liquid Specific gravity 1.57 at 34°C Boiling point 34°C
Hydrochloric acid	35%	Colored yellow by traces of iron Fumes in air Specific gravity 1.097 Maximum boiling azeotrope with water containing 20.24% hydrogen chloride.
Sodium hydroxide	40%	As manufactured by electrolysis method, products contain sodium chloride 2% maximum Specific gravity 1.43
Sodium hypochlorite	Active chlorine 8-12%	Yellowish, clear liquid Ordor of hypochlorite Very unstable under light and heat and loses active chlorine slowly, requiring to be stored in a cool dry place
	Active chlorine 4-7%	For foodstuff Clear, colorless liquid. Ordor of hypochlorite PH 13 ± 0.5 Specific gravity 1.12 Alkali : not more than 1% Iron : not more than 30 ppm

Caustic Soda Manufacturing Process Flow Sheet



solution in evaporators to prepare the product. It requires particular care in the arrangement of its process, because the operation in the evaporation process exerts great influences on the unit consumption of steam, product quality and yield.

Hydrochloric acid synthesis process

This is a process in which hydrogen evolved in the cathode is reacted in the synthesis tower with chlorine generated in the anode for the production of hydrogen chloride. It is produced in explosive reaction by the direct radiation of sun ray with the chlorine and hydrogen mixed gas as the chlorine detonating gas, while generating a large amount of heat. The produced hydrogen chloride gas is recovered by absorbing with hydrochloric acid solution in the absorption tower.

Sodium hypochlorite making process

Hypochlorite is produced by the chlorination of sodium hydroxide with the following reaction formula:

$$2NaOH + Cl_2 - NaClO + NaCl + H_2O + 25.31\ Kcal$$

Liquid chlorine making plant

The chlorine gas evolved in the electrolysis cells is liquefied through the process of refrigeration and

2) Equipment and Machinery

Caustic soda manufacturing section
- Salt dissolver
- Salt refining equipment
- Electrolytic cell
- Electrolyte transfer equipment and storage tank
- Vacuum pump
- Electrolyte concentrating equipment
- Caustic soda refining equipment
- Caustic soda concentration control and storage equipment

Liquid chlorine manufacturing section
- Hydrogen and chlorine washing tower
- Chlorine dryer
- Nash pump
- Refrigerator
- Condenser
- Liquefier
- Liquefied chlorine storage tank
- Liquefied chlorine filling machine

Sodium hypochlorite manufacturing section
- Sodium hypochlorite reactor

Hydrogen chloride manufacturing section
- Hydrogen chloride synthesis tower
- Hydrogen chloride absorbing tower
- Acid storage tank
- Cooler

3) Raw materials and utilities

○ 40% caustic soda

Raw materials and utilities	Requirement (per ton of product)
Raw salt	374 kg
Soda ash	2 kg
40% Caustic soda	21 kg
21% Hydrochloric acid	21 kg
Process water	2 m^3
Electric power	604 kw
Cooling water	3 m^3

○ Liquefied chlorine

Raw materials and utilities	Requirement (per ton of product)
Raw salt	900 kg
Soda ash	3 kg
40% Caustic soda	50 kg
21% Hydrochloric acid	50 kg
Sulfuric acid	80 kg
Electric power	188 kw
Water	6.5 m^3

○ 12% sodium hypochlorite

Raw materials and utilities	Requirement (per ton of product)
Raw salt	119 kg
Soda ash	0.4 kg
40% Caustic soda	7 kg
21% Hydrochloric acid	7 kg
Electric power	47 kw
Water	0.7 m^3

○ 35% Hydrochloric acid

Raw materials and utilities	Requirement (per ton of product)
Raw salt	312 kg
Soda ash	1 kg
40 Caustic soda	17 kg
21% Hydrochloric acid	17 kg

Example of Plant Capacity and Construction Cost

1) Plant capacity : 40% Caustic soda-640 m/t/month
Liquefied chlorine-105 m/t/month
12% Sodium hypochlorite-35 m/t/month
35% Hydrochloric acid-700 m/t/month

* Basis : 24 hrs/day, 30 days/month

2) Esimated construction cost (as of 1982)

○ Manufacturing equipment	:	US$1,133,000
○ Utility facilities	:	US$ 200,000
○ Installation cost	:	US$ 333,000
Total	:	US$1,666,000

* Plant site : Korea

3) Required space

○ Site area : 4,000m^2
○ Building area : 600m^2

4) Personnel requirement

○ Manager	:	2 persons
○ Engineer	:	3 persons
○ Operator	:	8 persons
○ Others	:	12 persons
Total	:	25 persons

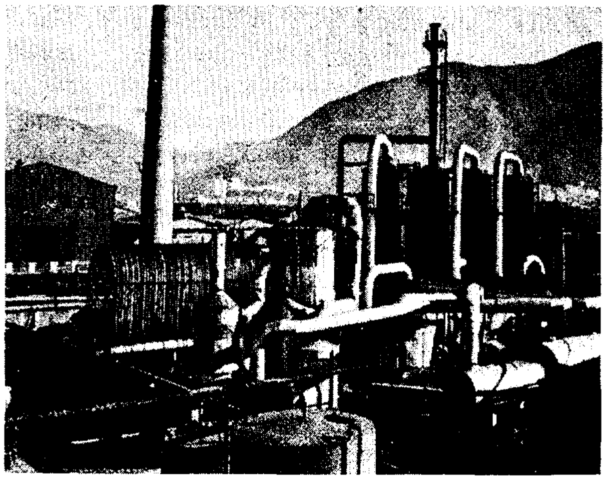
Sulfuric Acid Making Plant

Sulfuric acid is one of the most important basic chemical products along with ammonia, ethylene and caustic soda. It is used for chemical fertilizers, in the synthesis of various compounds, and also production of such various chemical products as pigment, paint, detergent, textile and cellulose film. Bsides, sulfuric acid is also widely used in metal smelting industry, paper industry, food industry and steel making industry.

Accordingly, the production of sulfuric acid occupies the most important position in the basic inorganic chemical industry, while it is the product to be developed and produced with greater priority than other products in the realization of initial-stage industrialization.

The sulfuric acid and fuming sulfuric acid making plant introduced here was engineered and constructed on the basis of Korea's own technology, relating to the contact process sulfuric acid making facilities using sulfur as a raw material.

In particular, this plant can be operated with ease by a relatively small number of personnel, while maximizing the utilization of waste heat generated in oxidation and conversion processes. It is also a highly economic plant having an advantage of high conversion rate from sulfur to sulfuric acid.



View of Suifuric Acid Plant

Products and Specifications

The sulfuric acid produced by this plant is divided into concentrated sulfuric acid above 98% in H_2SO_4 content and fuming sulfuric acid with 25% of SO_3. It is the product with minimum amount of such impurities as Fe, SO_2 and NOx as evolving from the process and originating in the raw material, with general properties as shown in table 1.

Table 1. General Properties of Sulfuric Acids

Chemical name	Purity	Descriptions
Sulfuric acid	Not less than 98%	Clear, colorless, odorless, oily liquid. Specific gravity 1.84 Strongly corrosive Boiling point varies over the range of 315-338°C due to loss of sulfur trioxide during heating to 300°C or higher. Miscible with water and alcohol with the generation of much heat. When diluting, the acid should be added to the diluent.
Fuming sulfuric acid	SO_3 25%	Clear, colorless, dense, oily liquid Fumes in air M.P. - 0.6°C (25%)

Contents of Technology

1) Process Description

This plant is based on the contact method sulfuric acid making process in which sulfur is burned in a combustion chamber and oxidized in the converter to produce sulfuric acid with the following four unit processes:

Sulfur melting process

Sulfur is a substance low in melting point and fluidic when melted, turning into yellow liquid. It requires to be melted in the melting vessel prior to burning. As a heat source, the steam generated by utilizing the waste heat from the converter is used. The temperature of the melting vessesl is adjusted to the level of 114°C, while impurities contained in the molton sulfur are settled and removed for the next process.

Sulfur combustion process

Removed of the impurities, the molten sulfur is pumped from a storage tank and fed into the combustion furnace. The spraying is carried out with a spray gun. The sprayed sulfur is converted to SO_2 gas while generating oxidation heat, which is recovered for utilization in melting the raw material.

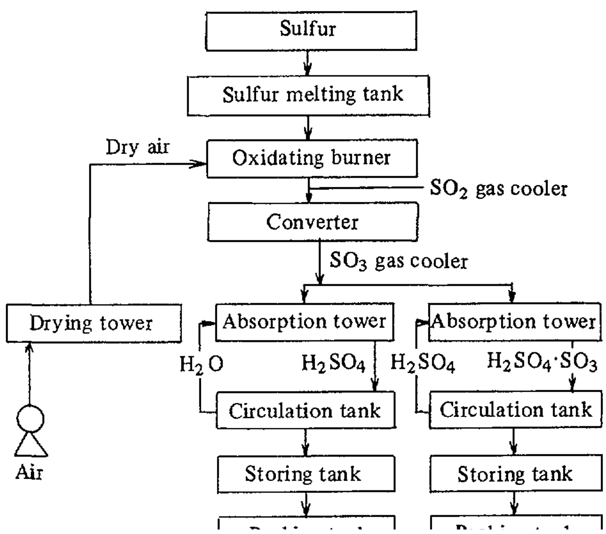
SO_2 conversion process

The generated SO_2 gas is converted to SO_3 gas in the multi-stage conversion tower in the presence of vanadium oxide catalyst. When Monsanto catalyst is used, the conversion rate is about 95-98.5%.

SO_3 gas absorption process

The converted SO_3 gas is properly cooled by SO_3 gas cooler and then absorbed with water or sulfuric acid to the extent of desired concentraction by circulation and absorption to obtain the product.

Sulfuric Acid Manufacturing Process Flow Diagram



2) Equipment and Machinery

Sulfur melting section
- Sulfur melting tank
- Liquid sulfur transfering system
- Liquid sulfur storage tank

Sulfur oxydating section
- Air blower
- Air drying tower
- Oxydating burner
- Spray gun
- SO_2 gas transfering system
- SO_2 gas precipitator

SO_2 gas converting section
- SO_2 gas converter
- SO_3 gas cooler

SO_3 gas absorbing section
- SO_3 gas absorbing towers
- Absorbing water and sulfuric acid circulating system
- Acid cooler
- Acid storage tanks

Others
- Cooling water transfering system
- Cooling tower
- Air polution controlling system
- Others

3) Raw Materials and Utilities

○ Sulfuric acid

Raw materials and utilities	Requirement (per ton of product)
Sulfur	360 kg
Water	0.07 m^3
Electric power	56.36 kw
Cooling water	1.86 m^3

○ Fuming sulfuric acid

Raw materials and utilities	Requirement (per ton of product)
Sulfur	390 kg
Water	0.08 m^3
Electric power	60.76 kw
Cooling water	2.01 m^3

Example of Plant Capacity and Construction Cost

1) Plant capacity : 1,500 m/t/month

2) Estimated construction cost (as of 1982)

o Manufacturing equipment	: US$467,000
o Utility facilities	: US$ 67,000
o Installation cost	: US$200,000
Total	: US$734,000

3) Required space

o Site area	: 1,700m^2
o Building area	: 600m^2

4) Personnel requirement

o Manager	: 1 person
o Engineer	: 1 person
o Operator	: 7 persons
Total	: 9 persons

FILE: G91
ISIC 3511

Trichloroethane Making Plant

Generally, petroleum-related products constitute the mainstay of cleaning agents. However, due to its high inflammability, the petroleum-related cleaning agent involves hazards of fire in its use or management. Therefore, 1,1,1-trichloroethane as a non-inflammable solvent was developed to solve such a problem.

Initially industrialized by Dow Chemical of the United States, it has been widely known worldwide under the commodity name of chlorothene. High in the standard threshold limit value (TLV), this product is not only least harmful to human body among the non-inflammable solvents developed thus far, but also has an advantage of being quick in drying speed because of its low boiling point.

Accordingly, it has achieved the most rapid growth among the cleaning agents in recent years, with the similar chlorinated solvent trichloroethylene also being replaced by this product due to the problem of its toxicity in advanced nations.

As can be seen in table 1, this product is widely used in degreasing such various products as textile, metal and electronic products. In the case of degreasing metals, the vapor cleaning based on this product is highly effective, with about 80% of the total demand for cleaning agents being met by the use of this product.

The 1,1,1-trichloroethane manufacturing technology introduced here relates to the production of this item based on a new process in which the past defect has been improved. It is characterized by the low cost of raw materials and simplicity of the process itself.

Table 1. Uses of 1,1,1-Trichloroethane

- Degreasing (removal of smear and dirt) of all textile products except acetate (spray cleaning)
- Dip cleaning and vapor cleaning of such metals as iron and copper
- Dip cleaning and wipe cleaning of electronic equipment, various precision machines, printed circuit boards, timepieces and component parts
- Spray cleaning and wipe cleaning of motors, various instruments, tools and various gauges
- Cleaning grease or dirt smeared on the cars, various cabinets, desks, electric fans and sewing machines
- Cleaning of printing machines and rubber rollers
- Production of adhesives
- Cleaning of film in photograph development laboratories
- Solvents of printing ink, paint and rubber
- Spray-type vapor pressure falling agent
- Cleaning of medical instruments
- Cleaning of gelatin capsules in pharmaceutical companies
- Removal of grease or dirt in cleaning houses or households
- Other diverse uses including the cleaning of all objects smeared with grease, oil, tar, wax and the like

Products and Specifications

A non-inflammable and high-performance degreasing solvent, the 1,1,1-trichloroethane produced by this plant is 350 ppm in its threshold limit value (TLV), remarkably higher than 200 ppm of toluene, 100 ppm of trichloroethylene and 100 ppm of tetrachloroethylene.

Also high in solvency, five times of gasoline, and superb in cleaning power, almost four times of gasoline, it is a solvent having very high drying speed. In practice, therefore, the degreasing work requires less energy consumption or time while being fast in drying, with the possibility of performing the work quickly and economically.

Table 2. Specification of 1,1,1-Trichloroethane

Test item	Specification
Color (APHA)	< 15
Water	100 ppm, max.
Acid (as HCl)	10 ppm, max.
Specific gravity (15/25°C)	1.283 - 1.334
Non-volatile material (NVM)	10 ppm, max.
Content of 1,1,1-trichloro ethane	90% (vol), min.
Distillation range	70 - 90°C
Al Test	Pass

Contents of Technology

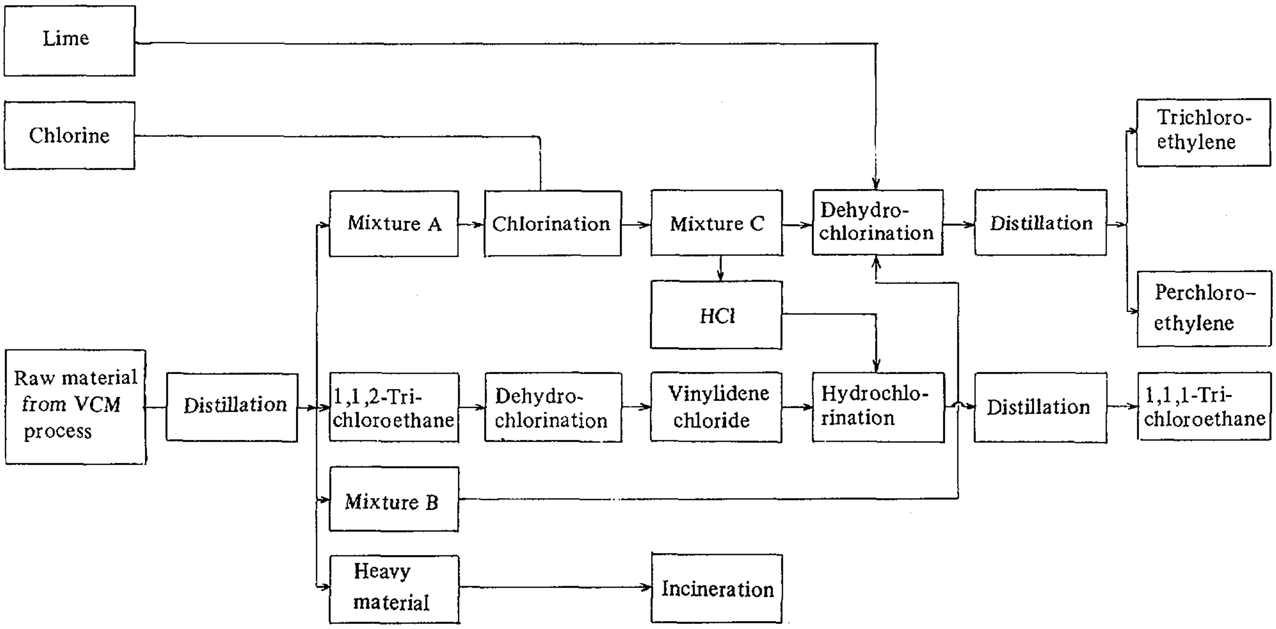
1) Process Description

The mixture of 1,1,2-trichloroethane produced as the by-product in the manufacture of vinylchloride monomer is fractionated in a distillation tower. The oil fractions produced hereby are respectively the mixture A which is a mixture of ethylene dichloride and 1,1,2-trichloroethane, 1,1,2-trichloroethane, mixture B (1,1,2-trichloroethane, perchloroethylene, tetrachloroethylene, pentachloroethylene) and other heavy materials.

The mixture A is reacted again with chlorine gas at high temperatures to produce mixture C (trichloroethylene, perchloroethylene, tetrachloroethylene and pentachloroethylene) and HCl gas. The produced mixtures B and C are dehydrochlorinated by lime milk and separated into trichloroethylene and perchloroethylene in a rectification column.

The 1,1,2-trichloroethane oil is dehydrochlorinated by lime milk or caustic soda solution to vinylidene chloride. It is then synthesized into 1,1,1-trichloroethane by reacting with hydrogen chloride in the presence of Friedel-Craft catalyst. The synthesized 1,1,1-trichloroethane is distilled again into pure 1,1,1-trichloroethane.

1,1,1-TCE Manufacturing Process Flow Diagram



2) Equipment and Machinery

- Raw material storage tank
- Distillation tower
- Mid-storage tank, EDC mix.
- Mid-storage tank, 112-TCE
- Mid-storage tank, tetra mix.
- Mid-storage tank, heavies
- Dryer, EDC mix.
- Dryer, VDC
- Chlorinator
- HCl scrubber
- Dehydrochlorinator, TCE
- Dehydrochlorinator, VDC
- Hydrochlorinator
- Condensers
- Storage vessels
- Pumps

3) Raw Materials and Utilities

Raw materials and utilities		Requirement (per ton of product)
Raw mixture from VCM process		3-3.5 tons
Chlorine	99.5% up	450 kg
Lime	95% up	650 kg
Ammonia	99.5% up	50 kg
Steam	9kg/cm^2	2,000 kg
Water, process and boiler		2,500 kg
Water, cooling, make up		5,000 kg
Electric power		30 kwh

Example of Plant Capacity and Construction Cost

1) Plant capacity : 2,000 m/t/year
   * Basis : 24 hrs/day, 300 days/year

2) Estimated construction cost (as of 1982)

○ Manufacturing machinery	:	US$333,000
○ Utility facility	:	US$ 40,000
○ Installation cost	:	US$ 40,000
Total	:	US$413,000

3) Required space

- ○ Site area : 5,000 m^2
- ○ Building area : 1,200 m^2

4) Personnel requirement

○ Manager	:	2	persons
○ Engineer	:	3	persons
○ Operator	:	20	persons
○ Others	:	10	persons
Total	:	35	persons

TAM Synthesis Technology

TAM is a systemic organic phosphate compound first developed in the United States in 1967 by Chevron Chemical Company. In Korea, TAM has been tested for two years, but continuous evaluation has also been carried out in many countries of the world.

TAM has a systemic action and a good stomach and contact poison action, coupled with a good residual effect. It is suitable for the control of sucking pests such as aphids, whiteflies and spider mites as well as such other biting pests as laphygma, prodenia, and trichoplusia. Notable properties of the product are that it also eradicates resistant strains and can be combined with various insecticides.

With the generic name of methamidophos, TAM has an active ingredient of 0, S-dimethyl phosphoramidothioate. It is used for not only crops but also ordinary and ornamental trees.

Products and Specifications

The common name of TAM is Methamidophos. It is usually called by the name of Monitor, Tamaron, with its structual formula as follows:

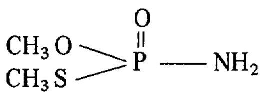


Table 1. Specifications and Available Formulations

○ Technical grade

Active Ingredient	73% min.
Appearance	Yellow to colourless crystals
Empirical formula	$C_2H_3NO_2PS$
Density	D_4^{20} = 1.239
Melting point	37 - 39°C
Vapour pressure	3 x 10^{-4} mmHg at 30°C
Boiling point	Can not be distilled.
Solubility	Readily soluble in water, alcohols, ketones, aliphatic chlorinated hydrocarbons; less soluble in ether; practically insoluble in petroleum ether.

○ Formulations available

600LC (Soluble concentrate) 60% w/v

200LC (Soluble concentrate) 20% w/v

50ULV (For testing)

Contents of Technology

1) Process Description

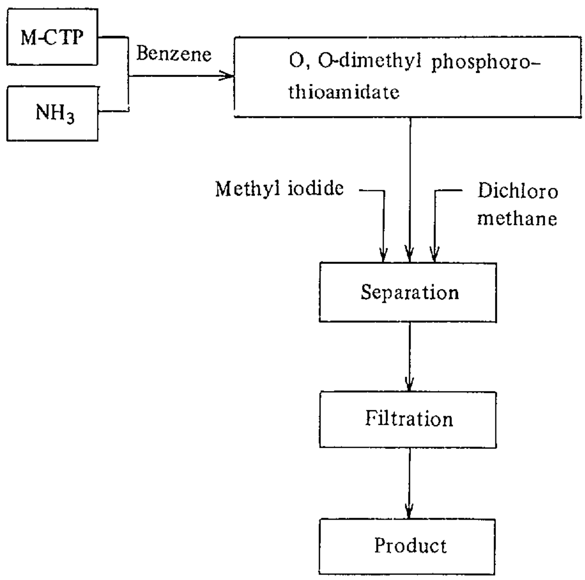
Methamidophos may be made by the isomerization of O,O-dimethyl phosphoramidothioates. The following is a specific example of the conduct of the process.

130 grams of O,O-dimethyl chlorophosphorothioate dissolved in 600 ml benzene is charged to a flask and cooled in an ice bath. Through this solution is passed 36 grs of ammonia gas at the temperature of 10° to 15°C. The solid is allowed to settle. The solution is filtered and the salt cake is washed with benzene. The solution is then stripped at 60°C and 20 mmHg.

The stripped product is combined with a 100 ml of methyl iodide and refluxed for six hours. The mixture is then stripped again at 60°C and 20 mmHg, and the residual oil is dissolved with stirring in 570 ml of mixed solvent containing 80% dichloromethane and 20% of hexane. The solution is filtered and the solid is removed.

The solvent is stripped from the filtrate at 60°C and 20 mmHg to obtain 98 grams of O-methyl-S-methyl phosphoramidothioate. This compound is a pale yellow liquid of moderate viscosity which crystallizes when left alone, melting completely at 32°C.

TAM Manufacturing Process Flow Diagram



2) Equipment and Machinery

SUS reactor
SL-reactor
Condenser (Carbon)
Condenser (SUS 304)
Vacuum pump
Receiver (SS + GL)
Receiver (SUS 304)
Separator
Centrifuge

3) Raw Materials and Utilities

Raw materials and utilities	Requirement (Per ton of product)
M-CTP	1.30 ton
NH_3	0.36 ton
CH_3I	0.10 kl
Benzene	0.60 kl
80%-dichloro methane/ 20%-hexane	0.57 kl
Electric power	800 kwh
Fuel	350 ℓ
Water	15 tons

Example of Plant Capacity and Construction Cost

1) Plant capacity : 4 m/t/day
 * Basis : 8hrs/day

2) Estimated plant cost (as of 1983)
 Total : US$ 1,800,000

FILE: G93
ISIC 3512

DEP Synthesis Technology

DEP, with the common name Trichlorfon, has an active ingredient, dimethyl 2, 2, 2-trichloro-1-hydroxyethyl phosphonate. It was first introduced in 1952 by Bayer AG under the trade mark "Dipterex".

DEP is an insecticide which has an excellent stomach poison action and a good contact and breathing poison action. DEP has a broad spectrum of activities against lapidopters, diptera and heteroptera. It is chiefly used for application to vegetable, rice, maize, sugar cane, grapes, fruits and cotton.

DEP has a low order of toxicity to bees. As soon as the spray has dried on the plants, it is no longer hazadous to bees.

Products and Specifications

DEP, an organic phosphorus compound, is a very effective insecticide. It's chemical structual formula is as follows:

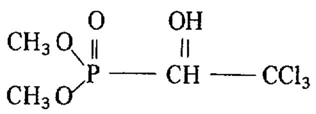


Table 1. Specifications and Available Formulations

○ Technical grade

Active ingredient	95% min.
Appearance	White crystalline powder
Melting point	83 to 84°C
Boiling point	100°C at 0.1mmHg 120°C at 0.4mmHg
Density	d_4^{20} = 1.73
Vapour pressure	7.8 x 10^{-6} mmHg at 20°C
Solubility	28 x 10^{-6} mmHg at 30°C The solubility of DEP in water at 25°C is 154g/1; Soluble in benzene, lower alcohols and most of chlorinated hydrocarbons. Insoluble in petroleum oils.
Compatibility	DEP is compatible with numerous fungicides. But it must not be mixed with Morestan or any other products having an alkaline reaction.

○ Formulation available

50%	Emulsifiable concentrate
50%	Soluble powder
50%	Wettable powder
2.5%	Granular
5.0%	Granular
5.0%	Dust

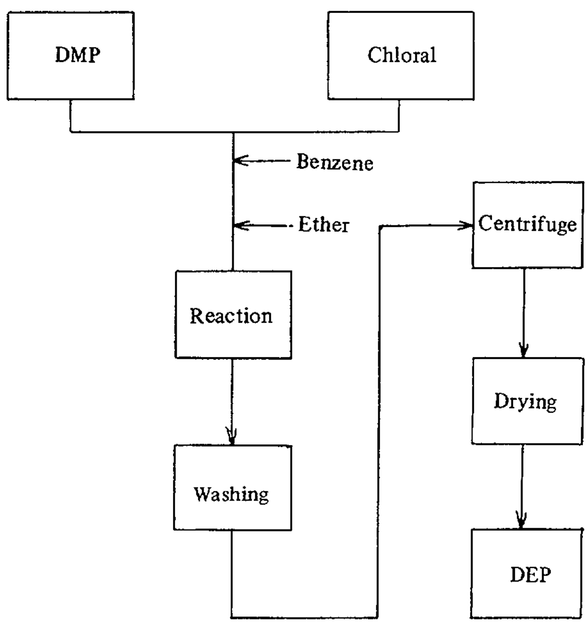
Contents of Technology

1) Process Description

DEP can be produced by the reaction of dimethyl hydrogen phosphite with chloral. After cooling, the oil is dissolved in benzene, and the benzene solution is washed with sodium bicarbonate.

After the solvent has been distilled off, almost all solidities remain. After washing with an ice cold mixture of ether, dimethyl 2,2,2-trichloro-1-hydroxyethyl phosphonate is obtained in the form of colorless crystal.

DEP Manufacturing Process Flow Diagram



2) Equipment and Machinery

GL Reactor
Vacuum pump
Condenser (Carbon)
Receiver (SS + GL)
Receiver (SUS 304)
Separator
Centrifuge
Dryer

3) Raw Materials and Utilities

Raw materials and utilities	Requirement (Per ton of product)
DMP	0.60 ton
Chloral	0.75 ton
Benzene	0.60 kℓ
Electric power	600 kwh
Fuel	200 ℓ
Water	10 tons

Example of Plant Capacity and Construction Cost

1) Plant capacity : 4m/t/day
* Basis : 8 hrs/day

2) Estimated plant cost (as of 1983)
Total : US$ 2,100,000

DDVP Synthesis Technology

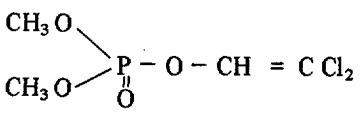
DDVP, with the common name dichlorvos, has an active ingredient, 2,2-dichlorovinyl dimethyl phosphate, which was first introduced by Ciba Geigy AG under the trademark "Nuvan" and by Shell Chemical Co. under the trademark "Vapona".

In Korea, DDVP has been tested for five years but continuous evaluation has also been carried out in many countries of the world.

DDVP has contact, stomach and breathing poison actions. It provides sure control of sucking, biting and mining pests such as aphids, spider mites, caterpillas and beetle larvae. On account of its very fast killing action and the relatively rapid rate at which it is broken down on the plant, it can be used safely on crops close to harvest.
DDVP features good plant tolerance, but it is harmful to bees.

Products and Specifications

DDVP, an organic phosphorus compound, is a very effective insecticide, with its chemical structual formula as follows:



Contents of Technology

1) Process Description.

The equation for the production of DDVP is as follows:

$$(CH_3O)_3P + Cl_3C\,CHO - (CH_3O)_2POOCH{=}CCl_2 + CH_3Cl$$

The feed materials are chloral and trimethyl phosphite. The reactants are usually employed in about equimolar quantities but lesser amounts of either reactant may be employed. A broadly applicable range of mol ratios of the reactants may be from 1:10 to 10: 1. A preferred range is from 2:1 to 1:2. Temperatures of 10°C up to 150°C may be used. The reaction is usually concluded by heating to 50 - 120°C.

Table 1. Specification and Formulation Available

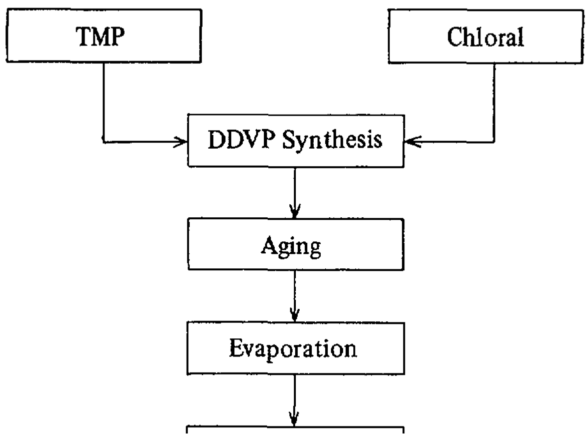
○ Technical grade

Active ingredient	95% min.
Appearance	Colourless or pale yellow transparent liquid.
Specific gravity	d_4^{20} = 1.415
Odor	With mild aromatic odor
Boiling point	74°C at 1mmHg
Vapour pressure	4.5 x 10^{3} mmHg at 10°C 3.0 x 10^{-2} mmHg at 30°C
Solubility	It is slightly soluble (about 1%) in water, and readily soluble in most organic solvents.
Stability	It is solwly hydrolyzed in the presence of water. It decomposes very rapidly in the presence of alkali, whereas in acidic conditions decomposition takes place more slowly.

○ Formulation available

DDVP 50% w/w emulsifiable concentrate
DDVP 50% w/w emulsifiable concentrate without solvent

DDVP Manufacturing Process Flow Diagram



2) Equipment and Machinery

GL reactor
Condenser (Carbon)
Vacuum Pump
Receiver (SS + GL)
Receiver (SUS 304)
Purification equipment

3) Raw materials and Utilities

Raw materials and utilities	Requirement (per ton of product)
Chloral	0.70 ton
TMP	0.57 ton
Electric power	500 kwh
Fuel	200 ℓ
Water	10 tons

Example of Plant Capacity and Construction Cost

1) Plant capacity : 3 m/t/day
   * Basis : 8 hrs/day

2) Estimated Plant cost (as of 1983)
   Total : US$ 1,300,000

Azodicarbonamide Making Plant

Generally, foaming agents are the substances forming pores or cells in the material. Among them, chemical foaming agents are the compounds which decopose with the generation of gases when heated within a fixed range of temperatures. The foaming agent is realized by making use of such gas generating characteristics.

Azodicarbonamide, one of the typical chemical foaming agents, is generally not easily soluble in solvents or ester plasticizer, but its foaming work can be effectively achieved since it is diffused with ease in rubber or plastics in accordance with conventional mixing methods. The foamed products are characterized by being odorless and not subject to contamination or discoloration.

This foaming agent is generally in use for rubber products, including synthetic rubber and natural rubber, and also for such plastics as polyolefin resins, including polyethylene and polypropylene, polyvinyl chloride resin, acrylonitrile butadiene resin, polystyrene resin, polyurethane resin and nylon.

With the rapid expansion of the market for diversified uses of such synthetic resin foamed products, the demand for azodicarbonamide is significantly on the increase. Such a phenomenon is likely to continue also in the future.

The azodicarbonamide making plant introduced here adopts the sodium dichromate oxidation process using sodium dichromate as an oxidizing agent. It is the process capable of simultaneously producing by-product basic chrome sulfate for use as a leather tanning agent.

Products and Specifications

The chemical structure of azodicarbonamide is as follows:

$$H_2N-\overset{\overset{\displaystyle O}{\|}}{C}-N=N-\overset{\overset{\displaystyle O}{\|}}{C}-NH_2$$

This compound is organic yellow to pale yellow decomposing in air at 195-205°C. Heated in a plasticizer above 210°C, the product evolves gas at the rate of 220 ml/g, the highest gas volume of all the organic foaming agents commercially available.

The specifications of azodicarbonamide and its by-product, basic chrome sulfate, are shown in table 1.

Table 1. Specifications of Azodicarbonamide and Basic Chrome Sulfate.

o Azodicarbonamide

Item	Specification
Appearance	Orange yellow, fine powder
Molecular weight	116
Specific gravity	1.65
Decomposition temp.	185 ~ 205°C
Gas volume	220 ± 5 ml/g at STP
Moisture	0.2% max.
Ash	0.2% max.

o Basic chrome sulfate

Item	Specification
Appearance	Dark green
Molecular weight	472
Chrome oxide content	26 ± 0.5%
Sodium sulfate content	24 ± 0.5%
Basicity	33.3 ± 0.5%

Contents of Technology

1) Process Description

There are chlorine oxidation process, sodium dichromate oxidation process and hydrogen peroxide oxidation process in manufacturing azodicarbonamide. The technology introduced here relates to the sodium dichromate oxidation process capable of simultaneously producing its by-product basic chrome sulfate.

Largely divided into azodicarbonamide synthesis process and basic chrome sulfate recovery process, this process can be outlined as follows:

Azodicarbonamide synthesis process

Raw materials, urea and hydrazine hydrate, are reacted in a reactor to obtain hydrazodicarbonamide as an intermediate. The ammonia evolved hereby is absorbed and sent to aqueous ammonia storage tank.

The product hydrazocarbonamide is separated from waste solution by centrifuge and returned to the reactor. An oxidizing agent, sodium dichromate solution, is fed to the reactor and reacted with sulfuric acid while cooling. On completion of the reaction, the reaction product is again separated from mother liquor of chrome sulfate by centrifuge for subsequent filtration and drying in a flash dryer. The dried product is collected in cyclones and bag filters to be conveyed to a silo.

The product in the silo is then fed into a micro mill by means of screw conveyor for pulverization. It is classified in accordance with particle sizes. The classified product is collected in cyclones for packing.

Basic chrome sulfate recovery process

The reaction product from the azodicarbonamide reactor is separated by centrifuge. The produced chrome sulfate mother liquor is transferred to a reduction reactor for addition of glucose as a reducing agent, followed by another addition of aqueous ammonia. On completion of the reaction, the reaction product is filtered by a filter press to obtain chromic hydroxide in cake state. The produced chromic hydroxide is then reacted with chrome sulfate mother liquor and transferred to a storage tank after adjustement of its basicity.

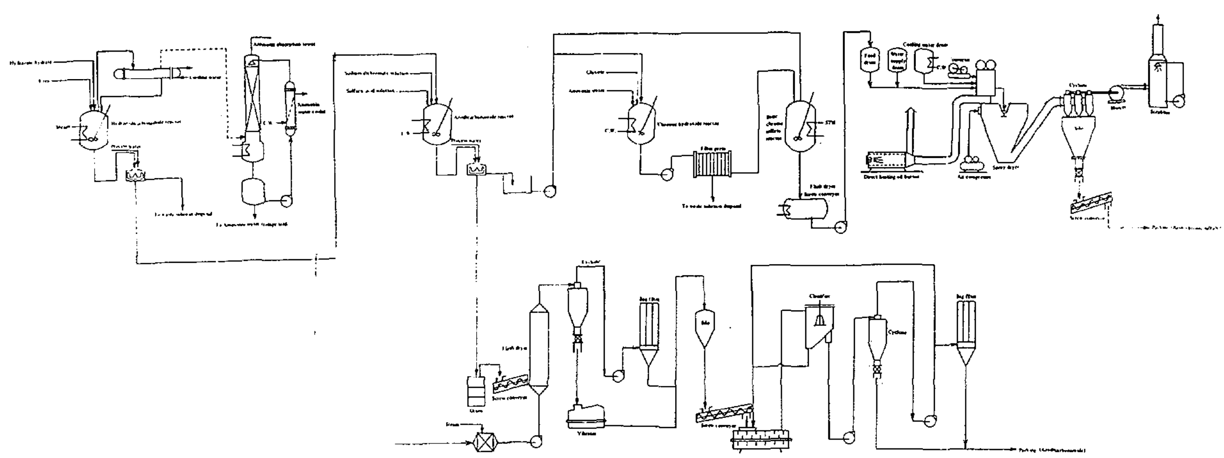
The stored mother liquor is spray dried in a spray dryer to be collected in a cyclone for delivery as final products.

2) Equipment and Machinery

Hydrazocarbonamide reaction process
- Urea dissolving tank
- Hydrazodicarbonamide reactor
- Ammonia condenser
- Ammonia absorption tower
- Ammonia water cooler
- Ammonia water storage tank
- Hydrazodicarbonamide centrifuges
- Pumps

Azodicarbonamide reaction process
- Sulfuric acid storage tank
- Sulfuric acid dilution tank
- Sodium dichromate dissolving tank
- Azodicarbonamide reactor
- Azodicarbonamide centrifuges
- Chrome liguor storage ponds
- Pumps
- Screw conveyors
- Unit heater
- Flash dryer
- Blowers
- Cyclone
- Vibrator
- Bag filter
- Silo
- Micro atomizer

Azodicarbonamide & Basic Chrome Sulfate Manufacturing Process Flow Sheet



Classifier
Control pannel
Basic Chrome Sulfate Reaction Process
Chromic hydroxide reactor
Filter press
Basic chrome sulfate reactor
Basic chrome sulfate solution storage tank
Basic chrome sulfate solution feed drum
Water supply drum
Cooling water drum
Direct heating oil burner
Air compressor
Spray machine
Multicyclone
Silo
Blower
Screw conveyor
Atomizer
Scrubber
Control pannel
Pump

3) Raw Materials and Utilities

- Azodicarbonamide

Raw Materials and utilities	Requirement (per ton of product)
Urea	1,300 kg
Hydrazine Hydrate (80%)	590 kg
Sodium Dichromate	1,025 kg
Electric Power	1,400 kwh
Fuel	500 ℓ
Water	55 m^3

Example of plant Capacity and Construction Cost

1) Plant capacity :
   - Azodicarbonamide plant – 600 m/t/year
   - Basic chrome sulfate plant – 600 m/t/year
   * Basis : 300 days/year

2) Esmated construction cost (as of 1983)
   - Equipment and machinery : US$ 800,000
   - Material cost : US$ 590,000
   - Installation cost : US$ 320,000

   Total : US$1,710,000

3) Required space
   - Site area : 5,000 m^2
   - Building area : 2,000 m^2

4) Personnel requirement
   - Manager : 1 person
   - Engineer : 5 persons
   - Operator : 20 persons

   Total : 26 persons

Any inquiry about the information contained should be sent to:
IO/COOP, Registry file No. ID/562/12, UNIDO, P.O. Box 300, A-1400 Vienna, Austria

H

Plasma Fractions Making Plant

The blood of a healthy person is extracted for use as highly effective individual components by the cold ethanol fractionating methods or heating ethanol fractionating methods. This can eliminate possible side effect, infection and waste of blood arising from the use of whole blood. It makes varied uses possible based on individual components and uses.

In other words, each component of the plasma has unique functions of its own. The blood is fractionated into respective components and only a deficient component is administered to a patient in case of a physiological trouble due to the shortage of a particular component, helping treat the disease.

Furthermore, though its effective period is only three weeks when blood is kept at temperatures of 0°C to 4°C, the fractionated components can not only be preserved for many years but also contribute to the smooth supply of blood with no phenomenon of coagulation.

This will greatly help improve the health of the nation and play the significant role of substituting imports.

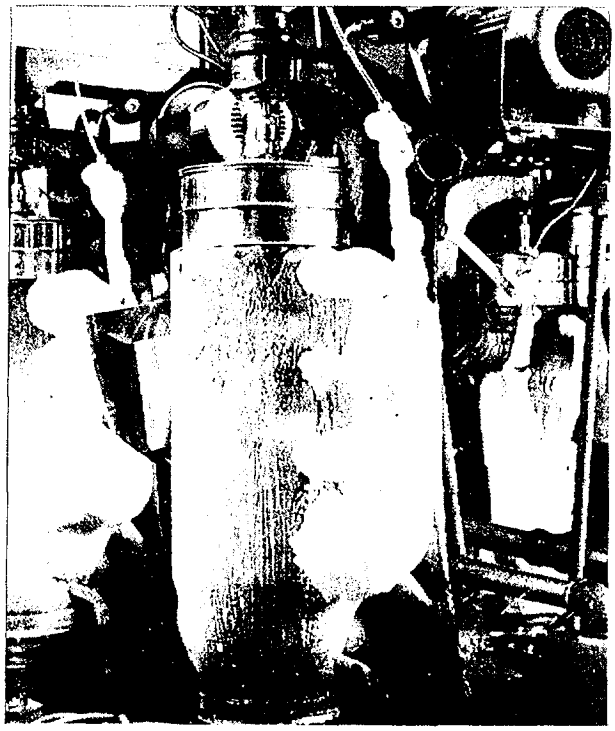


Table 1. Specifications of Plasma Fractions

Product	Specification		Indications
Plasmanate	100ml vial contains : Plasma protein fraction · Albumin · α–Globulin · β–Globulin Sodium caprylate (as stabilizer) Acetyltryptophan (as stabilizer)	 5gm 88% 7% 5% 0.004M 0.004M	For the general use in conditions which require plasma or serum. – Hypovolemic shock – Hypoproteinemia – Burns
Albumin	100ml vial contains : Normal serum albumin, human Sodium caprylate (as stabilizer) Acetyltryptophan (as stabilizer)	 25gm 0.02M 0.02M	For the general use in conditions which require plasma or serum. – Hypovolemic shock – Hypoproteinemia – Burns – Neonatal hyperbilirubinemia
γ–Globulin	100ml vial contains: Immune serum globulin, human Aminoacetic acid Thimerosal (as preservative)	 16.5gm 2.25gm 0.01gm	For the prevention and treatment of infections. For the treatment of a-/hypo-gamma-globulinemia.
I.V. Globulin	1 vial (1,000mg) contains: Immune serum globulin (PEG treated) Glycine (as stabilizer) Sodium chloride (as stabilizer)	 1,000mg 500mg 180mg	For the treatment of a-/hypo-gamma-globulinemia. Combined therapy with antibiotics in severe bacterial or viral infections.
Hyper–Tet	1 vial contains: Tetanus immune globulin, human Thimerosal (as preservative)	 250 i.u. 0.01w/v %	For the prevention and the treatment of tetanus. It is particulary indicated for patients who are sensitive or thought to be sensitive to horse serum, or who have received tetanus antitoxin of equine origin before.
Fibrinogen	1 vial contains: Fibrinogen, dried, human	 1g	For the restoration of blood clotting capability when the blood fibrinogen level falls below about 100 mg %. – Congenital hypofibrinogenemia – Acquired hypofibrinogenemia · Associated with abruptio placentae, amniotic fluid embolism and dead foetus in utero in obstetric field. · Associated with surgical and traumatic condition.

Products and Specifications

The products manufactured in this plant by fractionating human blood are Plasmanate, Albumin, γ-Globulin, I.V. Globulin, Hyper-Tet, Fibrinogen and A.H.F. Specifications and applicable cases are as given in table 1.

Contents of Technology

1) Process Description

It has long been observed that protain may be removed from aqueous solution by the addition of stituents of plasma was developed. This plant is also adapting this cold ethanol method.

In this method, ethanol at controlled temperature reduce the solubility of proteins and make it possible to fractionate various constituents of plasma. And, in the fractionation processes, several variables, such as temperature, concentration of ethanol and PH, should be effectively manipulated to accomplish the isolation of constituents.

As a reference, a rough fractionation system by cold ethanol method is shown in figure 1. And overall fractionation process can generally be described as follows:

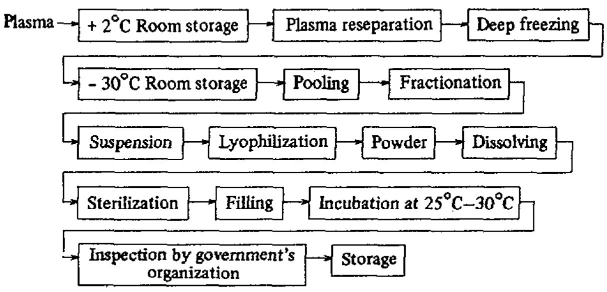
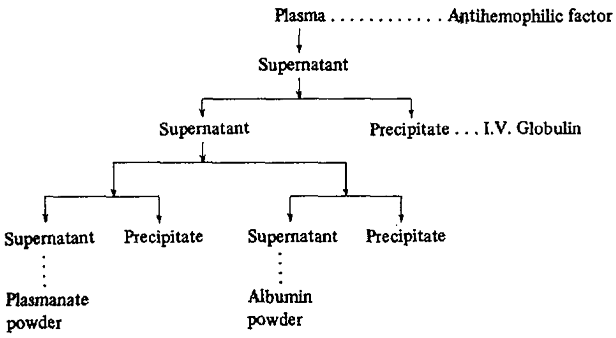


Fig 1. Plasma Fractionation System



2) Equipment and Machinery

Basic facilities
- -35°C Refrigeration facility for plasma preservation
- Pooling room
- Cooling room for fractionation (-6°C)
- Deep freezer
- Plasma dissolution tank
- Tanks
- Centrifuges
- Mixer
- Sparkler filter

Auxiliary facilities
- Washing room
- Machine room
- Laboratory
- Drying room
- Others

Finished product facilities
- Air handling unit
- Sterilization facility
- Filtering facility
- Filling facility
- Others

Example of Plant Capacity and Construction Cost

1) Plant capacity: 150,000ℓ/year

* Basis:
- Treated plasma
- Working hour: 2,400 hrs/year

2) Example of estimated construction cost (as of 1982)

o Equipment and machinery	:	US$2,800,000
o Installation cost	:	US$ 560,000
Total	:	US$3,360,000

* Plant site: Korea

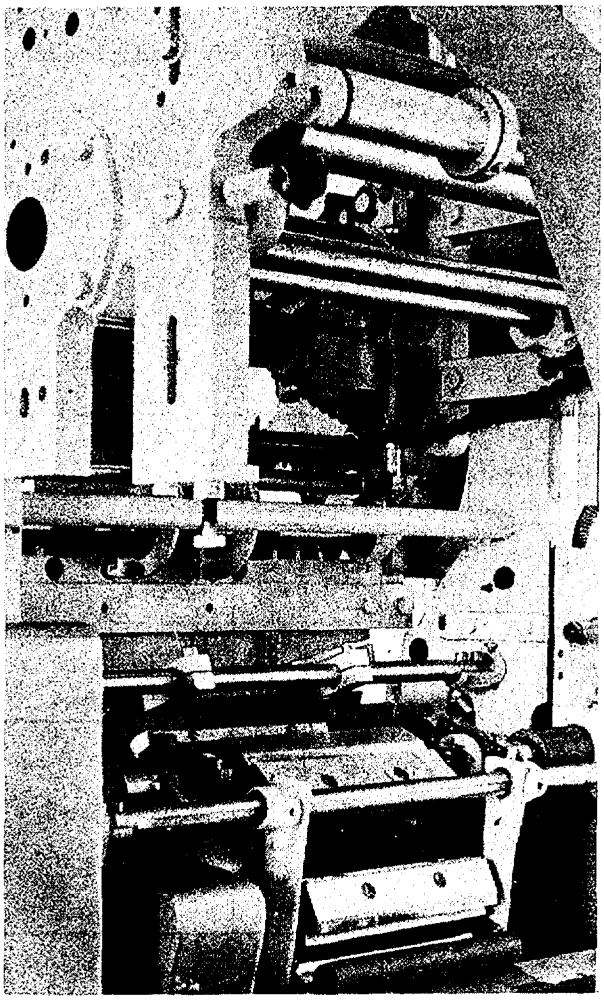
3) Required space
- o Site area : 26,400 m^2
- o Building area : 2,640 m^2

4) Personnel requirement

o Supervisor	:	7 persons
o Engineer	:	21 persons
o Operator	:	195 persons
o Others	:	48 persons
Total	:	271 persons

FILE: H5
ISIC 3529

Dynamite Making Plant


View of Cartridging Machine

Before use of the glycerol nitrate as an industrial explosive by Nobel in the 1860s, the black powder with half the explosive power of TNT was the only blasting explosive.

However, with the subsequent development of various types of explosives with strong explosive power and diverse performances as dynamite, work efficiencies in the fields of mining, tunneling, construction and excavation have been broadly improved, thus industrial explosives emerging as an essential product to save time and expenses.

In the meantime, the economic development of a nation has greatly expanded in construction demand to enlarge industrial and private installations as well as the demand for mineral resources as basic raw materials for industry.

At the same time, the demand for industrial explosives has also greatly expanded. Above all, particularly that for industrial explosives in sectors of coal mining, quarrying, metal mining, railway and other constructions has shown a rapid increase.

In chemical industrial aspect, the industrial explosives belong to a kind of fine chemicals and are evaluated as one of major key industries in the development of the national industry because of the high added value.

Therefore, by manufacturing basic chemicals with high added value, the industrial explosives manufacturing plant occupies an important position in the development of overall chemical industry. In addition, it is an industry with an important weight in the national economy including construction, mining and the like. Its necessity is well recognized in that it greatly contributes to drastically increasing the productivity in industries.

Products and Specifications

The products which can be produced in this plant are as follows:

Venus dynamite (Gelatine dynamite)
This is specially intended for underwater blasting. The cartridge can lie in water for a week without being damaged and also suitable for mechanical charging. The principal ingredients of this product are nitroglycerine, nitrocellulose, sodium nitrate, wood meal and dextrine.

Mercury dynamite (Ammonia gelatine dynamite)
This is an all-round explosive which can be used for all known types of blasting work with optimum results. Moreover, being manufactured by automatic process, it is suitable for mechanical charging as well as manual charging. The principal ingredients of this product are nitroglycerine, nitrocellulose, sodium nitrate, wood meal and dextrine.

Komite (Blasting gelatine)
This is the most powerful dynamite among those used for commercial uses and is mainly made of nitroglycerine and nitrocellulose.

Jupiter (Ammonium nitrate explosive)

This is a powder form explosive, primarily used as column charge. It can be used in most types of blasting work, especially in blasting works in open space and large scale. The principal ingredients of this product are ammonium nitrate and nitroglycerine.

Permissibles

These are special dynamites prepared for coal mining and passed the official tests to provide safety in coal mine blasting. The principal ingredients of this product are nitroglycerine, nitrocellulose, ammonium nitrate, sodium chloride and absorbents.

AN-FO

This is a uniform mixture of ammonium nitrate and fuel oil and suitable as column charge in dry hole above and below ground. The principal ingredients of this product are nitro-carbo-nitrate blend of AN prills and No. 2 diesel fuel.

Kogel

This is slurry or water-gel explosive containing 10-20% of water. It has many superior properties, of which the most important ones are its safety in handling, excellent water resistance and very good fume characteristics. Kogel is primarily intended for underground work, in that the quantity of poisonous gases which are developed is considerably less than with other explosives. Kogel is cap-sensitive and can be initiated by No. 6 detonator directly or using booster.

Finex

Finex–1. –This is specially prepared for smooth blasting, presplitting and cautious blasting. Finex–1 is semi-gelatinous explosive and used when smooth rock faces at the contour are required. Finex–1 is plastic pipe charge with connecting sleeve which has spacer wings to serve not only restain in pipe in the hole but also to center the pipe charge in the hole.

Table 1. Specifications of Explosives

Properties / Nomenclature	Type (strength) %	Strength(%)				Velocity of detonation (m/sec.)	Density	Gap test	Water resistance	Fume
		Grade	Bulk	Relative WT	Relative Bulk					
Blasting gelatine(komite)	100	100	100	100	100	7,000-7,500	1.45-1.50	5-7	Excellent	Very good
Venus dynamite	90	90	92	89	89	6,600	1.5	6	Excellent	Excellent
	80	80	85	81	81	6,600	1.5	6		
	70	70	78	74	74	6,300	1.5	6		
	60	60	72	68	68	6,000	1.5	4		
	50	50	65	63	63	5,800	1.5	0-4		
	40	40	55	57	57	5,500	1.5	4		
Mercury dynamite	90	90	89	86	84	6,600	1.45	6	Excellent	Excellent
	80	80	82	81	78	6,300	1.45	6		
	70	70	75	74	70	6,000	1.45	6		
	60	60	67	68	63	5,800	1.4	4		
	50	50	63	63	59	5,600	1.4	4		
	40	40	55	58	54	5,400	1.4	4		
Jupiter	No. 1	60	35	68	48	4,000	1.05	2-3	Fair	Good
	No. 2	50	20	63	44	3,500	1.0–1.05	2-3		
AN-FO (Ammonium nitrate with fuel oil mixed)	–	–	–	30-40	–	2,300-2,800	0.80-0.85		Poor	Poor
Permissibles	No. 1	35	50	56	56	4,500	1.5	4	Fair	Very good
	No. 2	20	43	44	34	3,000	1.15	1		
Finex	No. 1	30	25	50	43	4,000	1.3	8-10	Good	Good
	No. 2	55	44	70	51	3,500	1.1	2-3		

Finex–2. –This is powder form explosive primarily used as column charge for smooth blasting combined with Finex–1 on contour area of the blasting section. As Finex–2 is long plastic pipe charge, very effective and easy to handle and charge.

The detail specifications of above-mentioned products is shown in table 1. This explosive plant also has the technology to make various accessories, such as blasting cap, electric detonator and fuses.

Contents of Technology

1) Process Description

This process description relates mainly to an explanation on dynamite, a typical industrial explosive. The dynamite manufacturing process generally consists of raw material preparation and mixing, kneading, cartridging and packing.

Raw material preparation and mixing

First of all, nitroglycerine and nitrocellulose are blended in a mixer to produce gel-like master mix. Other blending components like nitrocompound, ammonium nitrate and starch are dried, crushed or filtered prior to mixing as required.

Kneading

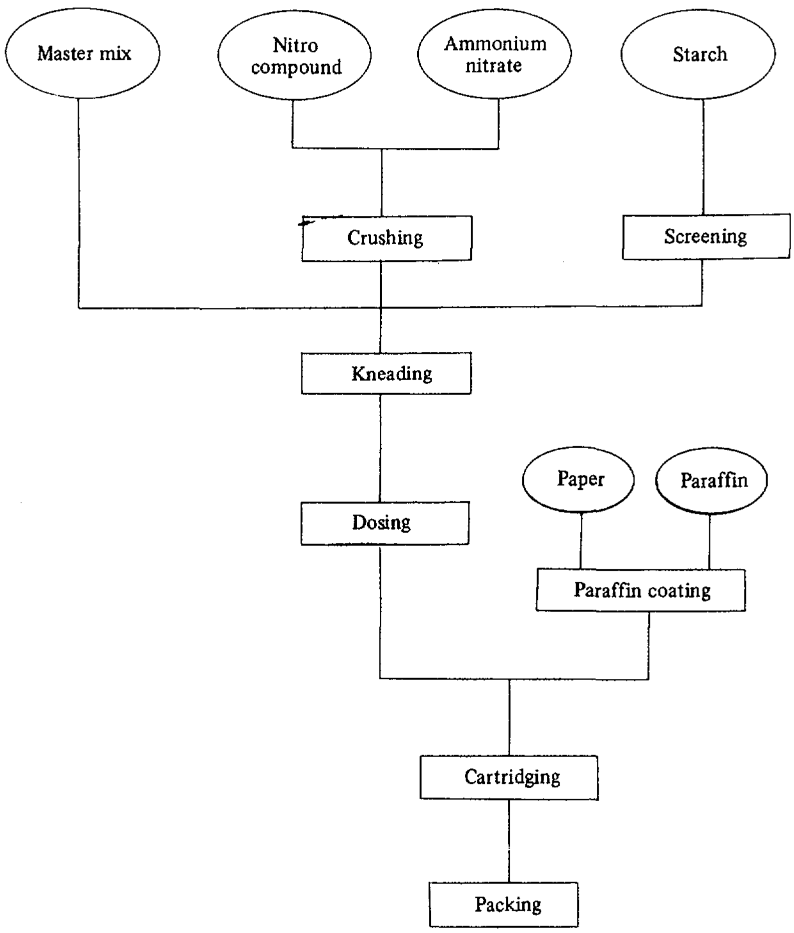
The prepared master mix and other blending raw materials are fed into a kneader for uniform kneading.

Cartridging

After kneading, the blended mixture is supplied in belt conveyor to the cartridging machine by menas of a dosing machine in a way to assure the optimum operational condition. It is then cartridged by the cartridging machine.

At this juncture, the blended mixture is pressed flat by rollers on the belt conveyor, cut in appropriate sizes and formed into catridges with cartridge paper. Cramping of both ends finishes the cartridge.

Dynamite Manufacturing Process Block Diagram



To improve the water-proofness of the cartridge paper used here, it is coated with paraffin and depending upon the circumstances paraffin may be sprayed over the finished cartridge.

Packaging

More or less 20 pieces of cartridge are packaged in a vinyl bag or 10 small vinyl bags are packed in a large vinyl bag and delivered in a carton box.

2) Equipment and Machinery

Bucket elevator
Jaw crusher
Hammer mill
Receiver tank
Dust collector
Kneader with driving unit
Control pannel
Forklift
Kneading pot
Paraffin coating machine
Tilting machine
Dosing machine
Cartridging machine
Vinyl packing machine
Conveyor
Automatic packing machine
Spare parts

3) Raw Materials and Utilities

o Dynamite plant

Raw materials and utilities	Requirement (per ton of product)
Master mix	0.3 ton
Ammonium nitrate	0.66 ton
Starch	0.04 ton
Electric power	14.7 kwh
Water	3 tons

Example of Plant Capacity and Construction Cost

1) Plant capacity : 5,000mt/year
   * Basis : 8 hours/day, 250 days/year

2) Estimated Equipment Cost

o Manufacturing machinery	:	US$10,133,000
o Utility facility	:	US$ 1,784,000
o Installation cost	:	US$ 2,493,000
Total	:	US$14,417,000

3) Required Space

o Site area	:	40,000 m^2
o Building area	:	8,300 m^2
Total	:	48,300 m^2

4) Personnel Requirement

o Manager	:	1 persons
o Engineer	:	4 persons
o Operator	:	131 persons
Total	:	136 persons

Any inquiry about the information contained should be sent to:
IO/COOP, Registry file No. ID/562/12, UNIDO, P.O. Box 300, A-1400 Vienna, Austria

FILE: H6
ISIC 3529

Carbon Black Making Plant

The carbon black industry is growing rapidly after World War II together with the expansion of synthetic rubber and automobile industries. By 1975, the total free world production of carbon black was estimated at 4.2 million tons per year. Approximately 55% of this tremendous annual production is used for reinforcing agent in rubber tires, 35% for non-tire rubber, 10% for non rubber application such as pigments as undermentioned. Especially in the developing countries, the demand for carbon black is expected to increase more rapidly than before with the development of automobile industry and other rubber products making industries.

Carbon black, a very large family of colloidal and non-graphite carbon, is used as follows:

- Reinforcing and filling agents for rubber and plastics.
- Light screening agents for plastics.
- Pigments and coloring agents for paints, inks, molded goods and foodstuffs.
- As important ingredient in many miscellaneous articles of commerce such as electrodes, dry cell, electrical resistors, explosives, pencil leads, polishes, leather finishes, cosmetics and mold release agents.

There are a number of carbon black manufacturing processes developed with respect to the grade of carbon black, including impingement process, furnace process and thermal black process. These processes may also be classified with respect to whether the primary raw material is gas (usually natural gas) or heavy hydrocarbon liquid (creosote oil, fluid catalytic cracking oil, naphtha cracking bottom oil, etc.).

But, in recent years, nearly 95% of the total world capacity of carbon black is devoted to the furnace process. Among the furnace processes, oil-furnace process occupies a dominant position since it began to replace gas-furnace process in 1950's.

The plant introduced here is also adopting oil-furnace process and has some merits. The plant is

Table 1. Specifications of Carbon Blacks

Grade	ASTM Stress/strain properties(from IRB #4)			Typical physico-chemical properties							
	Cured @ 145°C (min.)	Tensile strength kg/cm^2 (min.)	300% Modulus kg/cm^2	ASTM Iodin number mg/g	DBP absorp., cm^3/g	Ash content % (max.)	Heat loss %	Sieve residue % (max.) #35	Sieve residue % (max.) #325	Bulk density g/cm^3	Fines %(max.)
Reference black IRB #4	15	270	133	82	97	0.75	–	–	–	–	–
	30	276	168								
ISAF	15	-27	-7	122	115	0.75	2.5	0.0010	0.10	0.35	15.0
	30	-18	-5								
ISAF-LS	15	-34	-39	118	118	0.75	2.5	0.0010	0.10	0.42	15.0
	30	-25	-47								
HAF	15	-30	+3	82	102	0.75	2.5	0.0010	0.10	0.37	15.0
	30	-22	0								
HAF-HS (N-339)	15	-16	+23	90	120	0.75	2.5	0.0010	0.10	0.34	15.0
	30	-21	+20								
HAF-HS (N-375)	15	-23	+16	90	114	0.75	2.5	0.0010	0.10	0.35	15.0
	30	-21	+13								
HAF-LS	15	-2	-39	82	72	0.75	2.5	0.0010	0.10	0.46	15.0
	30	+6	-33								
FEF	15	-53	+7	42	122	0.75	2.0	0.0010	0.10	0.36	15.0
	30	-53	0								
GPF	15	-65	-16	35	91	0.75	1.0	0.0010	0.10	0.42	15.0
	30	-57	-24								

simple, compact and energy conservative, and can make high quality products at low cost.

Products and Specifications

Carbon blacks being produced in the plant introduced here can conform to pertinent specifications depending upon types of products for which carbon blacks are used. Current products include eight kinds such as ISAF (intermediate super abrasion furnace), ISAF-LS (intermediate super abrasion furnace-low structure), HAF (high abrasion furnace), HAF-HS (high abrasion furnace-high structure), HAF-LS (high abrasion furnace-low structure), FEF (fast extrusion furnace), GPF (general purpose furnace) and SRF (semi-reinforcing furnace). Specifications are as shown in table 1.

Contents of Technology

1) Process Description

A number of processes have been developed with respect to the grade of carbon black.

The first one is impingement process in which the carbon black is formed by impingement of open flames upon a surface from which the carbon black is recovered. This category includes the channel and oil impingement process, which is old-fashioned and hardly used these days.

The second one is thermal black process in which combustion and carbon black formation do not proceed simultaneously. This category includes cyclic thermal black and acetylene black process.

The third one is furnace process in which combustion and carbon black formation occur simultaneously in a confined reactor or furnace. This category includes gas-furnace and oil-furnace process, which are most worldwide processes.

The plant which is introduced here is now adopting oil-furnace process. So we will explain mainly about oil furnace process.

This plant consists of sections such as reaction, filtration, pneumatic conveying, pelleting, drying and storage and shipping.

Reaction section

Air, auxiliary fuel and feedstock oil are supplied to the reactor to form carbon black which is suspended in the reaction gases.

Process air which was preheated by air preheater is supplied by one set of blowers to all plant reactors. Simillary feedstock oil which was heated by steam to

air. Both nozzle spray pattern and longitudinal nozzle position affect black properties, and oil preheat which affects spraying characteristics must be closely controlled. The excess tangential air and axial air burn a portion of the feedstock oil, providing additional heat for the reactions converting the balance of the oil to carbon black.

Auxiliary fuel is burned in the tunnels of the reactor with the preheated air, the air usually being 40 to 100% in excess of theoretical volume depending upon the combustion temperature limitations of the refractories and economic consideration (combustion temperature is a function of air preheat and percent excess air and is maintained at a safe level by establishing and controlling the tangential heat input expressed as air enthalphy plus net heating value of fuel per standard cubic foot of air.)

Primary quench water sprays appropriately located stop the reaction and adjust the smoke temperature to that required for entry to the preheaters.

Filtration

Smoke leaving the preheaters is combined with that from the other reactors and enters collection system. Collection system uses bag filters which are made of silicone coated glass fiber.

Pneumatic conveying

Carbon black from the filter product outlet is usually pneumatically conveyed through a pulverizer to the surge tank feeding the pelletizer. The carrier gas is smoke withdrawn from the filter with the black. The pulverizer serves only to protect the product from possible inclusion of coarse residue particles (coke or refractory) which may infrequently be carried from the reactor.

At the surge tank a cyclone separator separates the black and delivers it to the surge tank. The cyclone operates with only a few inches of water pressure drop and, under the conditions of carrier gas black loading, may recover 90 to 95% of the entering black. The cyclone effluent gas, still carrying a little black, returns to the filter or may be directed to a separate small filter.

Pelleting

To facilitate shipping and handling, the carbon black is pelleted, giving a free-flowing product.

The preferred size range is such that the majority of pellet diameters are 0.25 to 2.0mm. Excessive fines (less than 0.125mm diameter) may cause handling problems. Pellets must be hard enough to resist breakage in shipping and handling, but if too hard the black may be difficult to disperse in end use.

Carbon black is fed from the surge tank through a absorbed by the black. The mixing and cutting action of the pins converts this damp mass into pellets, rounded to roughly spherical shape. To attain desired pellet properties, pelleting additives are frequently introduced with the pelleting water.

Optimum carbon black water ratio, additive level and revolutions per minute may vary with type of black, temperature of materials and pin condition, and must be adjusted by trial and error.

Drying

Wet pellets from the pelletizer are fed by a screw conveyer to the dryer where the moisture content is reduced.

Dryer product temperature must be high enough to produce suitably dry product, but temperatures too high may promote undesirable oxidation of the black or even create a fire hazard. Therefore close control, though difficult, is essential.

Storage and Shipping

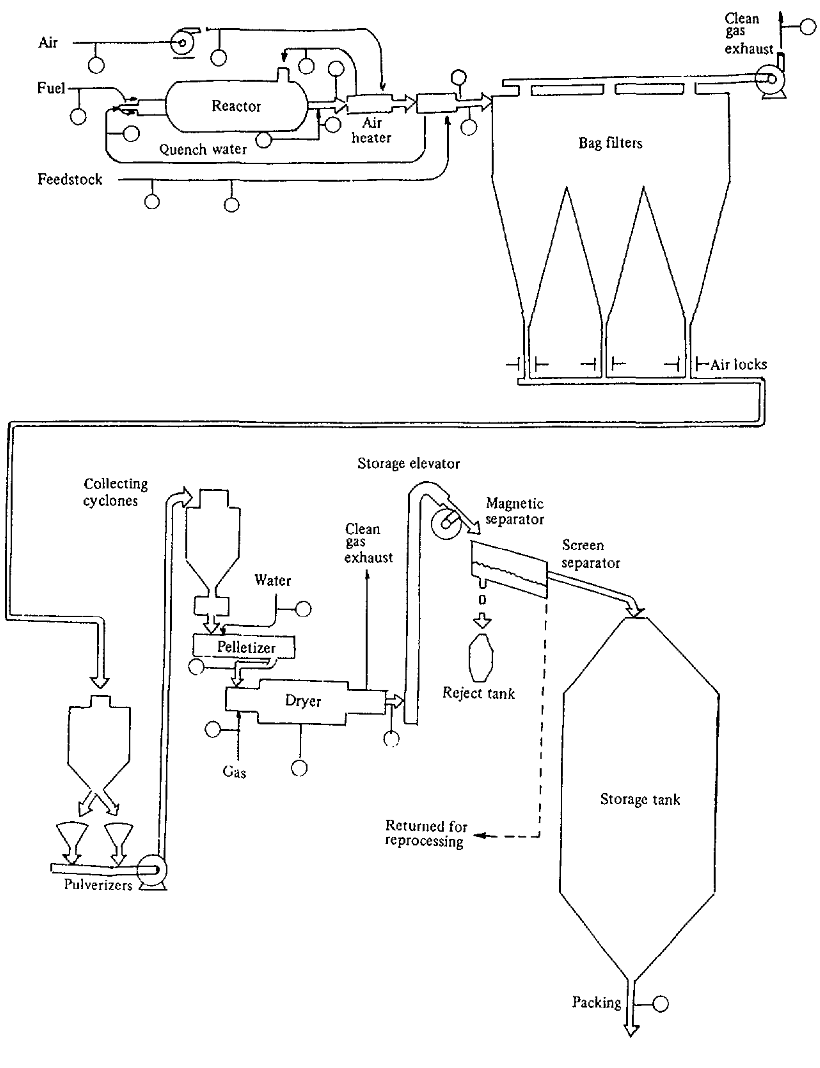
Storage tanks are elevated so that loading of bulk shipment and delivery to packaging equipment can be gravity flow.

Product leaving the dryer is lifted by a bucket elevator, passes over a magnetic separator and a screen separator, and is delivered to the proper storage compartment by a screw conveyer system.

The magnetic separator guards against inclusion of magnetic material, infrequently found, in the product. Since any magnetic material probably results from steel corrosion, its appearance calls for corrective action. The screen separator removes oversize pellets and is particulary needed for some types of black for which pelleting control is difficult.

Pelleted carbon black is shipped in bulk or packaged in bags or other containers.

Carbon Black Manufacturing Process Flow Sheet



2) Equipment and Machinery

Reactor
Preheater
After cooler
Rotary dryer
Cyclone separator
Bag filter
Pulverizer
Pelletizer
Storage bin
Utility storage tanks
Feedstock/product storage tanks
Raw material & product storage tank (with heater)
Additive storage and dissolving tank (with heater & agitator)
Load cell measuring tank
Load cell
Mixing tank
Conveyer
Bucket elevator
Blower & fans
Utility pumps
Package metering & mixing pumps

3) Raw materials & Utilities

Oil used as feedstock for the carbon process has been selected on the basis of high aromaticity, low content of refractory damaging materials and low contents of alkali metals.

Typical feedstock for oil furnace process of carbon black is:

- Catalytic cracker decant oil.
- Ethylene plant residium from naphtha cracking.
- Ethylene plant residium from gas oil cracking.
- Extract from solvent refining of catalytic cracker cyclic oils.
- Coal tar distillate, etc.

Unit consumptions of raw materials and utilities are shown in table 2.

Table 2. Raw Materials and Utilities

Raw material and utilities	Requirement(per cubic meter of product)
Oil	2.2 tons
Fuel (natural gas)	2.45 mmkcal
Electric power	400 kwh
Process water	2.0 tons

Example of Plant Capacity and Construction Cost

1) Plant capacity : 50,000 m/t/y
* Basis : 330 days/year

2) Estimated construction cost (as of 1983)

o Equipment and installation of equipment	:	US$ 18.0 million
o Instrument, controles and electric	:	US$ 3.0 million
o Piping and ducts	:	US$ 4.2 million
o Civil and buildings	:	US$ 4.8 million
Total	:	US$ 30.0 million

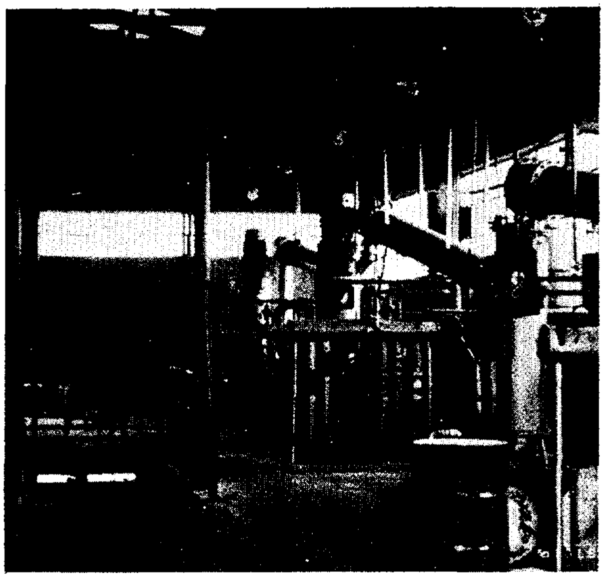
* Plant site: Saudi Arabia

Note: Engineering and contingency are omitted.

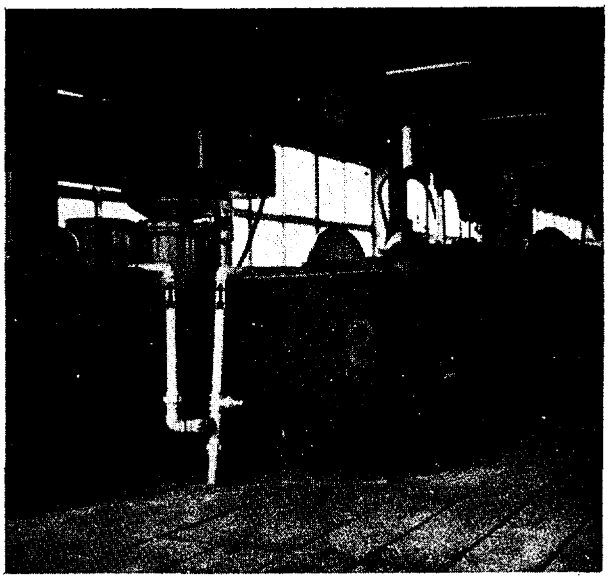
3) Personnel requirement

o Plant manager	:	1 person
o Clerk	:	6 persons
o Engineers	:	20 persons
o Skilled operator	:	45 persons
o Operators	:	8 persons
o Helpers	:	5 persons
Total.	:	85 persons

Paint Making Plant



View of Synthetic Resin Plant



View of Sand Mill

The paint is a material forming a thin film on the surface of an object to be painted for the purpose of protecting its body, while providing suitable designs. It generally breaks down to the paint, lacquer, varnish, enamel and auxiliary material.

The synthetic resins used as color developers in the manufacture of paints involve respective production technologies for alkyd, emulsion, melamine, urea and acryl depending upon necessary properties of the paints requiring waterproofness, durability, resistance to chemicals, and mechanical and electric properties.

Diverse in uses, exerting influences on the quality of other industries and having higher added values in terms of investment scale, the paints introduced here are indispensable for the basic industries in developing nations.

The paint manufacturing technology, along with other technologies for synthetic resins, raw materials of paints, have been accumulated over the past 30 years at this plant, while such special technologies as the polyester resin varnish production technology and its application skills, ship paint production technology and other special paint production technologies have been steadily developed.

As a result of introducing quality control techniques, these paints have been globally recognized in the quality and diversity of products.

Products and Specifications

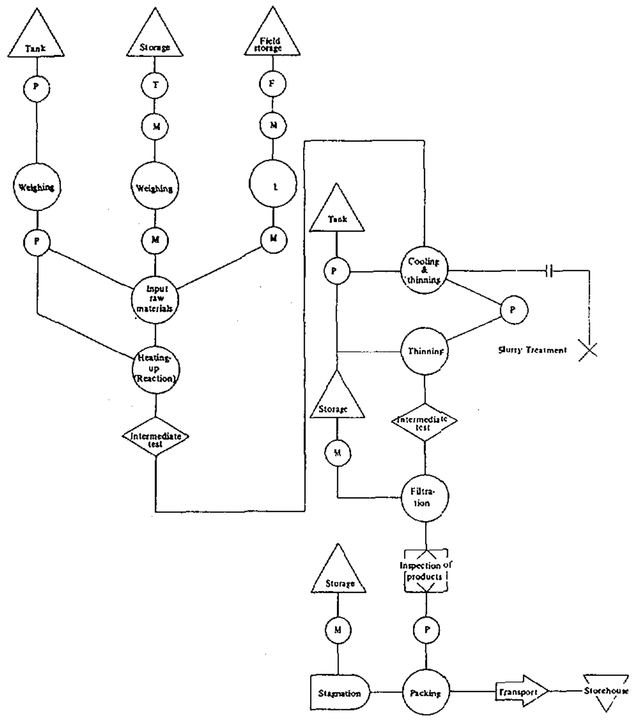
The items produced by this plant are divided by use as follows:

- Paints for building
- Paints for industrial uses
- Paints for structures and engineering works
- Marine and anticorrosive paints
- Paints for automobiles
- Paints for electric appliances
- Wire and coil coatings
- Paints for synthetic leather
- Can coat
- Paints for electrodeposition

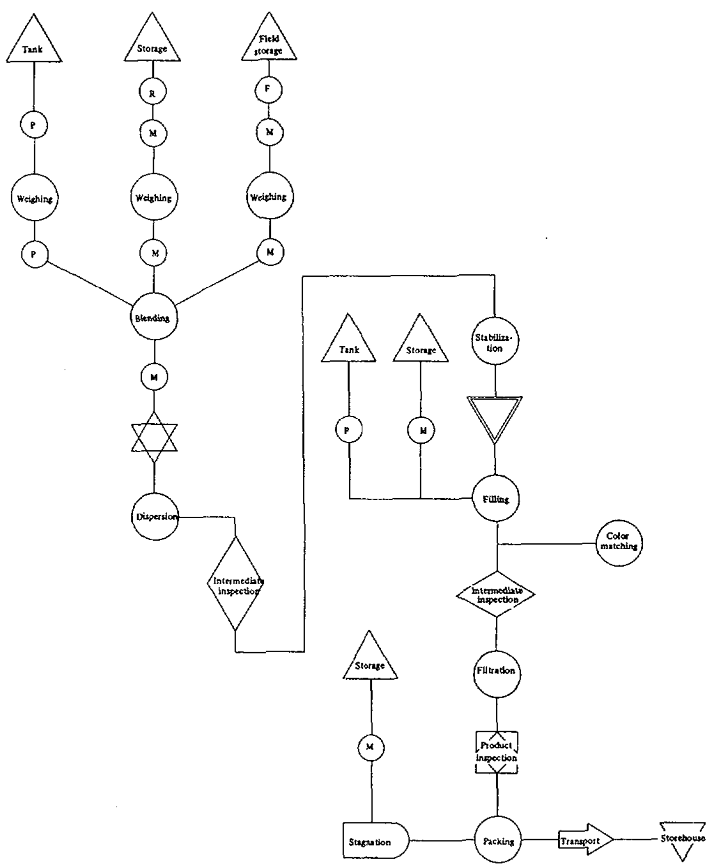
The products are classified by raw material synthetic resin and paint production technology as follows:

- Alkyd resin paint
- Emulsion resin paint
- Acryl resin paint
- Urethane resin paint
- Rustproof paint
- Special paint
- Liquid-phase and solid-phase epoxy resins

Resin Manufacturing Process Flow Diagram



Paint Manufacturing Process Flow Diagram



Contents of Technology

1) Process Description

Paint producing technology

Paints are divided into the transparent paint not containing any pigment and the colored paint containing pigments. The transparent paint process comprises the dissolving process, in which the film-forming portion and additive are uniformly dissolved in the solvent, the filtration process, in which foreign matters mingled in the raw material or dissolving process are eliminated, and the packing process in which the final product is filled into cans for delivery.

The colored paint additionally requires processes in which pigments are dispersed in the course of the transparent paint process and the color desired by the users is respectively adjusted. Namely, it is divided into the kneading, dispersing, dissolving, color matching, filtration and packing.

Synthetic resin producing technology

Each synthetic resin section based on the batch production system needs exclusive facilities, with from 0.5 ton up to 3 tons in capacity to meet users' requirements.

The production process is composed of four steps of reaction, dilution, filtration and packing. In the reaction process, each unit compound is reacted in a reactor to be synthesized into a high-polymer resin, while the synthesized high-polymer compound is diluted with solvent in the diluting process.

In the filtration process, the gel-like material occurred in the reaction and other foreign matters are eliminated, while the filtered resin is filled into drums or tanks for storage.

2) Equipment and Machinery

Paint manufacturing plant
- Kneader
- Dissolver
- Ball mill
- Sand mill
- Roll mill
- Dissolver
- Color mixing machine
- Filter
- Packing machine

Synthetic resin plant
- Reaction pot
- Dilution tank
- Leaf filter
- Weighing machine
- Drum
- Storage tank

Example of Plant Capacity and Construction Cost

1) Plant capacity : Paint ; 3,000 m/t/year
Synthetic resins ; 10,000 m/t/year
* Basis : 8 hours/day, 300 days/year

2) Estimated construction cost (as of 1983)

o Manufacturing machinery	:	US$	2,000,000
o Utility facility	:	US$	250,000
o Installation cost	:	US$	400,000
Total	:	US$	2,650,000

3) Required space

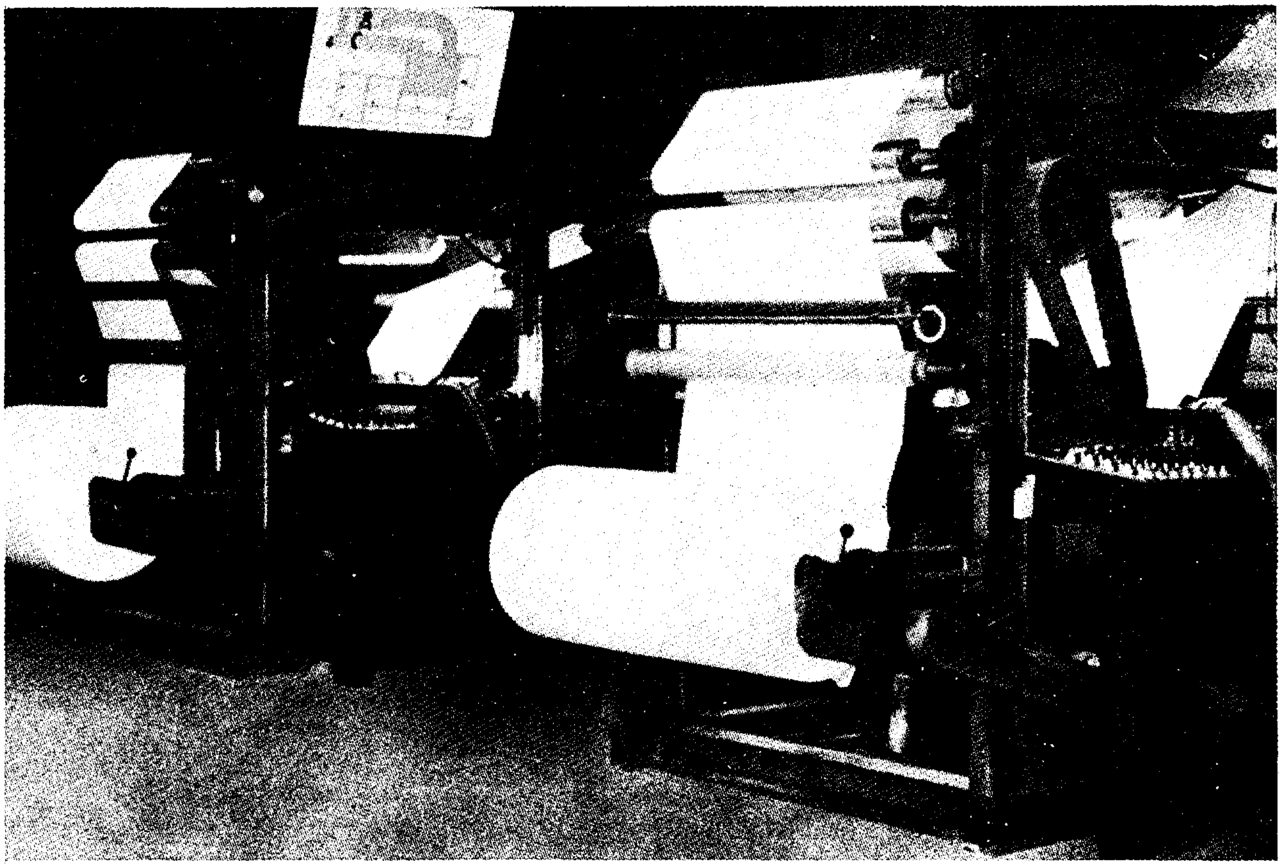
o Site area	:	16,500 m^2
o Building area	:	9,240 m^2
o Other	:	1,320 m^2

4) Personnel requirement

o Manager	:	3 persons
o Engineer	:	18 persons
o Operator	:	50 persons
o Others	:	6 persons
Total	:	77 persons

FILE: H8
ISIC 3529

Sensitizing Paper Making Plant



View of Coating Machine

The sensitizing paper produced by this plant introduced here is an indispensable items for use in civil engineering, architectural and plant designs. It is prepared by coating sensitizing liquid mixed with some chemicals on the base paper after making its surface smooth by using proper pigments.

The products come in blue and black colors and diazo-coated as generalized in most of the advanced countries, characterized by its bright copies and reasonable prices to the best advantage.

Despite the recent construction booms in many of the developing nations, they still heavily depend on the import for such sensitizing papers. The construction of this type of sensitizing paper making plant which brings higher added values compared with its investment scale will ensure the import substitution and protection of their own industries.

The sensitizing paper making technology owned by this plant has been developed over many years, with a global reputation for its superior product quality.

Products and Specifications

The items produced by this sensitizing paper making plant come in blue and black colors and diazo-coated for use in civil engineering, building and plant designs, with product types divided into GA type and MM type.

- GA type
  Sheet type : AO, A1, A2, A3, A4, B4, B5 size and special size.
  Roll type : 100yd, 50yd size and spcial size
- MM type
  Sheet type : AO, A1, A2, A3, A4, B4, B5 size

Contents of Technology

1) Process Description

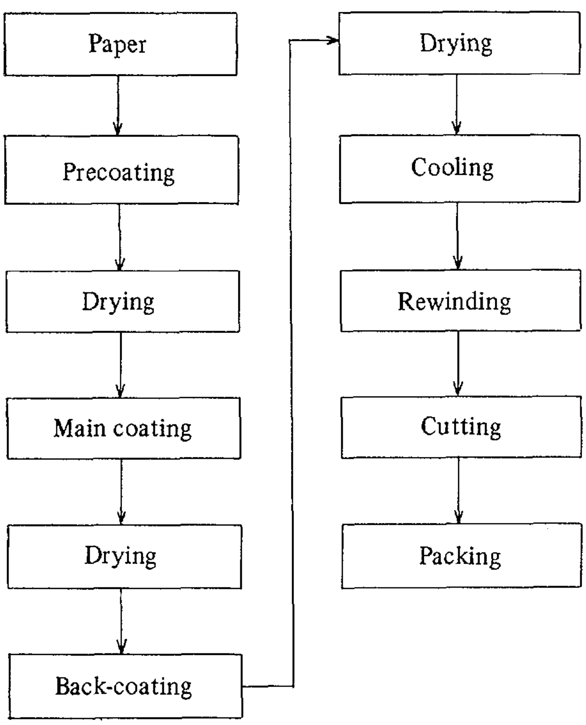
The process of this sensitizing paper is composed of the following unit processes :

Precoating

The base paper used in the production of sensitizing papers requires to be specially treated, both on its surface and internally, to suit the process.

However, still too rough to be made into sensitizing papers by coating sensitizing substance, the base paper requires the use of a proper pigment in precoating for more slippery and smooth surface.

Sensitizing Paper Manufacturing Process Block Diagram



The viscosity, temperature and pH have to be carefully controlled.

Main coating

It is a process in which the sensitizing liquid blended with several chemicals in addition to diazo and coupler is coated on the smoothened surface following the precoating.

Back-coating

It is a process in which the final back-coating is applied in order to prevent a possible curling phenomenon on the sensitized base paper after preliminary and main coatings.

2) Equipment and Machinery

Coating machine
Electric control box
Rotary cutter
Paper cutting machine
Homo-mixer
Electric chain hoist
I beam
Radiation moisture balance
Rewinding machine
Chemical agitate vessel
Auto-P.P. strapping machine
Copy-machine for dry
Copy-machine for wet
Balances
Viscotester
Reflectometer
Forklift

3) Raw Materials

Raw materials	Requirement (per ton of product)
2.3 Dihydroxynaphthalene-6-sulfonic acid sodium salt.	3 Kg
1-Diazoethyl hydroxylethyl aniline chloride-½zinc chloride salt.	1.0 Kg
1-Diazodimethyl aniline chloride-½ zinc chloride salt.	0.4 Kg
K - 606 (dye)	11 g
1-Allyl-3-hydroxylethyl-2-thio urea.	0.5 Kg
Citric acid	2.4 Kg
Diethylene glycol	6.0 Kg
Pre-coating solution	120 Kg
Zinc chloride	5.13 Kg

Example of Plant Capacity and Construction Cost

1) Plant capacity : 70 m/t/month
   * Basis : 10 hours/day, 25days/month

2) Estimated construction cost (as of 1983)

○ Manufacturing machinery	:	US$ 350,000
○ Installation cost	:	US$ 20,000
Total	:	US$ 370,000

3) Required space

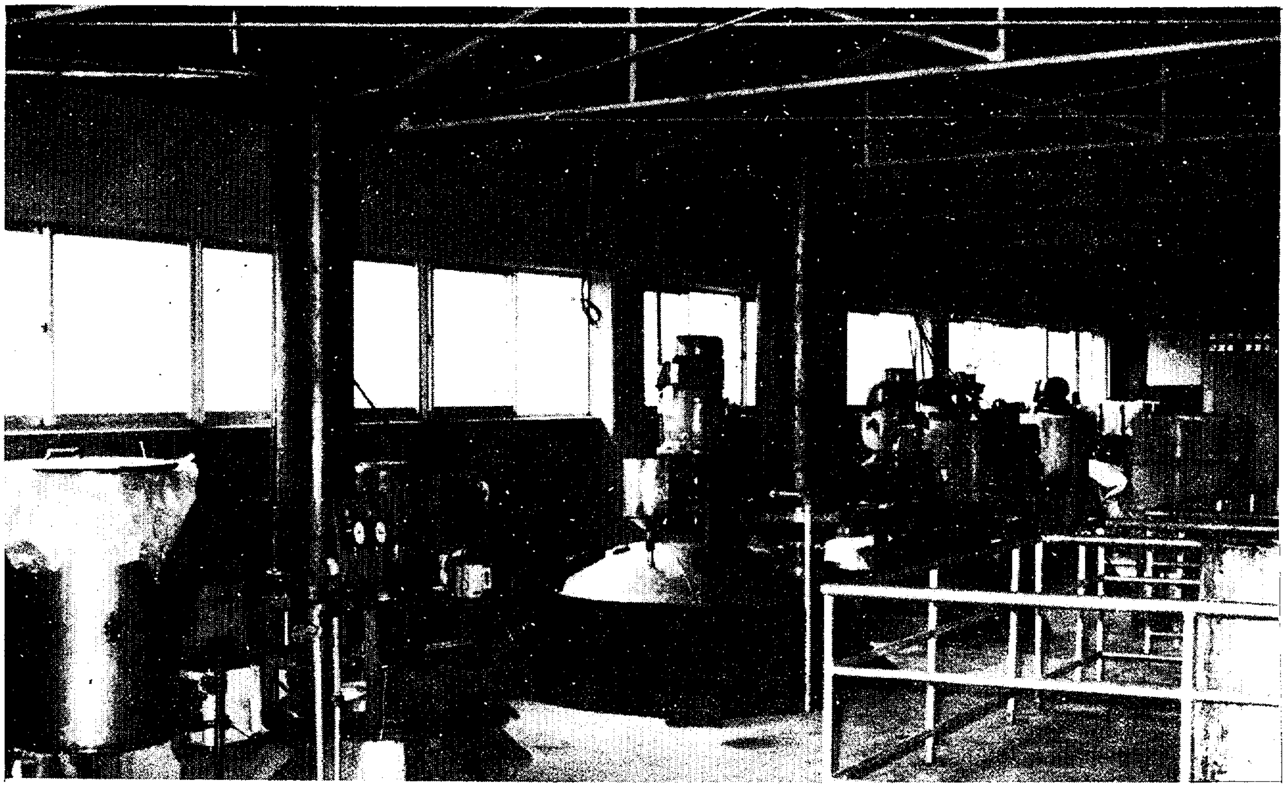
○ Site area	:	160 m^2
○ Building area	:	648 m^2
○ Others	:	214 m^2

4) Personnel requirement

○ Manager	:	2	persons
○ Engineer	:	2	persons
○ Operator	:	12	persons
○ Others	:	10	persons
Total	:	26	persons

FILE: H9
ISIC 3529

Adhesive Making Plant



View of Adhesive Reactor

Adhesives have been closely related to the daily life of human beings to the extent of having been used by ancient Egyptians. In early days, the jelly-like glue, prepared by making use of leather or bones of animals was mainly in use as an adhesive.

During the Second World War, casein glue and nitrocellulose glue were developed for military uses. However, it was not until in 1930 that such adhesives as utilizing urea resin and resocinol resin in terms of plastic resins were put on sale in the market.

Achieving a rapid development, the adhesive manufacturing technology has seen the development of various products with useful characteristics including hot melt adhesive, contact adhesive, emulsion adhesive, top cement, rubber-latex adhesive, synthetic resin-solvent type adhesive, etc.

In the case of Korea, the first plastic adhesive was produced in the 1950s, with technologies accumulated for more than 30 years now. There has been the development and accumulation of technologies capable of providing suitable, high-performance adhesives depending upon the kind of adhesive materials, special working conditions and diverse conditions of use.

Adhesives are extensively used nowadays in various industries including wood processing, plywood, textile finishing, paper making, footwear manufacturing, electric equipment, musical instruments, packing, ceramic industry, construction, shipbuilding, etc. Therefore, adhesives show a quick expansion in demand with the growth of these related industries, while the quality of the adhesives has great influence on the quality of such related products. It is said to be one of the fine chemicals occupying an industrially important position.

In particular, relatively simple in its manufacturing process, the adhesive plant requires small installation costs, with an advantage of increased added values if only know-how is properly secured. It is one of the most essential plants for the developing countries.

Table 1. Specifications of Adhesives

Emulsion type (1)

Product No.	Composition	N.V. Content (%)	Viscosity (cps/25°C)	Use
201	Vinyl acetate resin	27 ± 2	7000 – 10000	General adhesives for paper, wood, cloth, bamboo, and p.c. mortar. *Used for furniture, plywood, toys,* wall paper, paper bags. Construction, hard ware, sports and musical instruments, and the like. For binding various building materials; sound absorbing textiles, decorative veneer and flush door, etc.
210		30 ± 1	10000 – 15000	
205		42 ± 1	15000 – 25000	
209–SR		42 ± 2	17000 – 20000	
208		45 ± 2	30000 – 40000	
208–S		45 ± 2	40000 – 45000	
270		50 ± 2	35000 – 40000	
209		60 ± 2	30000 – 45000	
205–TB		42 ± 1	2000 – 4000	For porous materials and turbo jet jointing.
229–HD		55 ± 2	4000 – 6000	For edge bending of board; furniture, particle board, etc.
229–D		57 ± 2	18000 – 22000	
240		32 ± 1	18000 – 24000	Used for manufacture of paper tube, and for other mechanical applications.
260		42 ± 2	15000 – 25000	
205–H		42 ± 2	8000 – 8600	
240–B		30 ± 2	30000 – 39000	For paper lamination to plywood.
270–A		50 ± 2	25000 – 30000	For overlay of aluminium foil.
250		42 ± 2	18000 – 22000	Used for binding ceramic tile net.
H–40	Vinyl acetate-acryl resin	40 ± 1	37000 – 43000	For wood working and cork ware, etc.
H–30		*32 ± 1*	*28000 – 32000*	*Protective coating on surface of furniture, etc.*

Emulsion type (2)

Product No.	Composition	N.V. Content (%)	Viscosity (cps/25°C)	Use
100	Ethylene vinyl acetate resin	47 ± 1	12000 – 16000	For bonding; sheet or film of soft PVC, metallic foil and plastic foam to paper, plywood and particle board. Bonding of p.c. mortar and floor tile to concrete. Binder of p.c. mortar.
110		42 ± 1	15000 – 20000	
120		55 ± 2	2000 – 6000	
130		47 ± 2	15000 – 20000	
123	Vinyl acetate resin	33 ± 2	6000 – 10000	For padding and non-woven fabric binder (PE, PP).
123–P		35 ± 2	8000 – 12000	
151	VAc/Acryl resin	45 ± 2		Binder for textile coatings, padding and non-woven applications. For fabric backing and flocking adhesives.
155	Styrene/Acryl resin	45 ± 2		
156	Acrylic ester resin	45 ± 2		
161	VAc/Acryl resin	45 ± 2		
165	Acrylic ester resin	45 ± 2		
166		45 ± 2		
157	VAc/Acryl resin	45 ± 2		For manufacturing wall paper and abrasive paper.
158		45 ± 2		
501	Styrene/Acryl resin	48 ± 2		Coating for pigmented paper
503	Acrylic ester resin	41 ± 2		Vehicle of emulsion paints (for construction)
503–A	Styrene/Acryl resin	42 ± 2		
505		48 ± 2		
505–H		48 ± 2		
540	VAc/Acryl resin	45 ± 2	18000 – 22000	(for coating the surface of wood)

○ Elastomer type

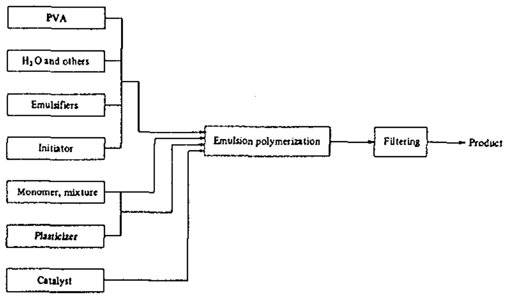
Product No.	Composition	N.V. Content (%)	Viscosity (cps/20°C)	Use
601	Chloroprene rubber Phenolic resin	25 ± 1	5000 – 10000	Bonding of rubber to metals. Mutual bonding of rubber, leather, cloth, wood, and others. Melamine or polyester laminated sheet *to plywood.*
630		22 ± 1	5500 – 8000	
601–A		24 ± 1	20000 – 24000	
PR–601	Synthetic rubber	17 ± 2		
601–D	Chloroprene rubber Phenolic resin	28 ± 2	5000 – 10000	Sticker adhesive for label, and the like.
603		31 ± 2	4000 – 6000	Cone paper to Cr plate frame, damper, and voice coil.
601–B		31 ± 2	4500 – 7000	Mgnet to the frame, bobbin, and duct cores.
D–730	Synthetic resin	5–10		For ABS, HIPS and acryl resin products.
609		31 ± 2	6500 – 7500	For plastics, Al plates, name plates, leather lining.
37–A	Chloroprene rubber Phenolic resin	35 ± 1	35000 – 40000	For insulating felt or carpets to metal.
701–SP		23 ± 1	200 – 900	For V-cut line (Chipboard etc), edge bending of veneer core. *Insulating* materials. (glass wool, urethane foam, etc).
700–H		30 ± 2	5000 – 8000	For shoe making. Attachment shoe soles; chloroprene rubber, SBR resin, etc, to leather and vinyl leather.
706		24 ± 1	3000 – 6000	
820	Chloroprene graft polymer	4 ± 1		
815	Urethane resin	20 ± 2	4000 – 7000	For bonding urethane foam to soft PVC and leather.

○ Solvent & paste type

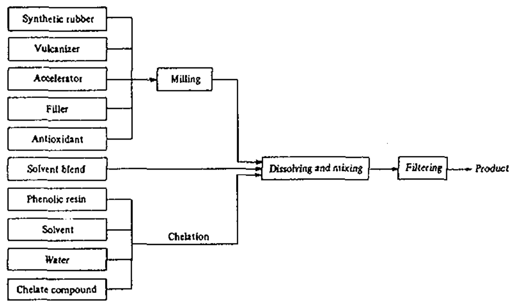
Product No.	Composition	N.V. Content (%)	Viscosity (cps/20°C)	Use
700–C	Cellulose	24 ± 1	8000 – 11000	For paper, wood, cloth, and celluloid, glass, etc.
300	Vinyl acetate resin	35 ± 1	5000 – 12000	Mutual bonding of wood, paper, cloth and leather. Bonding of styrene foam to concrete and p.c. mortar etc.
301		55 ± 2	30000 – 40000	
R–50	Resorcinol resin	50 ± 2		For manufacturing plywood, multilayer plywood. Bonding of various exterior thick plywood, and timber, etc.
PW–70	*Phenolic resin*	70 ± 2		
PO–70		70 ± 2		
825	Vinyl chloride resin	25 ± 2	500 – 1500	Hard and soft PVC sheet, plate and pipes.
825–A		10	50 – 300	For hard PVC plate and pipes jointing.
SB–1000	Butyl rubber	75 up	Paste	Sealing of joints in curtain wall construction, and structure joint of concrete and metals.
ST–1000	Polysulfide		Paste	
SA–1000	Acryl resin		Paste	
T–3000	Vinyl acetate resin		Paste	For fixing wall tiles, mosaic, floor tiles, to smooth backgrounds of plaster, concrete or light weight concrete.
T–3001				
T–4000	Synthetic resin			
T–4010				
T–4200				
T–4100-F			Powder	

Adhesive Manufacturing Process Flow Diagram

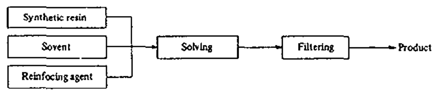
○ Emulsion type adhesive



○ *Elastomer type adhesive*



○ Synthetic resin type adhesive



Products and Specifications

The plant introduced here produces products of diverse specifications depending upon the kind of adhesive materials, working conditions and conditions of use. These products are largely grouped into emulsion type adhesive, elastomer type adhesive and solvent and paste type adhesive as follows:

Emulsion type (1)
- Adhesives of VAc emulsion.
- Adhesives of VAc-Acryl emulsion.

Emulsion type (2)
- Adhesives of EVA emulsion.
- Binding agents of VAc, Acrylic ester for textile and paper.
- Vehicles for emulsion paint.

Elastomer type
- Adhesive of synthetic resin.
- Sealants of synthetic resin.
- Adhesives of synthetic resin for tile attachment.

Solvent & paste type
- Adhesives of chloroprene rubber.
- Adhesives of synthetic resin and rubber.

Contents of Technology

1) Process Description

The manufacturing process for adhesives varies depending upon product types. In the emulsion type, it is produced by the polymerization of monomers of VAC or EVA in emulsion, whereas synthetic rubber, and solvent and paste type adhesives require raw material synthetic rubber or synthetic resins to be processed with solvents for the production of adhesives suiting various uses. Respective manufacturing processes are as follows:

Emulsion type adhesive

In the emulsion type adhesive, monomers are dispersed in water as a solvent for polymerization as products by the use of a water-soluble polymerization initiator.

This process description primarily concerns with the polymerization of VAc. Emulsifier, polymerization initiator, protective colloid and monomer are filled into the reactor equipped with an agitator, reflux cooler, and heating and cooling devices, with the reactor temperature maintained at 60-90°C.

Since the temperature in the reactor gradually rises due to its reaction heat to make the control difficult, it is better to feed the monomer batchwise at proper time intervals. Stabilizer, plasticizer and anticeptic are also added at this stage.

On completion of the reaction, the product is cooled and inspected for filling into containers for delivery as final products.

Elastomer type adhesive

Synthetic rubber is pulverized in a two-roll milling machine for five minutes, and then filler, vulcanizer and vulcanization accelerator are added in succession. The entire milling time is within 30 minutes, with the temperature so controlled not to exceed 60°C. When the milling is finished, the synthetic rubber is placed in the reactor for chelate reaction with the addition of phenolic resin, chelate compound and solvent.

The produced master batch is dissolved by solvent in a dissolving tank and then chelate phenolic resin is added for a sufficient blending. The blended product is filtered and inspected prior to delivery as finished products.

Solvent and paste type adhesive

In the form of various plastic adhesives, it is usually called "top cement". The selected synthetic resin, solvent and reinforcing material suting various uses are dissolved in a dissolving tank to produce this type of adhesive.

2) Equipment and Machinery

Reactor
Heater
Cooling water tower
Cooling water tank
Transfer pump
Raw material storage tank
Product storage tank
Milling machine (for elastomer type)
Testers

3) Raw Materials

○ Vinyl acetate emulsion type adhesive (solid 50%)

Raw materials	Requirement (per ton of product)
Vinyl acetate monomer	422.0 Kg
Polyvinyl alcohol	33.7 Kg
Sodium carbonate	2.0 Kg
Emulsifier (Non-ion type) (HLB 14-18)	21.0 Kg
Potassium persulfate	16.9 Kg
Plasticizer (DOP, DBP)	29.4 Kg
Water	525.0 Kg

○ Chloroprene rubber type contact adhesive

Raw materials	Requirement (per ton of product)
Synthetic rubber	140.0 Kg
Antioxidant 2246	2.8 Kg
Znic oxide	7.0 Kg
Magnesium oxide	11.2 Kg
Phenolic resin	63.0 Kg
Solvent blend	798.0 Kg
Water	2.8 Kg

○ Synthetic resin type adhesive

Raw materials	Requirement (per ton of product)
Synthetic resin	300 Kg
Plasticizer	5 Kg
Solvent mixture	700 Kg

Example of Plant Capacity and Construction Cost

1) Plant capacity : 200 m/t/month
   * Basis : 12 hrs/day, 25days/month

2) Estimated construction cost (as of 1983)

o Manufacturing equipment	:	US$33,000
o Utility equipment	:	US$10,500
o Installation cost	:	US$13,100
Total	:	US$56,600

3) Required space

o Site area	:	$4{,}000 m^2$
o Building area	:	$1{,}000 m^2$

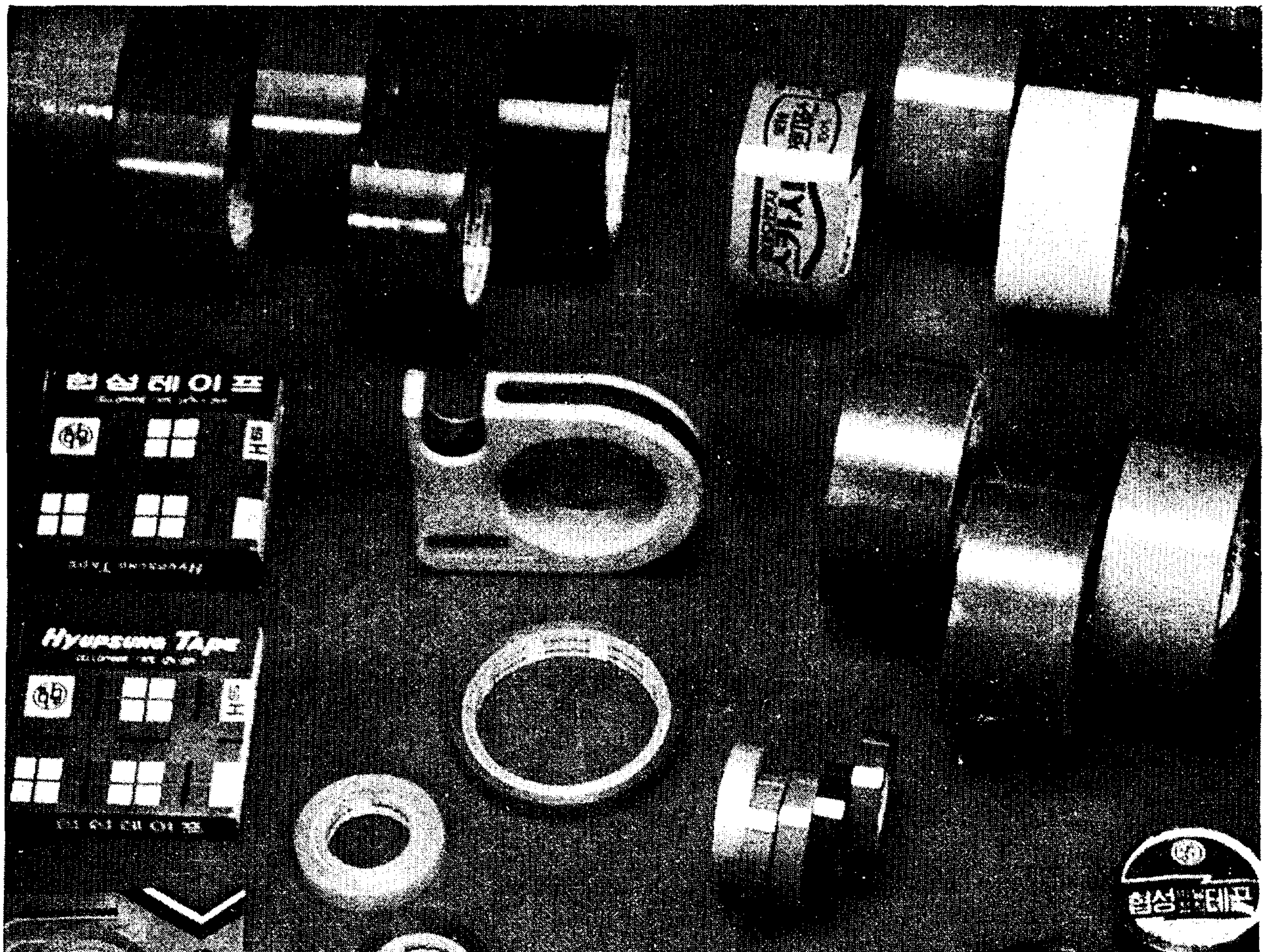
4) Personnel requirement

o Manager	:	2 persons
o Engineer	:	3 persons
o Operator	:	10 persons
o Other	:	5 persons
Total	:	20 persons

Any inquiry about the information contained should be sent to:
IO/COOP, Registry file No. ID/562/12, UNIDO, P.O. Box 300, A-1400 Vienna, Austria

FILE: H10
ISIC 3529

Self-Adhesive Tape Making Plant



View of Products

No particular high technologies are required for the manufacturing plant and its process including self-adhesive tapes for use in packaging, electric and electronic industries, and stationery.

Nevertheless, it is real circumstances that most of the developing countries depend on imports for the entire quantity of the above products.

Therefore, the introduction of this plant and related manufacturing technology will bring about the effect of import substitution, with its profitability expected to be very high compared with investment costs.

Products and Specifications

In this plant, various types of adhesive tapes, such as insulation tapes, light weight packaging tapes and heavy weight packaging tapes, are produced and their detail specifications are as shown in table 1.

Table 1. Products and Specifications

Type	Item name	Main use	Features & applications	Properties: Adhesion (g/25mm.w)	Properties: Tensile strength (kg/25mm.w)	Standard size: Width (mm)	Standard size: Length (m)	Standard size: Thickness (mm)	Color	Elongation %	Dielectric strength: volts	Volume resistivity: Ω-cm 20°C	Electrolytic corrosion	Temperature °C (°F)	Remarks
For insulation	Polyester tape	1. Anchoring transformer leads 2. Covering and insulating condensers	1. High heat and solvent resistance 2. Corrosion resistance 3. High initial adhesion	795 850	9.5 21	6~100 6~100	20, 25 20, 25	0.055 0.080		70 75	3000 6000	1.7×10^{14} 1.7×10^{14}	1.00 1.00	110 (230) 120 (248)	*Available in five colors: Red Yellow Blue Green, Black
	PVC tape	1. Insulating and wire harnessing 2. Splicing terminating wires and cables	1. All weather application 2. High adhesiveness 3. Excellent workability in cold weather condition 4. High voltage insulating	845	12	19	10, 12 15	0.20	Black Red White Blue Yellow	230	11500	1.0×10^{14}	1.00	90	
	Masking tape	1. Holding the lead of condenser 2. Fastening the primary and final winding of transformer coils	1. Better flexibility 2. Thermosetting electrical paper tape conforms to any irregular surface or contour	22	10.4	6~100	25 50	0.22	–	10	1100	3.0×10^{12}	0.70	140 (284)	
	Acetate cloth tape	1. Bundling deflecting coils of TV sets 2. Anchoring transformer leads	1. Stable electric properties over a wide temperature range 2. Resistance to electrolytic and copper corrosion	957	17.9	6~100	25 50	0.23	White	12	2600	9.0×10^{11}	1.00	110	
	Combination tape (Combination of polyester file and kraft paper) TK-2508	1. Covering and insulating condensers 2. Anchoring transformer leads	1. Corrosion resistance 2. High voltage insulating	–	22	480	50	0.13±0.05	–	12	4000	2.5×10^{14}	0.9	–	
For light weight packaging	Cellophane tape	Light packaging in general	1. Excellent adhesion 2. Good workability 3. Clean and transparent	850	8.5	12, 18 24	20, 25 30	0.055	Yellow	Above 17					Other sizes are available on request
	Kraft paper tape	Sealing cartons	1. Good workability 2. Super adhesion	900	12	25, 50	20, 30 40	0.15	Light Brown	9					
For heavy weight packaging	Opp tape	Sealing cartons	1. Strong adhesion 2. Water-proof, moisture-proof and more economical	920	11	25, 38 50	25, 50	0.08 0.09 0.1	Beige black Green red! Blue white Yellow Transparent	200					Other color will be printed on request
	PE cotton tape	Sealing cartons	1. Super adhesion 2. Excellent resistance to heat and cold	950	15	25, 50 38	10, 12	0.31	Green Beige	–					Available in longer yardage

Contents of Technology

1) Process Description

Adhesive manufacturing

Rubber, synthetic resin and other additives are blended with a solvent in a mixer for dissolving as an adhesive with sufficient adhesiveness.

OPP film printing

It is a roll printing process based on the gravure printing system (frontal printing).

Adhesive coating

The adhesive is coated on the film by making use of a knife coater.

Paper tube manufacturing

Kraft paper is roll-slitted at uniform intervals and adhered in overlap by the centrifugal force of

Drying (by heater)

Forced draft system based on the circulation of boiler steam.

Winding

Rubber roller pressing rotating system based on the insertion of a paper tube into the rotating shaft.

Cutting

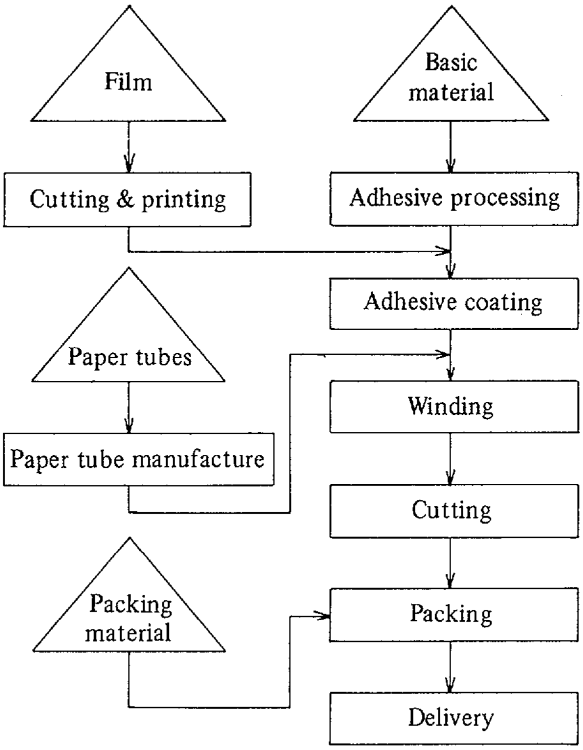
The system of cutting by pressing down with a ring knife while being motor-driven after insertion of the semifinished product into the shaft.

Packing

Finished products are put in polypropylene bags to be packed in carton boxes in uniform numbers after bags are sealed. The boxes are taped and banded for delivery.

Delivery

Self-Adhesive Tape Manufacturing Process Flow Diagram



2) Equipment and Machinery

Adhesive mixer tank
Coating machine
Heater, forced draft blower
Solvent recovery equipment (distillation)
Dryer box
Winder
Main motor
EPC (oil press type)
Conveyor belt (cloth)
Rubber roller, iron core, iron roller, silicone roller
Printing machine, AC processing, three-color printing
Paper tube making machine (large, small, medium)
Cutting machine, ring knife, slitting machine

View of Mixing Equipment

3) Raw Materials and Utilities

Raw materials and utilities	Requirement (per 1m² of product)
Cloth (opp)	45 g
Natural rubber	9.53 g
SBR	3.17 g
Resin	8.64 g
Escore I	8.13 g
Pb	1.4 g
BHT	0.25 g
Toluene	0.1 ℓ
Ink	8 g
RA	0.49 g
A-100	6.2 g
Electric power	0.06 kw
Water	0.75 ℓ

Example of Plant Capacity and Construction Cost

1) Plant capacity : 5,000,000 m²/year
   * Basis : 8 hrs/day, 330 days/year

2) Estimated construction cost (as of 1983)
   - Equipment and machinery : US$465,000
   - Installation cost : US$ 70,000

   Total : US$535,000

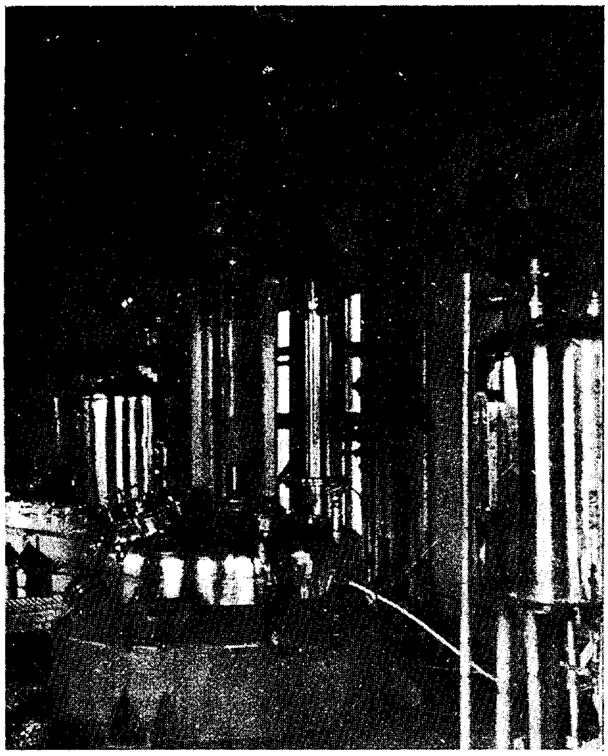
3) Required space
   - Site area : 7,000m²
   - Building area : 2,500m²

4) Personnel requirement
   - Plant manager : 5 persons
   - Engineer : 3 persons
   - Operator : 35 persons

   Total : 43 persons

FILE: H11
ISIC 3522

Ursodesoxycholic Acid Synthesis



View of Reactor

Ursodesoxycholic acid, an ingredient contained only in the bear's gall, has been studied since 1902, to establish its synthesis method in relatively recent years, with scientific researches on its phisiological action also conducted. As a result, with the administration of only a small amount quite different from the conventional liver medicine in its action mechanism, the product exhibits as a wonder drug very strong effects of protecting the liver.

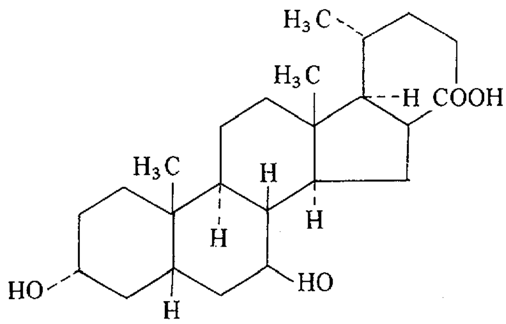
In other words, it is a cholagogue reviving the function of the liver because of the actions including the acceleration of bile secretion, formation and accumulation of liver glycogen, reviving of liver cells, removal of liver fat, reduction of blood sugar and cholesterol, removal of lipase and accelerated absorption of vitamin B_1 and vitamin B_2.

The ursodeoxycholic acid manufacturing technology introduced here is capable of synthesizing it from the raw material two stages lower. It can also be produced at lower prices than the technology based on the material only one stage lower. This technology is characteristic of its low plant construction cost and high yield.

Products and Specifications

With extensive actions and effects, the ursodesoxycholic acid can be administered for an extended period of time with no side-effects, having the following structural formula and medicinal actions:

(The chemical structure of ursodesoxycholic acid)



(Medicinal actions)

- Strengthening of the function of liver and promotion of detoxication:

The accumulation of fats in the liver weakens the activity of liver and decreases liver glycogen, thus causing a liver disorder. This product quickly removes the rest of fats deposited in the liver due to increased liver glycogen and enhances its detoxicating action by protecting and strengthening the liver. It is used against hepatitis, liver toxicosis and fatty liver.

- Acceleration of bile secretion and discharge of bile pigment:

This product increases the secretion of bile and facilitates its passage in the bile duct, thus discharging the bilestone into the intestine and quickly releasing the bile pigment (when excessively mingled in the blood, it causes jaundice) or harmful matters from the body. Therefore, it is highly effective in preventing and treating the cholelithiasis, inflammation of the gall bladder and jaundice.

- Increase in the utilization rate of vitamins B_1 and B_2 :

When taken with vitamins B_1 and B_2, this product helps these materials to be readily absorbed and instantly transformed into active vitamins, exhibiting noticeable effects for the deficiency of vitamins B_1 and B_2 including the beriberi, neuralgia inflammation of the lips, acne and eczema.

Acceleration of the secretion of digestive liquid or digestive enzyme:

Since this product accelerates the secretion of digestive liquid or digestive enzyme by invigorating the activity of the stomach and intestines or pancreas, the appetite increases and results in an improved digestion and absorption of the foods. In particular, indispensable for the absorption of fat or liposoluble vitamins (A, D, E, K), it exhibits good effects on the indigestion, constipation and poor appetite.

- Increase of liver glycogen and suppression of occurrence of lactic acid:

This product increases and accumulates the glycogen, source of physical strength, and at the same time prevents the occurrence of lactic acid or pyruvic acid, which is dubbed a fatigue stuff, and accelerates its decomposition, thus helping recover from the fatigue.

Contents of Technology

1) Process Description

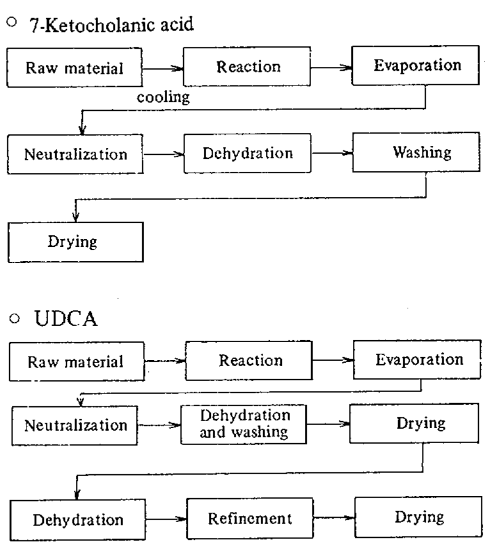
Synthesis of 7-ketocholanic acid

CDCA dissolved in alkaline solution is oxidized with the use of liquid bromine at low temperatures.

Synthesis of ursodesoxycholic acid

The 7-ketocholanic acid obtained is then reduced to UDCA by the use of sodium metal in the presence of a high boiling point alcohol.

UDCA Manufacturing Process Block Diagram



2) Equipment and Machinery

SUS 306 reactor
Refrigerator
Extractor
Steam dryer
Sparkler filter
Mill

3) Raw Materials

The main raw materials are as follows:

- 7-ketocholanic acid
  CDCA, methanol, $NaHCO_3$, bromine sulfuric acid, $Na_2S_2O_4$
- UDCA
  7-ketocholanic acid, isobutyl alcohol, sodium metal, sulfuric acid, $Na_2S_2O_3$, tap water, etc.

Example of Plant Capacity and Construction cost

1) Plant capacity : 800 kg/month
   * Basis : 8hrs/days, 25 days/month

2) Estimated construction cost (as of 1980)

o Manufacturing equipment	:	US$ 48,500
o Utility facility	:	US$ 22,700
o Installation cost	:	US$ 53,000
Total	:	US$ 124,200

3) Required space

- Site area : 120 m^2
- Building area : 120 m^2

4) Personnel requirement

o Manager	:	1 person
o Engineer	:	1 person
o Operator	:	3 persons
o Other	:	1 person
Total	:	6 persons

Any inquiry about the information contained should be sent to:

IO/COOP, Registry file No. ID/562/12, UNIDO, P.O. Box 300, A-1400 Vienna, Austria

Riboflavin Tetrabutyrate Synthesis

In the blood vessel of human body, there are accumulated various waste matters including the harmful lipid peroxide right from suckling days.

It has been found that these waste matters, including the lipid peroxide, are responsible for the arteriosclerosis in most cases. In particular, it has been confirmed that the causative material for the dreadful geriatric diseases such as cerebral hemorrhage and heart disease, which are prime causes for the fatality among the Asians, is no other than this lipid peroxide, drawing keen attention from throughout the world.

In addition, clinical reports have it that the lipid peroxide is also closely related to the hypertension, diabetes and obesity, which are most usual geriatric diseases, showing to what extent this matterial is harmful to the human body.

Generally, this material shows the following characteristics:

- It causes such geriatric diseases as arteriosclerosis and hypertension by hardening the blood vessel.
- It coagulates the blood by destroying platelets and even threatens human life by causing the cerebral hemorrhage and myocardial infarction.
- It destroys vital membranes by degenerating the protein in the body, thus accelerating symptoms of senility.
- It causes a mulfunction and weakens the body by destroying various vitamins.

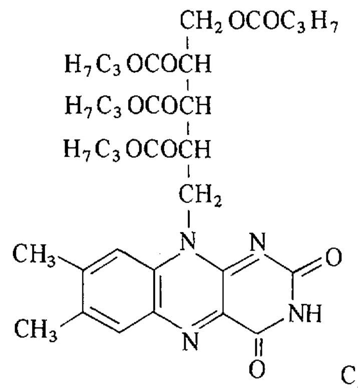
A combination of riboflavine and butyric acid, the riboflavine tetrabutyrate plays a role of decomposing and removing the aforementioned material of peroxide. Thus it is an ideal medicine fundamentally preventing and curing geriatric diseases.

Accordingly, the manufacturing technology introduced here is accorded due recognition for its need in that it can improve people's health through the prevention and treatment of the geriatric diseases, as well as help reduce the costs for pharmaceutical production on the basis of relatively simple but highly efficient synthesis technology.

Products and Specifications

Remaining in the human body for long hours to act as vitamin B_2 on a continued basis, this riboflavine tetrabutyrate is characterized by its correcting abnormalities in the lipid metabolism and also reducing the lipid peroxide, with the following structural formula and medicinal actions:

(Structural formula of riboflavin tetrabutyrate)



$C_{33}H_{44}O_{10}N_4 = 656.75$

(Medicinal actions)

- Arteriosclerosis and hypertension:

It has been made clear that the lipid peroxide damages the intermediate membrane among the triple membranes constituting the blood vessel, and at the same time causes the deposition of cholesterol and the like by producing various matters on the wall of the blood vessel.

This product prevents and treats the geriatric diseases by directly decomposing the lipid peroxide which causes arteriosclerosis and hypertension.

- Cerebral hemorrhage and heart diseases:

The lipid peroxide destroys platelets in the blood vessel and forms a thrombus as the result of coagulation of the blood, directly causing such diseases of circulatory organs as cerebral hemorrhage and myocardial infarction.

By directly decomposing and removing the lipid peroxide which causes such symptoms, this product prevents and treats the cerebral hemorrhage and other heart diseases.

- Obesity :

This product helps maintain normal weight by converting to energy the unnecessary lipid in the obesity patients caused by abnormalities in the lipid metabolism.

- Skin diseases:

This product decomposes and removes the lipid peroxide causing skin diseases, exhibiting distinct effects in the treatment of various skin diseases including the eczema, contagious dermatitis, dermatitis seborrheica, ordinary acne, facial black skin, dry scabies and inflammation of the lips.

- Ophthalmic diseases:

By decomposing and removing the lipid peroxide which degenerates the protein in eyeballs, this product prevents and treats such ophthalmic diseases as the cataract, arteriosclerosis retinities, prematurely-born infant retinitis and keratitis.

- Pregnancy toxicosis:

It has been confirmed that the lipid peroxide drastically increases in the body of the patients afflicted with pregnancy toxicosis.

This product helps shorten the period of pregnancy toxicosis by suppressing an increase of lipid peroxide. In particular, it remarkably improves such symptoms as hypertension, proteinurine, edema and abnormal lipid metabolism, which appear towards the end of pregnancy.

- Other diseases:

The lipid peroxide destroys vital membranes by degenerating the protein in the body, thus accelerating symptoms of senility. It was also made public by the research institute of the Japan National Cancer Center that the lipid peroxide is closely related to the cancer due to its chemical substance causing lesions in cellular components. This product is also used in preventing the cancer as well as many other diseases attributable to the lipid peroxide.

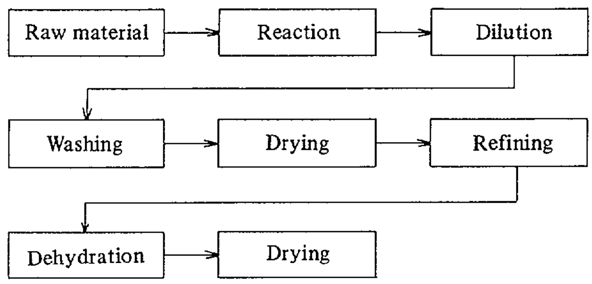
With no side-effects, this product can be taken for an extended period of time without worrying.

Contents of Technology

1) Process Description

A mixture of riboflavin and n-butyric acid is heated with ethylacetate, and then the reaction mixture is treated with pyridine and TSOH to obtain riboflavin tetrabutyrate.

Riboflavin Tetrabutyrate Manufacturing Process Block Diagram



2) Equipment and Machinery

GL Reactor
Dilution tank
Extractor
Dryer
Fitz mill

3) Raw Materials

The main raw materials are as follows:
vitamin B_2, n-butyric acid, pyridine, tosylchloride, methanol, tap water.

Example of Plant Capacity and Construction Cost.

1) Plant capacity : 250 kg/month
* Basis : 25 days/month

2) Example of estimated construction cost (as of 1980)

○ Manufacturing equipment	:	US$ 22,700
○ Utility facility	:	US$ 3,000
○ Installation cost	:	US$ 15,200
Total	:	US$ 40,900

3) Required space

- Site area : 180 m^2
- Building area : 180 m^2
- Other : 60 m^2

4) Personnel requirement

○ Manager	:	1 person
○ Engineer	:	1 person
○ Operator	:	3 persons
○ Other	:	1 person
Total	:	6 persons

Rifampicin Synthesis Technology

Rifampicin was named in 1957 by P. Sensi and his coworkers at Lepetit Laboratories upon confirmation of the materials produced from the strains of streptomyces mediterranei (now renamed nocaidia mediterranei) separated by them. It exhibited an antibacterial activity against gram-positive bacteria, in particular against tuberculous disease germs called mycobacterium tuberculosis. All-out studies were started thereafter.

At that time, members of the same family, including rifamycin A, B, C, D, E, F and Y, were produced in the culture liquid of wild strains, but an accumulation of quantities of rifamycin B was realized in the fermentation liquid by this technology as a result of the changes in its strains, culture media and method of culture. After preparing rifamycin O and S therefrom, 3-formyl rifamycin SV was synthesized.

Adopting a method of further reacting the synthesized 3-formyl rifamycin SV with AMP to produce rifampicin, this technology is characterized by excellent crystals of product coupled with high yield.

Products and Specifications

The rifampicin in accordance with this technology is used as an anti-tuberculosis medicine as well as a treating medicine against infections by gram-positive bacteria.

Table 1. Specification of Rifampicin

Item	Specification
Related substances	
3-Formyl-rifamycin SV	max. 0.5%
Rifamycin-quinone	max. 1.5%
Other impurities	max. 1.0%
PH	4.5 - 5.5
Loss on drying	max. 2.0%
Residue on ignition	max. 0.1%
Heavy metals	max. 20 ppm
Absorptivity	100 ± 4%
Mn	max. 50 ppm
Crystallinity	crystalline
Safety	nontoxic
Assay	
Assay (Chemical)	max. 90.0%
Bioassay	min. 900 mcg/mg

Contents of Technology

1) Process Description

Rifamycin B and 3-formyl rifamycin SV synthesis:

Streptomyces mediterranei CKD-1129 culture liquid is innoculated to meat juice and cultured for 72 hours at 28°C. It is then transplanted to the preliminary culture media containing organic nitrogen source (mostly peanut meal) and glucose and then further cultured for 48 hours to prepare seed bacteria.

By planting 5% of the bacteria prepared as above to the main culture media prepared through the addition of peanut meal, soy bean flour, starch, glucose, calcium carbonate, ammonium sulfate, calcium phosphate and other minor elements in 50 m^3 fermentator, perform the main fermentation for eight days. During the fermentation, one liter per minute of air is supplied per liter of culture liquid.

At the culture temperature of 28°C, the rotation speed of an agitator is 90-100 rpm with the nutrition sources being added at prescribed time intervals and speed for an accumulation of rifamycin B in the culture liquid with high yield.

Bacterial bodies in the culture liquid are removed and then rifamycin O is crystallized by adding an oxidizing agent and sulfuric acid solution.

Chloroform is added to the dried rifamycin O for dissolution and filtration, followed by hydrolysis with sulfuric acid. After hydrolysis, alcohol is added for the crystallization of rifamycin S and then dried. The dried rifamycin S is dissolved in an ether solvent and manganese dioxide and formalin are added. After filtration, sulfuric acid is added for reaction. It is then reduced by ascorbic acid for the synthesis of 3-formyl refamycin SV and dried.

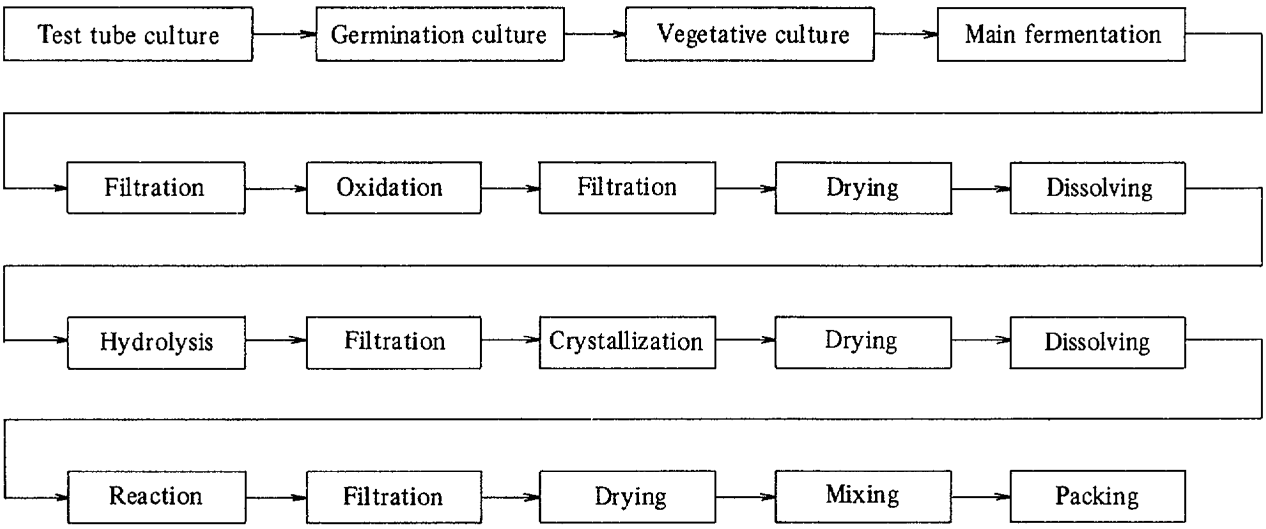
Rifampicin synthesis :

After dissolution of 3-formyl rifamycin SV in ethyl acetate, 1-amino-4-methyl-piperazine (AMP) is added for reaction. It is filtered and dried to gain rifampicin.

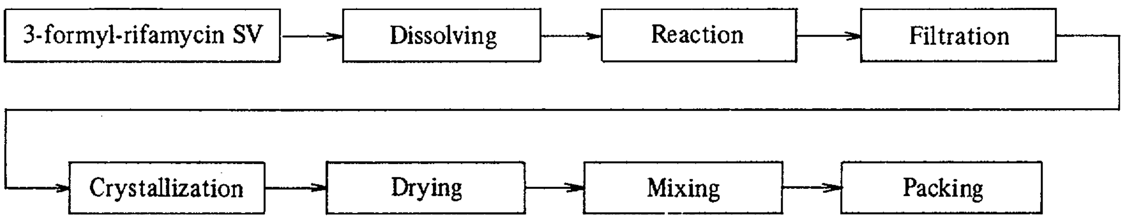
2) Equipment and Machinery

Rifamycin B & 3-formyl rifamycin SV synthesis section

3-Formyl-Rifamycin SV Synthesis Process Block Diagram



Rifampicin Synthesis Process Block Diagram



Incubator
Laminar flow bench
Spectrophotometer
SUS fermenters
Air compressor
Boiler
Freezer
SUS reactor
Rotary Vacuum filter
Super decantater
Tunnel dryer
Vacuum pump
GL reactor
Sparkler filter
Centrifuge
Dryer
Condenser
Mixer

Rifampicin synthesis section
Glass-lined reactor
Sparkler filter
Vacuum pump
Centrifuge
Condenser
Dryer
Mixer
Boiler

3) Raw Materials and Utilities

○ Rifamycin B and 3-formylrifamycin SV

Raw materials and utilities	Requirement (per ton of product)
Peanut meal	4,000 kg
Soybean flour	1,500 kg
Glucose	10,000 kg
Starch	15,000 kg
Ammonium sulfate	1,200 kg
Calcium carbonate	2,000 kg
Decalite	15,000 kg
Chloroform	30,000 kg
Oxidizing agent	1,700 kg
Ether	2,000 kg
Formaldehyde	8,000 kg
Ascorbic acid	1,000 kg
Electric power	160,000 kwh
Fuel	16,000 ℓ
Water	8,000 tons

○ Rifampicin

Raw materials and utilities	Requirement (per ton of product)
1-amino-4-methylpiperazine	610 kg
Ethyl acetate	450 kg
Electric power	40,000 kwh
Fuel	4,000 ℓ
Water	2,000 tons

Example of Plant Capacity and Construction Cost

1) Plant capacity :
  - ○ Rifamycin B and 3-formyl-rifamycin SV synthesis plant (A) : 20 m/t/year
  - ○ Rifampicin synthesis plant (B) : 20 m/t/year
    - * Basis : 24 hrs/day, 250 days/year

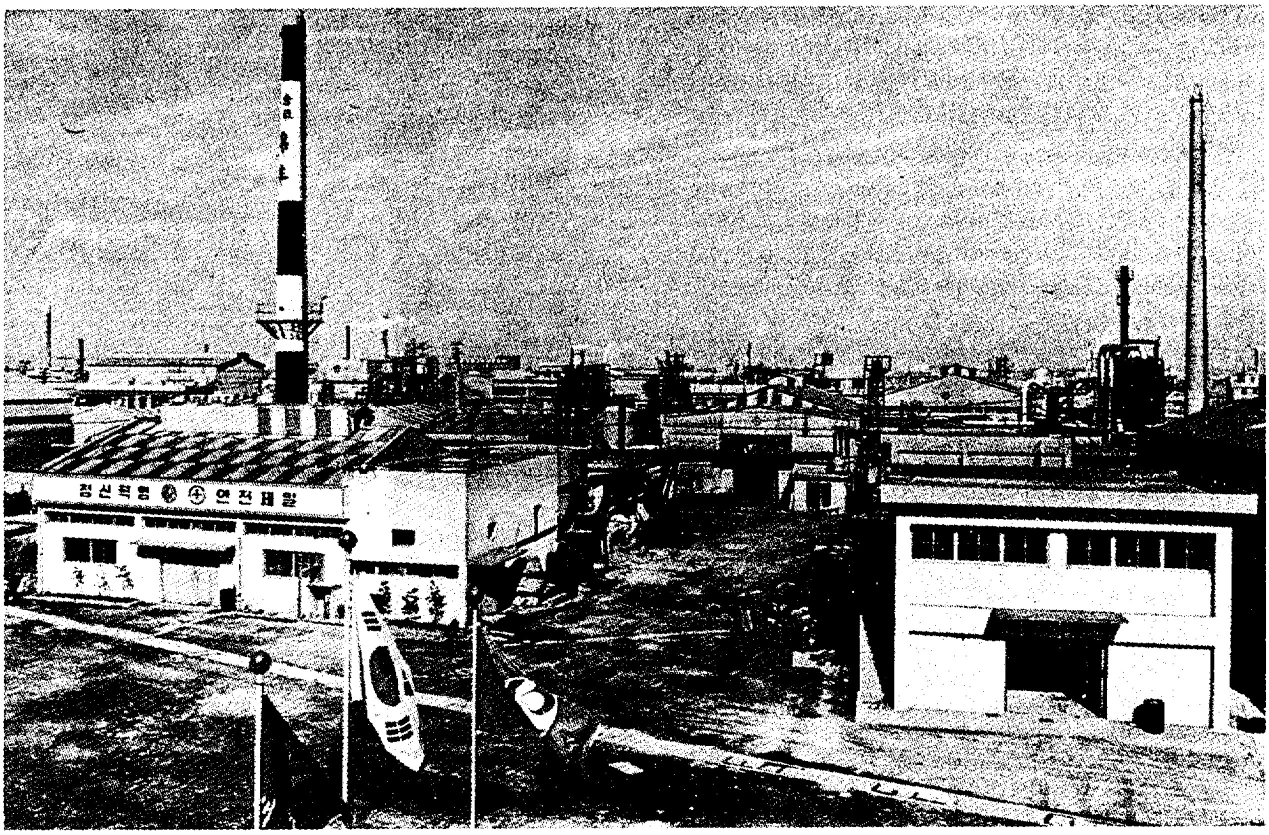
2) Estimated construction cost (as of 1983)
  - ○ A plant
    - ○ Manufacturing equipment : US$ 2,639,000
    - ○ Utility facility : US$ 584,000
    - ○ Installation cost : US$ 549,000
    - Total : US$ 3,772,000
  - ○ B plant
    - ○ Manufacturing equipment : US$ 267,000
    - ○ Utility facility : US$ 100,000
    - ○ Installation cost : US$ 97,000
    - Total : US$ 464,000

3) Required space
  - ○ Site area : 3,400 m^2
  - ○ Building area : 1,785 m^2

4) Required personnel
  - ○ Manager : 3 persons
  - ○ Engineer : 3 persons
  - ○ Operator : 30 persons
  - ○ Other : 5 persons
  - Total : 41 persons

FILE: H14
ISIC 3522

Saccharin Making Plant



View of Saccharin Plant

After discovery of saccharin in 1877 by professor I. Remen and professor C. Fahrbeg of the United States, a small-scale plant was set up in New York in 1884, heralding its commercialization.

With the rush of industrialization that followed in respective advanced nations, the market of saccharin has greatly expanded to occupy the weightiest position as an artificial sweetening agent.

About 500 times as sweet as cane sugar, saccharin is in wide use as a substitute of sugar for foodstuffs, medicines and cosmetics. Due to the limitation in sugar cane resources as raw materials of sugar, the demand for saccharin is on a steady increase.

Since the artificial sweetening agent is manufactured by chemical synthesis technology, unlike the natural sweetening, a steady improvement in its production skills or enlargement of scale has been realized, with the technological development actively underway for reducing production costs among the industrial circles.

There are a variety of saccharin manufacturing processes in industrial use today. Of these, the perchromate process using sodium perchromate as an oxidizing agent in accordance with electrolysis are no longer in use due to high installation costs as well as inferior product quality. The chrome anhydride process making use of mainly chrome anhydride is currently in the widest use.

This plant introduced here adopts the chrome anhydride process with improved facilities capable of recovering chrome anhydride as an oxidizing agent and sulfuric acid as a catalyst for reuse. It enables to economically produce the existing soluble saccharin, insoluble saccharin and imide with no changes in the manufacturing process.

The plant has the facilities for the production of OTSA (o-toluenesulfonamide), main raw material of saccharin, and it can also simultaneously produce such related products as PTSA (p-toluenesulfonamide) and PTC (p-toluenesulfonyl chloride).

Products and Specifications

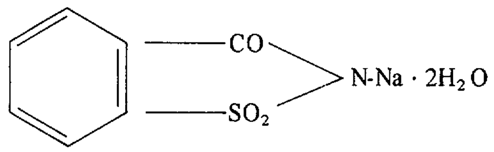
This plant produces soluble, insoluble and powdery saccharin in response to customers' demand, with a variety of grades available in these products depending upon particle size or OTSA content. In the case of saccharin sodium, there are both granular type products, generally 3 to 150 mesh in particle size, and saccharin in powdery form, while OTSA and PTSA contents are from 10 to 100 ppm. In the case of insoluble saccharin, it is 60-100 mesh in particle size and 10-25 ppm in OTSA content.

OTSA (o-toluenesulfonamide), main raw material for saccharin, is simultaneously produced with by-products PTC (p-toluenesulfonyl chloride) and PTSA (p-toluenesulfonamide). Of these, PTSA is produced in three different grades with less than 2%, 5% and 30% o-isomer content.

Table 1. Chemical & Physical Properties of Products

o Saccharin sodium

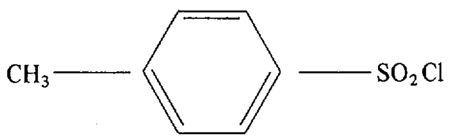
〈Structural formula〉



Appearance	Colorless and transparent crystal
Purity	Not less than 98%
Sweetness	450-550 times as sweet as sugar
Moisture	Not more than 15%
Sulfate	Not more than 100 ppm
Heavy metal	10 ppm maximum
Solubility	One gram dissolves in 1.2 ml water
	and in about 50 ml alcohol.
	Aqueous solutions are neutral or
	alkaline to litmus.

o p-Toluenesulfonyl chloride

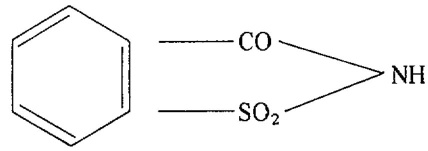
〈Structural formula〉



Appearance	White crystal
Composition	p-Toluenesulfonyl chloride
Purity	Not less than 96%
Solubility	Soluble in alcohol, and hot water,
	Sparingly soluble in cold water.

o Saccharin insoluble

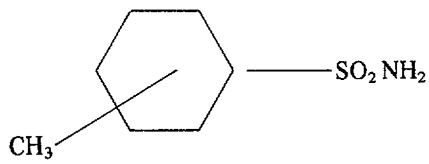
〈Structural formula〉



Appearance	Colorless monoclinic crystal
Mesh	60-100 mesh
Melting point	226-230°C
Specific gravity	0.83
Purity	Not less than 98%
Sweetness	In dilute aqueous solution it is 500
	times as sweet as sugar; the sweet
	taste is still detectable in
	1,100,000 dilution
Moisture	Not more than 1%
Sulfate	200 ppm maximum
Heavy metal	10 ppm maximum
OTSA	10, 25 ppm at customer's request
Solubility	One gram dissolves in 290 ml water,
	25 ml alcohol, 12 ml acetone, about
	50 ml glycerol. Freely soluble in
	solution of alkali carbonates. Slightly
	soluble in chloroform and ether.
Acid reaction	PH of 0.3% aqueous solution 2.0

o p-Toluenesulfonamide

〈Structural formula〉



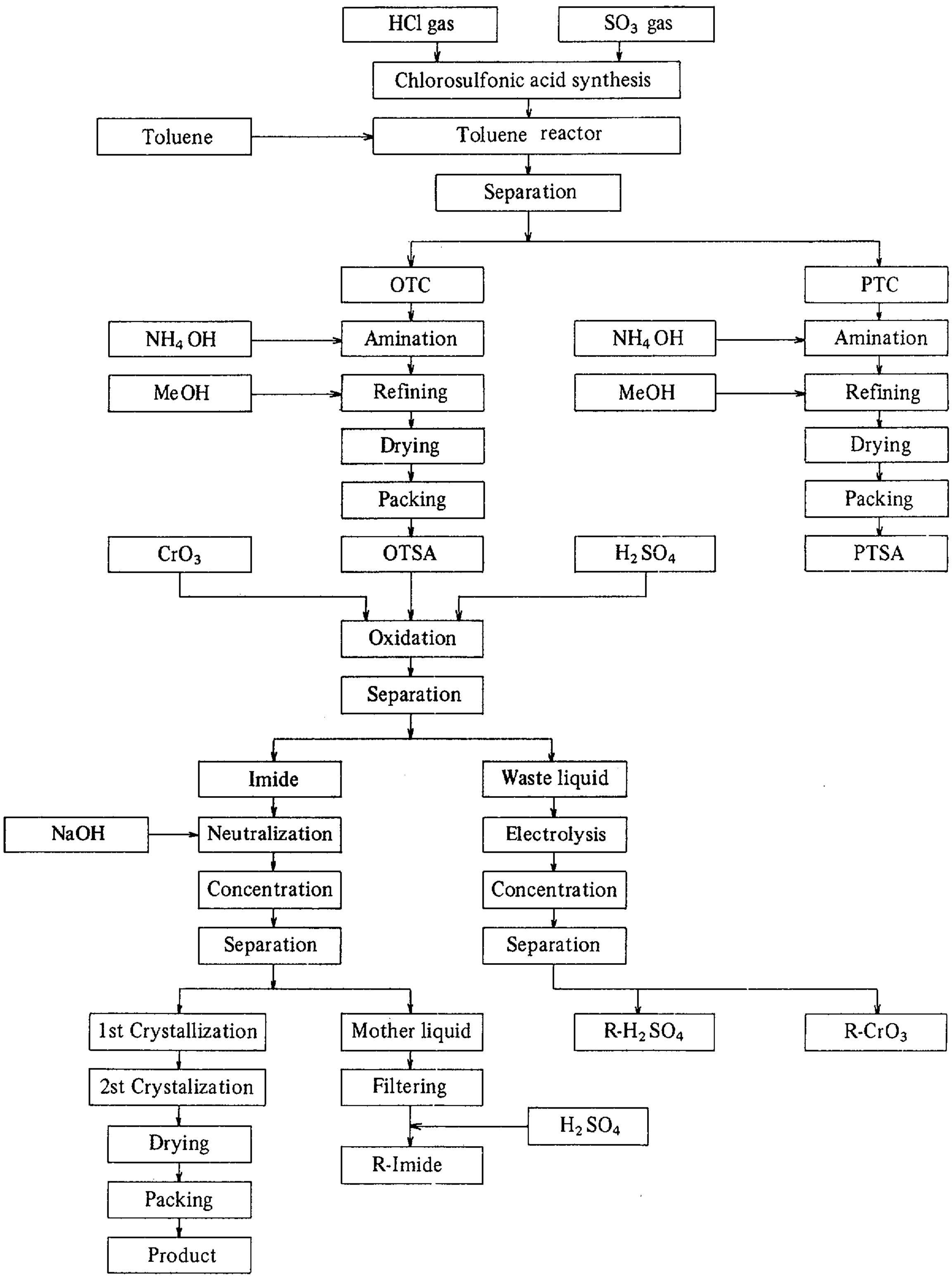
Appearance	Fine, white to light cream,
	granular particles
Purity	O-isomer content is not more than 2%
Moisture	Not more than 0.5%
Melting point	132-137°C
Ash	Not more than 0.05%
Acidity, pH	6.5-7.5
Heavy metal	10 ppm maximum
Iron	10 ppm maximum

Contents of Technology

1) Process Description

The saccharin manufacturing process is generally composed of the following unit processes:

Saccharin Manufacturing Process Flow Diagram



Chlorosulfonic acid synthesis

Sulfur trioxide gas generated by heating fuming sulfuric acid and hydrogen chloride gas are reacted in a reaction tower for the preparation of chlorosulfonic acid.

Sulfonation

The synthesized chlorosulfonic acid is reacted with touene in a toluene reactor, and then on completion of the reaction, the product is transferred to a storage tank.

While feeding the reaction product to a decomposition tank filled with sulfuric acid, the chlorosulfonic acid still remaining in excess is decomposed and removed. The reaction product, removed of the excess chlorosulfonic acid, is cooled in a cooling tower to be converted into oily OTC and crystalline PTC for subsequent centrifugal separation.

Amination and refining

The separated OTC is reacted with ammonia in an amination tank to obtain crude OTSA and then it is dissolved in alcohol for recrystallization. The final product is obtained by the separation and drying. Like OTC, PTC is also made into PTSA through amination and then obtained as its final product by refining and crystallization.

Oxidation process

After crushing, OTSA is reacted with chrome oxide (CrO_3) as an oxidizing agent and sulfuric acid as the catalyst in an oxidation tank. The reaction product is separated by centrifuge into imide and waste liquid. The separated imide is neutralized again with caustic soda.

Concentration and crystallization

After making imide soluble, it is concentrated in a vacuum evaporator, and then subjected to the primary crystallization by agitating and cooling in a crystallizer. It is recrystallized for enhancing its purity.

Drying and packing process

The recrystallized saccharin is dried in a fluidizing dryer, and then separated and packed to fit specifications depending upon particle sizes.

Recovery of oxidizing agent and catalyst

An electrolytic solution is prepared by making use of the oxidizing agent from the oxidation process on completion of the reaction, and then its oxidizing capacity is restored by electrolysis in an electrolysis tank. The electrolytic solution is concentrated in a vacuum evaporator, and then cooled again and separated into chrome oxide (CrO_3) and sulfuric acid for reuse in the oxidation process after replenishing the partial shortage.

2) Equipment and Machinery

- OTSA & PTSA plant
  - Chlorosulfonic acid synthesis
    - SO_3 gas generator
    - HCl stripper
    - CS acid reactor
    - HCl synthesis tower
  - OTC & PTC synthesis
    - Refrigerating facility
    - Toluene measuring tank
    - CS acid measuring tank
    - Toluene reactor
    - OTC & PTC separator
  - OTSA & PTSA synthesis
    - Amination tank
    - Ammonia measuring & storing tanks
    - Refining tanks
    - Vacuum evaporators
    - Dryer
  - Others
    - Reactant transferring facility
    - Filter press
    - Raw material storage tanks
- Saccharin plant
  - Oxidation section
    - Oxidation tank
    - Agitators
    - Refrigerating system
  - Concentration and crystallization section
    - Concentrator
    - Vacuum pump
    - Crystallizer
    - Centrifuge
    - Filter press
    - Agitators
  - Oxidizing agent and catalyst recovery section
    - Electrolysis facility
    - Vacuum evaporator
    - Vacuum pump
    - Centrifuge
  - Others
    - Cooling tower
    - Fluidizing dryer
    - Sieve
    - Packing facility

3) Raw Materials and Utilities

- Saccharin, insoluble

Raw materials and utilities	Requirement (per ton of product)
Saccharin sodium	1,460 kg
H_2SO_4	600 kg
Electric power	75 kw
Industrial water	6 m^3

○ Saccharin sodium

Raw materials and utilities	Requirement (per ton of product)
OTSA	862 kg
CrO_3	24 kg
NaOH	880 kg
H_2SO_4	450 kg
Diatom earth	16 kg
Electric power	6,192 kw
B-C oil	1,468 ℓ
Process water	26 m^3
Cooling water	113 m^3

Example of Plant Capacity and Construction Cost

1) Plant capacity

○ OTSA & PTSA plant: OTSA 90 m/t/month
PTSA 50 m/t/month
OPTSA 10 m/t/month

* Basis : 24 hrs/day, 30 days/month

2) Estimated construction cost (as of 1982)

○ Manufacturing machinery : US$ 1,067,000
○ Utility facility : US$ 160,000
○ Installation cost : US$ 267,000

Total : US$ 1,494,000

3) Required space

○ Site area : 2,500 m^2
○ Building area : 1,500 m^2

4) Personnel requirement

○ Manager : 1 person
○ Engineer : 3 persons
○ Operator : 36 persons

Total : 40 persons

Amoxycillin Synthesis Technology

While researching on the staphylococus variants in 1928, A. Fleming found that the propagation of bacteria being suppressed in culture media stained with mildews. It was named penicillin after the nomenclature of penicillium to which the material produced by mildews belonged, heralding the start of penicillin.

Studies on this material in terms of bacteriostatic agent rapidly progressed thereafter to make its industrial mass production possible. Meanwhile, various other derivatives of penicillin have been produced with its mother nucleus 6-APA as a starting material.

Of these, amoxycillin has similarities to ampicillin in actions and synthesis process, with a wide recognition of its efficacy as a primary selective medicine against a variety of inflammations of unknown germs of disease for more comprehensive antibacterial spectrum and stronger acid resistance than ampicillin.

Helped by the synthesis technologies on semisynthetic penicillin products accumulated over the past ten years, Korea has successfully developed a unique synthesis process providing the highest in both quality and yield. These items are currently in production.

The technology will greatly contribute not only to developing the pharmaceutical industry capable of making available antibiotics, harmless to human body and reasonable in prices, but also to improving the nations's health as a whole.

Products and Specifications

Amoxycillin · $3H_2O$ manufactured on the basis of this technology is an extensive antibiotic, with chemical assay showing 90-105%. Its detailed specifications are as indicated in table 1.

Table 1. Specification of Amoxycillin

Item	Specification
Description	White powder
PH	3.5 ~ 6.0
Water content	11.5 ~ 14.5% (K.F)
Specific rotation	+290 ~ +310°
Bioassay	900 ~1050 mcg/mg
Chemical assay	90 ~ 105%
Acid titration	min. 90%
Amine	min. 90%

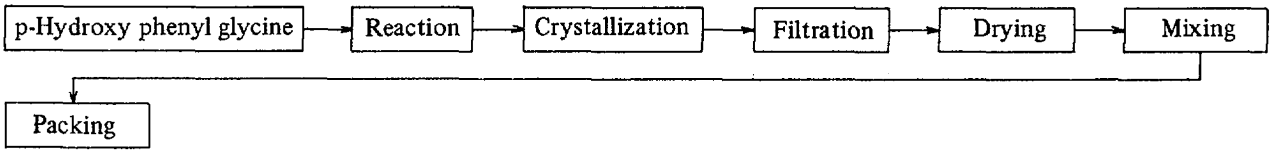
Contents of Technology

1) Process Description

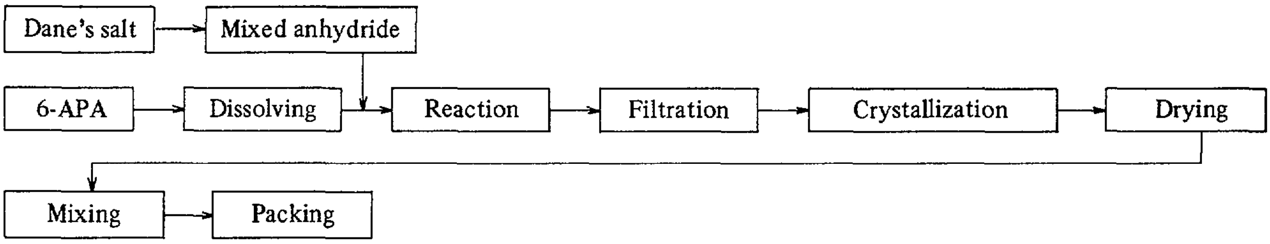
Dane's salt is prepared from p-hydroxy phenylglycine to be dissolved in pivaloyl chloride, followed by the reaction with 6-APA which gives crystals. The crystals are filtered and dried to obtain amoxycillin · $3H_2O$.

Amoxycillin Synthesis Process Block Diagram

○ Synthesis of dane's salt



○ Synthesis of amoxycillin · $3H_2O$



2) Equipment and Machinery

SUS reactor
Seitz filter
Receiver (SUS 304)
SUS tank
Vacuum pump
Condenser (SUS)
Centrifuge
Dryer
Pulverizer
Mixer

3) Raw Materials and Utilities

Raw materials and utilities	Requirement (per ton of product)
p-Hydroxy phenyl glycine	1,000 kg
Pivaloyl chloride	380 kg
6-APA	600 kg
Electric power	–
Fuel	–
Water	8,000 ℓ

Example of Plant Capacity and Construction Cost

1) Plant capacity : 40 m/t/year
 * Basis : 24hrs/day, 250 days/year

2) Estimated construction cost (as of 1983)

- Manufacturing equipment : US$203,000
- Utility facility : US$177,000
- Installation cost : US$ 89,000

Total : US$469,000

3) Required space

- Site area : 700 m^2
- Building area : 360 m^2

4) Required personnel

- Manager : 1 person
- Engineer : 2 persons
- Operator : 10 persons
- Other : 2 persons

Total : 15 persons

Any inquiry about the information contained should be sent to:
IO/COOP, Registry file No. ID/562/12, UNIDO, P.O. Box 300, A-1400 Vienna, Austria

Cephalothin Synthesis Technology

In 1948, Bortzu found that cephalosporium acremonium was secreted in the sea in the vicinity of the sewerage discharge on the shore of Sardinian and that cephalosporin N, cephalosporin P and cephalosporin C were produced therefrom.

Based on this discovery, various semisynthetic cephalosporin products have been developed. Among these, cephalothin is a cephalosporin developed in initial stages and designed to be used for injection.

Highly effective against both gram-positive and gram-negative bacteria, cephalothin is an extensive antibiotic which can be primarily administered to penicillin-sensitive patients and all other cases infected with various inflammations, with its effect widely known.

In Korea meanwhile, one of the cephalothins, the best in the world, is currently in production with performances of having exported it overseas in quantities at lucrative prices.

The cephalothin synthesis technology introduced here is characterized by the simplicity and ease of its process, coupled with the production with no particular technologies involved.

Products and Specifications

Cephalothin Na produced on the basis of this technology is an extensive antibiotic in use for injection. Specifications of the product is as shown in table 1.

Table 1. Specification of Cephalothin

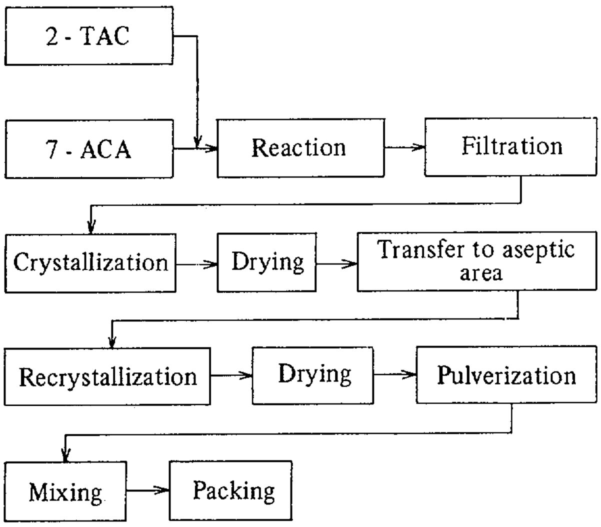
Item	Specification
Description	White crystalline powder
PH (25%)	4.5 - 7.0
Sp. rotation	$[\alpha]_D^{25} = +124 - +134°$
Water content	max. 1.5% (LOD)
Bioassay	min. 850 mcg/mg

Contents of Technology

1) Process Description

2-TAC is reacted in 7-ACA suspension, with sodium acetate added to the reaction mixture for crystallization. This crystal is moved to an aseptic room for recrystallization for use as injections.

Cephalothin Synthesis Process Block Diagram



2) Equipment and Machinery

SUS reactor
Seitz filter
Receiver (SUS 304)
SUS tank
Vacuum pump
Condenser
Centrifuge
Dryer
Reactor
Milling machine
Aseptic Hood
Pulverizer
Mixer
Nutze

3) Raw Materials and Utilities

Raw materials and utilities	Requirement (per ton of product)
7–ACA	1,000 kg
2–TAC	750 kg
Sodium acetate	630 kg
Electric power	–
Fuel	–
Water	14 tons

Example of Plant Capacity and Construction Cost

1) Plant capacity : 2m/t/year

* Basis : 24hrs, 250 days/year

2) Estimated construction cost (as of 1983)

- Manufacturing equipment : US$380,000
- Utility facility : US$152,000
- Installation cost : US$114,000

Total : US$646,000

3) Required space

- Site area : 700 m^2
- Building area : 360 m^2

4) Required personnel

- Manager : 1 person
- Engineer : 2 persons
- Operator : 8 persons
- Other : 2 persons

Total : 13 persons

Any inquiry about the information contained should be sent to:

IO/COOP, Registry file No. ID/562/12, UNIDO, P.O. Box 300, A-1400 Vienna, Austria

Pyrantel Pamoate Synthesis Technology

Pyrantel pamoate, originally used as an anthelmintic medicine for livestock, began to be administered to human beings as its high afficacy and low toxicity came to be widely known.

With an extensive anthelmintic range due to its actions suppressing the cholinesterase, unlike conventional anthelmintic medicines requiring meals to be skipped, it has an advantage getting rid of almost all parasites with a single dosage at any time.

In the case of simultaneous administration of oxantel pamoate capable of exterminating whipworms, its anthelmintic capacity proves almost perfect. Moreover, the round worms, tapeworms, hookworms and whipworms, which can be exterminated by these durgs are paracites widespread all over the world. When domestically produced and supplied, these medicines will not only greatly contribute to society and for that matter to the nation in terms of public health, but also will be significantly helpful in the technological development.

Products and Specifications

Pyrantel pamoate and oxantel pamoate produced on the basis of this technology are extensive anthelmintic medicines capable of exterminating various paracites in unison. Specifications of the products are as shown in table 1.

Table 1. Specifications of Pyrantel Pamoate and Oxantel Pamoate

Item	Specification	
	Pyrantel pamoate	Oxantel pamoate
Description	yellow to tan powder	slightly yellow powder
LOD	max. 2.0%	max. 3.0%
ROI	max. 0.5%	max. 0.5%
Heavy matals	max. 0.005%	max. 50 ppm
Iron	max. 0.0075%	max. 50 ppm
Pamoic acid	63.4 - 67.3%	97.0 - 103.0%
Assay	97.0 - 103.0%	97.0- 103.3%

Contents of Technology

1) Process Description

Pyrantel pamoate synthesis

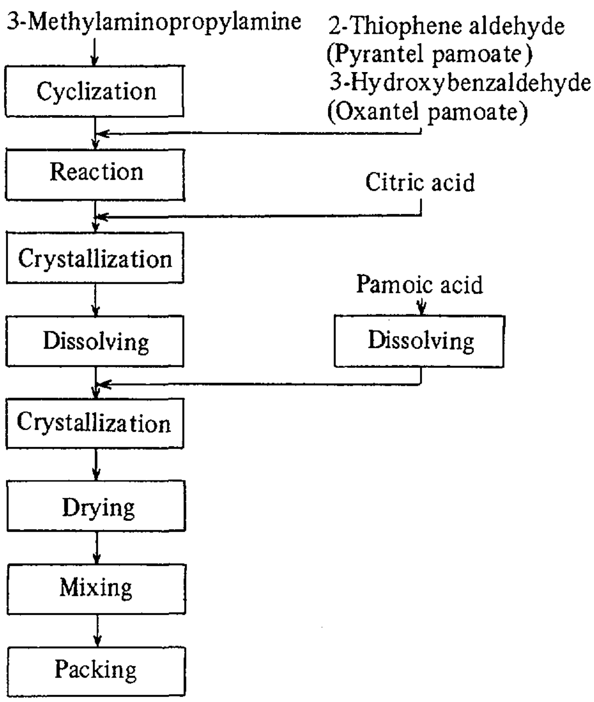
Acetonitride is first reacted with 3-methylamine propylamine to be further reacted with thiophene aldehyde and methylformate.

After distillation of the excess solvent, separately prepared ethyl alcohol solution of citric acid is added to the reaction mixture for reaction. Separately prepared DMF solution of pamoic acid is further added for recrystallization. The crystal is filtered and dried to obtain pyrantel pamoate.

Oxantel pamoate synthesis

The synthesis process of this medicine is almost similar to that of pyrantel pamoate except for several basic materials.

Pyrantel Pamoate & Oxantel Pamoate Synthesis Process Flow Diagram



2) Equipment and Machinery

Stainless steel reactor
Condenser (SUS 304)
Receiver (SUS 304)
Vacuum pump
Refractometer
Centrifuge
Dryer
Pulverizer
Mixer

3) Raw Materials

○ Pyrantel pamoate

Raw materials and utilities	Requirement (per ton of product)
MAPA	250 kg
TA	280 kg
Citric acid	600 kg
Pamoic acid	650 kg
Ethyl alcohol	1,200 ℓ

○ Oxantel pamoate

Raw materials and utilities	Requirement (per ton of product)
MAPA	380 kg
HBA	370 kg
Ethyl alcohol	2,300 ℓ
Citric acid	780 kg
Pamoic acid	650 kg

Example of Plant Capacity and Construction Cost

1) Plant capacity :

Pyrantel pamoate : 10 m/t/year
Oxantel pamoate : 5 m/t/year

* Basis : 24hrs/day, 250 days/year

2) Estimated construction cost (as of 1983)

○ Manufacturing equipment : US$190,000
○ Utility facility : US$101,000
○ Installation cost : US$ 76,000

Total : US$367,000

3) Required space

○ Site area : 700 m^2
○ Building area : 360 m^2

4) Required personnel

○ Manager : 1 person
○ Engineer : 1 person
○ Operator : 10 persons
○ Other : 2 persons

Total : 14 persons

Match Making Plant

The development of matches was preceded by centuries of experiment with many methods of fire making, but the production of fire by spontaneous chemical reaction was unknown until the 17th century.

A variety of experiments continued until the firction match, introduced in the 19th century, provided a means of making fire that was pocketable, reliable, safe and speedy.

With early methods of fire production it was common to use specially made splinters tipped with some combustible substance, such as sulfur, to transfer the flame.

An increased intrest in chemistry led to experiments to produce fire by direct means on the splinters.

The raw materials used by the match industry generally include wood splints, paper and chemicals such as potassium chlorate and red phosphorus. A global survey of the present state shows that the match industry is a monopoly in many countries.

Under this system matches are bought from private industry by the government, which monopolizes sales.

The consumption of matches steadily increased with the advance of sales of tabacco and increase in the population. Match makers can look forward to a continued increase in consumption as living standards go up.

Generally the consumption of match is three pieces per person. However, as can be seen in advanced nations, the supply would be eight pieces of match per person if match for advertisement could be anticipated.

Products and Specifications

- Wooden splint match (stick type)

The stick type match is generally square. But there are round and rectangular sticks. There are many kinds of woods for raw materials, such as white poplar is most widely used as splints.

The color, hardness and combustibility of white poplar are very superior.

- Paper splint match

The paper splint match is made from impregnated cardboard. It is widely used because it is suitable for advertisement. In order to preserve resources of wood and in countries where there are shortages of wood for match making, the paper splint match is used domestically.

Contents of Technology

1) Process Description

Splint manufacturing

Lumber is cut to suitable lengths by a circular saw. After the peeling of the bark, the log is peeled into veneer-like thin long shavings by the peeling machine. Then, the veneer-like shavings are split and chopped to the designated splint size by the chopping machine. These splints are impregnated by the splint impregnating machine and dried until 7% humidity. The dried splints are selected by the splint selecting equipment after drying, and the unsuitable splints are rejected.

Match manufacturing

The process starts from the feeding of suitable polished splints into the splints selecting and feeding machine. This machine is called the automatic match making machine. The selected splints are placed on trays where the splints are paraffined and dipped with head chemical; then, they are dried by the automatic match making machine.

Match box manufacturing

In this process, match boxes are manufactured to contain match sticks. Printed sheets for outer boxes delivered from printing houses are cut on a slitter, and cut and creased cardboard is delivered from paper stores. Then, paper boxes are made by the paper box making machine and side boxes are formed.

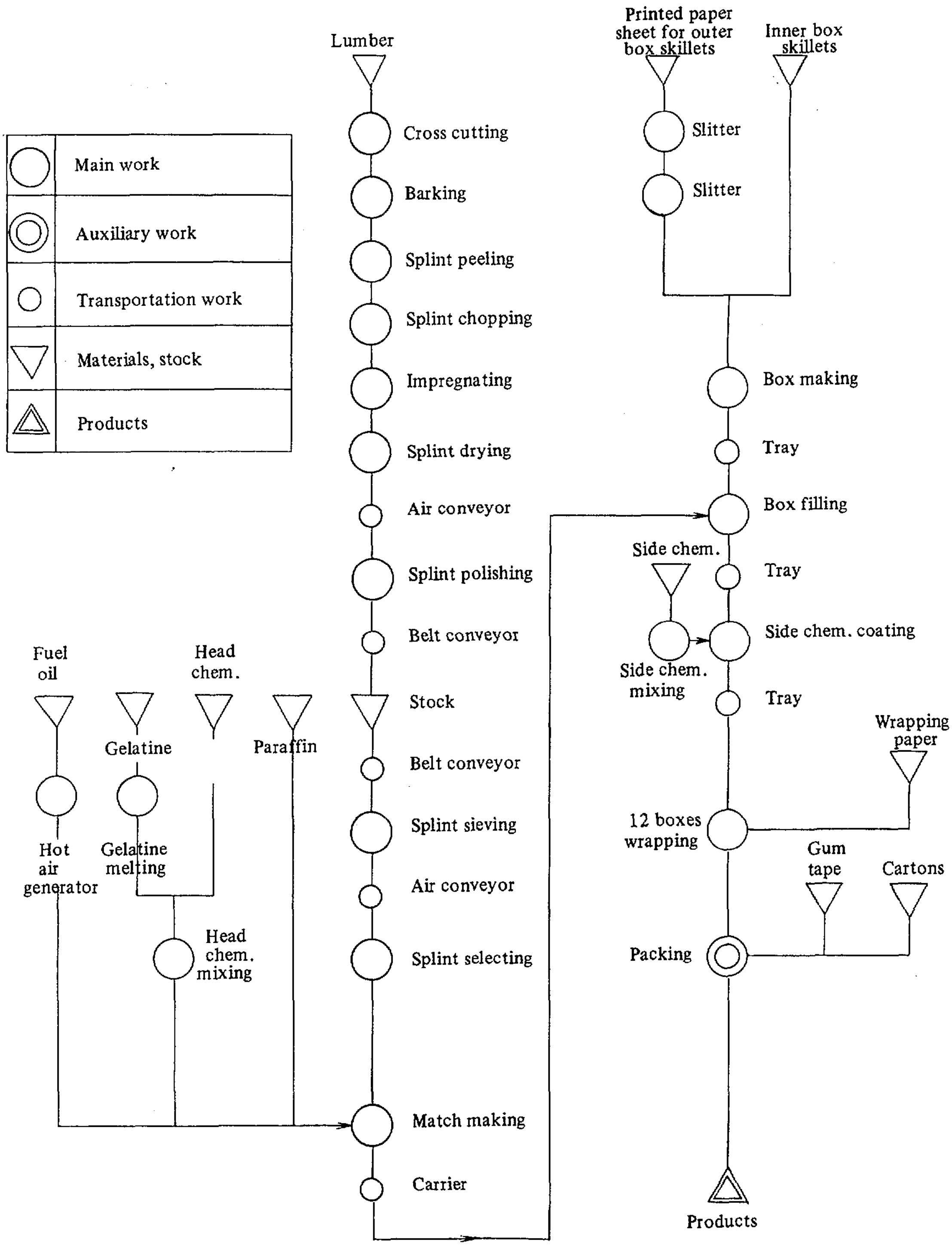
Filling

The match splints are filled into the match box by the automatic filling machine.

Finishing process

In this process, the side chemical coating machine applies chemical to the match boxes, which have been filled with match sticks by the box filling machine as they come on trays. Then the boxes are wrapped 12 boxes to a packet and 120 such packets are placed in a carton, and the matches are ready for marketing.

Match Manufacturing Process Flow Diagram



2) Equipment and Machinery

- Circular saw
- Peeling machine
- Chopping machine
- Impregnating and colouring machine
- Drying chamber
- Polishing machine
- Broken splint selecting machine
- Grinder
- Splinter collecting machine
- Automatic match making machine
- Oil furnace
- Ignition composition mixing machine
- Gelatin melting machine
- Slitter
- Box making machine

Match leveling machine
Box filling machine
Side chemical grinding machine
Side chemical coating machine
Packing machine

3) Raw Materials

Lumber for splint
$KClO_3$
Red phosphorus
Paraffin wax
Glue
Sulphur
Resin powder
MnO_3
Antimony sulphide
Glass powder
Potassium bichromate
Zinc oxide
Carbon-black
Box paper
Wrapping paper

Example of Plant Capacity and Construction Cost

1) Plant capacity : 2,000 gross boxes/day

* Basis : Box dimension . . . 51 mm x 36mm x 16mm
Length of splint . . 45.5mm x 2^2mm
No. of splint . . . 40 plints/box

2) Estimated equipment cost

○ Equipment and machinery :	US$714,000
○ Utilities :	US$ 20,000
Total :	US$734,000

3) Required space

○ Site area : 3,600 m^2
○ Building area : 1,500 m^2

FILE: H19
ISIC 3530

USED OIL REGENERATION

(prepared 1979)

Regeneration of used libricating oil has been increasing in recent years, partly on grounds of environmental protection, partly in order to reduce oil import requirements. The plant described in this profile is based on the acid/clay process, which has been successfully applied in many countries. Input capacity is 1,200 kg per hour of used oil, and resultant output - based on a 7 hour day, 250 days per year - would be around 1,500,000 kg of blended oils and 170,000 kg of gas oil. The plant has a capital cost of $ 1,564,150 and would employ 22 persons.

1. INTRODUCTION

The technology of used lubricating oil regeneration has been utilized for many years in industrialized countries and more recently in developing countries. This development has occured for two main reasons:

(i) to prevent pollution of ground and water by waste oil;
(ii) to reduce the need to import fresh crude oil or lubricating oils and hence diminish the national dependence on foreign sources.

The second reason is especially true for those developing countries which have no oil reserves.

2. TECHNOLOGY

A. Input Materials

The used oil regeneration plant is suitable to treat the following oils:

motor can oils (engine and gear); transformer oils; industrial oils (excluding steel-hardening oil and mixture of grease/oil); aviation lubricants; railway oils; and marine oils (bildge oils from ships).

In order to determine whether the waste oil is suitable for the treatment or not, laboratory tests have to be carried out.

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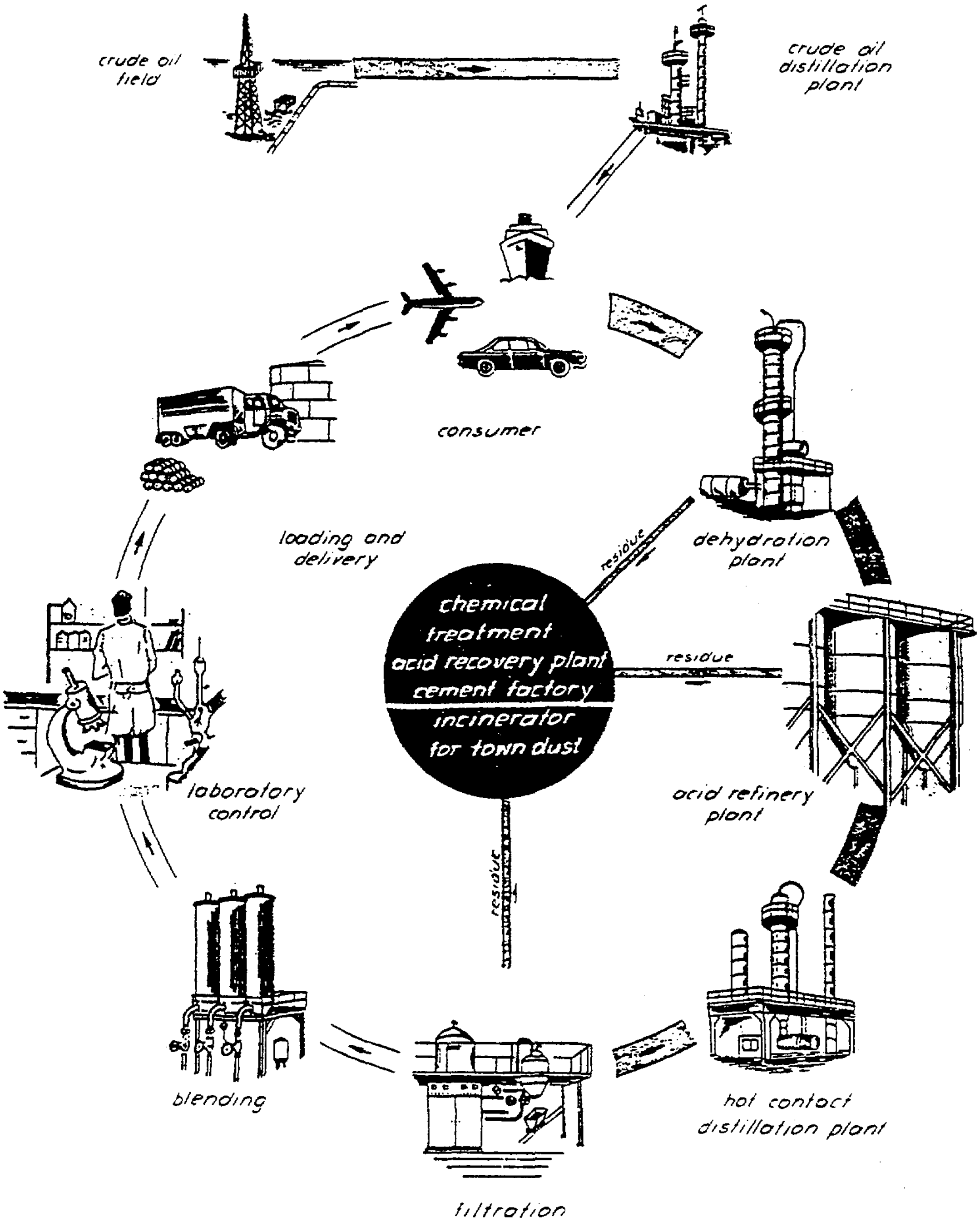
CIRCULATION OF LUBRICATING OIL



The plant presented in this profile is based on the acid/clay process. After a coarse filtration, collected oils flow into storage tanks, and then pass through different phases of the following processes.

- dehydration at 160°C under normal pressure; neutralization by sulphuric acid; decolourization by activated bleaching clay; vacuum distillation at 260° C-280° C, according to the oil viscosity intended; filtration through filter press to produce neutral lubricating oil; blending with additives and finally packaging.

The plant can be started within one hour and reaches after this time its full throughout capacity; it can be shut-down within 30 minutes, thus allowing a flexible scheme of operation.

C. Output Products

The acid/clay process is producing a regenerated oil that meets all characteristics required for virgin lubricating oils and from which many types of lubricating oil can be produced: crankcase-motor oils, gear-box oils, hydraulic equipment, industrial oils, etc.

Gas oil can be recovered at the end of the dehydration and the distillation phases, and can be used in the production process.

Residues from the process are waste water, acid tar, and filter cake. The waste water can be fed into an oil/water separator and afterwards channeled into the sewage system. The filter cake can be dumped in any refuse pit, and the acid tar can be stored in a refuse pit for chemicals, neutralized with lime or burnt in the rotating kiln of a cement plant.

D. References

The acid/clay process in the method of oil regeneration what has been most successfully applied in many countries: about 40 plants are operating or under construction units with a throughput capacities varying from 1,000 to 16,000 kg/hour.

3. PLANT CAPACITY

The plant described below is a small unit, the capacity of which can meet the requirements of many ACP countries, taking into account the size of markets and the transportation problems for collected oils.

A. Treatment Capacity

1,200 kg/h of used oil containing less than 2.5% water, i.e. 2,100,000 kg/year (7 h/day, 250 d/year).

B. Output Capacity

(i) 884 kg/h of blended oil, i.e. 1,547,000 kg/year; the blended oil contains 6.3% additives in average.

(ii) 100 kg/h of gas oil, i.e. 175,000 kg/year.

C. Waste Materials

(i)	waste water	170 kg/h	300,000 kg/year
(ii)	acid tar	245 kg/h	430,000 kg/year
(iii)	filter cake	65 kg/h	114,000 kg/year

The cost of disposal of waste material is taken as $ 0.012 per kg.

4. MATERIALS AND UTILITIES

Item	Consumption/hour	Annual consumption	Unit price($)
Used oil	1,200 kg	2,100,000 kg	0.027
Sulphuric acid 98-99%	112 kg	196,000 kg	0.61
Bleaching clay	42 kg	73,500 kg	0.49
Lime	1 kg	1,750 kg	0.65
Ammonia water 23%	6 kg	10,500 kg	1.23
Salt	0.5 kg	875 kg	0.28
Hydrazin	10 g	17.5 kg	0.001
Filter paper 70 g/m^2	4 m^2	7,000 m^2	0.25
Gas oil	140 kg	245,000 kg	0.25
Electric power 500 V	110 kW	192,500 kW	0.018
City water	3 m^3	5,250 m^3	0.37
Additives (aver.quantity)	56 kg	98,000 kg	1.59
210 litre drums (used several times)		4,000	30.00

Packaging can also be made according to the specific needs of the market.

5. WORKFORCE REQUIREMENTS

The following table shows personnel requirements for 1 shift production.

If it is necessary to produce on 2 shifts, there will be an additional demand of 3 operators and 8 unskilled workers.

Position	Number	Salary per year ($)
Commercial Manager	1	15,000
Production Manager	1	15,000
Chemist	1	9,300
Office clerk	1	2,250
Secretary	1	3,000
Operators	3	1,750
Welder	1	750
Fitter	1	750
Electrician	1	750
Unskilled workers	8	375
	15	

In addition 3 trucks drivers will be needed in connection with the collection of used oil. Their salaries have been included in the cost of the used oil.

6. INVESTMENT COST

The following figures have been extracted from a feasibility study done in 1978 for an ACP country in Africa, and, especially figures corresponding to local costs, must be considered only for guidance.

A. Fixed Investment

Item	Local $	Imported $
Site preparation	11,350	
Buildings	189,000	
Waste oil acceptance	32,750	4,550
Dehydration plant	137,350	34,450
Acid treatment	40,300	15,000
Distillation plant	144,900	85,000
Filtration plant	44,100	69,000
Intermediate tanks	71,800	22,050
Blending plant	50,400	66,350
Filling station	6,800	13,650
Laboratory equipment	5,300	47,250
Auxiliary equipment	85,700	117,900
3 trucks with 5m^3 tanks	-	60,400
Trailer with intermediate tanks	-	6,300
Freight and insurance	-	52,500
	819,750	594,400

Local part	$ 819,750
Imported	$ 594,400
	$1,414,150

B. Pre-Investment Expenses

This item amounts to $ 150,000 and comprises cost for:

- engineering works
- assistance to the plant erection and the start-up
- training of the Production Manager in Europe
- training of the local staff

C. Working Capital

This can be estimated according to the following requirement:

Item:	Required stock	Cost ($)
Used oil	6 weeks	6,800
Local raw materials	2 weeks	7,780
Imported raw materials	8 weeks	25,200
Finished products	4 weeks	65,220
Drums	5 weeks	12,570
Debtors	4 weeks	105,130
Personnel cost	1 month	4,500

In the case of the specific ACP country concerned, the working capital amounts to $ 227,200.

D. Total Capital Requirements

		$
Fixed investment		1,414,150
Pre-investment cost		150,000
Working capital		227,200
	Total	1,791,350

7. ANNUAL OPERATION COSTS

A. Operating Costs

Materials and utilities		570,800
Salaries		55,050
Repairs and maintenance (2% fixed capital)		28,300
Disposal of waste materials		10,200
Overheads (1% fixed capital 5% working capital)		25,500
	Total	689,850

B. Products Obtained

As mentioned earlier, the capacity output of the plant is 1,547,000 kg of blended oil and 175,000 kg of gas oil per annum. In the economic evaluation reported below it is assumed that annual sales comprise 1,500,000 kg of blended oil and 170,000 kg of gas oil.

8. EVALUATION (values in US $)

This is based on 10 year operating life, a 3 year build up to full capacity production, and a residual value for land, building and equipment. Fixed investment is 1,414,150 and pre-investment cost is 150,000. Working capital, 227,200 is taken in 3 installments. On year 1 : 75,734; on year 2 : 75,733; on year 3 : 75,733. The residual value, 300,000 , and working capital, 227,200, are returned in the 10th year of operation.

Thus, production costs build up as follows:

	Year 1 capacity (1/3)	Year 2 capacity (2/3)	Year 3 capacity (full)
Materials + fuel + water + elect.	190,267	380,533	570,800
Wages and salaries	55,050	55,050	55,050
Waste disposal	3,400	6,800	10,200
Repairs and maintenance	9,433	18,867	28,300
Overheads	25,500	25,500	25,500
	283,650	486,750	689,850

The following are the results of NPV analysis:

Discount Rate	Present value of total costs	Annual revenue required	Revenue required per kilo of oil
10%	5,250,366	997,664	0.63
20%	4,051,433	1,190,091	0.76
30%	3,351,046	1,406,820	0.91

As 170,000 kgs of gas-oil ($ 0.25/kg) is obtained per year, a constant value of $ 42,500 is substracted from annual revenues to get the sum which divided by 1,500,000 gives the revenue per kilo in the last column.

9. TECHNOLOGY TRANSFER CONDITIONS

The technology offered is not subject to a patent registration, thus there are neither any royalties nor licensing agreement for the exploitation, and the know-how is supplied as a part of the whole offer.

10. TIME SCHEDULE FOR ERECTION OF THE PLANT

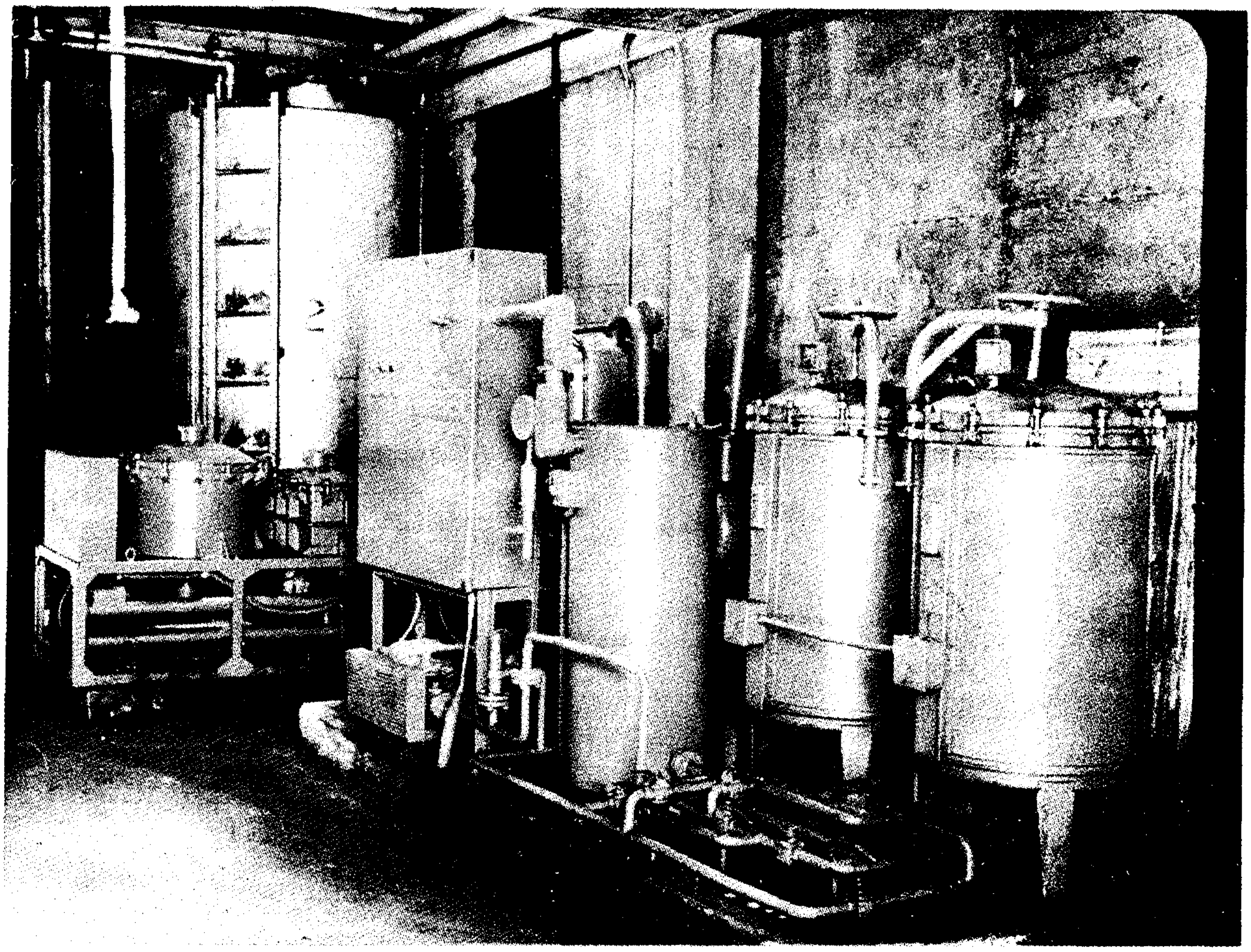
Engineering works can be completed 3 months after the order, and equipment delivered 5 months later. The start up of the plant can be expected 12 months after the order.

11. SPECIFIC ASPECTS

The problem of collection of used oil must be considered with particular attention: infrastructure aspects, quantity available, incentives or assistance to the storage of used oil, all require careful consideration.

The efficiency and the cost of collection will determine the success and the profit-making capacity of the project.

Transformer Oil Making Plant



View of Vaccum Filtration Set

Petroleum has long been used as insulating oils serving the purpose of insulating and cooling media for high-tension electric equipment. In particular, as the insulating oil was produced by using wax-free crude oil in early days of this century, it was possible to produce a product easily used in cold winter.

Depending upon uses, insulating oils are divided into various kinds, including the insulating oil for circuit breakers and transformers, condenser oil for high-tension condensers and oil-filled cables and cable oil for insulating the core wire of impregnated power transmission cables. The technology introduced here is related to the insulating oil for circuit breakers and transformers.

The transformer oil generally needs to be highly refined and free from the occurrence of degeneration due to impurities. It should also be large in insulating strength and excellent in cooling action, while having low pouring point to suit the use at low temperatures.

The production of this item requires high degree of refining and processing skills, since it should be low in evaporation loss at the level of 100°C and appropirate in inherent resistivity and total oil power factor. Because of such a need for refining, the transformer oil is generally 3-5 times as high as aviation oil in prices. Therefore, the transformer oil is one of the industrial products capable of maximizing the utility of petroleum resources and creating high added values.

Furthermore, this product is closely related to the service life of electric equipment having higher weight in industrial plants, justifying the need for its production from the standpoint of protecting industrial facilities of respective countries.

Since its production is possible on the basis of relatively simple processses such as acid refining, neutralization, adsorption and filtration, while the burden of funds for the construction of a production plant is affordable, this transformer oil is a product particularly suiting economic conditions of the developing countries.

Table 1. Typical Specifications of Transformer Oil

Properties		ASTM Test method	Mictrans		
			A	B	C
Color		D1500	L0.5	L0.5	L0.5
Flash point °C		D92/D93	156/152	154/150	154/150
Interfacial tension @25°C, dyne/cm		D971	45	45	45
Pour point, °C		D97	−22.5	−32.5	−47.5
Specific gravity, 15/15°C		D1298	0.874	0.878	0.880
Viscosity, cst,	@ 100°C	D445	2.50	2.50	2.50
	@ 40°C		9.38	9.45	9.60
	@ 20°C		22.10	22.35	22.65
	@ 0°C		54.0	55.0	57.0
	@ −15°C		155	158	165
Visual examination		D1524	clear & bright		
Dielectric breakdown voltage @60Hz					
Spherical electrodes, kV		(BS 148)	45	45	45
Disk electrodes, kV		D877	35	35	35
Power factor @ 60Hz, %,	@ 25°C	D924	0.01	0.01	0.01
	@ 100°C		0.07	0.07	0.07
Resistivity, ohm-cm,	@ 50°C	D1169	5×10^{14}	5×10^{14}	5×10^{14}
	@ 80°C		1.5×10^{14}	1.5×10^{14}	1.5×10^{14}
Corrosive sulfur		D1275	noncorrosive		
Water content,	ppm	D1533	20	20	20
Neutralization number,	mg KOH/g	D974	0.01	0.01	0.01
Oxidation stability					
72hrs @ 110°C	Sludge, % wt	D2440	0.03	0.03	0.04
	TAN, mg KOH/g		0.10	0.10	0.10
164hrs @ 110°C	Sludge, % wt		0.06	0.06	0.08
	TAN, mg KOH/g		0.18	0.18	0.20
75hrs @ 120°C,	Sludge, % wt	(JIS C2101)	0.06	0.06	0.07
	TAN, mg KOH/g		0.12	0.12	0.13

- The above data are recent average values only.
  Minor variations not affecting the product performance are to be expected in normal manufacturing.
- Any specific requirement can be met on request.

Products and Specifications

The transformer oil produced is this plant is an electrical insulating oil of high quality specially refined and carefully processed with the experiences of the past 20 years. The products are classified into two different series-Mictrans and Mictrans suffix I. The former is uninhibited mineral oil while the latter is inhibited one.

The general properties of these products are as follows:

- Superior electric properties
  High dielectric breakdown strength, low power factor and high resistivity.
- Fine physical and chemical stability
  Excellent oxidation stability and non-corrosive for long operations.
- Good in cooling effect
  Swift heat absorbing and discharging property.
- High flash point and low evaporation loss.

Contents of Technology

1) Processs Description

The production of insulating oil consists of four processes with the following general descriptions:

Sulfuric acid refining process

It is a process in which such impurities as aromatic compound, resin, asphalt and nitrate contained in the raw material oil are removed by adding a small amount of sulfuric acid. After sulfuric acid treatment, the impurities are eliminated from the product by setting at normal temperature, and the product is subjected to the next process of neutralization.

Neutralization process

Following the acid treatment, the oil is neutralized with caustic soda for the removal of naphthenic acid and free acid still contained. The treated oil is sent to the adsorption process after setting and reheating to the temperature of 60-80°C.

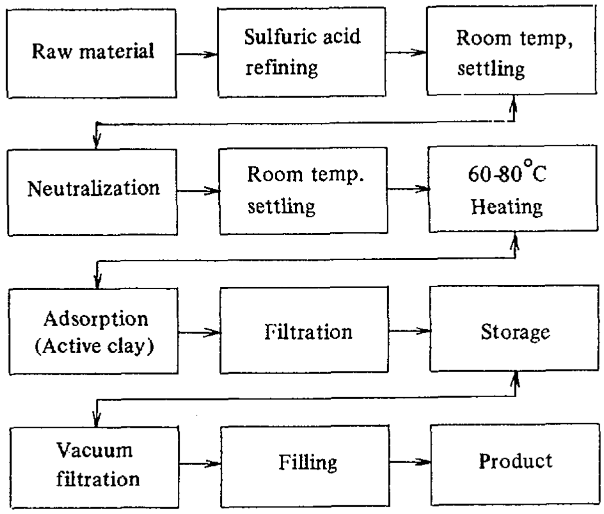
Adsorption process

It is a process in which the oil is refined by treating with active clay under the condition of heating to remove residual impurities or free water.

Vacuum filtration

The oil removed of almost all impurities is subjected to vacuum filtration to completely eliminate some moisture, ozone and oil still remaining in the oil and could influence the deterioration speed of the transformer oil. Following the vacuum filtration, the oil undergoes product inspection to be filled in containers as final products.

Transformer Oil Manufacturing Process Block Diagram



2) Equipment and Machinery

Raw material storage tank
Gear pump
Filter press
Boiler
Water storage tank
Acid refining tank
Neutralization tank
Alkali storage tank
Clay treating tank
Vacuum filteration set
Automatic filler
Compresser

3) Raw Materials

Raw materials	Requirement (per ton of product)
Crude oil (Naphthenic or paraffinic crude oil)	1.18 ton
Sulfuric acid	0.1 ton
Sodium hydroxide	0.01 ton
Active clay	0.08 ton
Filter paper	–
Filter cloth	–
Additive	–

Example of Plant Capacity and Construction Cost

1) Plant capacity : 30,000 ℓ/day
   * Basis : 8 hrs/day

2) Estimated construction cost

○ Manufacturing equipment	: US$ 100,000
○ Utility facility	: US$ 7,000
○ Installation cost	: US$ 160,000
Total	: US$ 267,000

3) Required space

- ○ Site area : 3,000m²
- ○ Building area : 1,200m²

4) Personnel requirement

○ Manager	: 1 person
○ Engineer	: 2 persons
○ Operator	: 10 persons
Total	: 13 persons

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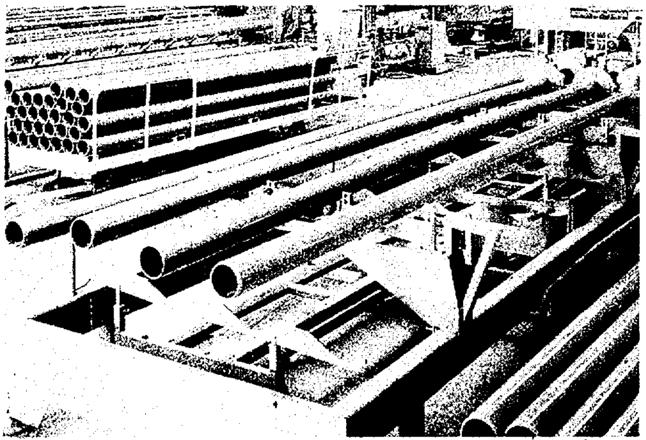
FILE: K13
ISIC 3560

Rigid PVC Pipe Making Plant


View of PVC Pipe Plant

As far as pipes are concerned, mainly metallic pipes have been used so far. With the development of synthetic resin industry, however, synthetic resin pipes have also been developed. The development of its molding technology has greatly improved the performance of synthetic resin pipes, replacing metallic pipes rather significantly.

The mainstay of the synthetic resin pipes is the rigid PVC pipe, being especially useful for transporting strongly corrosive chemicals and gases because of its superb resistance to corrosion. The rigid PVC pipe is non-toxic and in no way reacts with the fluid being transported nor affects the taste, flavor and color. Besides, smoothness of the interior surface of the pipe precludes any pressure loss related to fluid flow or occurrence of the deposit or scale which interfere with the fluid flow. Being flameproof, the PVC pipe is free from the hazard of fire. It is electrically an insulator and electrolytic corrosions, which frequently occur in metallic pipes, can be prevented. Particularly, since it has a large tensile strength and flexible, the PVC pipe is not subject to pressing or denting by pressure. It is light and makes its transportation and subsequent piping relatively easy.

Because of such varied characteristics, PVC pipes are being widely used in drainage piping as well as in pipings for general industries, gas and oil supply, irrigation, waste water treatment and electric conduits, with its demand steadily increasing.

In the long run, the PVC pipe is an essential piping material in making facilities light, durable and less expensive. In view of its large scale in market and expanding scope of uses, a continuous expansion is expected in the days ahead. The rigid PVC pipe manufacturing plant is evaluated to contribute to the development of plastic processing industry as well as other industries.

The PVC pipe manufacturing plant introduced here is capable of manufacturing diverse specifications on the basis of accumulated technologies over the years to match products of such public standards as BS, DIN and ASTM.

Products and Specifications

In this rigid PVC pipe manufacturing plant, products of varied types are manufactured to suit the conditions of piping. The products break down into four different types of plain ended pipe, rubber ring joint type pipe, TS type pipe (one end socket type, solvent cement welding method) and high impact type pipe.

Among them RR type and TS type are designed to help pipe more quickly and economically. In RR type pipes, a rubber ring is inserted in the groove formed at one end of the pipe and the other pipe is jointed by employing lubricant (See fig. 1) with the following advantages:

Advantages of RR method

- RR pipe is very simple and virtually foolproof. The design reduces the risk of making a faulty connection because the rubber gasket resists creeping out of the groove when the pipe is jointed.
- RR joint is flexible enough to allow for contraction, expansion or deflection caused by soil movement.
- The jointing work can be done in any weather condition.
- You simply lubricate the joint and push the pipe together, resulting in permanent joint with practically no leakage.
- The wall of the bell is thicker than the pipe providing additional strength at the joint and more resistance to deflection or other unexpected or adverse installation condition.
- One man can easily handle the operation because there is no solvent cement or heating required, so

RR pipe is most economical.
- No solvent cracking.

TS is abbreviation of taper sized solvent welding type. It is a method of jointing taking advantage of swelling of the PVC pipe caused by solvent cement (See fig. 1) with the following advantages:

Advantages of TS method
- TS joints are easily and quickly done in seconds by using solvent cement only.
- Connection strength is enough so that there is no leakage.
- No heating operation is necessary for the jointing, so no fire trouble will be caused.
- Jointing work can be done in any weather conditions.
- No skilled jointing technique is needed.
- Very economical method because of easy and fast connection.

In high impact type pipes, they are reinforced pipes in terms of mechanical strength, elasticity and impact strength. With the impact strength 3-5 times higher than ordinary PVC pipes, these PVC pipes for use in the area where the temperature is relatively low and the impact resistance is required.

Fig 1. RR and TS Jointing Method of PVC Pipe

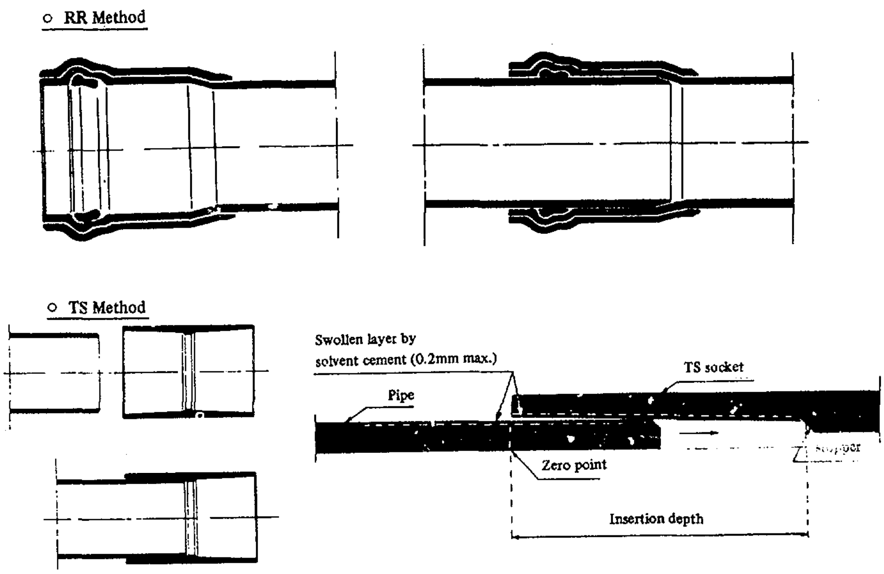


Table 1. Specifications of PVC Pipe

Name \ Item	Nominal size (mm)	Outside diameter (mm)	Wall tolerance (mm)	Wall thickness (mm)	Approximate inside diameter (mm)	Calculated weight (gr/m)
Plain ended pipe						
Water service	13 – 300	18 – 318	±0.25–±1.10	2.5 – 16.1	13 – 286	174 – 21,825
General purpose (pressure)	10 – 300	15 – 318	±0.6 –±2.2	2.2 – 15.1	10 – 286	140 – 21,962
General purpose (non-pressure)	35 – 300	42 – 318	±0.4 –±1.4	1.8 – 9.2[1]	38 – 298	359 – 13,701
Electrical conduit	14 – 100	18 – 111	±0.20–±0.50	2.0 – 5.9	14 – 100	144 – 2,605
Rubber ring joint type pipe						
Water service	50 – 300	60 – 318		4.5 – 16.1		7,088 – 144,962[2]
Irrigation & general purpose	50 – 300	60 – 318		4.1 – 15.1[1]		7,010 – 144,046[2]
Sewerage	100 – 300	114 – 318		3.1 – 9.2[1]		11,028 – 90,906[2]
Drain & vent	35 – 150	42 – 165		1.8 – 5.1[1]		359 – 3,941
TS pipe[3]						
Water service	50 – 300	60 – 318		4.5 – 16.1		6,808 – 137,979
High impact PVC pipe	14 – 80	18 – 111	±0.20–±0.50	2.0 – 5.1	14 – 100	

Remarks : 1) Minimum wall thickness
2) Calculated weight (gr/pc)
3) One end socket type, solvent cement welding method.

Contents of Technology

1) Process Description

The process of extrusion consists, basically of forcing hot plastic melt through a die having an opening shaped to produce a desired finished cross section.

Extrusion

PVC compounds which are mixed with PVC resin, stabilizer, lubricants and other additives are fully plasticized and passed on to the die by extruder which consists of barrel and screw.

Cooling

Hot PVC melt issued through the die passes through a cooling water bath.

Pulling

Cooled PVC pipe is pulled by caterpillar puller.

Cutting

After pulling, the pipe is cut to length by travelling saws.

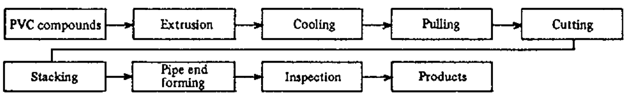
Stacking

After cutting, the pipe is stacked by automatic stacking unit.

Pipe end forming

The pipe end is heated and formed by socketing and grooving machine.

PVC Pipe Manufacturing Process Block Diagram



2) Equipment and Machinery

Manufacturing equipment

- Twin screw extruder
- Cooling unit
- Haul-off unit
- Cutting unit
- Stacking unit
- Auto loader
- Socket forming m/c
- Crusher
- Die block, die & mandrel
- Printer
- Crane
- Fork lift
- Resin tank, etc.

Laboratory equipment

- Tensile strength tester
- Impact tester
- Dielectric strength tester
- Heat distortion tester

3) Raw Materials and Utilities

Raw materials and utilities	Requirement (per ton of product)
PVC resin and additives	1.02 ton
Electric power	37 kwh
Water	40 m^3
Air	55 m^3

Example of Plant Capacity and Construction Cost

1) Plant capacity : 5,100m/t/year
   * Basis : 20 hours/day, 25 days/month

2) Estimated equipment cost (as of Sep., 1981)

o Manufacturing machinery	:	US$1,755,810
o Laboratory equipment	:	US$ 49,420
o Tools for maintenance	:	US$ 14,200
o Utility facilities	:	US$ 49,640
Total (FOB)	:	US$1,869,070

3) Required space

- o Site area(120mx80m) : 10,560m^2
- o Building area : 1,808m^2

4) Personnel requirement

o Plant manager	:	1 person
o Engineer	:	2 persons
o Operator		
Extruder	:	9 persons(3persons/shift)
Socket forming machine	:	4 persons (2persons/shift)
Crusher	:	1 person
Testing equipment	:	1 person
Maintenance & power service	:	6 persons (2 persons/shift)
Machine tool	:	1 person
o Office worker	:	4 persons
o Warehouse and products shipping worker	:	4 persons
o Guard	:	3 persons
Total	:	36 persons

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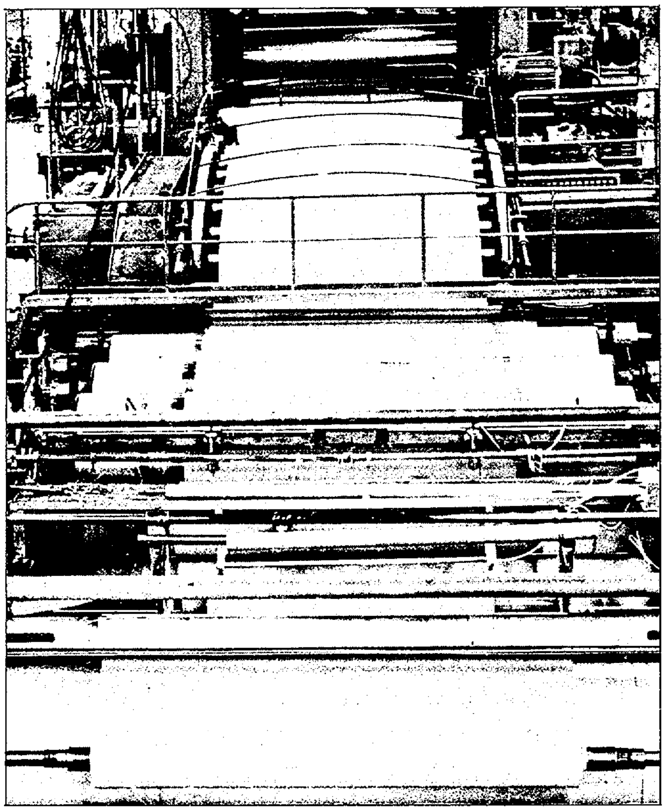
PVC Flooring Making Plant



View of Calendering Machine

As the living standard of mankind improves, the desire to improve its own living environment also rapidly increases. Particularly, an increase in westernized apartment houses as well as mansions stimulates the demand for proper interior materials. Floor coverings are foremost among them.

However, such floor coverings must have characteristics and function matching uses and purpose of customers. In other words, a floor covering should be resistant to tear and wear and durable not to be easily damaged or deformed in its long use. Changes in the quality of a floor covering due to such external factors as water, chemicals and rays of the sun, depending upon the condition of its use, should be minimized.

Besides, it also should have various characteristics of the anti-static property, soundproofness, sound absorptivity, heat insulation, cushion effect and sanitation not to affect the human body or arouse discomfort.

To add to such varied features, the interior material should have both natural beauty and formative beauty capable of excerting comfortable and pleasant influences on human psychology.

On the other hand, the economy is also an important element promoting the sale of floor coverings with varied functions to customers. In other words, it should be comparatively low-priced and also convenient as well as economical in its installation and maintenance.

A floor covering developed in line with various required characteristics as described above is the PVC floor covering with wide uses for stores, hotels, general buildings, offices, hospitals and other commercial installations, not to sepak of households.

The excellent cushion property coupled with its economy have been continuously expanding its demand. In the long run, the relative low price of the PVC floor covering plays a significant role in improving the living environment while the demand is expected to increase in the future as the living pattern is quickly westernized. In this respect, the necessity of the PVC floor covering is fully recognized.

Products and Specifications

As can be seen in fig. 1, the floor covering produced in this plant consists of four layers. Its upper layer is 0.08mm, the middle layer is 0.12mm and the bottom layer is 0.6mm, the total thickness being 0.8mm.

Fig 1. Structure of PVC Flooring

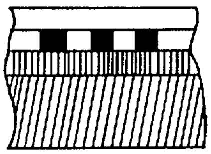


Fig 2. Structure of PVC Sponge Flooring

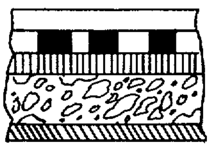


Table 1. Specifications of PVC Floor Covering

Item / Spec.	PVC flooring		Sponge flooring	
Thickness	0.8mm approx.		2.0mm approx.	
Width	72"	80"	72"	80"
	183cm	203cm	183cm	203cm
Net weight	72" Approx. 2,100gr/yd 80" Approx. 2,330gr/yd		72" Approx. 1,400gr/yd 80" Approx. 1,560gr/yd	
Packing	Just 30yds (or 25 yds) per roll in continuous length to be wrapped with woven cloth		Same as left	
Min. q'ty/color	1,500 yds		1,200 yds	

Products of respectively 72" and 80" in width are usually manufactured (table 1), with the production of diverse products in color and design customers require also possible.

When an expanding oven is added to this production line, the sponge flooring with the structure as shown in fig. 2 is also possible.

Contents of Technology

1) Process Description

The manufacturing process of PVC flooring generally consists of the following sections:

Blending

PVC resin, plasticizer, stabilizer, filler and other additives are blended homogeneously by mechanical ribbon type blender or henschel mixer.

Banbury mixing

After blending, PVC compounds are fully plasticated by powerful shearing stress between chamber and special shaped two steel rotors in this chamber under high temperature and pressure.

Two roll milling

Plasticated PVC compounds are more plasticated by open type horizontal two steel rolls to some temperature range to make PVC compounds rolling easy on calender rolls. Two roll mill feeds a hot PVC compound strip to the calender and strip temperature can be between 340-350°F.

Straining

In case of using some parts of PVC scrap to produce back layer, mixed PVC compounds with some virgin and scrap grade after two roll milling are fed to strainer to filter impurities in the PVC compounds, passing the screen mesh of die head in front of strainer. The strainer feeds a linear bar type PVC compounds to the calender continuously.

Calendering

The fed PVC compounds, bar type, is rolled to sheet of desired thickness by four steel rolls, passing these four rolls. The first calender rolls contacted are the coolest, while the last of strip off roll is the hottest (350-370°F). Hot PVC sheet issued through the calender pass through several cooling drums and then are wound up to desired length on surface winder.

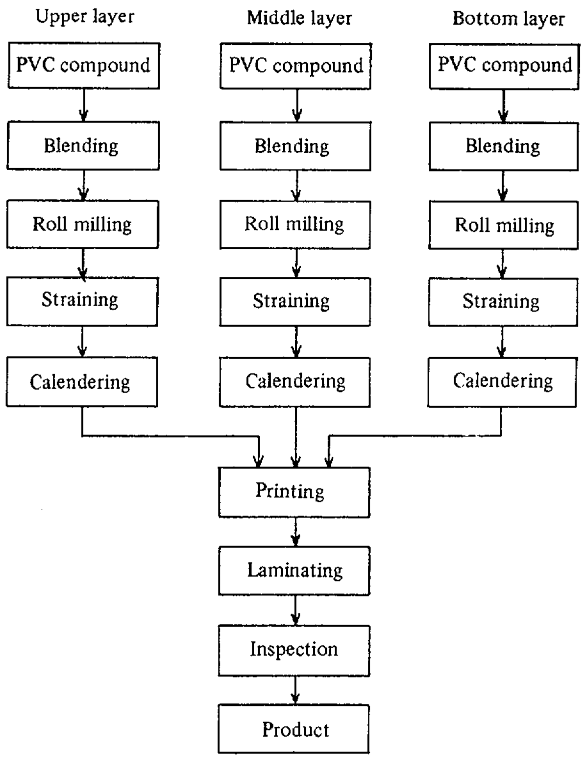
Printing

The middle layer sheet in roll are printed on printing machine to give some desired printing pattern.

Laminating

The three kinds of sheet, upper layer, middle layer after printing and bottom layer, are laminated on the laminating machine to make finished products.

PVC Flooring Manufacturing Process Block Diagram



2) Equipment and Machinery

Manufacturing equipment
- Blender
- Banbury mixer
- Two roll mill
- Strainer
- Calender and all electrical equipment

Printer
Laminator

Auxiliary equipment
Boiler
Feed pump
Feed water tank
Service tank
Bunker-C oil storage tank
Water treating equipment
Compressor
High voltage tie-transformer
Low voltage tie-transformer
Calender
Conveyors
Overhead crane
Cooling-water manufacturing equipment

Laboratory equipment
Tensile strength tester
Test roll mill
Sieve analyzer
Test oven
Viscometer
Specific gravity tester

3) Raw Materials and Utilities

○ Raw materials

Raw materials	Requirement (per 100,000m of PVC flooring)
PVC resin	33.1 tons
PVC scrap	146.4 tons
Plasticizer	9.8 tons
Stabilizer	1.2 tons
Pigment	3.0 tons
Filler	105.5 tons
Other additives	1.8 tons

* Basis : Product size 0.8 mm x 72"

○ Utilities

Utilities	Requirement
Electric power	1,540 kwh
Water	123.7 m^3/hr
Steam	2,958 kg/hr
Air	364 m^3/hr

* Estimated for the plant with capacity, 400,000m/ month

Example of Plant Capacity and Construction Cost

1) Plant capacity : 400,000 m/month
 * Basis : 20 hours/day, 25 days/month, 0.8mm x 72" product.

2) Estimated equipment cost (as of Dec., 1981)

○ Manufacturing machinery	:	US$3,063,000
○ Utility facilities		US$ 693,130
○ Laboratory equipment		US$ 60,200
Total (FOB)	:	US$3,816,330

3) Required space

○ Site area : 16,000m^2 (160m x 100m)
○ Building area : 4,228m^2

4) Personnel requirement

○ Section chief	:	1 person
○ Engineer	:	2 persons
○ Operator (per shift)		
Foreman	:	2 persons
Blending	:	4 persons
Banbury	:	4 persons
Mixing and straining	:	3 persons
Calendering	:	4 persons
Printing	:	6 persons
Laminating	:	4 persons
Inspection	:	2 persons
Total	:	32 persons (per shift)

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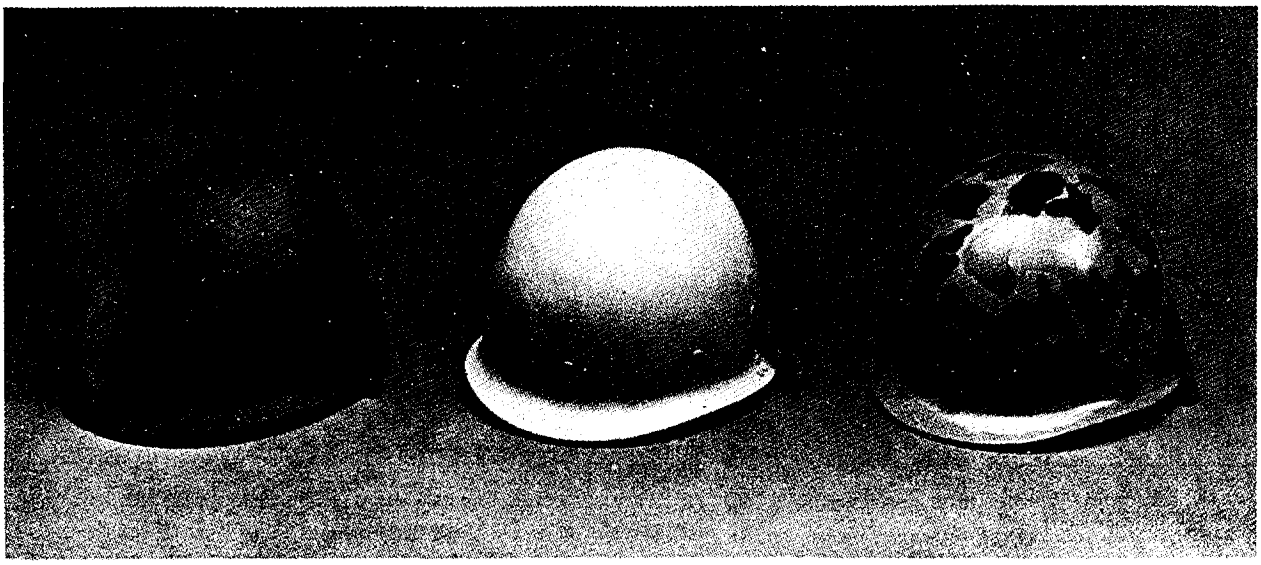
FILE: K15
ISIC 3560

NRP Ballistic Helmet Making Plant



NRP Ballistic Helmet

NRP (Nylon Reinforced Plastic) Ballistic Helmet has been designed to replace heavier steel halmets while still meeting all the requirements in headgear design for combat wearing.

The new NRP Ballistic Helmet assures maximum comfort and also overcomes the disadvantages of conventional steel helmets.

Advantages of the NRP Ballistic Helmet

Better bullet-proof effect:

The results of tests performed by a world-famous testing laboratory have shown that the NRP Ballistic Helmet has better bullet-proof capability than standard steel helmets. This is due to the high elastic property of the laminated materials. These test results, accepted by the Korean Armed Forces, have demonstrated that the NRP Ballistic Helmet is serviceable combat headgear of the highest quality.

Light weight:

The NRP Ballistic Helmet is molded under high pressure, using special resin-impregnated nylon cloth. The total weight of the NRP Helmet is more than one pound lighter than a standard steel helmet.

Simple design:

Old steel helmets, consisting of the helmet liner and a steel shell, are quite uncomfortable and unstable in active combat conditions. The new NRP Helmets come in one piece with the interior harness attached directly to the shell. The easily interchangeable inner fittings are made of cotton webbing, high quality leather, and corrosion-resistant steel parts.

Lower heat conductivity:

Conventional steel helmets are extremely uncomfortable to wear in hot weather. The new NRP Ballistic Helmet, however, has a much lower heat conductivity so that it is comfortable to wear in hot as well as cold weather.

Interiors:

Interiors are removable. Therefore a user can easily replace the helmet by himself in case the helmet or interior is damaged.

Comparison Between Steel Helmet and NRP Ballistic Helmet

Particular \ Helmet	NRP ballistic helmet	Steel helmet
Weight (gram)	800 - 900±50	1,450 including steel and liner
Thickness (mm)	Top 4.9 - 5.7 ± 0.2 Side 4.4 - 5.2 ± 0.2	1.2
Bullet proof effect (fps) V50	Min. 1,000	Min. 900
Unit	One unit	Two unit
Interior	Removable	Fixed to fiber liner

Products and Specifications

The helmets produced in this plant varies depending upon its uses. The standard products are ground troop's helmet, parachutist helmet, rock jumping helmet, navy ballistic helmet and linear helmet, and their specifications are as shown in table 1.

Table 1. Specifications of NRP Ballistic Helmet

Products	Application	Specifications
NRP Ballistic helmet	Ground troop's helmet	OM-101, olive green 900 ± 50 gr OM-102, desert tan 900 ± 50 gr OM-103, jungle camouflage 900 ± 50 gr
	Parachutist helmet	OM-104, 930 ± 50 gr OM-204, 880 ± 50 gr OM-304, 420 ± 14 gr
	Rock jumping helmet	OM-401
	Navy ballistic helmet	OM-501
	Liner helmet	OM-301, olive green 380 ± 14 gr OM-302, desert tan OM-303, jungle camouflage

Contents of Technology

1) Process Description

○ Method of manufacture

Body

- Based on 3-1 make a coating of resin and O.G. pigment on the nylon cloth and mold 8 ply with press.
- The rim of this molded helmet should be smoothly and uniformly finished and it must be attached tightly in the shape of a ball.
- Drilling: In order to attach hardware on the body, 15 drilling is performed.

Interior

- 6 clips are attached to head band so that they can be worn or removed from body.
- Back head rest must be attached on the rear head with buckle so that it can be flexible for adjustment of position.
- By using 6 spring clips on the head band, head band leather is attached.

- To attach neck band on both sides of body so that it is fixed on its position, use clips to band so that helmet is removable when it sustains an impact.

Paint

Paint olive green mixed with walnut powder so that it is not lustrous.

Weight

The weight of the entire helmet must be 900 ± 50 grams including its interior.

○ Test

Ballistic test

- Testing method
  The helmet will be tested at H.P. White Laboratory in the United States on the basis of ROK-MIL-E-7008. (Reference : Firing Record)
- Ballistic resistance
  Based on U.S. MIL-STD-662B (23 July 1971), V50 of bullet-proof must be more than 900 feet per second (same as steel helmet) when it is shot in the distance of 17½ft, with Caliber 22.

Impact test

- When helmet is impacted with a material with a weight of 3.6 Kg in a height of 1.5 meter, there must not be any damage in the hardware part and interior.
- Helmet must be manufactured so as not to occur any damage from engravings and attachment.

○ Packing

Outside Packing

A cross compartment set up inside carton box and 5 helmets are placed in each compartment and the exterior of the carton box is fastened with plastic band in the shape of a cheque (#)

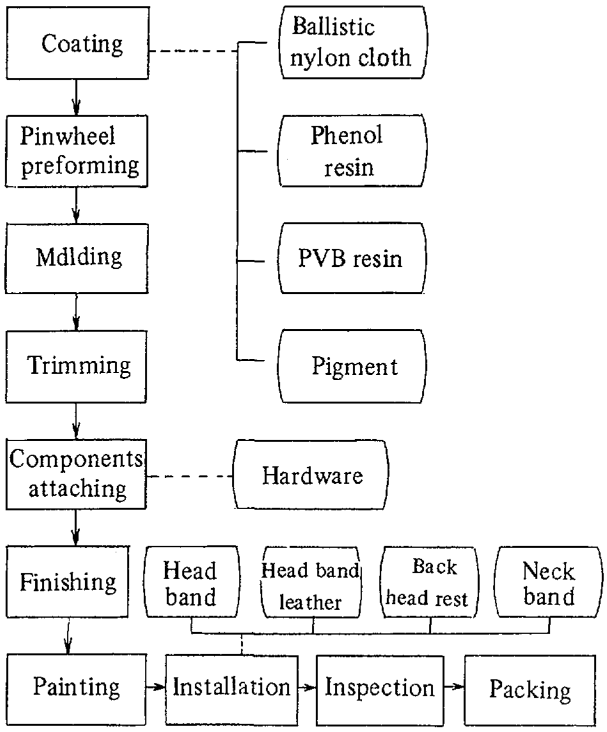
Inside packing

Wrap each helmet with paper and place 5 helmets in a poly bag and then seal the bag.

2) Equipment & Machinery

Mixer
Coating machine
Hydraulic press
Mold
Trimming machine
Cutting machine
Grinding machine
Drilling machine
Riveting machine
Welding machine
Lathe
Piping
Balance
Sewing machine
Boiler
Compressor
Painting system
Oven

NRP Ballistic Helmet Manufacturing Process Flow Diagram



3) Raw Materials and Utilities

Raw materials and utilities	Requirement (per ea of product)
Ballistic nylon cloth	$2m^2$
Phenol formaldehyde resin	0.4 kg
Polyvinyl butyral resin	Small amount
Olive green pigment	Small amount
Rubber edging	Small amount
Adhesive	Small amount

Example of Plant Capacity and Construction Cost

1) Plant capacity : 5,000 helmets per month

2) Estimated construction cost (as of 1983)

- Equipment and machinery : US$312,000
- Utilities : US$125,000
- Installation cost : US$160,000

Total : US$597,000

3) Required space

- Site area : 1,500 m^2
- Building area : 500 m^2

4) Personnel requirement

- Plant manager : 2 persons
- Engineer : 4 persons
- Operator : 30 persons
- Others : 6 persons

Total : 42 persons

Any inquiry about the information contained should be sent to:

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Ceramic Rod for Carbon Film Resistor

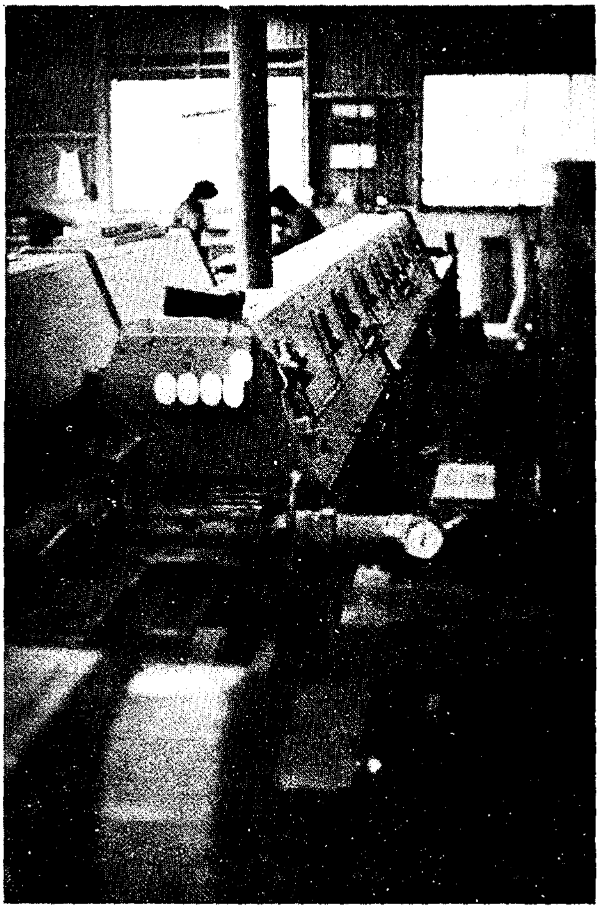
The carbon film resistor is one of the most important component parts in the electronic parts industry. Its demand has greatly increased with the development of the electronics industry.

Thus the ceramic rod for resistor is a basic element of the carbon film resistor, and 70% of which is composed of kaolin. It is therefore one of the products capable of maximizing the utilization of richly available natural resources and enhancing their added value. In particular, the production of this ceramic rod requires relatively small investment scale, while being labor-intensive. It has characteristics of suiting industrial conditions in developing countries short of capital funds. The product can be spotlighted not only in the import-substitution industry, but also in the export industry.

Generally, various materials, including steatite, forsterite and mullite, are used for the ceramic rod of carbon film resistor. Among the materials, the mullite ceramic rod is highly insulation-resistant within the scope of its working temperature or voltage, while it is mechanically strong and excellent in its heat resistance and resistance to thermal impact. It is also superb in adhesion to a carbon film to be made of the largest use.

However, it is known that even the mullite rod has a defect shortening the characteristic life of the resistor when its carbon film is damaged by the rise in working temperature or voltage. Therefore, the technology introduced here has been developed to improve and supplement the conventional process so that the products can be manufactured with more productivity by compensating the defect of mullite ceramic rods. It can now turn out the products outstanding in electric and thermal characteristics.

Furthermore, because of the need for skills to adjust the physical and chemical properties in addition to electric characteristics of the ceramic rods so that various requirements can be met in the manufacture of resistors, this ceramic rod manufacturing technology, when properly acquired, will provide technical backgrounds capable of producing new ceramics,



View of Forming Line

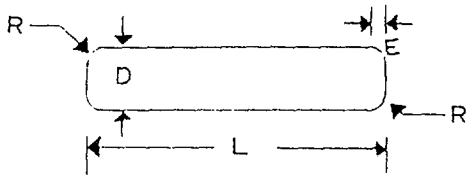
thus occupying an important position from the viewpoint of technology accumulation for the manufacture of next-stage ceramic products.

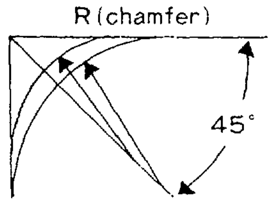
Products and Specifications

The product from this plant has the following features:

Improved in strength by increasing its alumina content (65 ± 1%), the ceramic rod can endure high-speed capping and welding machines. The raw materials used are also alkali-free for portecting the product from noise. Specifications are as shown in table 1.

Table 1. Specifications of Ceramic Rods





(Unit : m/m)

Item / Type	Dia.	D-Range	Length	L-Range	R-Chamfer	Roundness L≦20	Bending	E	E-Range
						max.			
1/16 W	1.3	± 0.03	3.0	± 0.2	0.15 ~ 0.25	0.03	0.1	0.7	± 0.1
1/8 W	1.70	± 0.03	5.50	± 0.2	0.3 ~ 0.4	0.03	0.1	1.2	± 0.2
1/4 W	2.00	± 0.03	7.50	± 0.2	0.3 ~ 0.5	0.03	0.1	1.6	± 0.2
1/2 W	3.00	± 0.03	8.00	± 0.3	0.4 ~ 0.9	0.04	0.1	1.9	± 0.2
1/1 W	3.00	± 0.03	10.00	± 0.3	0.4 ~ 0.9	0.04	0.1	1.9	± 0.2
1 W	4.50	± 0.04	14.00	± 0.4	0.8 ~ 1.5	0.06	0.1	3.1	± 0.2
3 W	7.00	± 0.07	30.00	± 0.5	1.1 ~ 2.2	0.1	0.22	3.1	± 0.2
5 W	7.00	± 0.07	51.00	± 0.6	1.1 ~ 2.2	0.1	0.24	3.1	± 0.2
Cement 2 W	2.50	± 0.03	13.00	± 0.4	0.4 ~ 0.9	0.04	0.1	1.9	± 0.2
Cement 5 W	4.00	± 0.04	16.50	± 0.5	0.8 ~ 1.2	0.05	0.1	1.75	± 0.2
Cement 10W	4.00	± 0.04	41.00	± 0.5	0.8 ~ 1.2	0.05	0.24	1.75	± 0.2
Cement 15W	4.00	± 0.04	53.00	± 0.6	0.8 ~ 1.2	0.05	0.24	1.75	± 0.2

Insulation resistance ; More than $5 \times 10^{12}\ \Omega \cdot cm$
Heat resistance ; Not damaged at 100-1,100°C
Bending strength ; 2,600–3,300 kg/cm^2 on the basis of the formula below

$$Z = 8\ pm \times L/3.14D^3 \quad (kg/cm^2)$$

Z ; Bending strength, L ; Distance of supports
pm; min. broken weight, D ; Diameter of rod

Coefficient of linear expansion ; About 5.66 ~ 6.79 x 10^{-6}/°C at 400-800 °C
Moisture absorption ; Less than 0.01%
Apparent density ; 2.8 – 3.0 g/cm^3
Color and surface ; White and finished of 30 to 40 micro inches
Acceptable quality level ; Maximum 2% (in total defect)

Contents of Technology

1) Process Description

The manufacturing process of ceramic rods for carbon film resistors comprises the following unit processes:

Raw material preparation process

It is a process for preparing raw materials. Prescribed amounts of kaolin, silica and other raw materials are weighed and fed into a ball mill for wet crushing. When the particle size of raw materials reaches a constant level, the milling is discontinued, with the slurry transferred to a storage tank for constant agitation to prevent possible sedimentation.

The slurry is passed through screens and eliminated of pieces of iron by a magnetic separator to be transformed into cake-like raw materials by means of a filter press. The raw material in cake state is kneaded under vacuum in a pug mill and then subjected to aging to give the raw material having 24% moisture content.

Forming process

The prepared raw material is extruded through prescribed nozzles in the form of noodles by a vacuum extrusion forming machine for removing part of the moisture in a dryer. The cutting is carried out by a cutting machine fitted with knives at fixed intervals. The scraps caused by the cutting are returned to the ball mill for crushing and reuse.

Drying process

On completion of the cutting, the formed products are placed in containers in uniform quantities and pushed into a hot-air drying chamber for vaporizing the moisture.

Calcination process

Following the drying, the formed products are put into heatproof cases and placed on a kiln car for subsequent calcination at constant temperatures in the tunnel kiln.

Grinding process

On completion of the calcination, the formed products are placed in grinding machine in uniform bundles along with abrasives for grinding to provide the chamber suitable for capping and the surface roughness suiting the later fitting.

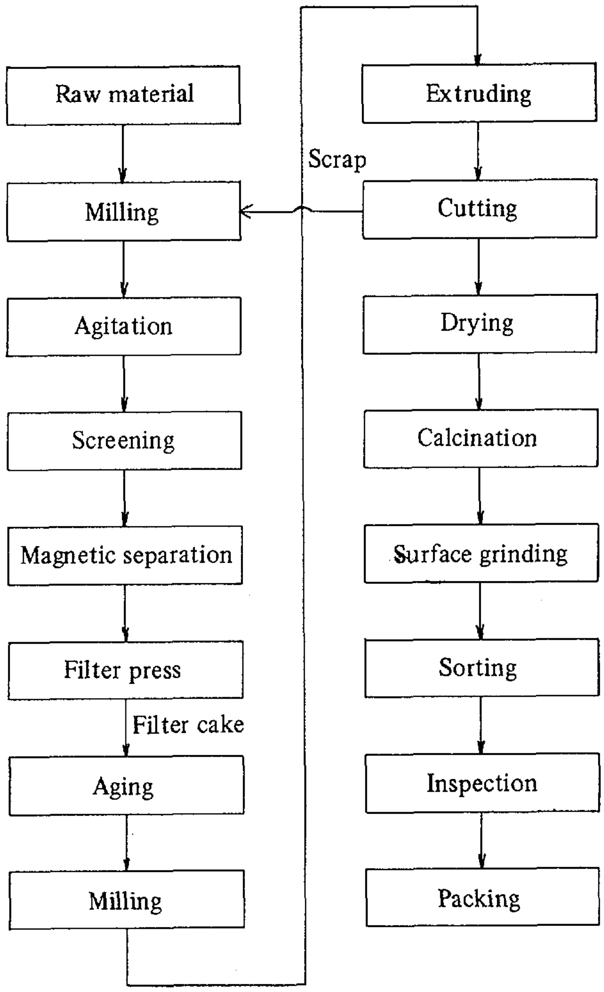
Sorting process

Following the product grinding, defective products are sorted out and removed with a sorting machine.

Inspection process

An inspection of the products as to appearance and dimension follows the sorting for delivery as final products only such ones as passing the inspection within the limit of prescribed range.

Ceramic Rod Manufacturing Process Block Diagram



2) Equipment and Machinery

Raw material preparation section
- Ball mill
- Slurry tank
- Agitator
- Ferro-filter
- Slurry pump
- Membrane pump
- Filter press
- Air compressor
- Balance

Kneading section
- De-airing auger machine

Forming section
- De-airing extruder
- Noodle cutter set
- Conveyer belt with chamber dryer
- Cutting machine set

Drying and calcination section

Drying room
Tunnel kiln
Dust collector

Grinding section

Barrel grinding machine
Pot mill
Dehydrator
Hot air dryer

Sorting and inspection section

Electric furnace (for test)
Strength tester
Particle size analyzer
Microscope
Drying oven
Electric balance
Others

3) Raw Materials and Utilities

Raw materials and utilities	Requirement (per ton of product)
Alumina	0.982 ton
Kaolin	0.761 ton
Clay	0.418 ton
Abrasive	0.259 ton
Sagger	30 ea
Others	0.295 ton
Electric power	5,136 kwh
Industrial water	48 tons
Light oil	1,352 ℓ

Example of Plant Capacity and Construction Cost

1) Plant capacity : 12 m/t/month
   * Basis : Product - 1.7 ϕ x 5.5
     10 hrs/day, 25 days/month

2) Estimated construction cost (as of 1983)
   - Manufacturing machinery : US$ 633,000
   - Utility facility : US$ 253,000
   - Installation cost : US$ 380,000

   Total : US$1,266,000

3) Required space
   - Site area : 3,300 m^2
   - Building area : 2,000 m^2

4) Personnel requirement
   - Manager : 2 persons
   - Engineer : 5 persons
   - Operator : 35 persons
   - Others : 3 persons

   Total : 45 persons

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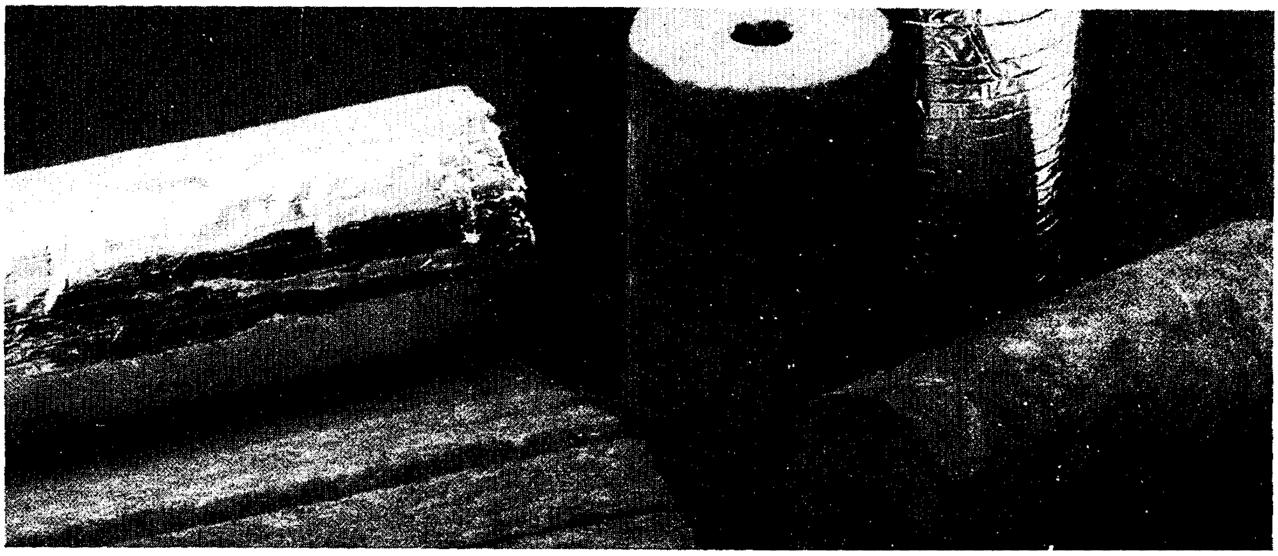
Insulation Glass Fiber Making Plant

View of Blanket



View of Pipe Cover, Lamella Mats

The following processes are currently used for the production of glass fiber:

- Steam-blown process
- Spinning process
- Flame-attenuation process
- Textile or long-fiber process
- Rotary process

Among the processes, the flame-attention process is introduced here.

Major advantages of the process are:

- Low manufacturing cost

In this process, crushed glass can also be used as raw materials. This may be a primary factor in lowering the manufacturing cost.

- Easy start-up and shut-down

This process is designed to be started and stopped easily. For the purpose of maintenance or temporary cease of operation, the whole line can be stopped at any time without trouble. So this system is suitable to a small-capacity plant.

Products and Specifications

The glass fiber products produced in this plant are board, mat and pipe cover. These products are used for various uses as follows:

- For housing–wall, ceiling, floor and basement.
- Air conditioning facilities–heating and cooling equipment insulation for warehouse.
- Transportation equipment–automobile, train, aircraft, ship and refrigerating container.
- Electronic equipment–electronic jar, refrigerator and cooler.
- Others–audio facilities, industrial equipment, farming facilities and power plant.

Contents of Technology

1) Process Description

Pieces of cleaned crushed glass or glass marbles accumulated in raw material preparation area fed into the electric furnace to be melt. The molten glass is drawn through the bushing installed at the bottom of furnace to form fine filament by the drawing rollers located underneath the furnace. The blast from burners further attenuates the filament and it is transformed into long and even finer fiber. While spraying binder over it, the fiber is deposited uniformly on a continuously moving belt by suction fan to form mat.

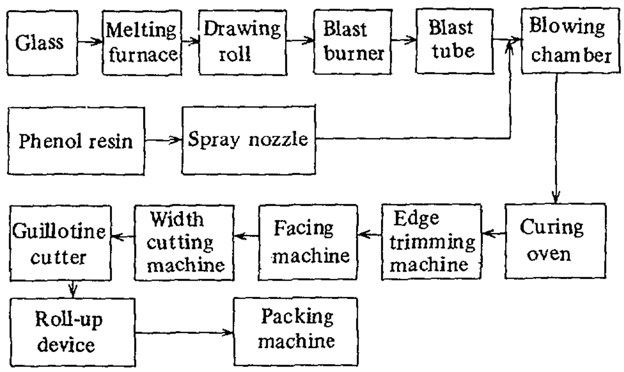
The uncured mat is fed into curing oven to be cured to the desired thickness and density. Several kinds of finishing machines are prepared to complete the product. Edge trimming machine is used for cutting off both edges of the mat with exact width and shape, and then facing machine is used for pasting glass cloth or asphalt craft paper on one side of the mat, if required. Then, the mat goes through width cutting machine and guilllotine cutter to get exact dimension as required.

At the receiving station, a conveyor is prepared. When the board is produced, the end of conveyor is raised up to level height, and the end of conveyor is lowered for the mat to be rolled by roll-up device.

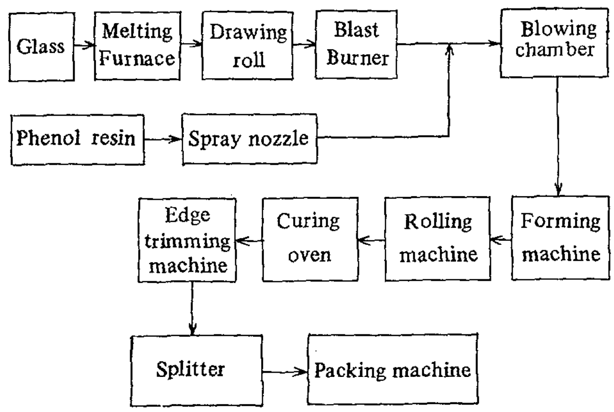
Almost the same processes are used for manufacturing pipe cover product, but there are some differences in the processes following fiberizing process. The uncured mat fed from blowing chamber is cut to a certain length and rolled around pipe-mold by the rolling machine to get exact shape and smooth surface and cured in the curing oven by hot air.

The mold is taken out after curing, and the cove. goes through edge trimming machine for its edge to be cut off and through splitter to be slitted for easy application.

Glass Fiber Mat & Board Manufacturing Process Block Diagram



Glass Fiber Pipe Cover Manufacturing Process Block Diagram



2) Equipment & Machinery

Raw material preparation facility
Electric melting furnace
- Hoist
- Glass feeder
- Melting furnace
- Automatic voltage regulator
- Transformer
- Electric distribution panel
- Frame and platform

Fiberizing machine
- Drawing roll unit
- Blast burner

Blast tube
Piping for blast burner
Air tank and piping
Frame and platform

Binder system
Water tank and tower
Cooling water tank
Resin storage tank
Resin mixing tank
Water return tank
Settling tank
Refrigerator
Spraying system
Mixing pump
Piping

Fiber collecting equipment
Main frame
Net conveyor
Slide plate
Suction fan
Position control device
New washer
Blower
Driving system

Curing oven for mat and board
Oven
Elevating device
Air curtain
Driving system
Duct

Curing oven for pipe cover
Oven
Mold return conveyor
Hot air system
Air curtain
Mold
Driving system
Duct
Platform

Finishing machine for mat and board
Feeding conveyor
Edge trimming machine
Facing machine
Width cutting machine
Guilotine cutter
Length measuring device
Quick feed conveyor
Roll-up device
Platform
Driving system
Scrap crusher
Dust collector

Finishing machine for pipe cover
Extension conveyor
Inclined conveyor
Forming machine
Rolling machine
Feeding conveyor
Edge trimming machine
Scrap crusher
Splitter
Dust collector
Packing machine

Laboratory equipment

Auxiliary equipment
Air compressor with accessory
Oil storage tank
Oil service tank
Water treatment system
Filter press

Electrical equipment
Power panel for furnace
Power panel for main line
Control panel for furnace
Control panel for conveyor
Control panel for forming machine
Control panel for finishing machine
Control panel for oven

3) Raw Materials and Utilities

Raw materials and utilities	Requirement
Crushed glass	*1 1,100Kg
Binder	*1 1,400Kg
Electric power	*2 600,000 Kwh/month
Fuel (light oil)	*2 341,000 Liter/month
Compressed air	*2 360,000 Cu. m/month
Water	*2 1,500 Cu. m/month

* 1) Based on 1 ton of product
* 2) Based on 2,000 tons/year

Example of Plant Capacity and Construction Cost

1) Plant capacity : 2,000 m/t/year

2) Estimated construction cost (as of 1983)

Equipment and machinery	: US$ 1,000,000
Installation cost	: US$ 100,000
Total	: US$ 1,100,000

3) Required space

Site area	: 15,000 m^2
Building area	: 5,600 m^2
Production line	: 2,400 m^2
Ware house	: 3,000 m^2
Office building	: 200 m^2

4) Personnel Requirement

For production line	: 72 persons (24 persons x 3 shift)
For quality control	: 6 persons (2 persons x 3 shift)
For product handling	: 4 persons (4 persons x 1 shift)
For maintenance	: 9 persons (3 persons x 3 shift)
Total	: 91 persons

* Executive staff, laboratory staff, stand-by personnel and drivers are not included in this list.

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Mosaic Tile Making Plant

With the modernization of living environment for human beings, buildings are getting both bigger and varied, while building materials in colorful products are also being produced.

Among such building materials, tiles have been developed as products for decroating walls or interior sapce of buildings. They are now one of the most essential building materials for the durability as well as protection of the buildings.

Therefore, the tile manufacturing industry is closely related to the development of building materials, the modernization and vitalization of which leads to the progress of the tile industry. In the case of Korea, the tile industry has become firmly rooted as a result of invigorated business situation on the part of the domestic housing industry.

Korea's rapid growth in the overseas construction has also helped increase the export of tiles, contributing to fostering the business as one of the important export-oriented industries.

In particular, the tile manufacturing industry uses such natural resources as clay, silica and feldspar, which are richly available the world over. Its process technology is relatively simple, with the result that the investment cost for the construction of production facilities is also comparatively low, while it is a labor-intensive industry having the effect of increased employment. So it becomes one of the essential basic industries to be fostered in the developing as well as less developed countries.

The technology introduced here relates to the plant producing various types of mosaic tiles. Outstnading in heat resistance, resistant to tear and wear and anticorrosive, the life of these tiles is semi-permanent, while greatly improving the durability of the buildings thanks to the dual functions of waterproofness and heatproofness.

Tiles are also the items greatly enhancing the decorative appearance of the buildings because of the creation of diverse color tones and patterns in products with the development of quality glazes.

Products and Specifications

In this plant, porcelain type tiles are produced in colorful patterns for use on outer walls, inner walls and floors in various houses.

Depending upon the use of glazes, tiles break down to glazed tiles and unglazed tiles. The glazed tiles are gnerally used for decoration purpose, whereas the unglazed tiles are for floors.

Tiles are available in various sizes including 50 x 50mm, 40 x 40mm, 19 x 40mm, 19 x 19mm and 100 x 100mm. The back mounting of many tiles on perforated papers, mesh or specially treated kraft papers is also possible for the economy and speediness of tiling works.

Contents of Technology

1) Process Description

Manufacture and formation of base material:

Mining of raw ores
Such lumpy raw materials as agalmatolite, feldspar and silica are mined by blasting, while powdery raw materials including clay and kaolin are mined on the ground.

Crushing
The mined mineral raw materials are crushed by hammers to the size of about 20 cm prior to the primary crushing in a jaw crusher. It is then further crushed in an impeller breaker to the 4-mesh size and below.

Pulverizing
The crushed mineral raw materials and powdery raw materials are blended in a fixed mixing ratio for pulverization in a ball mill together with water. The pulverization continues for about 17 hous at a rotation speed of 17 rpm.

Drying
When the slip, a mixture of raw materials and water, is sprayed and dried at temperatures of about 450-500°C, the powder with about 7% of residual moisture content is produced.

Aging
The dried powder is left in aging for 48-72 hours to facilitate subsequent formings.

Forming
On completion of the aging, the powder is put into

metallic molds according to sizes and formed by applying the pressure of 300-350kg/cm^2.

Glazing

The formed semi-finished products are sprayed with glazes until the glazing reaches a prescribed thickness while moving on a net conveyor.

Calcination

The semi-finished goods, completed of the blazing, are put in a refractory box and then placed on a cart. The cart is pushed into a terminal kiln for burning at 1,250°C for about 33 hours.

Screening, back mounting on paper and packing:

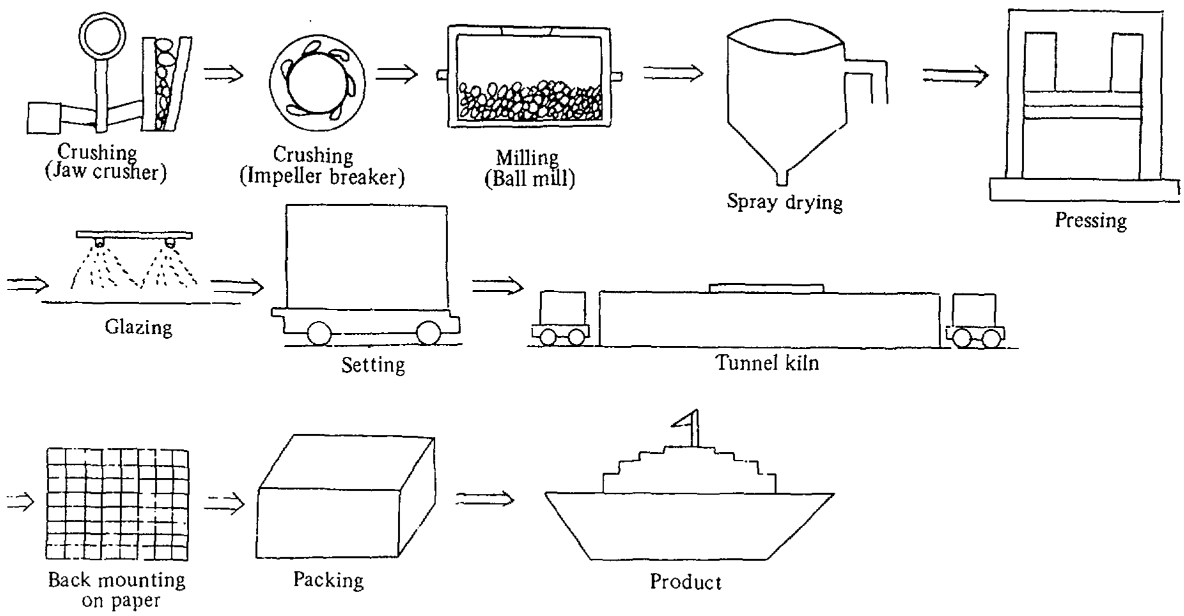
The products calcined in the kiln are screened. Many tiles are arranged to be back mounted on papers. After back mounting, the products go through inspections prior to delivery as finished products.

Manufacture of glazes

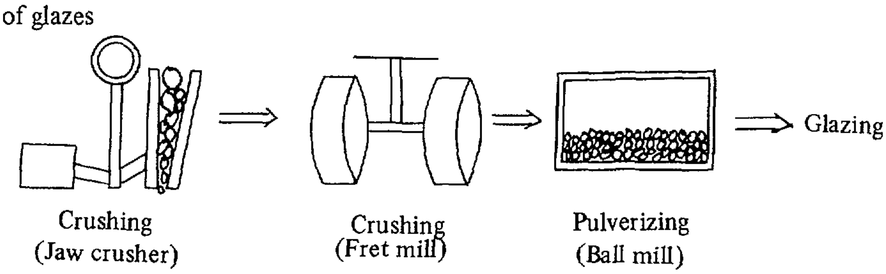
The mineral raw materials for the manufacture of glazes are crushed in a jaw crusher and then crushed to the 25-mesh size in a fret mill. The crushed raw materials are pulverized in a ball mill together with base material. It is then mixed with chemicals for the preparation of glazing materials.

Mosaic Tile Manufacturing Process Flow Sheet

○ Manufacture and formation of base material



○ Manufacture of glazes



2) Equipment and Machinery

- Jaw crusher
- Impeller breaker
- Vibrating screen
- Conveyer belt
- Bucket elevator
- Fret mill
- Ball mill
- Spray dryer
- Friction press
- High pressure press
- Glazing machine
- Tunnel kiln

3) Raw Materials and Utilities

Raw materials and utilities	Requirement (per 3.3m² of product)
Raw ore	48 kg
Chemicals	0.960 kg
Pigments	0.144 kg
Electric power	31.5 kw
Fuel oil	9.66 ℓ

Example of Plant Capacity and Construction Cost

1) Plant capacity : 49,500 m²/month
   * Basis : 24 hrs/day, 30 days/month

2) Estimated construction cost (as of 1985)

- ○ Manufacturing equipment : US$ 897,000
- ○ Utility facility : US$ 45,000
- ○ Installation cost : US$1,558,000

Total : US$2,500,000

3) Required space

- ○ Site area : 13,200 m²
- ○ Building area : 6,620 m²
- ○ Others : 1,650 m²

4) Required personnel

- ○ Manager : 10 persons
- ○ Engineer : 5 persons
- ○ Operator : 150 persons
- ○ Others : 10 persons

Total : 175 persons

CEMENT-BASED TILE PLANT

(prepared 1979)

The profile describes a process for making floor and wall tiles from cement using a portable installation. The example presented has a production capacity of 55,000m^2 tiles per annum, requiring an initial investment of $ 342,424 and a labour force of 12. The average sales price used is $ 13.30 per m^2.

1. INTRODUCTION

The "Lenoble" process for manufacturing floor and wall tiles from cement was perfected by a Belgian engineer. From 1964 until the present day, the "Lenoble" process has undergone considerable technical development and is used in more than 40 factories.

The material used is extremely simple and comprises rubber moulds (patented), vibrating tables (patented), base plates in asbestos cement and mixers. The installation is mobile, which allows the licensee to set up his production on the site where the tiles will be used. The material is adapted to each licensee's requirements and production can be increased by the simple acquisition of additional rubber moulds and vibrating tables.

2. TECHNOLOGY

A. PRODUCTION PROCESS

The wearing surface of the tile is made first. After mixing the raw materials, measured amounts are poured into the flexible moulds either manually or automatically. Each mould then travels the length of the vibrating table for approximately 60 seconds.

An exceptionally high compaction of the aggregates and fine cement is obtained by eliminating air bubbles and water veins within the mix through the first vibration. After a period of time varying from one to two hours, depending on climatic conditions, a second and thicker layer of ordinary concrete is added to the first, and the moulds are vibrated again. The result of the vibrations is a perfect compaction and hold between the two layers. The tile hardens in the mould and is demoulded on the following day without the need of any demoulding products. The concrete then dries in controlled conditions of temperature and humidity.

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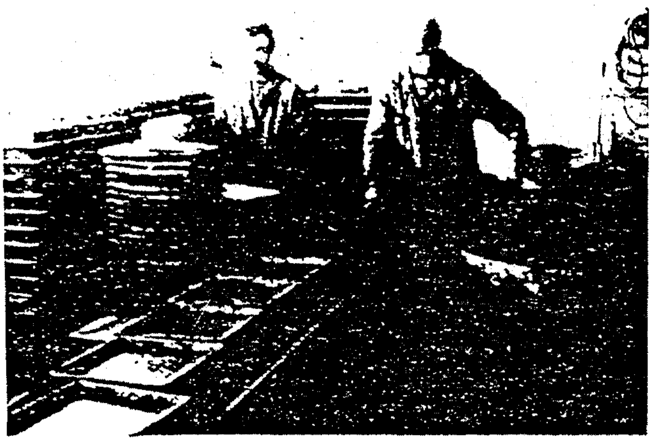
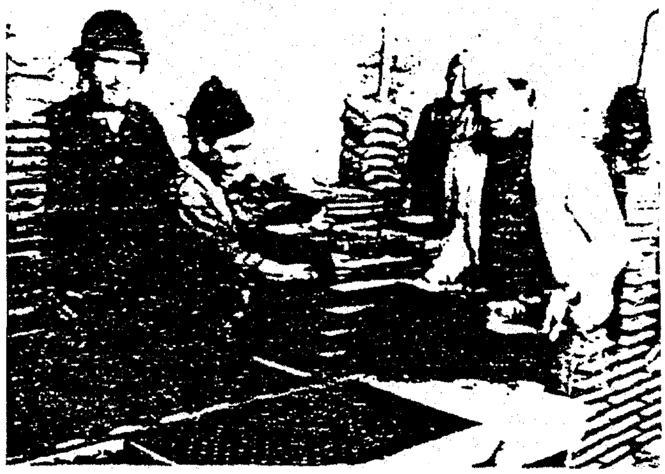


Filling moulds



Deloading moulds from the vibrating table

In comparison with the traditional press system, this system obtains good results.

	Products
Compression	650 kg/cm^2
Wear (depends on the aggregates)	2 mm (AMSLER test)
Porosity	2.5%

B. MATERIAL INPUTS

The raw materials used are:
(a) those of local origin:
- sand
- gravel
- grey cement
- marble chips (optional)

(b) those of foreign origin:
- white cement
- pigment (iron oxide)
- acrylic resins

C. CHARACTERISTICS OF PRODUCT

The "Lenoble" process allows the manufacture of:

(a) all types of decorative tiles in cement for floor covering from 20x20 cm to 60x40cm
(b) all types of tiles in industrial cement with a strong resistance to wear and shocks
(c) tiles imitating certain ceramics for floor or wall covering (without the need for an oven)
(d) floor and wall tiles for exterior decoration

(e) granito tiles known on the market
(f) shiny wall tiles (imitating ceramics)

More than 40 factories throughout the world use this process with a production capacity varying from 50,000 to 600,000 m^2 per year.

3. PLANT CAPACITY

The plant presented hereafter is a small one whose annual capacity is approximately 55,000m2 and which can meet requirements of many ACP countries, taking into account the size of the market.

4. RAW MATERIALS AND UTILITIES

Raw materials used in one year by a plant with a capacity of 44,000 m^2 producing tiles whose thickness varies from 1 to 3cm and whose surface varies from 20 x 20cm to 60 x 40 cm:

(a)	sand	843 tonnes	
(b)	grey cement	477 tonnes	
(c)	gravel	1650 tonnes	
(d)	pigment	24 tonnes	
(e)	white cement	53 tonnes	(providing one third of the production is of light-coloured tiles, these 53 tonnes should be substracted from point b)
(f)	marble chips and powder	324 tonnes	(in the event of 50 % of production being composed of granito tiles, this would involve a considerable reduction in the amount of sand and gravel given in points a) and c))
(g)	cement additives (as a reminder)		
(h)	other products (as a reminder)		
(i)	electric power		4 kW per hour (a standard 3 phase -50 or 60 cycles- supply is required)
(j)	water supply		5 m^3 per day (for mixing, washing down and curing)
(k)	resins (depending on the quantity of tiles to be produced)		
(l)	packaging (depending on the specific needs of the market).		

5. WORK FORCE REQUIREMENTS

The following table shows the personnel requirements for the production of 55,000 m^2.

Position	Number	Monthly cost US $
Managing Director also responsible for business and production	1	1,083.3
Office clerk	1	233.3
Secretary	1	183.3
Skilled workers (foreman)	1	433.3
Unskilled workers	8	1,066.6
Total	12	$ 3,000.0

B. OPERATING COSTS

	Year 1 1/3 capacity	Year 2 2/3 capacity	Year 3 full capacity
i) Raw materials (at $1.964 per m^2)	36,007	72,013	108,020
ii) Electricity and water (at $0.16 per m^2)	2,933	5,867	8,800
iii) Wages and salaries (for 12 persons)	36,000	36,000	36,000
iv) Maintenance (at 5% of machinery cost at full capacity)	4,513	9,025	13,538
v) Overheads (1% of investment cost + 5% of working capital)	34,936	35,337	35,745
vi) Distribution & sales costs	88,889	177,778	266,667
Total	$203,278	$336,020	$468,770

C. RESIDUAL VALUE

0.5 (16,666.6 + 51,666.6) + 0.1 x 270,758 = 61,242

D. EVALUATION (values in US $)

This is based on 10 year operating life, a 3 year build up to full capacity production, and a residual value for land, building and equipment. Fixed investment is 342,425. Working capital, 179,334, is taken in 3 instalments. On year 1 : 59,778; on year 2 : 59,777; on year 3 : 59,779. The residual value, 61,242, and working capital 179,334, are returned in the 10th year of operation.

The following are the results of NPV analysis :

Discount Rate	Present value of total costs	Annual revenue required	Revenue required per m^2
10%	2,927,309	556,241	10.11
20%	2,081,613	611,460	11.11
30%	1,599,635	671,551	12.21

FILE: M10
ISIC 3691

FIREBRICK MANUFACTURING PLANT

1. PREFACE

The firebrick manufacturing plant is suitable for manufacturing products for furnace-lining.

The basic materials used in the plant are normal clay, rejected bricks and chamotte. Chamotte is produced from the clay in the same plant on a separate production line.

The equipment and the plant can be easily tailored to suit different requirements, ranging from plants using production methods which require a high proportion of manual work to others equipped with automatic machinery lines which require a relatively small amount of labor.

2. POTENTIAL CUSTOMERS

Potential customers for the products of a firebrick manufacturing plant are:

- Industries which require lining materials (for lining tempering furnaces, power stations, storage heaters etc.)

3. CAPACITY OF THE PLANT

The capacity of the plant for the manufacture of firebricks is medium-large.

The production is approximately 2,000 tons per annum of firebricks as well as 500 tons of mortar and smaller quantities of chamotte.

4. BRIEF DESCRIPTION OF THE PROCESS

Firebricks are made primarily of chamotte, crude clay, bonding clay and rejected bricks.

Chamotte is made of crude clay which is fed to the plug mill and then to the drying section.

The material is then fed through the tunnel kiln. From there, the chamotte is either put into storage or fed to the further processing stage to make mortar and firebricks.

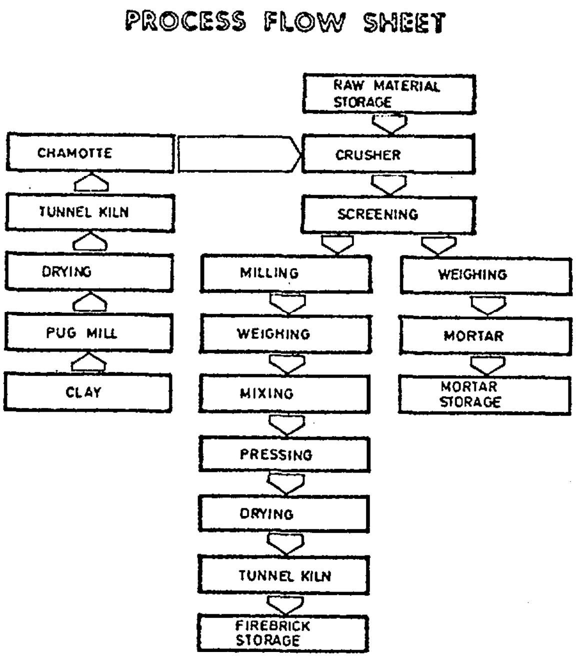
In the crusher, binding clay and chamotte are crushed together, after which the material is fed to the screening section. The mortar passes to the weighing stage and then a part is put into storage.

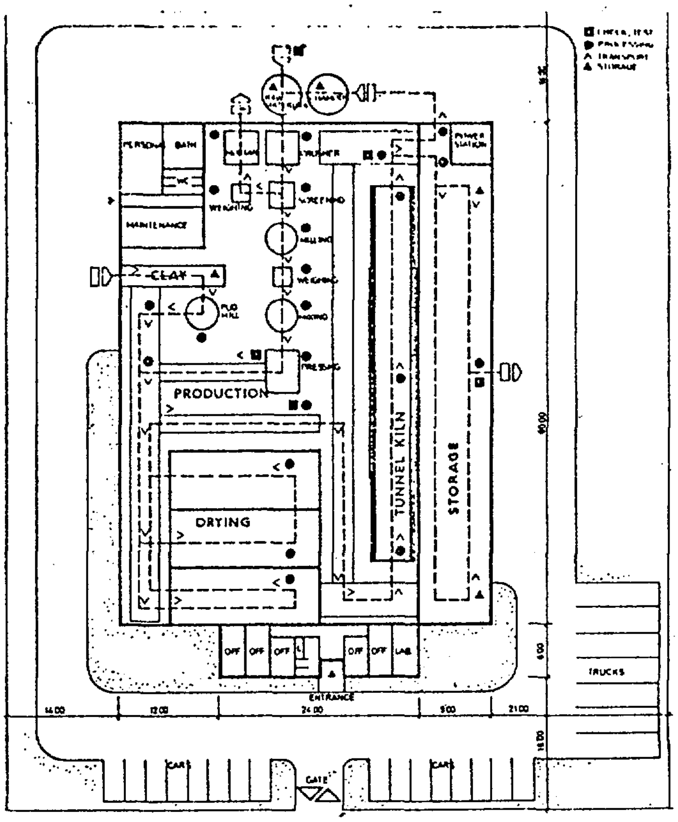
The rest of the mortar is fed to the milling section and then via the weighing section to the mixing stage.

In the mixing stage, the material is prepared for pressing. The bricks are pressed in the pressing stage and are then fed to the drying section.

The dried bricks pass through the tunnel kiln. The firing temperature lies between 1,250°C and 1,500°C.

The finished firebricks are taken to the storage area.





5. <u>REQUIRED BASIC AND AUXILIARY MATERIALS</u>

The quantities of the various materials used depend on the particular product mix and the methods used.

Below are the approximate materials requirements of the plant for one year's production:

- Raw materials 2,960 tons
- Various additional materials

6. AREA REQUIREMENTS

Required site area: 7,680 m^2

Required building area

Production hangar:	2,160 m^2
Storage hangar:	540 m^2
Office building:	140 m^2

Structural:

Production hangar, storage hangar

Columns and beams	- prefabricated concrete or steel construction
Walls	- brick-lined
Floors	- concrete
Roof	- metal sheet on a sawtooth roof construction

Office building

Columns and beams	- concrete
Walls	- brick-lined, plastered
Floors	- PVC-paved
Roof	- concrete ceiling with metal sheeting

Special installations:

Air circulation plant for the drying chambers

7. MACHINERY AND EQUIPMENT (Estimated total FOB price: approx. US$ 4,200,000)

Description:	Quantity:
Crusher unit (complete)	1
Screening unit (complete)	1
Milling unit (complete)	1
Weighing unit (complete)	2
Drying unit (complete)	1
Tunnel kiln (complete)	1
Chamotte-making unit (complete)	1
Filling unit (complete)	2
Transportation equipment	1 set
Laboratory equipment	1 set
Maintenance workshop	1 set

8. POWER REQUIREMENTS

Power type:	3 x 380 V, 50 Hz
Built-in capacity:	150 kW
Total power consumption during simultaneous operation:	125 kW
Power consumption per year:	720,000 kWh

extremely abrasion-resistant, especially under critically heavy-duty conditions. Applicable to drum brake for commercial buses.

MR-S450: Excellent braking effect with soft brake pedal feeling and good braking performance at high speeds. Applicable to drum brake for highway buses and heavy-duty trucks.

MR-S500: Made of molded rubber and excellent in flexibility. Applicable to side brake for various vehicles.

Contents of Technology

1) Process Description

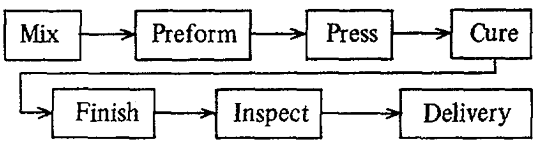
Resin mold type

After preliminarily molding the blended raw materials with hydraulic press, the mixture is molded by heating with the hydraulic press. The molded product is subject to heat treatment for 4-8 hours to be followed by internal and external grindings prior to inspection and delivery.

Roll and flexible type

Various raw materials are mixed and molded by the molding machine. The molded product is heat treated for 13-14 hours and cut in accordance with the specification required by the user to be inspected and delivered.

Brake Lining Manufacturing Process Block Diagram



2) Equipment and Machinery

- Resin mould type
  - V type mixing machine
  - Mixing machine
  - Hydraulic press
  - Oven
  - Inside grinding machine
  - Outside grinding machine
- Roll & flexible type
  - Mixing machine
  - Moulding machine
  - Oven
  - Cutting machine
  - Inside grinding machine
  - Outside grinding machine

3) Raw materials and Utilities

Raw materials and utilities	Requirement
o Resin mould type * Basis: 45x5.6x240x 110R	* Per 250,000 ea of product
Asbestos	17.88 ton
Resin	7.15 ton
Friction partical	3.6 ton
Inorganic filler	5.36 ton
Organic filler	1.79 ton
o Roll & flexible type * Basis: 45x5.6x240x 110R	* Per 750,000 ea of product
Asbestos	39 ton
Oil	19.5 ton
Friction partical	9.75 ton
Inorganic filler	29.25 ton

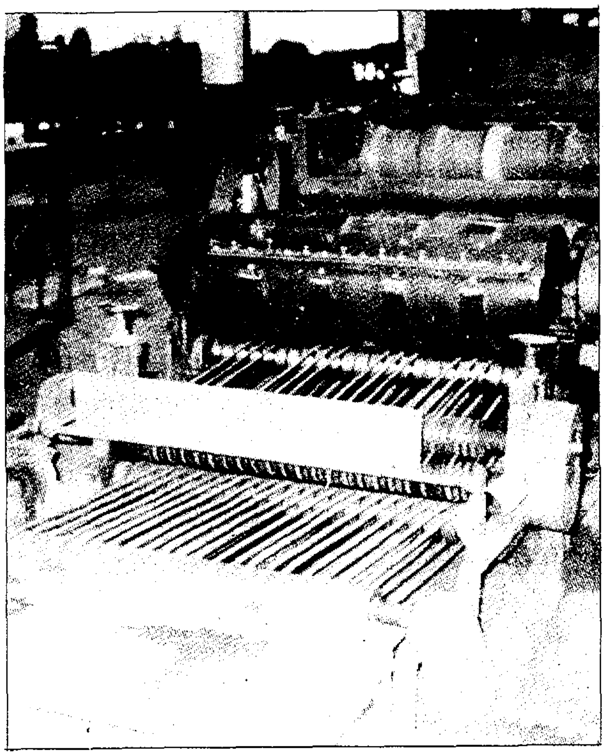
Example of Plant Capacity and Construction Cost

	Resin mould type	Roll & flexible type
1) Plant capacity	250,000 pc * Basis = 45 x 5.6 x 240-110R	750,000 pc 45 x 5.6 x 240-110
2) Estimated equipment cost		
o Equipment and machinery	US $300,000	US $200,000
o Utilities	US $ 50,000	US $ 50,000
Total	US $350,000	US $250,000
3) Required space		
o Site area	6,600m²	2,000m²
o Building area	720m²	480m²
4) Personnel requirement		
o Plant manager	8 persons	8 persons
o Engineer	4 persons	4 persons
o Operator	19 persons	20 persons
o Others	3 persons	3 persons
Total	34 persons	35 persons

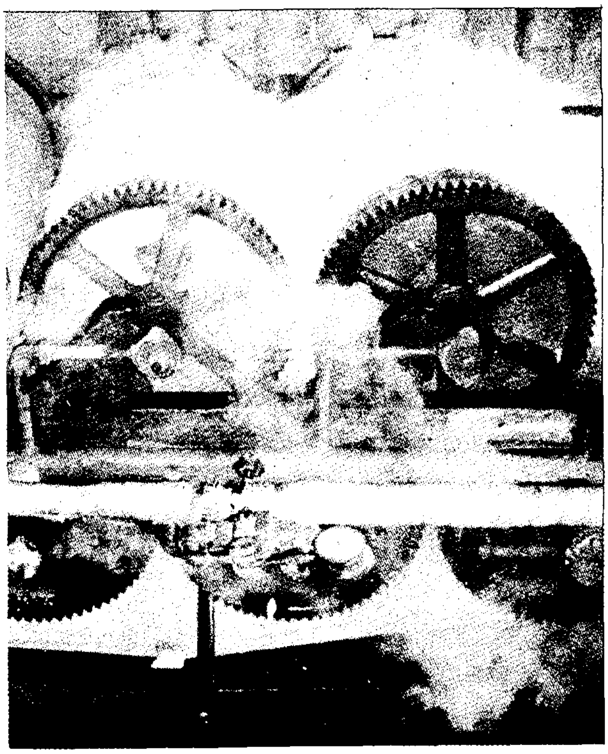
Any inquiry about the information contained should be sent to:

IO/COOP, Registry file No. ID/562/12, UNIDO, P.O. Box 300, A-1400 Vienna, Austria

Coated Abrasives Making Plant



View of Product Cutter



View of Mangle

Coated abrasives are the products manufactured by coating the paper, cloth or vulcanized fiber sheet with such powder abrasives as aluminium oxide, silicon carbide and garnet for use in various types of grinding work.

Generally used in processing a wide range of products such as metal products, including the stainless steel pipe, steel material and cast iron, and the wood, synthetic resin, leather, stoneware and rubber products, these abrasives are wide-ranging in the market of demand.

With the development of industries, the abrasives show the trend of rapid increases. In particular, since the grinding work exerts important influences not only on the productivity of various machinery works but also on the quality of the products to be machined, the demand for excellent abrasives ever deepens day by day.

Moreover, these coated abrasives are manufactured by relatively simple process and the facility itself is simple and requires small-scale funds for construction. Above all, it is one of the products to be developed and produced with priority for the development of the existing industries in developing countries which have not enough money to spare.

Products and Specifications

The abrasives produced by this plant include the abrasive cloth, abrasive paper and abrasive disc, and also come in sheets, rolls, belts and discs depending on the type of products.

These abrasives generally consist of three basic elements including the backing, abrasive and adhesive bond. Cloth, paper, vulcanized fiber sheet and non-woven farics are in use as backings, while aluminum oxide, silicon carbide and garnet are used as abrasives.

The abrasive bond is composed of two layers. Namely, one is called a make coat and the other is called a size coat. By changing the combination of these two adhasives in the coating process, various products can be manufactured.

Fig. 1. Structure of Coated Abrasives

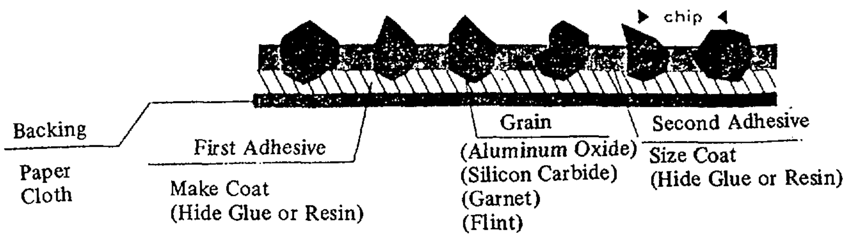


Table 1. Size and Use of Abrasive Material

Product	Abrasive	Size	Use
Abrasive cloth sheet	Aluminium oxide silicon carbide	9" x 11" (228mm x 280mm)	Suitable for grinding steel, cast iron, stainless products, stone, rubber products. Metal, nonferrous metals, wood and leather products etc.
Abrasive cloth roll	Aluminium oxide silicon carbide	Width – 1" ~36" (25mm ~ 900mm) Lenth – 36.5m (40 yds)	Suitable for grinding metals, stainless, wood, stone, leather, rubber products etc.
Abrasive cloth belt	Aluminium oxide	Width – 1" ~36" (25mm ~914mm) Length – As per oder	Suitable for grinding by machinery various kind of metal products, wood and musical instruments etc. at high speed.
Water proof paper sheets, roll, belt	Silicon carbide Aluminium oxide	Sheet – 9" x 11" (228mm x 280mm) Roll – 4½" ~ 18" Belt – 1" ~ 18"	Suitable for removing coated paints from coated metals and coated wooden products etc. Suitable for grinding carbody, electric products, furniture and musical instruments etc.
Fiber disc	Aluminium oxide Silicon carbide (Base fiber-vulcanized fiber)	4", 5", 6", 7", 9"	Suitable for removing rusts on the surface of thin steel plate, vessel, autobody, stone, nonferrous metals, grinding welded part, concrete, iron products etc.
Dry paper roll, sheet, belt.	Silicon carbide Aluminium oxide Garnet Metallic stearate	9" x 11" (228mm x 280mm)	Suitable for grinding/trimming furniture, musical instruments, wooden products and also for removing paints from coated above merchandises.
Wide belt paper	Aluminium oxide Silicon carbide white aluminium carbide	Width – 100mm ~1,310mm Length – As per order	Suitable for grinding/trimming wooden products (ply wood, furniture etc) and real leather (hide etc).

Contents of Technology

1) Process Description

Though there exist some differences depending upon the type of products, this abrasive material manufacturing process largely breaks down to the cloth processing and treatment process, adhesive coating, grain coating and after treatment, with the following manufacturing process by product:

(a)Adhesive cloth

Cloth processing

After treating the cloth with chemicals, the surface to be fixed with abrasives is smoothed out with a steam-heated roller. The reverse side of the cloth is also treated with reinforcing materials to supplement its strength. The cotton drill used here is largely divided in two kinds. Relatively light and flexible drills are suitable for abrasive cloths to be used in manufal and mechanical grinding, while stiff and tough cotton drills are suitable for abrasive cloths to be used in heavy mechanical grinding.

First adhesive coating

Prior to coating grains, the first adhesive is applied to the cloth for the grains, whereby such thermoplastic resins as phenolic resin, melamin resin, polyester resin and epoxy resin are used as adhesives in roller coating.

Grain coating

It is a process in which grains are adhered on the cloth, usually by electro-coating or gravity coating. However, the electro-coating method is used here, which is advantageous in that the grains are coated by electric force to provide uniform grain distribution and sharp abrasive surface.

Drying and second adhesive coating

Following the grain coating, the product is dried in a drying oven and then moved to the second adhesive coating process designed to prevent the adhered grains becoming loosened. On completion of the second adhesive coating, it is dried again in the drying oven, followed by the printing of necessary matters on its back, to be wound by a winding machine. The product is transferred to a hardening oven to be cured for many hours.

Flexing

After curing, the product goes through the flexing work to be provided with desired level of flexibility. Among the single flexing, double flexing and triple flexing, the triple flexing is applied here.

After treatment

After flexing, the product is cut to desired sizes and packed for delivery or can be prepared in the form of belts or rolls through such after treatment processes as slitting, skiving, bonding and pressing.

(b)Waterproof paper sheets and dry paper sheets

Printing

Particulars of trademark and specifications are printed on the back of the adhesive papers by the roller-type printing machine.

Water-proofing treatment

The kraft paper is treated with varnish or epoxy resin to improve the waterproofness of the adhesive papers.

First adhesive coating

The first thermosetting resin is applied in roller coating so that grains can adhere on the water-proof or untreated kraft paper.

Grain coating and drying

As in the case of abrasive cloth, the backing paper coated with the first adhesive is subjected to grain coating by electro-coating method, followed by drying in an oven.

Second adhesive coating and drying

In order to reinforce the cohesive strength of the coated grains, it is coated with the second adhesive and dried in the oven, followed by curing.

Cutting and inspection

Following the curing, the product is taken up by the winding mahcine and cut to desired specification for subsequent inspection and delivery packing.

(c)Abrasive disc

Fiber cutting

The vulcanized fiber sheet as the backing material is cut to the product specification by the press, and then trademark and technical data are printed on the back of the cut vulcanized fiber sheets.

First adhesive coating

Theremosetting resin is applied by the roller coating machine for adhering the grains.

Grain coating

The grains are dispersed for coating through a hopper in accordance with the gravity coating method. Discs thus produced are suitable for grinding rough surface.

Second adhesive coating and drying

In order to prevent the grains from becoming loosened, the second adhesive is applied by the curtain coating amchine, followed by drying and curing.

Flexing

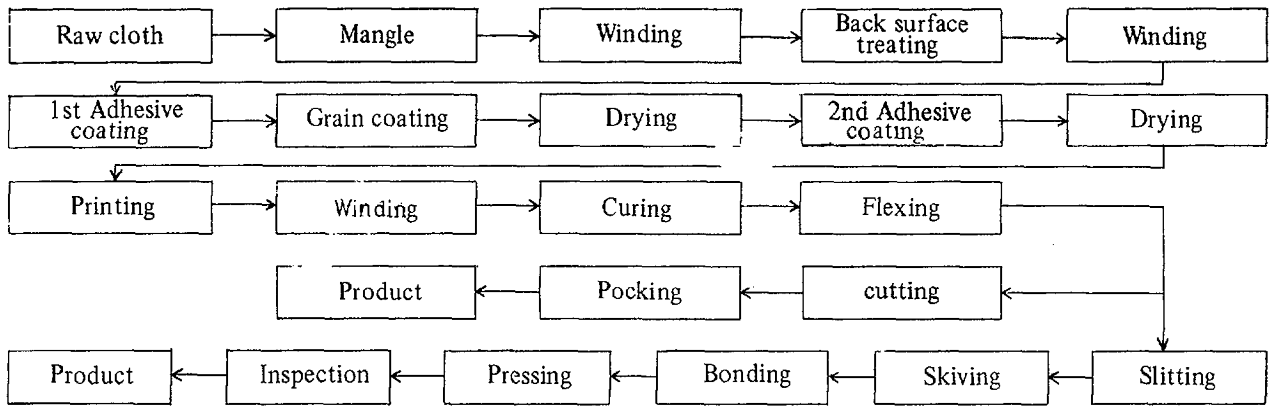
The dried product is subjected to double flexing to be provided with desired level of flexibility.

Inspection and packing

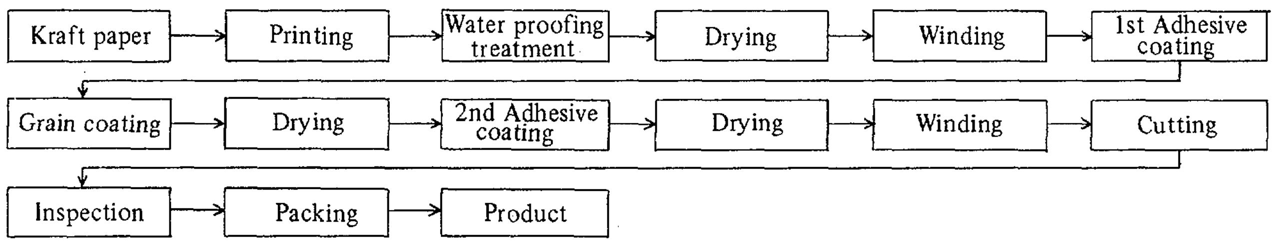
Following the flexing, the product undergoes various testing inspections for the confirmation of its abrasive capacity, and then packed for delivery.

Abrasive Cloth and Paper Manufacturing Process Block Diagram

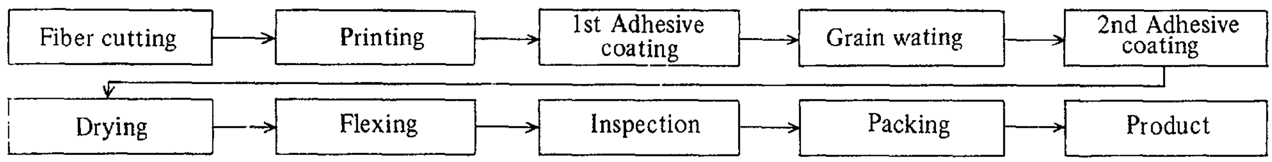
○ Abrasive Cloth



○ Water-proof paper sheets and dry paper sheets



○ Abrasive disc



2) Equipment and Machinery

○ Abrasive cloth
- Mangle
- Back surface treating machine
- Adheasive coaters (Roller)
- Grain coater
- Drying furnaces
- Printing machine
- Winding machine
- Curing furnace
- Flexing machine
- Cutting machine
- Slitter
- Skiving machine
- Press

○ Abrasive dry and water-proof paper sheets
- Printer
- Grain coating machine
- Drying furnace I, II & III
- Roller coater I & II
- Winders
- Cutting machine

○ Abrasive disc
- Fibre press
- Printer
- Roller coating machine
- Curtain coating machine
- Grain coating (Gravity)
- Drying furnace
- Flexing machine

3) Raw Materials

Unit : g

Raw materials	Requirement			
	1st Adhesive	2nd Adhesive	Grain	Water proofing agent
*1 Abrasive cloth				
#40	15	28	48	
#150	8	11	18	
#320	6	8	11	
*2 Abrasive paper (and water-proof paper)				
#120	3	8	12	12
#320	2	4	6	40
*3 Abrasive disc				
#16	4	25	60	
#60	1.5	7	15	
#110	0.5	3	4	

*1. 9" x 11" sheet, *2. 9" x 11" sheet,
*3. 7" round

Example of Plant Capacity and Construction Cost

1) Plant capacity : Abrasive cloth sheet – 800,000 sheets/month
Abrasive paper – 300,000 sheets/month
(Including water-proof paper)
Abrasive disc – 300,000 sheets/month

* Basis Product – Cloth sheet: 9"x11" sheet
Paper sheet: 9"x11" sheet
Disc : 7" round
Operating time – 8hrs/day, 25 days/month

2) Estimated equipment cost (as of 1983)

- Abrasive cloth : US$ 114,000
- Abrasive paper : US$ 18,600
- Abrasive disc : US$ 20,300

* Excluding utility facility and installation cost

3) Required space

- Building area
  - Abrasive cloth : 2,000 m^2
  - Abrasive paper : 750 m^2
  - Abrasive disc : 400 m^2

4) Personnel requirement

- Abrasive cloth

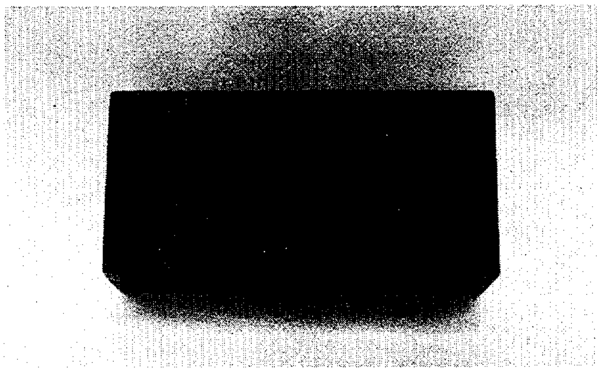
Manager	:	3 persons
Engineer	:	1 person
Operator	:	30 persons
Total	:	34 persons

- Abrasive disc

Engineer	:	1 person
Operator	:	13 persons
Total	:	14 persons

FILE: M13
ISIC 3691

Clay Brick Making Plant



View of Product

Earthen walls or adobes have been in use over several thousand years in building houses for mankind. It has also been empirically known that the buildings in which these materials are used provide coolness in summer and warmth in winter. It is because clay is outstanding in heat insulation and capable of adjusting the himidity.

However, since the start of modernization in the buildings with the emergence of the 20th century, the clay has been pushed aside by cement with hardly no uses. Such a phenomenon is attributable to the fact that clay bricks cannot be used in the modern buildings because they are not substantial enough in the first place and cause heterogeneous phenomena to take place when adhered to cement.

Consequently, the clay brick to be introduced here has been so developed as to eliminate such defects as its strength and heterogeneous phenomenon, while making the best use of its characteristics referred to in the foregoing. It is generally has the following advantages:

- It can be mass-produced with ease because of the adoption of a production process in which special acidic cement is mixed with adhesive hardening agent to be formed.
- Because of the natural drying in the production of clay bricks, energy and installation costs can be significantly reduced.
- Because it expedites the water hardening by absorbing the moisture in the air, the reaction heat evolving from the process can be used in strengthening the unity and cohesion of particles in the mixture body, thus providing the products of high strength.
- The utilization of boundlessly preserved clay resources can be maximized.
- Its production cost is low.
- Outstanding in insulation effects, the clay brick can adjust the moisture and ventilation, eliminating the necessity of additional of chemical insulating materials. Energy conservation in the buildings and the creation of comfortable dwelling environment are also possible.

Products and Specifications

The clay brick of this plant is produced without calcination process, but in its moisture absorption and strength, it is superior to the existing calcined bricks. That is to say, the absorption rate of the existing calcined bricks is 20-23%, whereas it is 12-14% in the case of this clay brick. In the compressive strength, it is usually 100-150 kg/cm^2, while this clay brick exhibits 180-260 kg/cm^2.

With a possibility of using for both interior and exterior layings, this clay brick can be produced in colorful patterns depending upon the design of molds. The standard size currently in use in Korea is 215 x 102.5 x 65mm.

Table 1. Properties of Clay Brick

Property	Clay brick	Test method
Volume specific gravity	1.70 - 1.80	KSL 3114
Water absorption (W/O)	12.60 - 14.30	"
Apparent porosity(V/O)	22.70 - 24.30	"
Compressive strength (Kg/cm^2)	198 - 266	KSL 3110
Thermal conductivity (Kcal/m. hr. °C)	0.49-0.53	KSL 3121

Contents of Technology

1) Process Description

The clay dried in the storage yard is conveyed by a bucket elevator and fed into a rotary crusher through a hopper for crushing. The crushed powder is screened with sieves to the particle size of 0.1 mm and below for storage. The remainder is moved out of the shute.

At this juncture, acidproof cement is added to the clay to enhance the strength of the brick or the combination with cement, and when necessary, mineral filler is also added.

The powdery clay is conveyed again to a mixer by the bucket elevator to be mixed with powder-type hardening agent. The mixed clay is mixed throughly again with the solution sprayed from the solution tank.

The mixed powder is fed into brick molds by the feeder, and then formed by applying pressure with a press. The formed bricks are transferred to the belt conveyor by a robot.

The completely formed bricks are placed on a panel to be dried in the atmosphere for delivery as products.

2) Equipment and Machinery

Hydraulic press
Mixer
Bucket conveyor
Agitator tank
Hopper
Feeder
Robot
Crusher
Sieve
Belt conveyor
HM Liquid heating tank
Mold

Example of Plant Capacity and Construction Cost

1) Plant capacity : 30,000 ea/year
 * Basis : 8hrs/day, 264 days/year

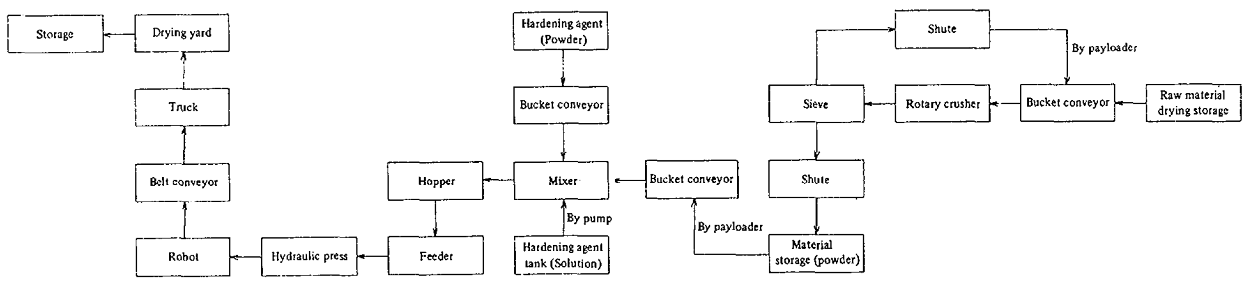
2) Estimated equipment cost (as of 1983)
 ○ Manufacturing equipment cost : US$ 250,000

3) Required space
 ○ Site area : 23,400 m²
 ○ Building area : 900 m²
 ○ Other : 186,000 m²

4) Personnel requirement

○ Manager	:	1	person
○ Operator	:	9	persons
Total	:	10	persons

Clay Brick Manufacturing Process Flow Diagram



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FILE: N2
ISIC 3710

Spiral Weld Pipe Making Plant

The spiral weld pipes are manufactured from steel strip or plate by the Driam and Torrance patented process.

The capital expenditure is quite low compared with other manufacturing process when and if the projected production capacity does not exceed 100,000 tones per year. Depending on the market situation, it will be necessary to limit the production and therefor a frequent changeover periods without tool changes are advantageous. Spiral weld pipe mill will save times and expenses occuring from the frequent tool changes. Pipe in any dimension and lengths can be produced continuously. From hot rolled strip of one dimension, pipes of a whole series of diameter can be manufactured without wasts of materials resulting from cutting.

The pipe will be produced from hot rolled coils. The pipe produced in this facilities are widely used for transmission of water and other liquid as well as piling for construction and mechanical use.

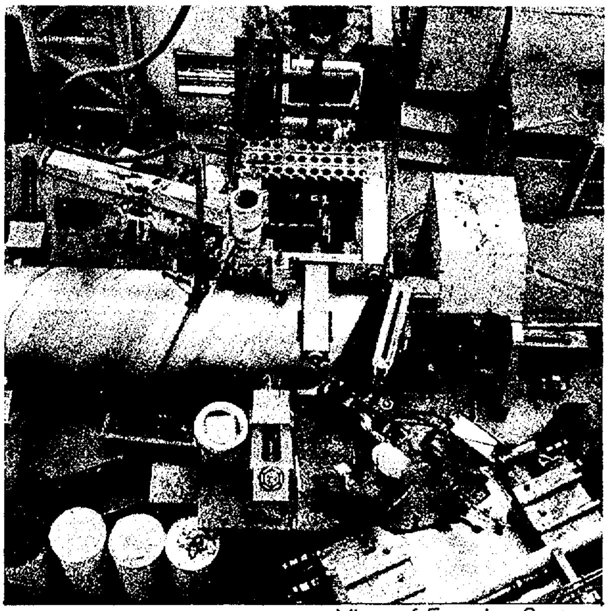
This mill is designed to have a production capacity of 40,000 tonnes of pipe working on a two-shift (16 hours/day) based on the production of 1,000mm pipe in diameter with 9mm thickness.

Products and Specifications

The facilities are designed for the manufacture and finishing of continuously formed and spiral weld pipe ASTM, JIS, BS standards having a diameter range from 400mm to 1,650mm with material thickness from 5mm to 12.7mm.

Table 1. Specifications of Spiral Weld Pipe

Range of pipe diameter	400 – 1,650mm Shoe forming method : Less than 600 mm Roll forming method : Over than 600 mm
Max. strip width	1,650mm
Running-in angle	45° – 75° (economical angle: 50° – 60°)
Max. strip thickness	12.7mm
Max. welding speed	1.2m/min


View of Forming System

Contents of Technology

1) Process Description

Spiral pipe making machine

This machine can make all sizes of pipes within the range by varying forming angle from 45 to 78 degrees. The capacity is dependent on the weld length and the welding speed.

So the ratio of the pipe diameter to coil width is very important. The ratio between 1.6-2.0 is the most reasonable but 2.9 is maximum ratio because of the forming angle limit.

The heavier weight of coil unit is, the better productivity. Most devices of this machine are operated and controlled by the hydraulic cylinders. This machine has to be operated by the experts.

Non-Destructive Inspection

To obtain high quality of weld, ultrasonic inspection should be done continuously on the welded seam. When any flaws arc checked by the ultrasonic tester, after cutting-off the pipe the accurate position and size have to be seen by the X-ray tester in order to repair. And the repaired welds have to be rechecked by one of both tester.

Hydraustatic tester

All of the water pipes are subjected to be tested to the specificed hydraulic pressure according to the applied specification or standard.

- ○ plunger pump: 40HP x 900 R.P.M.
- ○ centrifugal pump: 40HP x 1,800 R.P.M.

Blasting machine

Whole surface of pipes to be coated, not only inside but also outside surface, have to be throughly cleaned by blasting. The blasting should remove all rust, scale and other impurities from the surface, exposing base metal over all, which presents a grayish appearance. This operation shall be performed by shooting grits onto surfaces by compressed air.

Priming

To promote the adhesion of coating material to steel surface, the suitable primer coating is essential. The priming is done usually by airless sprayer.

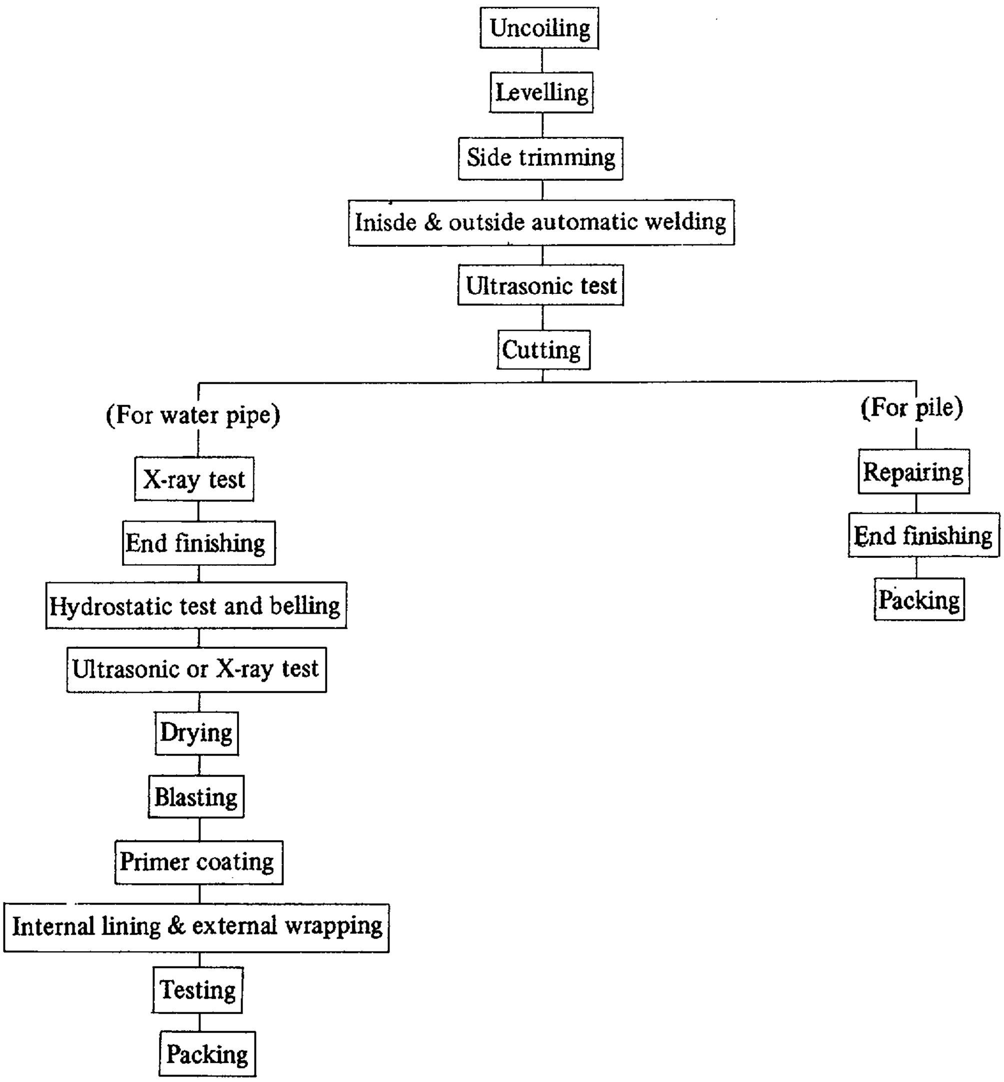
Inside coating (Lining)

The application of the lining materials to the inside surface of all pipes other than specials shall be by centrifugal casting by the feed-line method. During the application the pipe should be revolved at speed best suited to produce a smooth, glossy lining of uniform thickness.

Outside wrapping

Outside wrapping shall be performed by pouring melted material on the revolving pipe and spreading it

Spiral Weld Pipe Manufacturing Process Block Diagram



to the specified thickness. Wrapping materials shall be spirally applied by the felt-application equipment on the coating, while the coated material is held warm.

Melting kettles

The coating material shall be heated in agitated heating kettles equipped with recording thermometers. The maximum temperature to which the coating material may be heated and the maximum time that the coating material may be held in the kettle at application temperature are very important.

Drying device

Moisture is harmful in blasting and hazardous in priming and coating. In advance of these process heating pipes are necessary according to the weather and climate in your country.

2) Equipment and Machinery

Spiral pipe making machine
Flux sweeping device
Pipe rotating device
Pipe facing and bevelling machine
Pipe transportation equipment
Portable ultrasonic tester
Heating facility
Blasting machine
Primer coating machine
Preheating facility
Inside lining machine
Outside coating and wrapping machine
Engine lathe
Shaper
Power station
Laboratory equipment

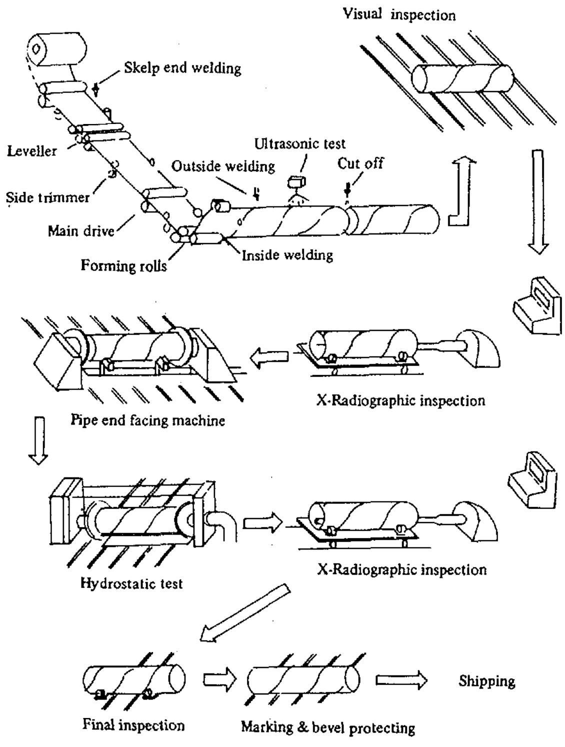
Example of Plant Capacity and Construction Cost

1) Plant capacity: 40,000 m/t/year
* Basis: 2-shift

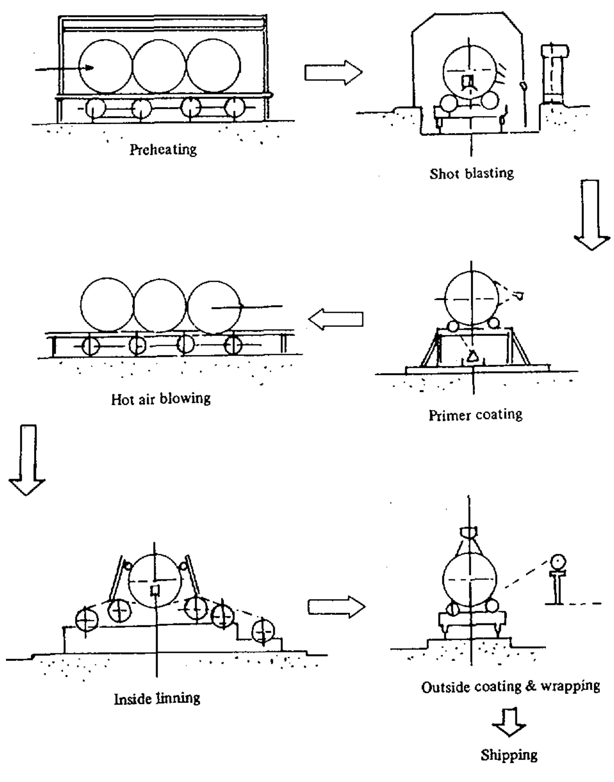
2) Estimated equipment cost (as of June, 1981)

o Pipe making factory	:	US$7,722,000
o Coating factory	:	US$1,238,000
o Maintenance shop	:	US$ 457,000
o Electric equipment	:	US$ 880,000
o Laboratory	:	US$ 254,000
o Others	:	US$3,785,000
Total	:	US$14,336,000

Spiral Weld Pipe Manufacturing Process Flow Sheet



Spiral Weld Pipe Coating Process Flow Sheet

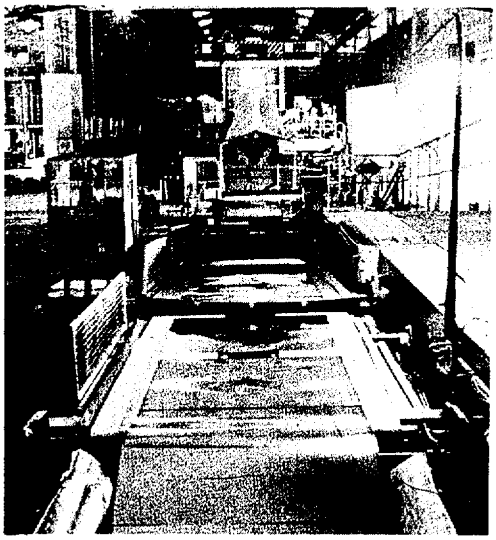


3) Personnel requirement

Portion	Foreman	Worker	Total (8 hrs-one shift)	(16 hrs-two shift)
Pipe making	1 x 3	1 x 44	47	97
Pipe coating	1 x 3	1 x 41	44	88
Inspection	1 x 8		8	12
Laboratory	1 x 3		3	6
Maintenance and others	1 x 3	1 x 42	45	67
Total	20	127	147	267

FILE: N3
ISIC 3710

Tin Plate Making Plant


View of Electrolytic Tin Plate Making Plant

Tin plate may be described as full-finish black plate additionally processed and coated on both sides with commercially pure tin.

The wide-spread use of tin plate arise from its combination of the strength of steel with the protective properties and solderability of tin.

Tin coatings are applied to steel sheet either by electrolytic deposition or by immersion in a molten bath of tin.

When coated by the hot-dip process, the tin plate is termed "Coke Tin Plate" or "Charcoal Tin Plate".

When coated by the electrolytic process, it is termed "Electrolytic Tin Plate". But most of tin plates are produced by electrolytic process now.

The importance of tin plate to the food industry is well recognized and its wide spread utilization attests to the unique properties of this product in which are combined the strength of steel and the corrosion resistance of tin.

The largest use of tin plate is for containers, and many of the improvements in its manufacture have been the result of research directed toward meeting the requirements of the container-manufacturing industry.

Tin cans are used not only for food and beverages, but also for paints, oils, tobacco, insecticides and proprietary drugs.

Table 1. Temper Grade

	Temper	Expected average control hardness (Rockwell 30T)	Steel Type	Example of usage
Box annealed	T-1	49 ±3	L, MR	Drawing requirements, nozzles, spouts, closures
	T-2	53 ±3	L, MR	Rings and plugs, pie pans, closures, shallow drawn and specialized can parts.
	T-2.5	55 ±3	L, MR	Can ends and bodies
	T-3	57 ±3	L, MR	Can ends and bodies, large diameter closures, crown caps
Continuously annealed	T-4CA	61 ±3	L, MR	Crown caps and closures
	T-5CA	65 ±3	MR	Can ends and bodies
	T-6CA	70 ±3	MC	Very stiff applications
Double reduced	DR-8	73 aim	L, MR	Bodies and ends for small-diameter cans requiring high strength
	DR-9	76 aim	L, MR	Bodies and ends for large-diameter cans requiring high strength
	DR-9M	77 aim	L, MR	Ends for beer and beverage can requiring higher strength.
	DR-10	80 aim	L, MR	

Notes:

L : Base metal low in metalloids and residual elements, sometimes used for improved internal corrosion resistance for certain food product containers.

MR: Base metal similar in metalloid content to Type L but less restrictive in residual elements, commonly used for most tin mill products.

MC: Base metal rephosphorized, with residual elements similar to Type MR, employed where greater strength is required and internal corrosion resistance is of lesser importance.

DR: Base metal produced by the double cold reduction process; offers greater rigidity and strength than conventional base metal and, consequently, provides the same strength in lighter sections. Because of this advantage, more cans can be made per unit weight of tinplate.

Products and Specifications

Our electrolytic tin plate comes in a wide range of types to allow selection of the tin plate most suitable for any specific application.

- Wide range of coating weights
- Differential coatings available
- Wide range of tempers available; Double-reduced tin
- plate is also available
- Wide variety of surface finishes
- Various types of base metals
- Comes in both cut and coils

Table 2. Tin Coating Weight

Type	Coating number	Nominal coating weight (gr/m²)	Minimum average coating weight test value (gr/m²)
Equally coated weights	# 25	5.6	4.9
	# 50	11.2	10.5
	# 75	16.8	15.7
	# 100	22.4	20.2
Differentially coated weights	# 25/50	2.8/5.6	2.25/5.05
	# 25/75	2.8/8.4	2.25/7.85
	# 25/100	2.8/11.2	2.25/10.1
	# 50/75	5.6/8.4	5.05/7.85
	# 50/100	5.6/11.2	5.05/10.1
	# 75/100	8.4/11.2	7.85/10.1

Notes:

1. Coating weights for equally coated one indicate the weight of tin per square meter of both sides. Coating weights for differentially coated indicate the weight of tin per square meter of one side.
2. Various coated tin plate not specified in the above table can be subject to negotiation.

Table 3. Surface Finish

Type	Remarks
Bright finish	Standard finish, smooth base with flow brightened tin coating.
Matte finish	Such as used for some Crown Seals, grit roughened base with unflowed tin coating
Stone finish	Grinding stone roughened base with flow brightened tin coating. This finish exhibits a linear surface texture parallel to rolling direction
Silver glow finish	Melted finish produced on a specially treated base metal.

Table 4. Size Availability

	Conventional size		Double reduced size	
	Sheets	Coil	Sheets	Coil
Thickness mm (1b)	0.18-0.50 (65-175)	0.18-0.50 (65-175)	0.15-0.27 (55-95)	0.15-0.27 (55-95)
Width mm (in.)	710-940 (28-37)	710-940 (28-37)	710-940 (28-37)	710-940 (28-37)
Length mm (in.)	458-1,104 (18-43½)	–	458-1,104 (18-43½)	–
Inside dia. mm (in.)	–	406 & 508 (16 & 20)	–	406 & 508 (16 & 20)
Weight m/t (1b)	–	3-15 (6,500-33,000)	–	3-15 (6,500-33,000)

Contents of Technology

1) Process Description

Entry process

The entry end of an electrolytic line is usually so designed as to provide two uncoilers in line. This permits the operator to "pay off" from one uncoiler while charging a coil into the other.

In preparing a coil for processing, the lead edge of the strip is manually engaged in a set of small pinch rolls which can be opened and closed by air pressure and which are usually motor driven. The function of these rolls is to permit the operator to advance the lead edge of a new coil into the welding assembly.

It is desirable to maintain a high strip speed in the plating baths, so facilitates are provided to join fresh coils to the strip without reducing line speed. As the coil in process is being unrolled, the operator take care that the maximum amount of strip is contained in the looper located just after the entry bridle.

Main process

From the looper the strip enters the main process section of the line.

The tension bridle is to produce sufficient drag on the strip to maintain a positive strip tension throughout the line.

In the acid-electrolyte units, the strip passes from the drag bridle to the alkaline electrolytic cleaners.

The strip passes from the alkaline cleaner into a rinsing unit. Its function is to remove all alkali from the strip in preparation for the pickling operation. This rinsing unit is usually comprised of water sprays playing both sides of the strip and of rotary bristle brushes which rotate vigorously against the strip.

The strip-pickling units is the hot immersion type, and this tanks are filled with hot sulfuric acid of 3 strength varying up to 12 percent.

After pickling, the strip is again rinsed in a unit similar to the one used after the alkaline cleaner and enters the plating tank.

A halogen-type electrolyte consists of a series of small cell, each with its own circulation system, contact roll and anode tank.

After passing through a number of these units, the strip is deflected upward and backward so that the original top of the strip now becomes the bottom. It then passes through another series of similar plating cells until the desired amount of tin is deposited on this side of the strip.

The tin coating, as it emerges from the plating bath, is gray-white and semi-lustrous. It does not in appearance resemble tin plte as it is commonly known.

It is melt and quench the electrodeposited tin which gives it the brilliant luster typical hot-dipped plate.

Unlike hot dipped tin plate, the electrolytic plate is not oily as it emerges from the coating operation; hence it is necessary to deposit a controlled film of lubricant on the product in order to improve its handling properties in succeeding operations.

The strip next enters the unit which supplies tractive power to the strip to pull it entirely through the electrolytic line.

Delivery process

Delivery process lines are provided with large loopers and a single recoiler at the delivery end into which the strip pass from the drive bridle.

The coil of coated product is sent to the shearing unit where it is sheared to size, assorted, counted and piled.

The methods of inspection and classification of electrolytic tin plate on these flying shears are rather ingenious. Located somewhere after the melting unit is a noncontacting thickness gage.

A device sometimes called a pinhole detector utilized a photoelectric cell to continuously scan the coated strip and cause sheets with perforation to be deflected into the piler.

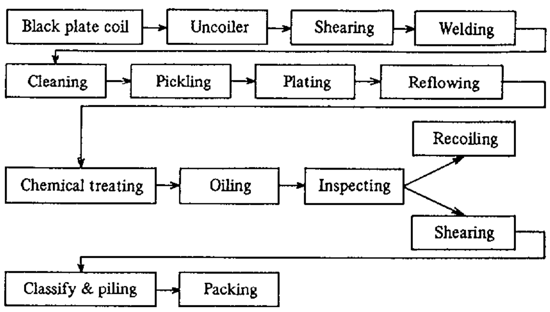
2) Equipment and Machinery

Uncoiler
Pinch rolls
Welding assembly
Looper
Entry bridle
Tower type looper
Drag or tention bridle
Electrolytic cleaner
Rinsing unit
Pickler
Plating unit
Fusion unit
Quench tank
Chemical-treating unit
Drying unit
Oiling unit
Pull through bridle
Loopers
Shearing unit
Flying shear
Pilers
Sheet counter
Thickness gauge
Pin hole detector

3) Raw Materials and Utilities

Raw materials and utilities	Requirement (per ton of process)
Black plate	1 ton
Tin	6.3 kg
Electric power	160 kwh
Steam	0.3 ton
Compressed air	50 m^3

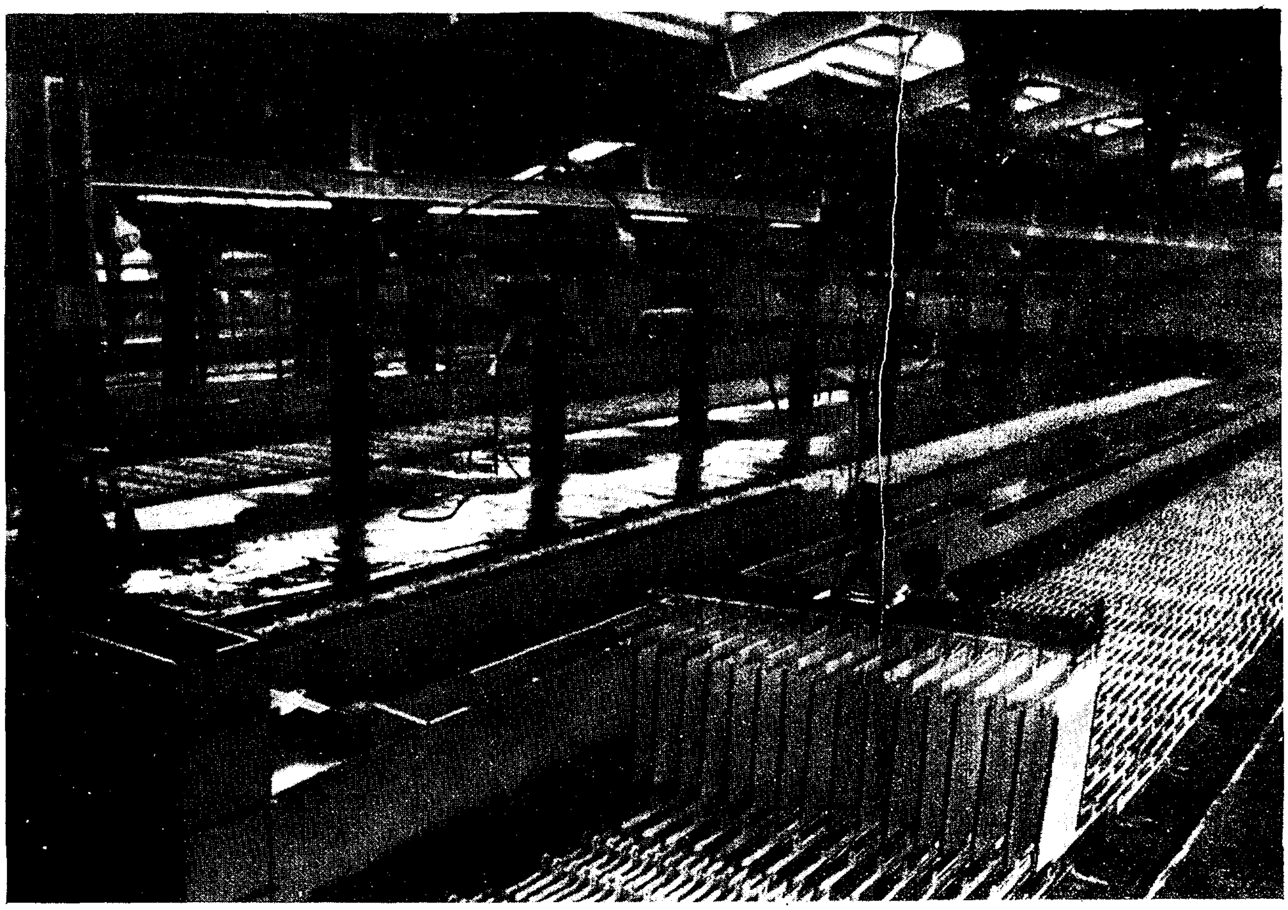
Electrolytic Tin Plate Manufacturing Process Block Diagram



Any inquiry about the information contained should be sent to:

IO/COOP, Registry file No. ID/562/12, UNIDO, P.O. Box 300, A-1400 Vienna, Austria

Zinc Making Plant



View of Zinc Electrolysis Facility

The main product zinc obtained from its smelting is an important item for wide use in suck key industries as steel-making, automobile, shipbuilding and chemical industries. Its major uses are: 1) Corrosion inhibition of steel products (galvanized steel sheets and steel pipe products), 2) Basic metal die casting for precision component parts, 3) Brass-alloy manufacture and 4) Raw materials for paint industry. Sulfuric acid as its by-product is an essential item for such key industries as fertilizer, steel-making and textile industries.

It can also supply cadmium metal and copper products (copper ingot and cupric sulphate) as by-products to enhance its profitability, thus significantly contributing to motivating the progress of key industries, as well as development of available resources (zinc metal ores).

Contrary to the dry smelting process, the wet smelting process can directly produce high-purity products (about 99.99% in purity). However, what matters here are the yield of products and the unit consumption of auxiliary matetials and utilities in addition to plant facilities in terms of overall profitability and operation management. Accordingly, the technology based on ample experiences is most important in this connection.

Products and Specifications

The zinc metals produced in this plant are electrolytic zinc, zinc alloy for die casting, zipper and galvanizing, and zinc anode. Also, as by products, cadmium stick, cupric sulfate and sulfuric acid are produced and their specifications are shown in table 1 and table 2.

Table 1. Specifications of Zinc Ingot

Products	Item	Specifications								
		Unit	Chemical compositions (%)							
			Al	Cu	Mg	Pb	Fe	Cd	Sn	Zn
Electrolytic zinc	SHG	20 kg	–	–	–	< 0.003	< 0.002	< 0.002	< 0.001	> 99.995
	HG	20 kg	–	–	–	< 0.007	< 0.005	< 0.004	–	> 99.99
	ORD	20 kg	–	–	–	< 0.02	< 0.01	< 0.005	–	> 99.97
Zinc alloy for die casting	DC I	10 kg	3.9~4.3	0.75~1.25	0.03~0.06	< 0.003	< 0.02	< 0.002	< 0.001	Remainder
	DC II	10 kg	3.9~4.3	< 0.03	0.03~0.06	< 0.003	< 0.02	< 0.002	< 0.001	Remainder
	DC III	10 kg	4 ~ 4.2	2.7 ~3.3	0.04~ 0.05	< 0.002	< 0.008	< 0.001	–	Remainder
Zinc alloy for zipper			2.3~2.7	0.005	0.004	< 0.015	< 0.008	< 0.002	< 0.002	Remainder
Zinc alloy for galvanizing	G 1	20 kg 1 Ton	0.30~0.35	0.002	–	0.15~0.20	< 0.005	< 0.002	< 0.001	Remainder
	G 2	5.5 kg	3.9 ~4.3	0.003	–	< 0.003	< 0.075	< 0.002	< 0.001	Remainder
	G 3	20 kg	3.9 ~4.3	0.03	–	< 0.02	< 0.075	–	–	Remainder
	G 4	20 kg	9 ~10	–	–	< 0.005	< 0.025	< 0.002	< 0.001	Remainder
	G 5	20 kg	1.8~2.2	0.001	–	< 0.005	< 0.01	< 0.002	< 0.001	Remainder
	G 6	2 ton	0.30~0.35	–	–	< 0.03	< 0.015	< 0.002	< 0.001	Remainder
	G 7	2 ton	0.38~0.43	–	–	0.08~0.10	< 0.005	< 0.002	< 0.001	Remainder
Zinc anode	Anode	5 kg 10 kg	–	–	–	< 0.07	< 0.005	< 0.004	–	Remainder

Table 2. Specifications of Cadmium Ingot, Cupric Sulfate, and Sulfuric acid

Product	Item	Chemical compositions(%)					
		Unit	Cd	Pb	Cu	Fe	Zn
Cadminum stick	CDI	13m/mφ 26m/mφ	99.99	0.006	0.003	0.002	0.002
Cupric sulfate ($CuSO_4.5H_2O$)	98.5% up						
Sulfuric acid (H_2SO_4)	98% up						

Contents of Technology

1) Process description

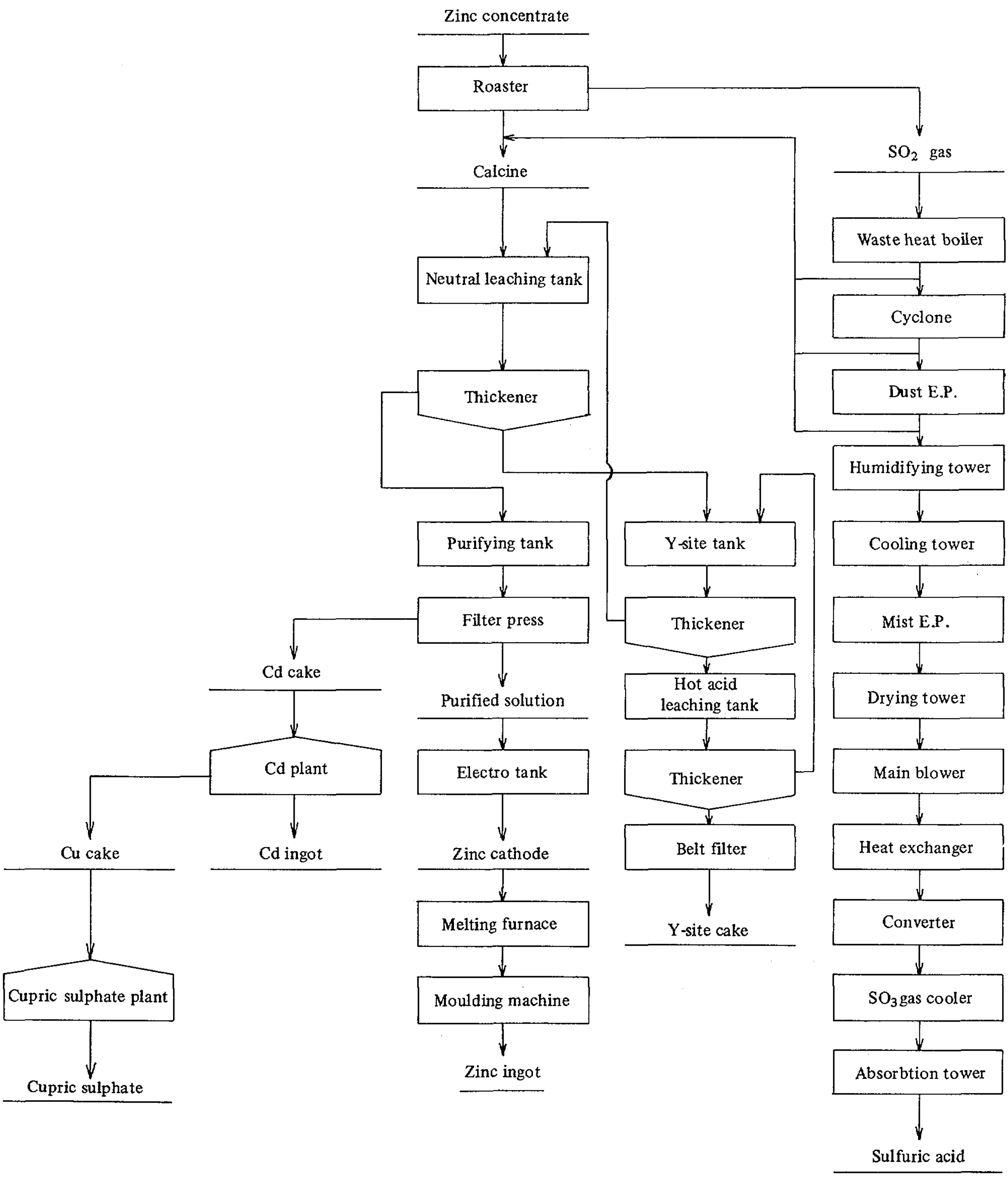
As shown in the flow sheet below, the zinc concentrate as raw materials is roasted to obtain acid-soluble roast. Its zinc metal portion is dissolved in the neutral dissolving process for the removal of various impurities in the subsequent refining process.

In the electrolysis process, the zinc metal, electrolytically deposited on the cathode is stripped by the new solution and melted in the lowfrequency induction furnace to produce zinc ingots.

The zinc metal portion, not dissolved in the preceding metal dissolving process is additionally dissolved in the residue dissolving process in accordance with the concentrated acid and high temperature method for recovery in the main process. It improves the real yield in the long run.

As the by-product of this process, sulfuric acid is produced by utilizing the sulfur dioxide gas generated in the roasting process, while cadmium ingots and cupric sulphate are produced by making use of cadmium and copper cake from the purifying process.

Zinc Manufacturing Process Flow Diagram



2) Equipment and Machinery

Roasting process
- Roaster
- Waste heat boiler
- Air blower & hot gas fan
- Dust cottrel
- Bag filter

Acid making process
- Humidity and cooling tower
- Mist cottrell
- Drying tower and absorption tower
- Irrigation cooler
- Converter
- Heat exchanger
- Storage tank

Leaching process
- Calcine bin
- Leaching & Y-site tank
- Leaching thickener
- Leaching solution tank
- Belt filter & drum filter
- Heat exchanger
- Vacuum pump
- Purifing tank
- Filter press
- Hydraulic pump

Electrolysis process
- Cooling tower
- Electro tank
- Anode plate
- Cathode plate
- Rectifier

Casting process
- Melting furnace
- Moulding machine
- Bag filter
- Ingot case

Cd making process
- Leaching tank
- Filter press
- Electro tank
- Cathode and anode plate
- Melting pot
- Ingot case

$CuSO_4$ making process
- Reverberating furnace
- Leaching tank
- Concentration tank
- Centrifuge

Example of Plant Capacity and Construction Cost

1) Plant capacity : 50,000 m/t/year

2) Estimated construction cost (as of 1977)

o Equipment and machinery	:	US$61,983,000
o Utilities	:	US$26,859,000
Total	:	US$88,842,000

* Above equipment and machinery cost include installation cost

3) Required space

o Site area	:	194,400 m^2
o Building area	:	48,600 m^2

4) Personnel requirement

o Manager	:	50 persons
o Engineer	:	100 persons
o Operator	:	350 persons
Total	:	500 persons

Any inquiry about the information contained should be sent to:
IO/COOP, Registry file No. ID/562/12, UNIDO, P.O. Box 300, A-1400 Vienna, Austria

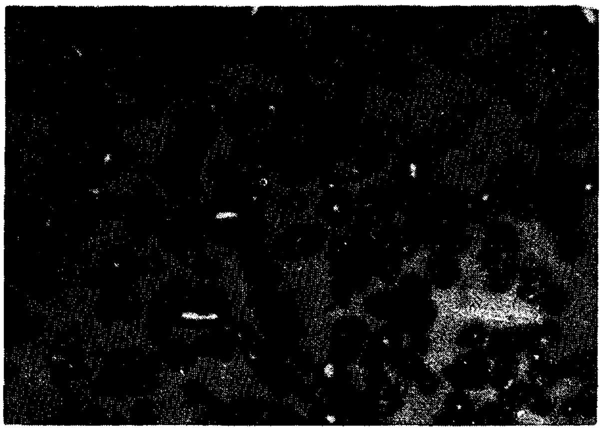
Atomized Metal Powder Plant

'There exist a variety of powder metallurgical products, but this product introduced here is mainly in use as raw materials for the manufacture of copper-related oilless bearings applicable to household electric appliances, general industrial machinery, cars and audio equipment.

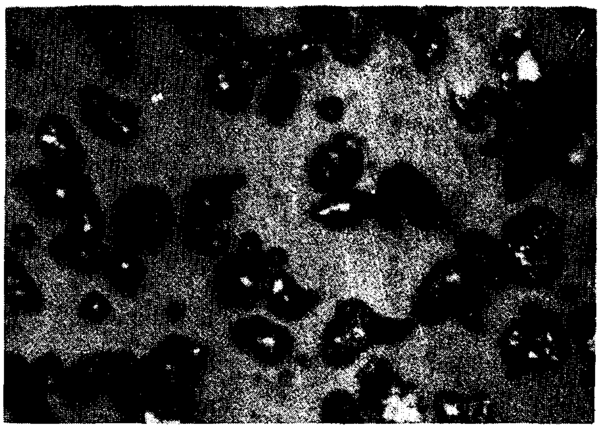
Depending upon its way of manufacturing, the metal powder is classified into the electrolytic metal powder, atomized metal powder and stamping milled metal powder. It also breaks down to the bronze powder, brass powder, kelmet powder, copper powder, tin powder, lead powder and aluminum powder depending upon respective raw materials.

Developed by the Korea Advanced Institute of Science and Technology (KAIST), the manufacturing technology of this product is related to the production of copper powder and tin powder in accordance with such processes as atomization, oxidation and reduction.

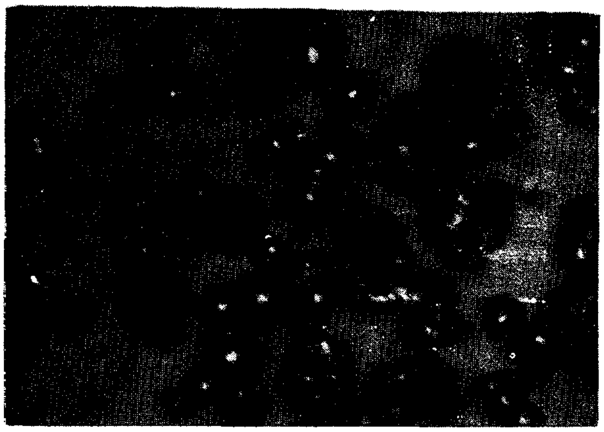
The produced powder is adjusted to have suitable characteristics as a raw material of oilless bearings, whille maintaining its apparent density below 3g/cm^2 as a blending source before forming. It is also the technology improving the workability of the oilless bearing itself by providing the necessary property of fluidity, and mass-producing bronze powder on the basis of water atomization process.



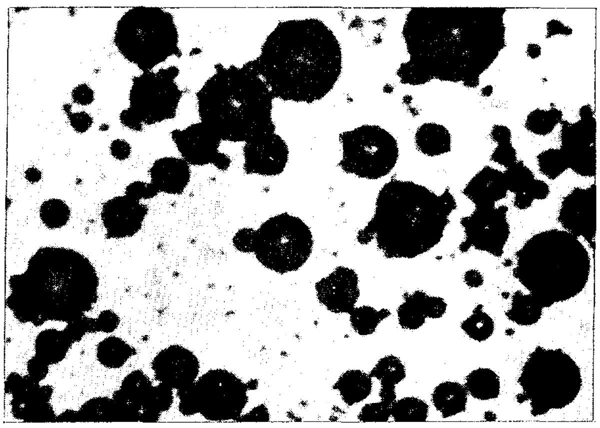
Mixing bronze powder



Brass powder



Lead bronze powder



Kelmet powder

View of Products

Products and Specifications

This plant produces bronze, copper, brass, kelmet, tin, lead, zinc, aluminum and colder powders. Among these, specifications of the brass powder are as shown in Table 1.
in table 1.

Table 1. Specifications of Brass Powder

Spec. \ Model no.		ABra–20	ABra–30
Apparent density (g/cm^3)		2.7 ~ 3.3	2.7 ~ 3.3
Fluidity (Sec/50g)		max. 35	max. 35
Composition (%)		Cu 80 Zn 20	Cu 70 Zn 30
Size distribution	mesh 100 ±	max. 5	max. 5
	150 ±	5 ~ 15	5 ~ 15
	200 ±	10 ~ 20	10 ~ 20
	325 ±	20 ~ 30	10 ~ 30
	325 –	40 ~ 50	40 ~ 60

Table 2. Uses of Metal Powders

Product \ Use		Powder metallurgy	Friction disc	Contact-electrode	Metallikon	Pigment	Catalyst	Application
Bronze powder	Cu-Sn	○	○		○			5, 10, 13, 15, 17, 22, 30
Cu powder	Cu	○	○	○	○	○	○	1, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 15, 17, 19, 20, 21, 25, 27, 28, 30, 31
Brass powder	Cu-Zn	○	○		○	○		6, 9, 11, 12, 15, 17, 30
Kelmet powder	Cu-Pb	○	○		○			5, 9, 11, 12, 15, 17, 30
Sn powder	Sn	○	○		○	○	○	5, 10, 11, 12, 17, 23, 24, 31
Pb powder	Pb	○	○		○	○	○	4, 5, 6, 11, 12, 14, 15, 16, 17, 18, 25 27, 31
Zinc powder	Zn	○			○		○	9, 15, 17, 31
Al powder	Al	○			○	○	○	1, 2, 3, 4, 5, 15, 17, 20, 21, 30, 31
Solder powder	Sn-Pb	○			○			5, 13, 17, 21, 22, 23, 24, 28

1 Pyrotechnics
2 Thermit Reactions
3 Cold Solder
4 Rubber Compounds
5 Bearing
6 Brazing
7 Contact-Electrodes
8 Brush
9 Corrosion Resistance
10 Filter
11 Friction Disc
12 Machine & Ordance Parts
13 Grinding Wheel
14 Anti-Fouling Paint
15 Plastics
16 Grease
17 Plating
18 Sound Equipment
19 Welding Rods
20 Iron & Steel Foundries
21 Ammunition
22 Radiator
23 Jewelry
24 Special Solder
25 X-Ray & Radiation Control
26 Printed Circuit
27 Sound Dampening Compound
28 Additions to Iron Powder
29 Infiltrating Powder
30 Friction Parts
31 Catalyst

Contents of Technology

1) Process description

The melting process makes use of an ordinary metal melting process, while the atomizing process breaks down to the air and water spraying methods depending upon the kind of products.

In the spraying process, the metal powder having required form and particle size can be manufactured by appropriately adjusting the spray nozzle, spray pressure and spray medium, while its particle size can be adjusted up to -325 mesh.

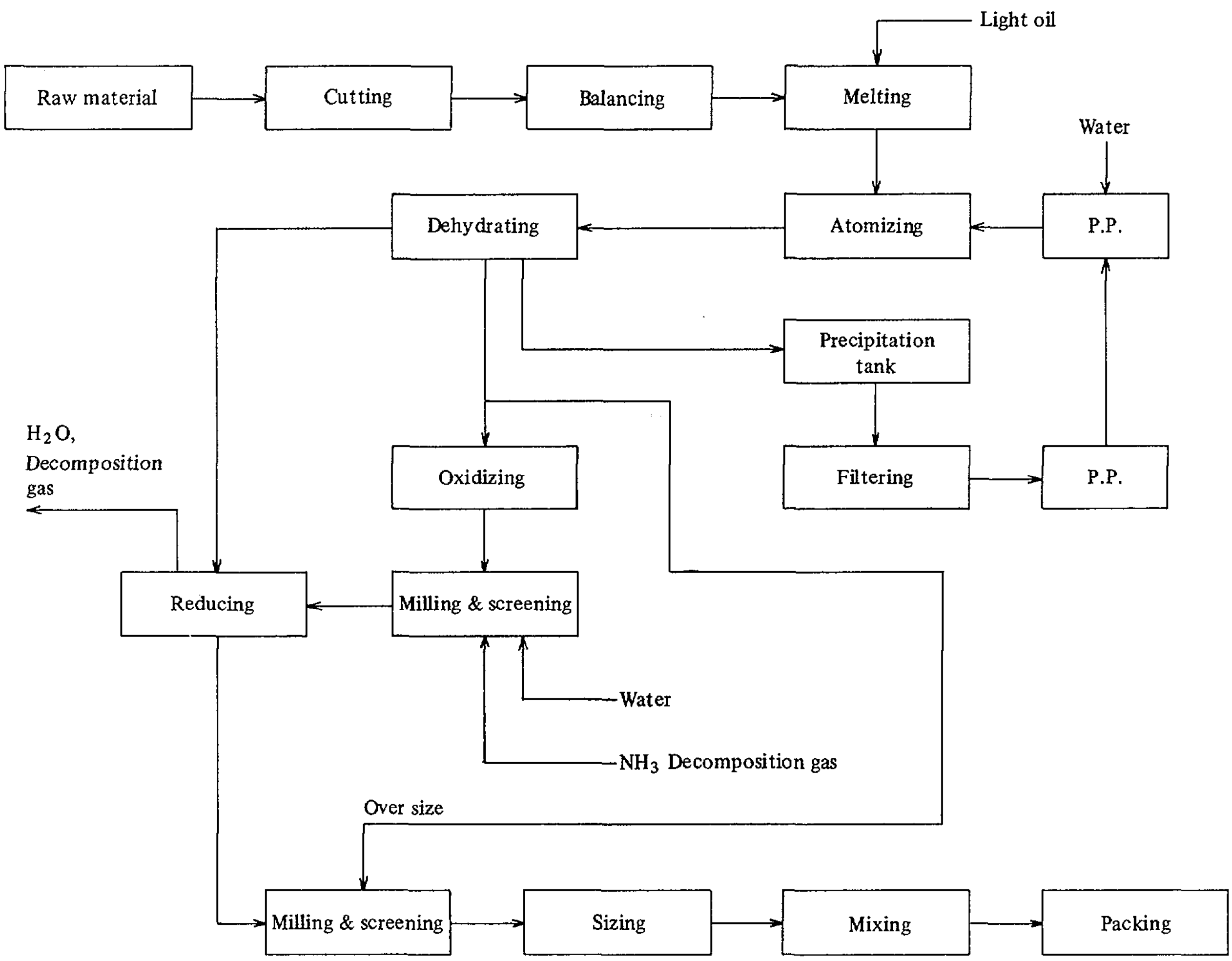
When water-sprayed, a dehydration process is necessary. The powder of irregular and porous form can be produced by oxidation and reduction processes depending upon the use of products.

The particle size adjustment as well as the addition of a lubricant are required for conforming to such conditions as its flow rate and expansion when sintering.

2) Equipment and Machinery

- Mechanical press
- Melting furnace
- Atomizing chamber
- Plunger pump
- Oxidizing furnace
- Crusher
- Sieve
- Reduction furnace
- Duble cone mixer

Atomized Metal Powder Manufacturing Process Flow Diagram



3) Raw Materials and Utilities

○ Bronze powder

Raw materials and utilities	Requirement (per ton of product)
Electrolytic copper	934.5 Kg
Tin	118.8 Kg
Electric powder	340 Kwh
Water	20 M/T
Light oil	4 D/M
NH_3	5 Kg

Example of Plant Capacity and Construction Cost

1) Plant capacity : 200 m/t/year

2) Estimated equipment cost (as of 1981)

- ○ Equipment and machinery : US$285,000
- ○ Utilities : US$100,000

Total : US$385,000

3) Required space

- ○ Site area : 3,240 m^2
- ○ Building area : 784 m^2

4) Personnel requirement

- ○ Plant manager : 1 person
- ○ Engineer : 2 persons
- ○ Operator : 14 persons
- ○ Others : 3 persons

Total : 20 persons

0

FILE: 011
ISIC 3819

STEEL FABRICATION AND IRONWORK FACTORY

1. PREFACE

A steel fabrication and ironwork factory is suitable for the manufacture of light steel buildings, cold-bent plate profiles, pressed plate doors, single-beam cranes, crane tracks with columns, aluminum profile products, vessels, tanks etc.

The basic materials used in the plant are normal cold-rolled or hot-rolled steel plates and profiled steel as well as aluminum profiles.

The equipment and the plant can be easily tailored to suit different requirements, ranging from plants using production methods which require a high proportion of manual work to others equipped with automatic machinery lines which require a relatively small amount of labor.

2. CAPACITY OF THE PLANT

The plant for manufacturing light steel buildings, cold-bent plate profiles, pressed plate doors, single-beam cranes, crane tracks with columns, aluminum profile products, vessels, tanks etc. is of medium-sized capacity.

Basic materials consumption may be up to 2,300 tons per year.

The capacity of the plant can be increased by increasing the number of shifts.

3. BRIEF DESCRIPTION OF THE PROCESS

The basic materials are stored according to type in the materials store, from where they are taken to the manufacturing section by hand or machine-powered materials handling equipment.

The manufacturing process consists of the cutting stage, the machining stage, testing, surface treatment, assembly and final quality control.

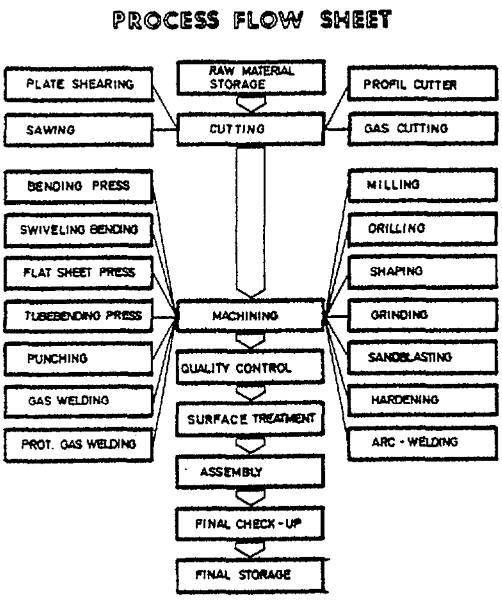
The finished products are stored according to type in final storage.

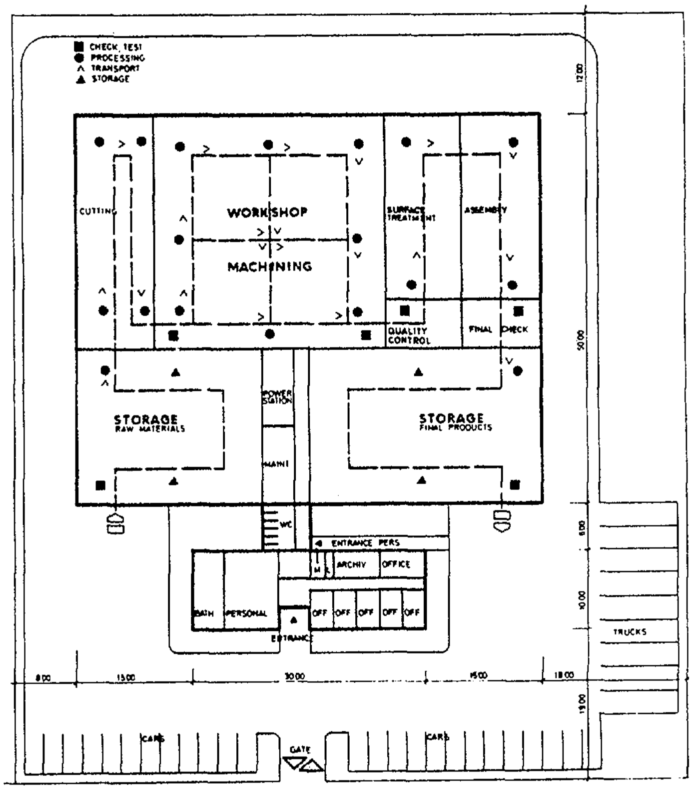
At the cutting stage, the materials are prepared by sawing, shearing, profile cutting and gas cutting. They are then taken to the machining shop.

At the machining stage, the prepared parts are machined by bending, pressing, punching, milling, drilling, shaping, grinding, different kinds of welding, sand-blasting and hardening, to become semi-finished products.

The semi-finished products are checked and tested before passing to the surface treatment stage where equipment is installed for surface preparation and painting. The parts then go to the assembly stage.

The finishing products are either delivered straight to the customer or stored in the final storage area.





4. REQUIRED BASIC AND AUXILIARY MATERIALS

The quantity of the various materials required depends on the product mix and the methods used.

Below are the approximate material requirements of the plant for one year's production.

- Cold-rolled or hot-rolled steel plates	1,200 tons
- Profiled steel	800 tons
- Aluminum sheet plates	100 tons
- Aluminum profiles	200 tons
- Electrodes	
- Welding wire	
- Oxygen	
- Acetylene	
- Protective gas	
- Cleaning materials	
- Chemicals and paints	
- Various additional materials	

5. AREA REQUIREMENTS:

Required site area:	8,340 m^2
Required building area:	
Production hangar	1,800 m^2
Storage hangar:	1,200 m^2
Office building:	324 m^2

Structural:
Production hangar, storage hangar

Columns and beams	- steel construction
Walls	- corrugated iron sheets
Floors	- concrete
Roof	- metal sheeting on sawtooth roof construction

Office building

Columns and beams	- steel construction
Walls	- corrugated iron sheets, brick-lined
Floors	- PVC-paved
Roof	- steel construction with metal sheeting

6. MACHINERY AND EQUIPMENT (Estimated total FOB price:approx. US$ 1.375.000)

Description:	Quantity:	Description:	Quantity:
Plate shearing unit	1	Gas welding unit	2
Sawing unit	2	Protective-gas welding unit	3
Profile cutter	2	Surface treatment unit	1
Bending press	2	Air compressor	1
Swiveling bending device	1	Right angle grinder	4
Flat sheet press	1	Diesel fork lift	2
Tube-bender	1	Hand fork lift	6
Punching machine	2	Workbench, assembly bench	10
Milling machine	1	Tool cabinet, shelf unit,cupboard	6 of each
Shaper	1	Lathe	1
Pillar drill	2	Hand tools, machine tools	
Grinding machine	2	Welding tool kit, metalworker's tool kit, mechanic's tool kit electrician's tool kit	1 of each
Sand blaster	1		
Tempering furnace	1		
Arc welding unit	8	First aid box	7

7. POWER REQUIREMENTS

Power type:	3 x 380 V, 50 Hz
Built-in capacity:	120 kW
Total power consumption during simultaneous use:	92 kW
Power consumption/year:	184,000 kWh

8. PERSONNEL REQUIREMENTS

Production staff

- Master technicians	3
- Master skilled workers	12
- Skilled workers	36
- Semi-skilled workers	12
- Unskilled workers	15

Management and administrative staff

- Technical plant managers	1
- Commercial plant managers	1
- Technicians	3
- Sales managers	1
- Purchasing managers	1
- Clerical staff	5

Work-time base

Number of shifts taken into consideration:	1 shift per day
Work-time taken into consideration:	8 hours per day
Number of work-days:	250 days per year

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FILE: 012
ISIC 3819

ELECTROPLATING WORKSHOP

1. PREFACE

Electroplating workshops are primarily service workshops, offering their services to a wide range of industries.

The electroplating workshop can plate various materials, such as cast iron, steel, Sn/Pb (centrifugally cast), brass, copper and various alloys.

In the plant, the materials can be zinc-plated, nickel-plated or chrome-plated.

The electroplating dips can be changed easily, permitting the plating of copper, brass and auralloy.

The equipment and the plant can be easily tailored to suit different requirements, ranging from plants using production methods which require a high proportion of manual work to others equipped with automatic machinery lines which require a relatively small amount of labor.

2. POTENTIAL CUSTOMERS

Potential customers for the services of an electroplating workshop are:

- The machinery industry
- The electrical industry

3. CAPACITY OF THE PLANT

The capacity of the electroplating workshop for zinc, nickel and chrome plating is small.

The raw materials passage may be up to 100 tons per year, with individual components of 0.05 to 0.5 kg.

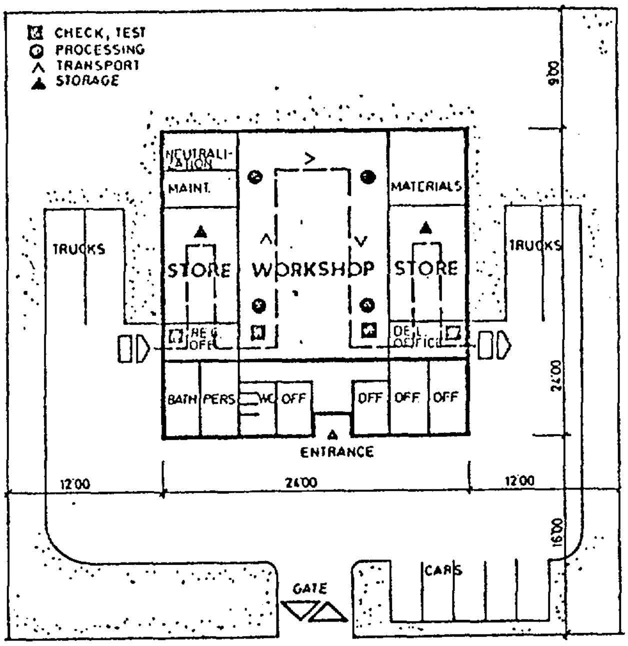
The plant's capacity can be increased by increasing the number of shifts.

4. BRIEF DESCRIPTION OF THE PROCESS

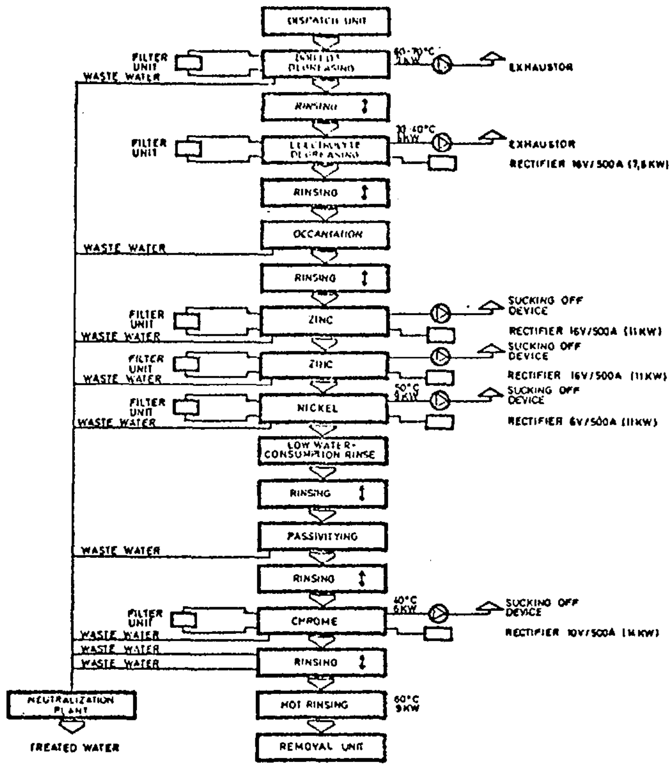
In general, the metal parts to be plated are inserted into the galvanizing cylinder at the despatch unit and are removed by the removing unit at the end of the process.

During processing, the parts pass through different stages: boiled degreasing, electrolytic degreasing, rinsing, hot rinsing, decantation, passivation, zinc plating, nickel plating and chrome plating.

The process flow sheet shows all the possible necessary treatments in one series. The actual processing stages must be laid down individually for each basic plating material and plated surface.



PROCESS FLOW SHEET



5. REQUIRED BASIC AND AUXILIARY MATERIALS

The quantities of the various materials needed depend on the nature of the work which is done in the plant and the methods used.

Below are the approximate materials requirements of the plant for one year's operation:

- Electrolytic degreasing mixture	2,400 kg	
- Boiling degreasing mixture	2,400 kg	
- Decantation HCL/water = 1/1	2,000 l	(supplement after
- Nickel	500 l *	analysis)
- Passivation	30,000 l	
- Chrome	500 l *	
- Zinc	1,000 l *	
- Water	5,760 m^3	

*) Occasionally necessary depending on analysis results.

6. AREA REQUIREMENTS

Required site area:	2,350 m^2
Required building area	
Production hangar:	288 m^2
Storage hangar:	144 m^2
Office building:	138 m^2

Structural:
Production hangar, storage hangar, office building

Columns and beams	- prefabricated concrete
Walls	- brick-lined, plastered
Floors	- concrete, PVC-paved
Roof	- concrete ceiling with metal sheeting

7. MACHINERY AND EQUIPMENT (Estimated total FOB cost: approx. US$ 350.000)

Description:	Quantity:	Description:	Quantity:
Tank: 1000 x 1000 x 750 mm	10	Additional control unit	1
Tank: 1200 x 1000 x 750 mm	12	Air compressor	1
Galvanizing Cylinder:		Universal lathe	1
450 mm dia x 750 mm	6	Pillar drill	1
Longitudinal feeder	2	Framed saw	1
Transverse feeder	2	Universal milling machine	1
Mounting frame	22	Shaper	1
Exhaustor	6	Arc protective gas welding	
Rectifier 10V/ 500 A	2	unit	1
Rectifier 6 V/ 500 A	1	Gas welding unit	1
Rectifier 16 V/ 500 A	2	Metal worker's tool kit	1
Cylinder drive	6	Electrician's tool kit	1
Filter unit	6	Grinding machine	1
Metering and control system	1	Portable tool box	2

Workbench, assembly bench, shelf unit, tool cabinet, cupboards,machine tools, hand tools, etc.

8. POWER REQUIREMENTS

Power type:	3 x 380 V, 50 Hz
Built-in capacity:	170 kW
Power consumption during simultaneous operation:	140 kW
Power consumption per year:	280,000 kWh

9. PERSONNEL REQUIREMENTS

Production staff

- Master technicians	1
- Master skilled workers	2
- Skilled workers	2
- Semi-skilled workers	2
- Unskilled workers	10

Management and administration staff

- Plant managers	1
- Technicians	1
- Clerical staff	2

Work-time base

Number of shifts taken into consideration:	1 shift per day
Work-time taken into consideration:	8 hours per day
Number of work-days:	250 days per year

The plant is also suitable for operation in more shifts.

This information has been prepared for UNIDO by Horst Langbauer, Austria. Any inquiry about the information contained should be sent to: IO/COOP, Registry file No.ID/562/12, UNIDO, P.O. Box 300, A-1400 Vienna, Austria.

FILE: 013
ISIC 3819

METAL PUNCHING PLANT

1. PREFACE

A punching plant is suitable for manufacturing strap-hinges, corner plates, flush latches, mouse and rat traps, clamps, draw pulls, countersunk door pulls for cupboard or wardrobe doors and other small metal parts.

The basic materials used in the plant are normal steel sheets, aluminum sheets, copper sheets and brass sheets.

The equipment and the plant can be easily tailored to suit different requirements, ranging from plants using production methods which require a high proportion of manual work to others equipped with automatic machinery lines which require a relatively small amount of labor.

2. CAPACITY OF THE PLANT

The capacity of the plant for manufacturing strap-hinges, corner plates, flush latches, mouse and rat traps, clamps, draw pulls, countersunk door pulls for cupboard or wardrobe doors and other small metal parts is small.

Basic material consumption may be up to 250 tons per year for production of approx. 800,000 units.

The capacity of the plant can be increased by increasing the number of shifts.

3. BRIEF DESCRIPTION OF THE PROCESS

The basic materials are stored according to type in the sheet store, from where they are taken to the machining shop by hand or machine-powered materials handling equipment.

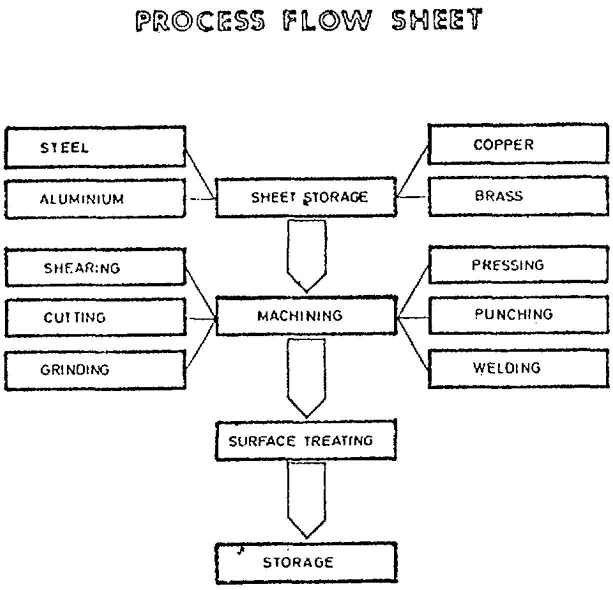
The manufacturing process is made up of the machining stage and the surface treatment stage.

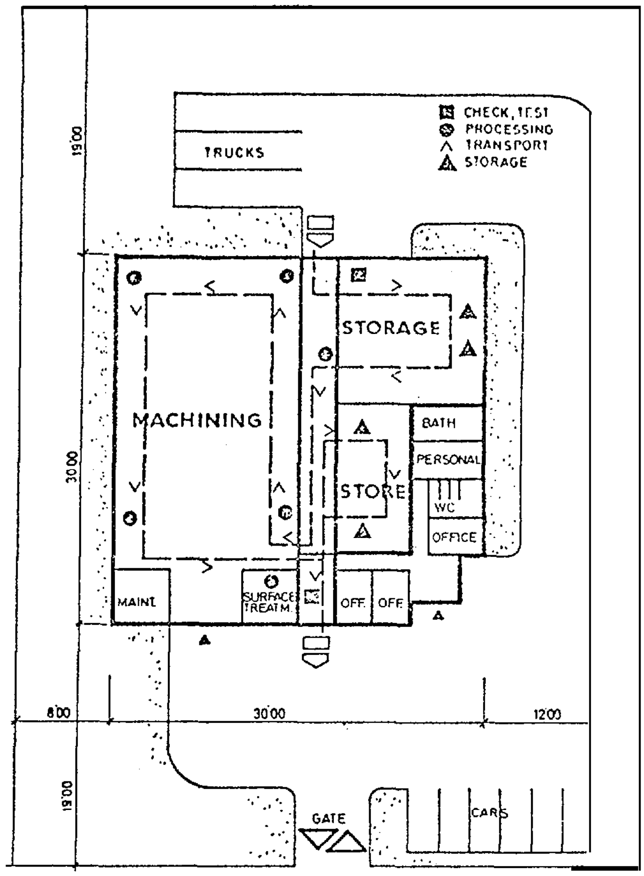
At the machining stage, the sheets are prepared for further machining by shearing and cutting.

The prepared sheets are machined by pressing, punching, welding and grinding, resulting in semi-finished products.

The semi-finished products are checked and tested before being taken to the surface treatment stage where equipment for surface preparation and painting is installed.

The products are then taken to the store. From there, the finished products are either delivered straight to the customer or put into final storage.





4. REQUIRED BASIC AND AUXILIARY MATERIALS

The quantity of the various materials needed depends on the particular product mix and on the methods used.

Below are the approximate material requirements of the plant for one year's production:

- Steel sheets 150 tons
- Aluminum sheets 50 tons
- Copper sheets 25 tons
- Brass sheets 20 tons
- Other sheeting 5 tons
- Electrodes
- Welding wire
- Oxygen
- Acetylene
- Protective gas
- Cleaning chemicals
- Chemicals and paints
- Various additional materials

5. AREA REQUIREMENTS

Required site area:	3,400 m^2
Required building area:	
Production hangar:	450 m^2
Storage hangar:	306 m^2
Office building:	124 m^2

STRUCTURAL:

Production hangar, storage hangar

Columns and beams	- prefabricated concrete or steel construction
Walls	- brick-lined
Floors	- concrete
Roof	- metal sheets

Office building

Columns and beams	- concrete
Walls	- brick-lined, plastered
Floors	- PVC-paved
Roof	- concrete ceiling with metal sheeting

6. MACHINERY AND EQUIPMENT (Estimated total FOB price: approx. $US 700,000)

Description:	Quantity:	Description:	Quantity:
Small-scale punching device	3	Right angle grinder	2
Large-scale punching device	2	Air compressor	1
Press	1+1(two types)	Tempering furnace	1
Punching machine	3	Diesel fork lift	1
Shearing machine	1	Hand fork lift	3
Cutter	1	Assembly workbench	5
Universal lathe	1	Tool cabinet	3
Universal milling machine	1	Shelf unit	3
Framed saw	1	Cupboard	3
Shaper	1	First aid box	2
Grinding machine	1	Welding tool kit	2
Pillar drill	1	Metalworker's, mechanic's, electrician's tool kit	1 of each
Prot. gas welding unit	1		
Arc welding unit	1		

7. POWER REQUIREMENTS

Power type:	3 x 380 V, 50 Hz
Built-in capacity:	120 kW
Total power consumption during simultaneous use:	92 kW
Power consumption per year:	184,000 kWh

8. PERSONNEL REQUIREMENTS

Production staff

- Master technicians	1
- Master shilled workers	2
- Skilled workers	6
- Semi-skilled workers	4
- Unskilled workers	5

Management and administrative staff

- Plant managers	1
- Technicians	1
- Clerical staff	1

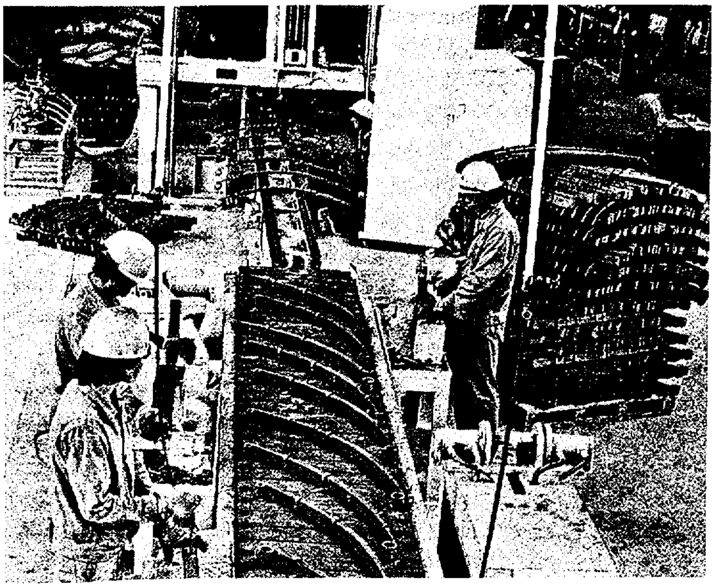
Work-time base

Number of shifts taken into consideration: 1 shift per day
Work-time taken into consideration: 8 hours per day
Number of work-days : 250 days per year.

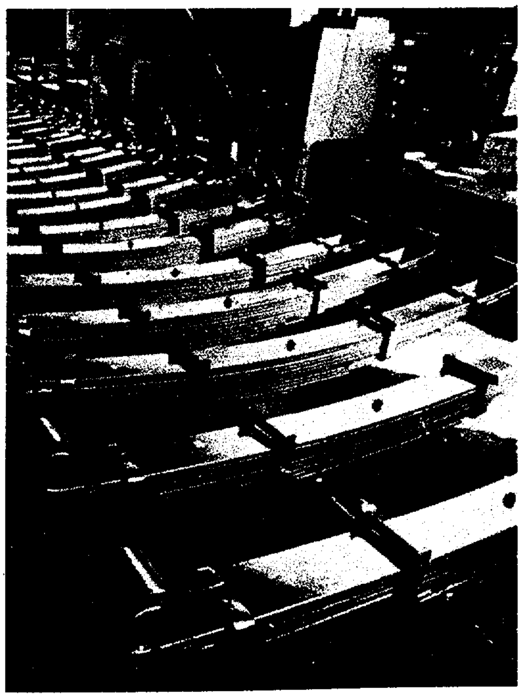
This information has been prepared for UNIDO by Horst Langbauer, Austria. Any inquiry about the information contained should be sent to: IO/COOP, Registry file No. ID/562/12, UNIDO, P.O. Box 300, A-1400 Vienna, Austria.

FILE: 014
ISIC 3819

Leaf Spring Making Plant



View of Leaf Spring Assembling Process



View of Products

The spring is one of the mechanical elements making maximum use of the elasticity of material and the energy absorption capacity. It has such functions as shock absorption, anti-vibration (suspension spring), maintenance of constant force or torque (valve spring, spring washer, watch spring), and indication or adjustment of load and torque (scale spring, manometer).

Mainly, the material of spring steel is heated (approximately 900°C) for forming to be formed into the spring, with the material used hereby called the hot-formed material. For the reason, it is applicable mainly for large-size plate spring (leaf spring), coil spring and torsion bar rather than small-size spring.

The material used here is manufactured through processes of steel making and rolling, and the selection of materials suiting respective occasions of use is of much significance, since the effect of its mechanical property is also important to the product quality.

First of all in particular, as the most essential properties for the purpose of uses, the elastic coefficiency, form, dimension and accuracy and other mechanical properties of the material should be familiarized for the subsequent determination of design, arrangement for materials and heat treatment conditions.

The technology and manufacturing plant here relate to the production of got rolled leaf springs. The plate springs are used mainly as rear springs of small-size cars, rear springs of small-size trucks, front and rear springs of medium and large-size trucks, front and rear springs of buses and springs of the rolling stock.

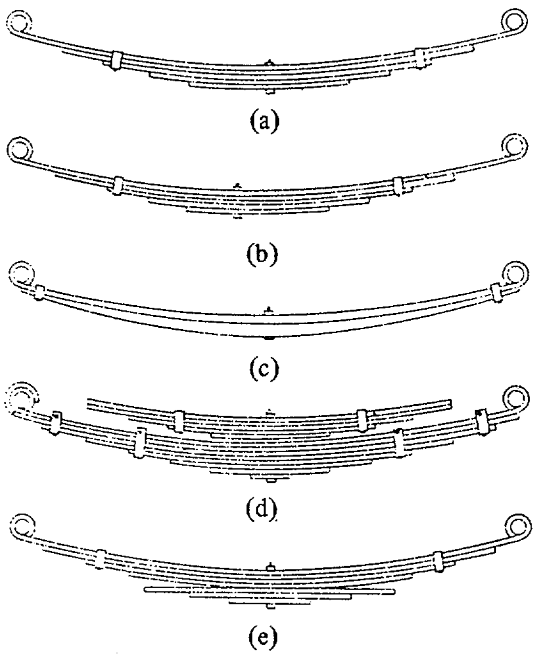
The important element of spring consists of heat treatment and test of materials. Arranged to suit the circumstances of developing countries, the technology and plant have the advantage of being easily digested and utilized.

Products and Specifications

In the above figure, (a) is the symmetrical and general spring, while (b) is called the unsymmetrical spring and used mainly as rear springs of cars. The unsymmetrical spring is characterized by its spring constant of preventing rolling and wind-up phenomena compared with similar symmetrical spring. (c) is the parabolic spring mainly used as rear springs of cars and trailer springs, being capable of reducing the weight of spring while maintaining the same strength and also enhancing the feeling of car riding. (d) is the combination of main spring and auxiliary spring and mainly used as rear springs of heavy-duty trucks with the main spring primarily working and the auxiliary spring also working as the load increases. (e) is the progressive spring and mainly used as rear springs of medium and small trucks, being the type more developed than the above springs of (a), (b), (c) and (d). It is used to improve the feeling of car riding, because the spring constant changes as the load increases.

Depending upon such uses, it is possible to manufacture various types of leaf springs of 5-35mm in thickness, 45-125mm in width and up to 2 meters in length.

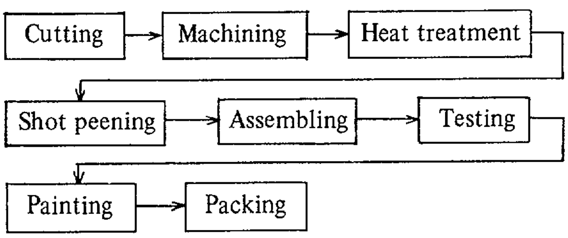
Fig 1. Types of Leaf Spring



Contents of Technology

1) Process Description

Leaf Spring Manufacturing Process Block Diagram



Cutting

As to the spring steel prescribed by the Korean Industrial Standards (KS), it is SPS1 carbon steel and used as leaf springs of the rolling stock, with almost no SPS2 being used. The types of steel mainly used in Korea at present are four different kinds of SPS1, 3, 5A and 7.

Regarding the hot-forming spring steel, SUPS and SUP4 are prescribed as spring carbon steel in JIS G 4801, while Si-Mn steel (SUP6, SUP7), Mn-Cr steel (SUP9), Cr-V steel (SUP10) and B steel (SUP11) are prescribed as alloy steel.

SUP3 and SUP4 have been much used for the rolling stock, but are being replaced recently by SUP9 for the purpose of improving the anti-fatigue and quenching properties. SUP6 and SUP9 are widely in use as suspension spring, and SUP10 and SUP11 are used for large-size springs of industrial machinery and vehicles for their excellent quenching property.

Depending upon uses, flat bars of the types of steel described above are purchased and cut in necessary length.

Machining

The machining is performed to drill the center hole for inserting the center bolt binding all plates together and fixing the spring after attaching to the car, and the eye-forming work is done to make eyes of the first plate.

To provide the spring with a taper when necessary, the tapering work is performed with taper rotor to be followed by the drilling work for inserting rivets which play the role of protecting the carrier plate and controlling the lateral thrust when the spring rebounds.

Heat treatment

Regarding the quality of spring function, the heat treatment method is, along with the selection of material, an important element, being very important process in manufacturing springs. In forming the spring, there are two different methods; the cold forming method by which the material with required property as spring is first formed at room temperature, and the hot forming method by which the material heated and then formed to be subject to the heat treatment providing the characteristics of spring. The latter method is used here.

The formed spring is once heated to the fixed temperature and put in the fixed oil bath for quenching to enhance its hardness, followed by the tempering to obtain the necessary toughness characteristic of the spring. The tempering is continuously performed to prevent any aging crack caused by the quench stress as a result of quenching. The tempering temperature is usually 400-520°C though varying depending upon the types of steel and the hardness required.

Shot peening

The steel particles with the diameter of around 1mm are projected to the surface of product at high speed (600m/sec) and keep the residual compressive stress on the outermost surface (0.2-0.3mm) so that its fatigue strength is improved by offsetting the tensile stress produced by the other load.

Highly effective for such defects as rolling flaw and heat treatment flaw, the shot peening also has the blasting effect since it can get rid of such flaws or scale.

Assembling

After rivetting in bolt type or clinch type, the bushing is inserted. The bushing is generally divided into the metallic bushing and nonmetallic bushing. Materials of the metallic bushing are iron, bronze, phosphorus bronze and brass. There is also the double bushing with iron surface and bronze interior (or phosphorus bronze).

The rubber bushing usually breaks down into the flange type and pipe type. The advantage of rubber bushing is that no noise is produced between the shackle and bushing and the feeling of car riding is improved, while its disadvantage is relatively poor durability coupled with short life. Therefore, the rubber bushing is widely used for cars and medium and small-size trucks, with the metallic bushing used for large-size trucks. After inserting the bushing, its accuracy is adjusted by reamer to begin the assembling.

Load testing

The basis of the spring testing load is generally the stress of 90kg/mm^2 occurring on the surface of spring as prescribed by KS B 2401 and JIS B 2701. In actuality, however, it should be the vertical live load exerted on the spring. The vertical live load depends upon road conditions and running speed. In case of Korea, the basis is within 2g of the normal load, that is 1.75-2g for the front spring and 2-2.5g for the rear spring, being generally 2g.

The setting load is 1.1 times of the testing load as prescribed in the KS and JIS, but in case testing load conditions are not given, the test should be conducted with the load above the yield point. The yield point can usually take without difficulty 88 percent of the tensile strength and about 90 percent of the tensile strength is taken for the setting stress.

Following the processes described above, the products are painted and marked prior to packing and delivery.

2) Equipment and Machinery

Shearing line
- Hoist crane
- Stand with feeding conveyor
- Shearing machine with plate conveyor
- Diamond cutting machine
- Punching machine
- Center heating furnace
- End heating furnace
- Air cooling equipment
- Side cutting (trimming) machine
- Eye forming machine
- Wrapper forming machine
- Hydraulic press
- Flat correction press
- Taper rolling machine
- Drilling machine
- Grinder

Heat treatment line
- Walking beam type hardening furnace (3T/hr)
- Walking beam type hardening furnace (1T/hr)
- Walking beam type hardening furnace (2T/hr)
- Carrier conveyor
- Curving roller
- Curving roller (small)
- Quenching bath with conveyor
- Chain conveyor type tempering furnace
- Clip forming press
- Grinder for brinell hardness testing
- Brinell hardness tester

Assembling line
- Shot peening machine
- Camber corrector
- Surface plate (L type)
- Primary painting conveyor with painting bath
- Eye grinder
- Bushing machine
- Reamming machine (finish)
- Assembling conveyor with air vice
- Riveting machine
- Presetting and load testing machine
- Carriage tool
- Jib crane
- Carrier conveyor
- Acrossing conveyor
- Weather booth for painting
- Airless spray unit
- Final conveyor for painting

3) Raw Materials

○ One-ton truck leaf spring

Raw materials	Requirement (per ton of product)
Flat steel Bushing Center bolt Paint	1,070 kg

Example of Plant Capacity and Construction Cost

1) Plant capacity: 1,000 ton/month

2) Example of estimated construction cost (as of 1983)

o Equipment and machinery	:	US$ 3,006 850
o Utilities	:	US$ 321,050
o Installation cost	:	US$ 1,006,690
Total	:	US$ 4,334,590

3) Required space

o Site area	:	30,000m^2
o Building area	:	9,000m^2

4) Personnel requirement

o Plant manager	:	5 persons
o Engineer	:	10 persons
o Operator	:	150 persons
Total	:	165 persons

Any inquiry about the information contained should be sent to:

IO/COOP, Registry file No. ID/562/12, UNIDO, P.O. Box 300, A-1400 Vienna, Austria

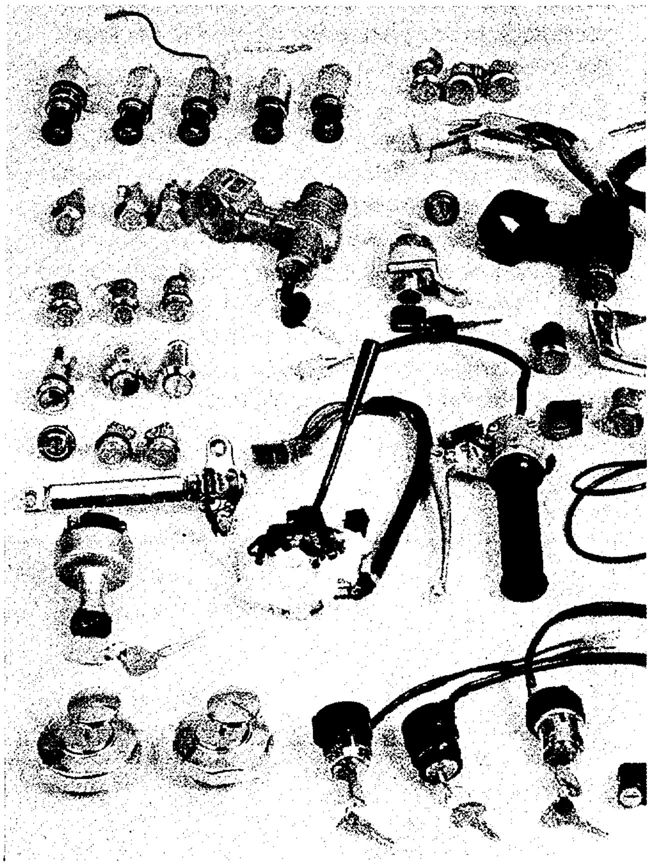
Automatic Key Set Making Plant

The key sets produced by this key set manufacturing plant are parts for automobiles and motorcycles.

The products are characterized by the use of above 1,000-code keys and can be operated only by specific ones depending upon types, because the key sets are arranged in combination with other component parts (lock plate).

The devices with various functions and fixed on the locks can be such function devices as serving the purpose of ignition starting, door locking and fuel tank locking.

With a 10-year history in manufacturing technically tied up with the Jakairika of Japan, this key set manufacturing plant has brought about a tremendous technical improvement. It has already been designated by the Korean government as one of the auto part (key set) plants.



Products and Specifications

Largely divided into the automobile use and motorcycle use, the key sets produced by this plant include the following types and functions:

Production	Application
Key sets for automobile	
· Ignition switch	On-off switch for electric current automobiles including the function of starting switch
· Steering handle lock	Functions of ignition switch and steering handle lock
· Door lock	Function of locking the door (RH and LH uses)
· Truck lid lock	Function of locking the truck
· Fuel tank lock	Function of locking the fuel tank
Key sets for motorcycle	
· Combination switch	Function of on-off switch in motorcycle
· Steering handle lock	Function of locking the steering handle lock
· Fuel tank cover lock	Function of locking the fuel tank
· Front box lock	Function of locking the front box lock
· Helmet holder	Function of locking for the custody of helmets
· Seat lock	Function of locking the seat

Contents of Technology

1) Process Description

- Raw materials: Zinc alloy ingot, aluminum alloy ingot, acetal and nylon resins, steel plate and copper plate are purchased from the market for distribution to each process.
- Die casting: Zinc alloy ingot and aluminum alloy ingot are respectively melted and refined while worked on by the die casting machine, with produced burrs completely eliminated. It undergoes various kinds of machinings including drilling and tapping to be subject to metal plating for the prevention of gloss and corrosion prior to be committed to the assembly line.
- Injection molding: Such resins as acetal, nylon and polyvinyl chloride are made into respective products by injection molding machines to be supplied to the

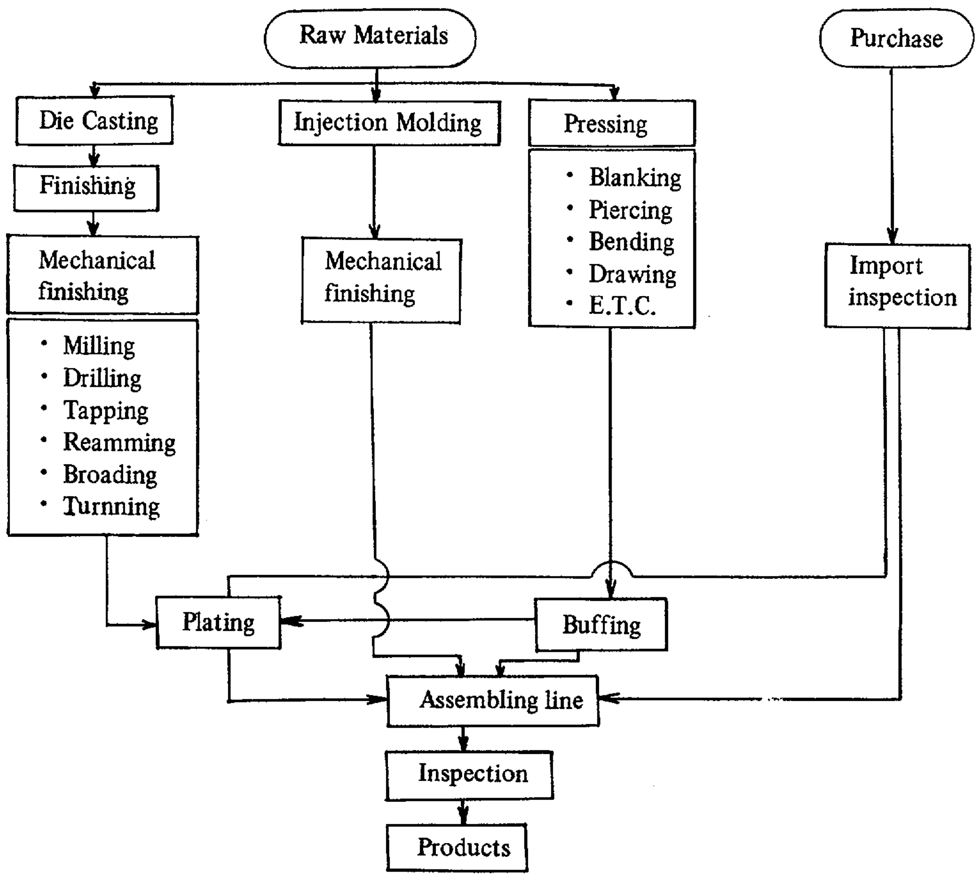
assembly line after simple machining.

- Press work: Steel plate, copper plate and resin plate are processed into fixed shapes of plates and other formed products by means of press machines. When gloss is required or beautiful surface is desired, the products go through buffing process prior to committment to the assembly line. In case possible corrosion is feared to take place, such component parts undergo the plating and supplied to the assembly line.
- External order and purchase: The items for which no production facilities are available at the plant or the production is difficult due to conditions involved are externally ordered and purchased in quantities out of the available products. However, only such items as meeting the quality and other conditions required by the acceptance inspection are supplied to the assembly line, and the component parts deemed to cause corrosion are committed to the assembly line after proper plating.
- Assembling: The pre-cast parts, injection-molded parts, pressed parts and other purchased parts are assembled at the streamlined assembly line based on the principle of process control as well as quality control.
- The finished products are subject to the delivery inspection to see whether they meet the requirements of various specifications and conditions for automobiles and motorcycles to be equipped with such products. Only those products passing the final inspection are delivered to the customers.

2) Equipment and Machinery

Die casting machine
Injection molding machine
Crush machine
Power press
Accentric press
Shearing machine
Air compressor
Tool grinder
Bench lathe

Key Set Manufacturing Process Flow Sheet



Ordinary lathe
Bench drilling machine
Riveting machine
Spot welding machine
Shot blasting machine
Coating
Filter
Barrel grinder
Buffing grinder
Dryer
Rectifier
Plating tank
Horizontal milling
Ultrasonic cleaner
Booster press

Example of Plant Capacity and Construction Cost

1) Plant capacity: 300,000 set/year

2) Estimated equipment cost (as of 1982)

o Equipment and machinery	:	US$ 1,500,000
o Utilities	:	US$ 640,000
o Installation cost	:	US$ 64,000
Total	:	US$ 2,204,000

3) Required space

o Site area	:	6,000m^2
o Building area	:	4,000m^2

4) Personnel requirement

o Plant manager	:	3 persons
o Engineer	:	20 persons
o Operator	:	150 persons
Total	:	173 persons

Any inquiry about the information contained should be sent to:
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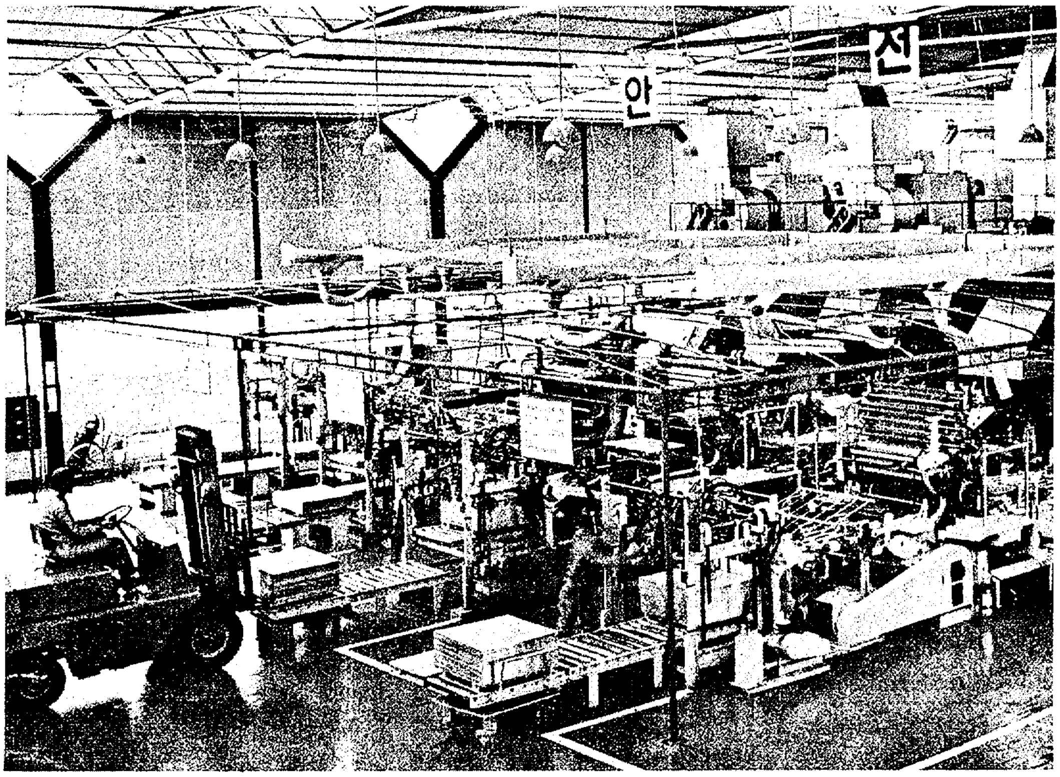
FILE: 016
ISIC 3819

Crown Cap Making Plant



View of Crown Cap Manufacturing Shop

The crown cap is an essential item for use in bottling beer, other beverage and general foodstuffs. In general, high pressure crown caps lined with PVC sol or cork inside the caps are used for beer and Coca Cola, while P.P. crown caps as low pressure products are in use for juice, liquor and other foodstuffs. The high pressure crown caps are made mainly of the tin plate as raw material and low pressure crown caps are made of the aluminum sheet.

The demand for crown caps tend to gradually increase with the increase in demand for favorite foods and also types of the product have diversified in accordance with customer's requirements.

The crown cap making plant consists of three sections of cork disc manufacturing, tin plate printing and crown cap manufacturing. The products thus manufactured undergo water tightness and pressure tests prior to delivery.

Produced in this plant are quality crown caps which already passed standards and sanitation tests of the Coca Cola Company of the United States in 1970. It has technology capable of manufacturing in quantities anytime the superb products customers require.

Products and Specifications

Crown caps of diverse specifications can be produced in this plant in response to orders from customers.

Contents of Technology

1) Process Description

The process of crown cap manufacturing plant generally consists of four steps: plating-making, printing, press and lining.

Plate-making

Design: A process drafting in accordance with definite standards the type, size and color of crown as well as the model of trademark and lettering clients require.

Photographing: A process making the negative film as a standard by photographing the designed draft.

Printing: A process reversing the photographed film to the negative or positive depending upon working conditions.

Film drying: A process drying the printed film.

Editing: A process making the original film for plate-setting on the printing tin plate by editing one negative or positive film into multiple films.

Coating with sensitizer: A process making the sensitive plate by coating sensitizer on the polished plate and subsequent drying.

Developing: A process in which the water-soluble photograph portion not affected by the light on the exposed tin plate for printing is developed by water and corroded.

On completion of the entire process, the plate is retouched and then protected with rubber solution coating for finailizing the entire process.

Printing

On completion of the plate making, the film is fixed on the printing roller. When the machine is started, tin plates automatically fed by an auto-feeder get printed while passing the printing roller, and then conveyed by a conveyor to the coater in which coating is applied for protecting the design. Tin plates are then automatically fed into a dry oven to be dried and loaded on a rear-side stacker.

To transfer the leaded tin plates to the cutting process, the stacker is reversed by the pack turnover and transported by a forklift to the gang slitter for side cutting.

Table 1. Specifications of Crown Cap

Product items		Standard		Use	Distinctiveness
		D (mm)	H (mm)		
Crown	Cork crown	32.05	6.68	Beer	T.F.S.Plate Tin Plate
	P.E. Crown	32.05	5.97	Hard spirits	
	P.V.C. Crown	32.05	5.97	Soft drinks	
	P.V.C. Dry blend crown	32.05	5.97	Soft drinks	
P.P. Cap	P.P. 18mm Standard	18.4	12.65	Whisky, Brandy	Al Sheet
	P.P. 22mm Standard	22.4	15.1	Ginseng wine, fruit wine	
	P.P. 25mm Standard	25.6	16.8	Soft drinks, Ginseng wine	
	P.P. 25mm Deep	25.6	19.35	Ginseng wine, Whisky	
	P.P. 28mm Standard	28.4	18.3	Tonic drinks	
	P.P. 28mm Shallow	28.4	15.6	Soft drinks	
	P.P. 28mm Deep	28.4	25.1	Soft drinks, Whisky	
	P.P. 28mm Alutain	28.4	18.3	Soft drinks	
	P.P. 30mm Extra deep	29.7	34.7	Whisky, Brandy	
	P.P. 30mm Stel	29.8	60.2	Whisky, Brandy	
	S 31mm Easy off	31.0	21.1	1.8-liter Sake	
	P.P. 38mm Alutain	38.4	17.4	Soft drinks	
	S 39mm P.P.	39.5	25.4	Ginseng wine	
	S 70 P.P.	70.5	16.25	Beverages	
Special cap	Lug cap	66.37	9.65	Food	T.F.S.Plate Tin plate
	Screw cap			Coffee bottles, etc.	
Etc.	Plastic injection blow molding			Milk bottles, Medicine, Food containers, etc.	Plastic Resin
	Neck seal			Food containers, etc.	
	Polyethylene sheet			Cap gaskets	

Press

Tin plates cut to the prescribed size by the gang slitter are stacked again and carried by the forklift to the press, where they are automatically fed by an auto-feeded and formed into crowns, 22 pieces at one stroke. The formed crowns, after seperation of defective ones on the side conveyor by a magnetic conveyor. The crowns thus conveyed are fed into the lining machine by a belt conveyor.

Lining

The polyethylene melted by an extruder is cut into 200-220mg pieces and are dropped on the crowns fed into the lining machine, where the crowns are pressed by punches, respectively in concave and covex forms, and then cooled by cooling water to be subsequently on a conveyor.

Crowns are fed into a counter machine for counting, and finished products are transported to the storage room by means of a conveyor.

2) Equipment and machinery

Plate making section

- Table type vertical process camera
- Temperature controlled sink
- Vacuum contact printer
- Film drying cabinet
- Handy horizontal step and repeat printer
- Whirler (plate coating machine)
- KOBASTEP (Semi-automatic type photo-composing machine)
- Polishing machine
- Plate drying cabinet
- Light tables

Printing section

- Turn table
- Auto feeder
- Printing press
- Plain coater
- Drying oven
- End stacker
- Pack turn over

Press section

- Gang slitter
- Turn table
- Callahan press

P.E. lining section

- Belt conveyor
- Magnetic conveyor
- Velt conveyor
- P.E. lining machine
- Counter

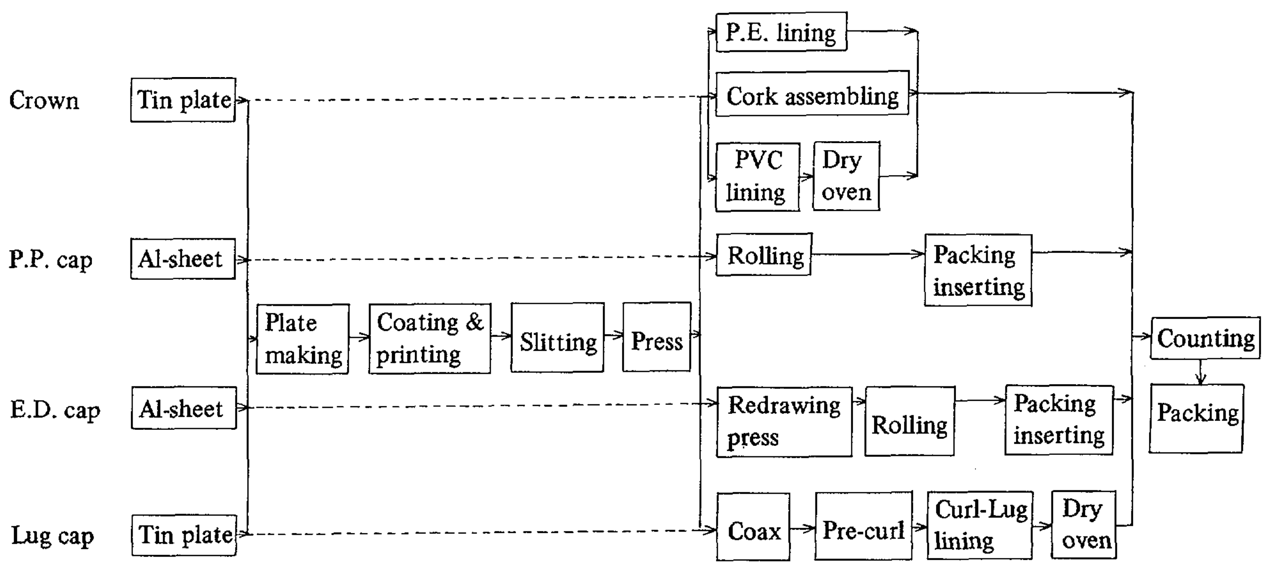
Machine tool equipment

- Laths
- Milling
- Polishing machine
- Cutting machine
- Lapping machine

Testing and analysis equipment

- Incubator
- Drying oven
- Water bath
- Gas volume tester
- Hopping tester
- Crowned
- Rockwell hardness tester
- Up right dial gage

Crown Cap Manufacturing Process Block Diagram



3) Raw Materials and Utilities

Raw materials (8 hr)

Description	Spec.	Unit	Q'ty	Remark
Varnish	SK101	kg	32	Size coating
Varnish	HLD-79 (Germany)	kg	32	Inside coating
Varnish	SK301	kg	32	finishing
Ink (Red)		kg	1	For metal
Ink (Black)		kg	1	For metal
Reducer		kg	1	Appendix for painting
Blanket rubber	1.8t x 920 x 110	SH	0.2	For printing cylinder
Molleton	¢ 84	M	3	For damping roller
Molleton	¢ 80	M	3	For wished machine
Gasoline		L	20	
Tine Free steel	0.28 x 727 x 886	SH	1,660	
P.E. Resin	KPM	kg	185	

Utilities (8 hr)

Utilities	Requirement
Electric power	320 kwh
Water cooling	18m/h (at 15C)
Compressed air	
Capacity	8m/min
Pressure	7kg/cm
HP	50HP
Oil kerosine	30ℓ/h

Example of Plant Capacity and Construction Cost

1) Plant capacity: 105,000 pieces/hour

2) Estimated construction cost (as of Feb. 1979)

- o Interior production : US$528,700
- o Foreign production : US$689,400
- o Engineering and know-how fee : US$365,400
- o Supervision of election and installation fee : US$61,983

Total : US$1,645,400

* The following facilities and charges are not included.

Civil and building works
Building materials
Raw materials
Fuel, oil, and chemicals
Water piping, air piping, and fuel oil piping
Wiring materials and works
Spare parts
Training fee
Outside and inside transformer and electrical wiring

3) Personnel requirement

- o Administration division : 13 persons
- o Production division : 28 persons
- o Laboratory : 3 persons

Total : 44 persons

Any inquiry about the information contained should be sent to:
IO/COOP, Registry file No. ID/562/12, UNIDO, P.O. Box 300, A-1400 Vienna, Austria

Can Making Plant

Methods of preserving foodstuffs have been steadily improved since ancient times. Various methods of preserving current foodstuffs include canning, refregerating, drying and smoking, but the canning is most ideal from the standpoint of preservation, transportation, sanitation and economy.

The tin plate can used in canning is a metallic container with the advantage of protecting the contents from going bad or absorbing moisture.

The tin plate can is of high strength and can safely keep its contents. In recent years, beautiful cans for drinks, beverages and other foods can also be produced as a result of the development of printing technology.

The tin plate as raw material for cans is produced by steel manufacturers with capabilities of cold roll coil and electrotinning processes. Various grades of tin plate with differing luster, strength and hardness are manufactured depending upon uses.

Though partially limited in the use of cans due to a worldwide decrease in tin resources, chrome coated tin free steel (TFS) has also been widely used since 1970. This TFS is produced at lower prices than those of ordinary tin plate.

The tin plate cans are widely used nowadays as containers of drinks, foods, petroleum products (light oil, gasoline, motor oil and lubricant) and the like, the shape and size varying depending upon their uses.

Food cans are usually heated for sterilization, and depending upon its structure, it breaks down into three-piece can consisting of the body, top end and bottom end, and two-piece can for which the body is made by deep drawing of the tin plate, and a lid is attached to the top end.

On the contrary, general purpose decorated cans and other miscellaneous cans do not require any sterilization and are mainly for dry foods, paints, chemicals, cosmetics and oil.

Cans produced in this plant include the cemented side seam tin free steel can with easy open end and lead soldered can for beer and othr beverages in addition to other general cans of circular cans, angular cans and fine art cans which are manufactured in the high-speed, automatic line in a continuous operation.

View of Products

Products and Specifications

Cans of diverse specifications can be produced in this plant in response to orders from customers, and it is possible to change the metal thickness in accordance with client's gas volume.

Contents of Technology

1) Process Description

Can body

The plate is placed on a roller table. When inserted in the fixed position of the sheet feeder, the plate rises automatically. It is picked up one by one by vacuum suction and sent to the slitter and cut into two. Then the sheets in the right angle direction sent to the body maker at regular intervals. The four corners of the plate are properly cut off, and two ends are bent. After going through embossing, bending, interlocking, and bumping processes, the two ends are simultaneously flanged by the squeezer.

The bottom end and the top end made on a seperate line are seamed by the respective seamers. The seamed portions of both bottom end and the top are respectively soldered to the body. Then, the seamed side portion of the body is soldered.

The flux remaining on the plate during the soldering process and oil adhering to the can surface are removed by water spray washing and can washer brushing.

Leakage tests are done by an air tester, and the cans are dried in a drying oven.

The finished cans are bundled into six cans per pack, placed on a pallet by the palletizer, and stored in the warehouses.

Bottom end

The plate is cut to the proper size by the slitter and press-formd by the press machine to make the finished product.

Top end

The forming process is the same as the bottom plate but a filling hole is made by the transfer press machine.

Galvanized wire handle made on a seperate machine and a tin plate clip are assembled together and spot-welded to the central portion of the top.

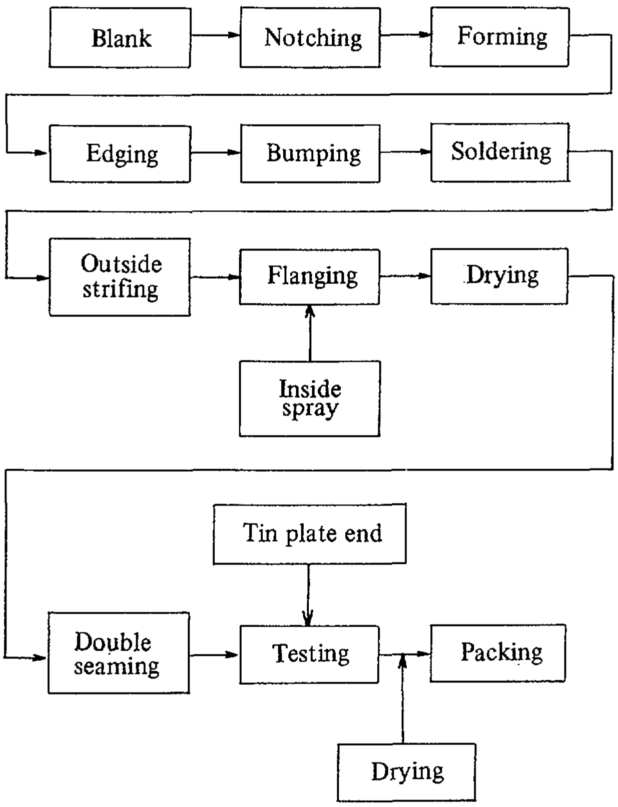
Table 1. Can and End Specification for Beer and Beverage

Item	Can size	209/211x413 2PC Steel	209/211 x 413 2PC Aluminum	211 x 413 3PC Steel	202 x 504 3PC Steel
Metal thickness	Body	.0123+-.005 (.312mm)	.015" (.381mm)	.0063+-10% (.16mm)	.0063+-10% (.16mm)
	Lid aluminumı	.013+-.0013 (.33mm)	.013+-.0013 (.33mm)	.013+-.0013 (.33mm)	.0122+-.0013 (.31mm)
Lid aluminum	Curl diameter	2.840+-.010 (72.13mm)	2.840+-.010 (72.13mm)	2.945+-.010 (74.80mm)	2.415+-.005 (61.34mm)
	Curl thickness	.095+-.007 (2.413mm)	.095+-.007 (2.413mm)	.095+-.007 (2.413mm)	.095+-.007 (2.413mm)
	Ends per 2"	21+-1	21+-1	21+-1	23+-1
	Countersink depth	.250+-.005	.250+-.005	.250+-.005	.250+-.005
	End flange width	.272 aim. (.262 min.)	.272 aim. (.262 min.)	.272 aim. (.262 min.)	.218+-.003 (.215 min.)
	Compound weight (volume)	61+-9mg (44mm)	61+-9mg (44mm)	83+-12mg (61mm)	57+-9mg (42mm)
Empty can	Height of can	4.812+-.015 122.22mm	4.812+-.015 122.22mm	4.812+-.015 122.22mm	5.250+-.007 133.35mm
	Inside diameter of can body	Midwall 2.581+-.005 (65.56mm)	2.583+-.005 (65.61mm)	2.577+-.005 (65.46mm)	2.069+-.003 (52.55mm)
	Can flange width	.102+-.010 (2.59mm)	.102+-.010 (2.59mm)	.097 aim(.085-.105) (2.46mm)	.095+-.005 (2.41mm)
	Max. inside pressure	300 Psi(2068KPA)	300 Psi(2068KPA)	150 Psi	150 Psi
(Diamension recommended by supplier.) Double seam	1st seam thickness	.092 aim (2.34mm)	.093 aim (2.36mm)	.092 aim (2.34mm)	.093+-.005 (2.36mm)
	2nd seam thickness	.059 aim (1.50mm)	.062 aim (1.57mm)	.059 aim (1.50mm)	.056+-.002 (1.42mm)
	Countersink depth	.259+.012 Max. (6.58mm)	.259+.012 Max. (6.58mm)	.259+-012 Max. (6.58mm)	.245+-.005 (6.22mm)
	Body hook	.078 aim+-.012 (1.98mm)	.078 aim+-.012 (1.98mm)	.078 aim+-.012 (1.98 mm)	.078+-.003 (1.98mm)
	Cover hook	.070 min. (1.78mm)	.070 min. (1.78mm)	.070 min. (1.78mm)	.070 min. (1.78mm)
	Overlap	.040 min. (1.016mm)	.040 min. (1.016mm)	.040 min. (1.016mm)	.040 min. (1.016mm)
	Can height	4.812+-.015 (122.2mm)	4.812+-.015 (122.2mm)	4.812+-.015 (122.2mm)	5.250+-.007 (133.35mm)

2) Equipment and Machinery

Soldered side seam line
Tandem litho printing press
Litho coater
Double die press line
Automatic packer-gluer-compression unit
Sanitary can line-soldered side seam
Others

Beer aud Beverage Can Manufacturing Process Block Diagram



3) Raw Materials and Utilities

○ Lead soldered can

Raw materials	Requirement (per unit of product)
Tin plate body	41.929 g
Tin plate end	7.695 g
Al plate EOE	4.51 g
Tap coil	25.01 m/m
Tin ingot	0.0299g
Lead ingot	1.482 g
Compound	0.257 g
Lacquer	0.989 g

○ Cemented side seam tin free steel can

Raw materials	Requirement (per unit of product)
Hi top-body	34.31 g
Hi top-end	6.276g
Al plate EOE	4.51 g
Tap coil	25.01 m/m
Bonding agent	0.112g
Compound	0.257g

Example of Plant Capacity and Construction Cost

1) Plant capacity: 144,000,000 can/year
   * Working condition: 8 hrs/day, 300 days/year
2) Estimated equipment cost (as of 1979)
   - ○ Manufacturing equipment : US$3,227,310
   - ○ Machinery installation and operation costs : US$ 470,826
   - Total : US$3,698,136
3) Required space
   - ○ Site area : $6{,}640m^2$
   - ○ Building area : $2{,}780m^2$

Vacuum Metallized Film Making Plant

View of Metallizing machine

The vacuum metallizing is referred to as a work forming metallic films by vaporizing a metal with heating under the state of high vaccum to have the metal vapor condensed and crystallized on the surface of an object in mind.

This technical principle was discovered by Thomas Edison towards the end of the 19th century while working on the incandescent lamp. Since then both basic and applied techniques have been steadily developed, and in recent years, various vacuum metallized films have been developed and produced, helped by the emergence of plastic films in particular. The products manufactured by the vacuum metallizing are generally characterized as follows:

- Beautiful metallic luster can be obtained with ease.
- Effects are extraordinarily high compared with the volume of the metal consumed. (Resource strategic aspects)
- Reasonable in prices.
- Free from pollution.
- Excellent in sealing property.

Because of such advantages, the vacuum metallized products have a wide range of uses for gold and silver threads, condenser, stamping foil, label sticker, packaging and decoration, with the demand rapidly increasing.

Particularly, the demand in the field of packaging has seen the quickest increase with the prospect of great expectations in the industrial sector.

Products and Specifications

Mainly produced by this plant are aluminum metallized films which can be used for general packaging and sundry goods. Paper and polypropylene film are chiefly used as base films, while polyester and polyethylene films are also used depending upon respective uses. General specifications of the products are 20-60 in thickness and 500-1,000 mm in width.

Contents of Technology

1) Process Description

As can be seen in the process flow diagram, the manufacturing process of vacuum metallized films is relatively simple. It consists of three major unit processes of the base film winding, metallizing and slitting, with the laminating process additionally required in the case of metallized papers.

The base film in rolls is rewound onto one large roll of films by winding machine to suit the metallizing operation. Here, it must meet the following conditions so that the film to be used helps facilitate the metallizing and does not affect the quality of the product either:

- Moisture and other volatile components should be neligible:

In case the base film contains moisture to a certain extent, the vacuum metallizing cannot be satisfactorily carried out, resulting in reduced adhesive strength and luster. Therefore the moisture or other volatile components require to be eliminated by drying in advance.

- It should have a good affinity with the metallizing metal:

Depending upon the material quality of base films, the adhering strength differs greatly, requiring polyolefin films or polyester films to be provided with antistatic treatment or undercoating.

- The film should have sufficient strength:

A proper strength or thickness is required not to cause any deformation when metallizing.

- It should have proper slipping property:

In case the slipping property is inferior when the rolls or films are in friction each other, it causes the film to be creased in metallizing.

- It should be heat-resistant:
  Because the metallizing surface is affected by the radiation heat from heating source (approximately 1,450°C) and also the condensation heat of the metal vapor, the film requires to be heat-resistant even only for a short period of time.
- The film should have small deviation in its thickness with good roll formation:
  When the film having deviation in thickness is wound in a roll, its hardness is not uniform as can be confirmed by pressing with fingers and a band phenomenon including looseness and crease occurs when spread back, making the high-speed vacuum metallizing difficult.

The base film wound onto a rewinder is fed into the metallizing machine for subsequent metallizing, whereby two different metallizing methods can be used depending upon the machine involved as follows:

There is the method of putting a high-purity metal in a graphite crucible and vaporizing it by high-frequency heating, while the other method is to continuously metallize by feeding the corresponding wire to the heated boat on a continued basis. The both methods can be applied in this plant.

The metallic vapor generated by heating is condensed through the vacuum on the film wound onto a cooling drum. The metallized film formed hereby is usually several hundred A° in thickness. The outer structure formed varies to a great extent depending upon metallizing conditions including the degree of vacuum, with the product quality directly influenced by the controlling of such metallizing conditions.

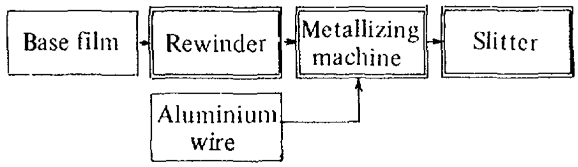
In order to prevent a wrinkage or deformation while metallizing, the metallizing machine has to be reasonably designed for ensuring the precise layout and tension adjustment of the roll for the base film or paper.

On completion of the metallizing, the base film is continuously fed into a slitting machine for a prescribed slitting. However, in the case of metallizing paper, the metallic film is laminated on the paper coated with adhesive by dry laminator, while the base film is recovered for reuse.

2) Equipment and Machinery

Metallizing machine
Dry laminator
Rewinder
Separator
Embossing machine
Slitter
Gravure printing machine
Aluminium wire rewinder

Metallized Film Manufacturing Process Block Diagram



3) Raw Materials

Raw materials	Requirement (per m^2 of product)
Film	5.1 g
Metal (aluminium)	1.5 g
Paper	37.0 g
Adhesive	20.0 g
The others	8.0 g

Example of Plant Capacity and Construction Cost

1) Plant capacity : 200,000m/month
   * Basis : 24hrs/day, 25days/month

2) Estimated equipment cost (as of 1983)

○ Manufacturing equipment	:	US$ 1,700,000
○ Utility equipment	:	US$ 70,000
Total	:	US$ 1,770,000

3) Required space

○ Site area : 10,000 m^2
○ Building area : 5,000 m^2

4) Personnel requirement

○ Manager	:	7 persons
○ Engineer	:	10 persons
○ Operator	:	53 persons
Total	:	70 persons

Any inquiry about the information contained should be sent to:
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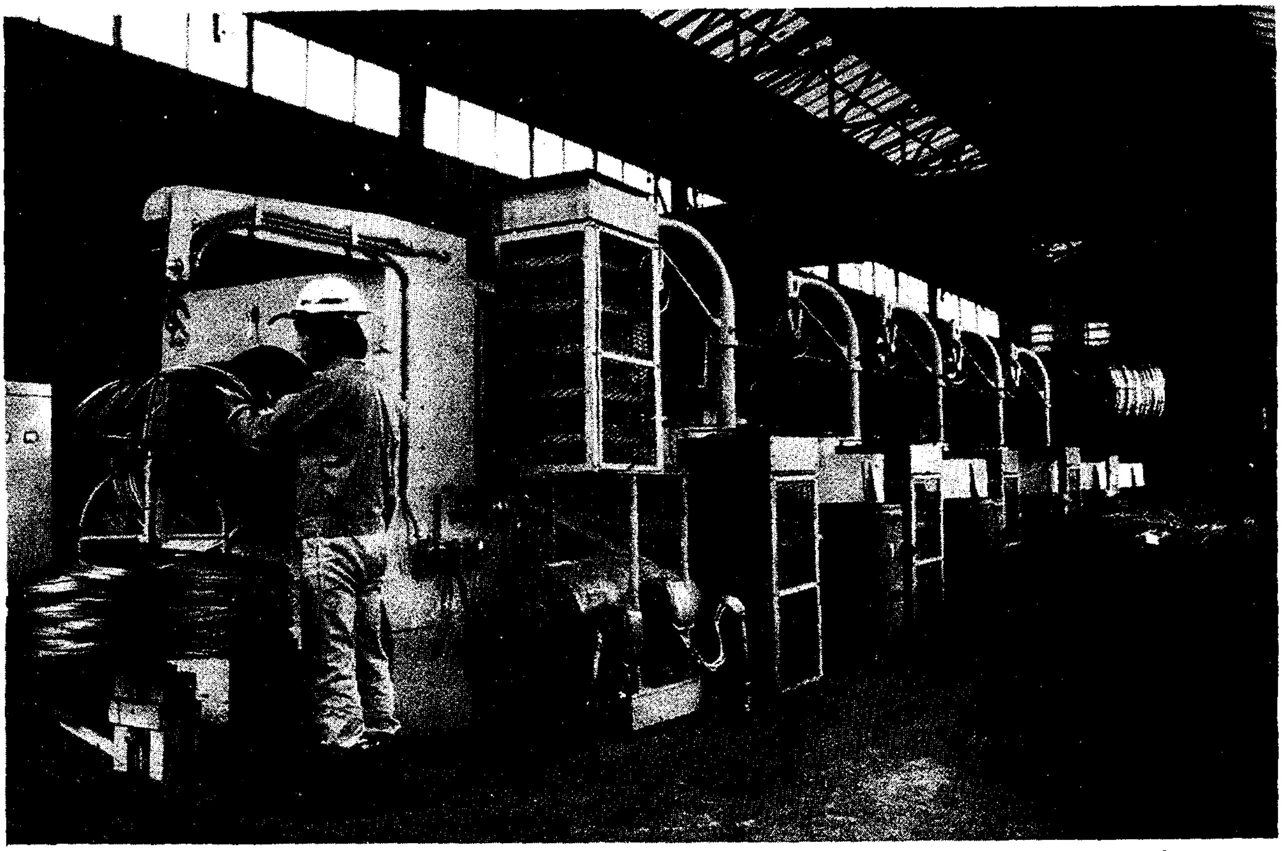
Copper Covered Steel Wire Plant



View of Facility

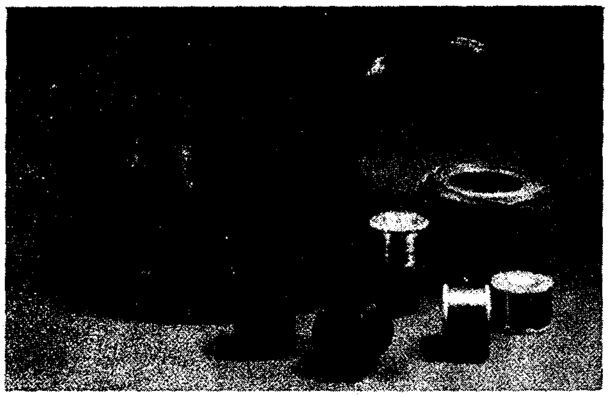
Copper covered steel wire has the strength and toughness combined with conductivity and corrosion-resistance of copper. It is closely plated with uniform layer of pure copper by the advanced continuous electroplating process. The stranded conductors and single conductors are produced in a variety of sizes and types to meet specific needs as per ANSI/ASTM B227, B228, B229, B452 and BS 4087 for power distribution, transmission and telecommunications. Due to unique characteristics, the conductors are used for single bonds to complete the electrical circuit for long spans crossing mountains and rivers for telecommunications overhead lines. It is also called copper plated steel wire, copper coated steel wire, steel cored copper wire and copper-weld wire in different names.

Characteristics

- Steel wire closely plated with uniform layer of pure copper
- High tensile strength
- Corrosion-resistant
- Lightweight
- Powerful distribution and transmission
- Low-cost in construction
- High frequency (or attenuation) characteristics
- Lower maintenence expenses

Uses

- Messenger wire
- Bare wire for transmission and distribution
- Telephone dropwire and rural distribution wire
- Leadwire for electronics
- Signal and message carring wire for railroad
- Self supporting distribution wire
- Jewelery chain, piano string covering, pipe insulation wire, TV antenna wire, bind wire, barbed wire, fence spring wire, etc.
- High frequency coaxial cablc



View of Products

Products and Specifications

Quality of finished wire,

- Wire cleanly drawn to the specified dimensions.
- Copper coating securely bonded to the steel.
- Copper coating free from harmful defects:

Table 1. Tolerance on Diameter (BS 4078)

British units			Equivalent metric units		
Nominal wire diameter		Tolerance	Nominal wire diameter		Tolerance
Over	Up to and including		Over	Up to and including	
in	in	in	mm	mm	mm
–	0.050	± 0.0005	–	1.27	± 0.013
0.050	0.100	± 0.0010	1.27	2.54	± 0.25
0.100	–	± 1% of the diameter	2.54	–	± 1% of the diameter

Table 2. Mechanical & Electrical Properties

Nominal size		Resistance at 20°C maximum		Minimum copper thickness		Nominal weight	Minimum breaking load			
Diameter							Grade 1		Grade 2	
		30% conductivity	40% conductivity	30% conductivity	40% conductivity		30% conducitivity	40% conductivity	30% conductivity	40% conductivity
mm	in	ohm/km	ohm/km	mm	mm	kg/km	kg	kg	kg	kg
4.88	0.192	3.138	2.354	0.28	0.44	152.2	1615	1457	1917	–
4.62	0.182	3.494	2.622	0.27	0.42	136.7	1474	1333	1775	–
4.47	0.176	3.734	2.801	0.26	0.40	128.0	1380	1266	1662	–
4.06	0.160	4.518	3.389	0.23	0.37	105.7	1186	1077	1437	–
3.66	0.144	5.577	4.183	0.21	0.33	85.63	997	909	1211	–
3.25	0.128	7.060	5.295	0.19	0.39	67.67	817	747	992	–
2.95	0.116	8.594	6.450	0.17	0.26	55.55	695	638	834	–
2.90	0.114	8.836	6.630	0.17	0.26	54.06	676	621	812	–
2.64	0.104	10.69	8.022	0.15	0.24	44.65	582	534	674	601
2.59	0.102	11.14	8.357	0.15	0.23	42.87	558	513	662	576
2.34	0.092	13.66	10.25	0.13	0.21	34.98	455	418	541	469
2.03	0.080	18.08	13.56	0.12	0.18	26.43	367	349	408	379
1.83	0.072	22.31	16.74	0.10	0.16	21.38	283	259	314	286
1.63	0.064	28.25	21.19	0.10	0.15	16.83	223	204	248	226
1.42	0.056	36.87	27.64	0.08	0.13	12.94	171	156	190	173
1.22	0.048	50.19	37.66	0.07	0.11	9.498	125	115	139	127
1.14	0.45	56.50	42.35	0.07	0.10	8.458	112	102	124	113
1.02	0.040	72.33	54.23	0.06	0.09	6.623	87	80	97	88
0.91	0.036	89.29	66.98	0.05	0.08	5.350	71	65	78	72
0.81	0.032	113.3	84.94	0.05	0.07	4.219	56	51	62	56
0.71	0.028	147.5	110.7	0.04	0.06	3.230	43	39	48	43
0.61	0.024	200.8	150.7	0.04	0.06	2.388	31	29	35	32
0.56	0.022	239.0	179.3	0.03	0.05	1.993	26	24	29	27
0.51	0.020	289.2	217.0	0.03	0.05	1.652	22	20	24	22

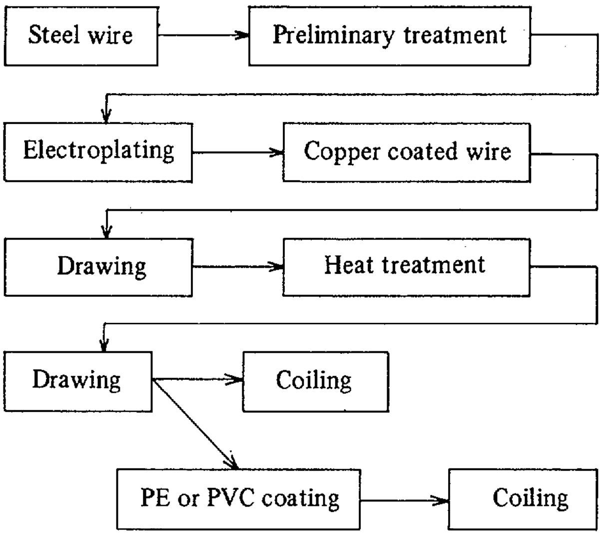
Contents of Technology

1) Process description

The high tensile steel wire, thickly covered with copper in accordance with the special electroplating process, is drawn to the required size and given heat treatment when necessary.

The drawn wire is provided with PVC or PE coating to use as wire cores for the telephone between a pole and house.

Copper Covered Steel Wire Manufacturing Process Block Diagram



2) Equipment and machinery

Electroplating tank
Rectifier
Drawing machine
Heating system
Insulation machine
Stranding machine

Example of Plant Capacity and Construction Cost

1) Plant capacity : 100 tons/month

2) Estimated construction cost (as of 1983)

o Equipment and machinery	: US$ 1,333,000
o Installation cost	: US$ 266,000
Total	US$ 1,599,000

3) Required space

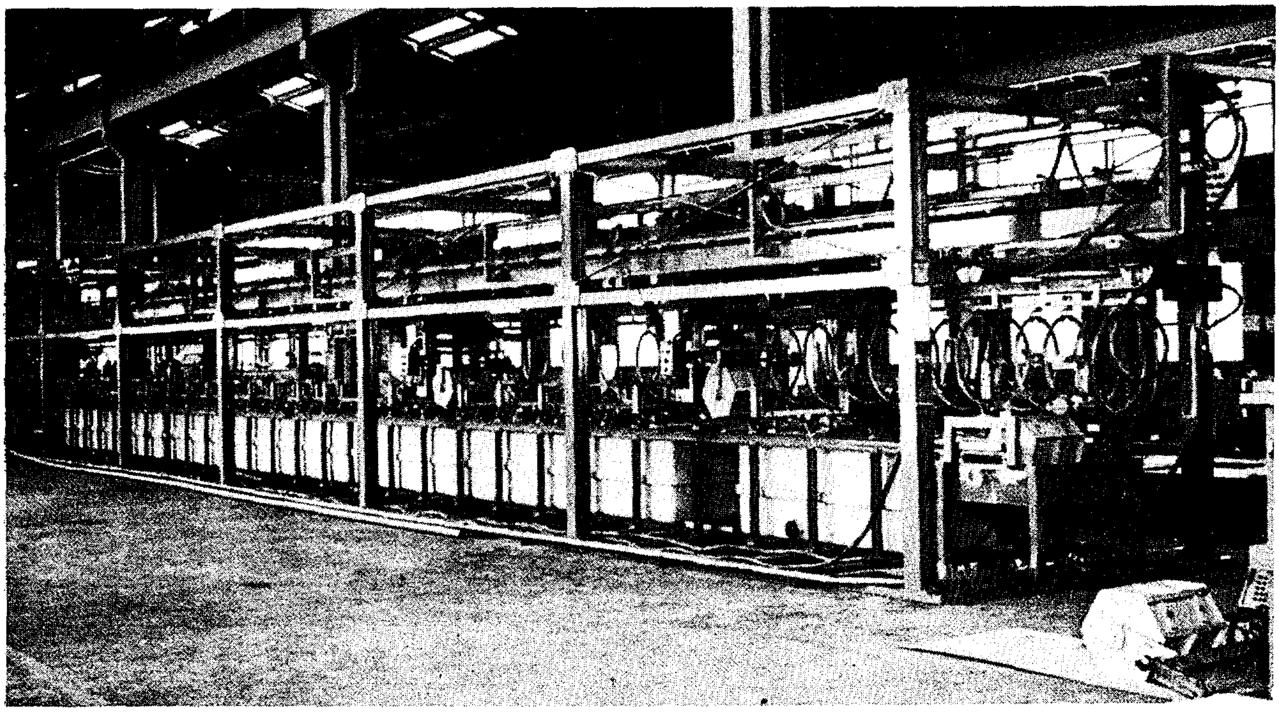
o Site area	: 5,000 m^2
o Building area	: 3,000 m^2

4) Personnel requirement

o Manager	: 6 persons
o Engineer	: 6 persons
o Operator	: 50 persons
Total	: 62 persons

Any inquiry about the information contained should be sent to:
IO/COOP, Registry file No. ID/562/12, UNIDO, P.O. Box 300, A-1400 Vienna, Austria

Electroplating Plant



View of Plating Equipment

Most of the articles of living or transportation vehicles are usually coated with paint or plating, because iron is corroded in the atmosphere. As the industry developes, the demand for iron products has significantly increased, also increasing the plating products.

With much progress in plating techniques, the plating has wide applications including ornamental articles and household goods. To cope with such an increasing demand, the electroplating plant should be so constructed as to be equipped with the latest facilities taking into consideration the emerging problem of how to reduce the labor force.

The electroplating facilities described here are of the I-C carrier type as well as hydraulic elevator type, with the following characteristics:

- I-C carrier type
  - ROM I-C makes simple changes in plating process as well as future expansion possible.
  - The use of an approach switch makes it semipermanent.
  - The use of a remote control panel makes an automatic operation possible. If necessary, it can be switched over to an ordinary control panel to be semiautomatic or manual in operation.
  - It is fitted with a shock-absorbing control device providing the soft start and stop by the use of a pole change motor.
  - It is fitted with a device preventing erroneous actions.
- Hydraulic elevator type
  - It is automatic and continuous, making the consistent preliminary treatment, plating and after-treatment possible.
  - It is the return type capable of doing one-man loading and unloading.
  - Fitted with a warning device against erroneous actions, it can prevent hazards.
  - Fitted with a special carbon on the hanger, the passage of a current is perfect.
  - The change of working hours is possible.

Products and Specifications

This plant is capable of carrying out the copper plating, nickel plating, decorative and industrial chromium plating, zinc plating, cadmium plating and tin plating, with explanations focused on the zinc plating.

Contents of Technology

1) Process Description

The surface of a metallic article has to be first removed of impurities prior to electroplating, because the oil and fats, oxide, hydroxide and dirt are deposited on it during manufacturing treatment process, transportation or storage. Mainly pickling and degreasing are carried out as the preliminary treatment.

Polishing

The polishing improves the adhering strength of the final plating as well as the appearance. There are two polishing methods for the plating, namely the buff polishing and barrel polishing. The buff polishing breaks down to the belt-type polishing and electromotive polishing. Excellent in cutting property, the belt-type polishing is suitable for polishing the surface of a metallic article. The electromotive buff polishing has separate steps of initial cutting, intermediate buff and finishing buff. The barrel polishing is used in a mass polishing for small component parts.

Pretreatment

In order to obtain a good plating surface, the impurities deposited on the surface of a metallic article have to be removed, and the surface must be activated. Approximately 50-70% of the defective plating is caused by the inappropriateness and negligence in the pretreating process. As such a pretreatment in the plating, the degreasing and acid treatment are mainly used. The degreasing is an operation of eliminating the grease deposited on the surface of a metallic article, having such methods as solvent degreasing, alkali degreasing, electrolytic degreasing, emulsion degreasing and mechanical degreasing.

The object of the acid treatment is to remove oxides, hydroxides and salts on the surface of a metallic article, with the methods of pickling, acid etching and acid dipping mainly used.

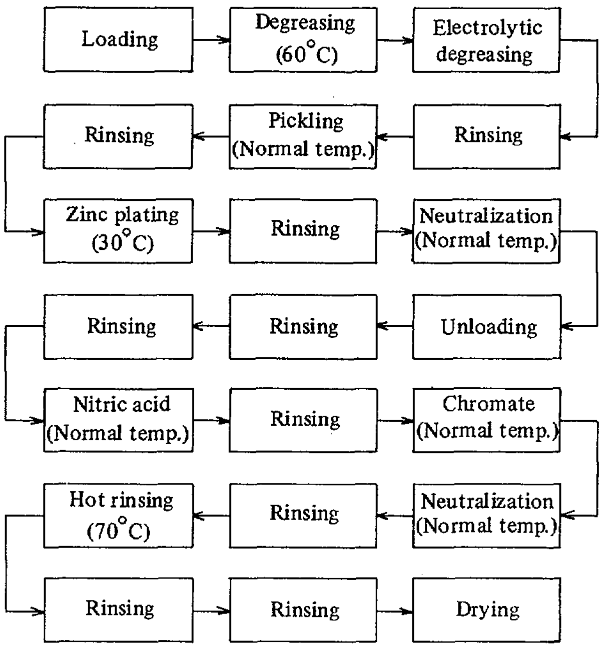
Plating

On completion of the pretreatment, the metal is conveyed for plating, which is mainly electroplating and divided into the rack type and barrel type depending upon the form of component parts. At the cathode, the metal ions are reversed to metal and deposited on the metal surface in plating, while at the anode there is a dissolving metal plate and replenishes the metal ions consumed. Each plating solution contains an appropriate lustering agent which improves the state of the surface plated.

After-treatment

On completion of the plating, the component parts are washed with hot water and then dried. Depending upon the type of plating, some are subjected to an appropriate treating process for preventing changes in quality or hue.

Electroplating Process Block Diagram



2) Equipment and Machinery

Semiautomatic barrel zinc plating apparatus
Control board
Barrel
Rectifier
Filter
Exhaust equipment
Thickness tester

3) Raw Materials

○ Bolt and nut

Raw material	Requirement (per one barrel)
Alkali cleaner	100 Kg/900 ℓ *1
Sodium cyanide	15 Kg/ 500 ℓ *2
Caustic soda	15 Kg/ 500 ℓ *2
Sulfuric acid	45 Kg/ 500 ℓ *3
Sodium carbonate	20 Kg/ 500 ℓ *4
Zinc oxide	92 Kg/2,500 ℓ *5
Sodium cyanide	200 Kg/2,500 ℓ *5
Caustic soda	92 Kg/2,500 ℓ *5
Nitric acid	0.2 Kg/ 110 ℓ *6
Chromic anhydride	20 Kg/ 110 ℓ *7
Sulfuric acid	1.5 Kg/ 110 ℓ *7
Nitric acid	1.5 Kg/ 110 ℓ *7
Sodium carbonate	5 Kg/ 110 ℓ *8

Note
- * 1: Degreasing
- * 2: Electrolytic degreasing
- * 3: Pickling
- * 4: Neutralizing
- * 5: Zinc plating
- * 6: Nitric acid treatment
- * 7: Chromite
- * 8: Neutralizing

Example of Plant Capacity and Construction Cost

1) Plant capacity : 1,500 kg/day
 * Basis : This electroplating plant example is applicable to zinc plating accompanied by chromate treatment of iron bolts and nuts with 5 barrels (30 kg/barrel)

2) Estimated construction cost (as of 1983)

○ Equipment and machinery	:	US$ 75,000
○ Utilities	:	US$ 28,000
○ Installation cost	:	US$ 7,000
Total	:	US$100,000

3) Required space

- ○ Site area : 200 m^2
- ○ Building area : 140 m^2

4) Personnel requirement

o Manager	:	1 person
o Engineer	:	1 person
o Operator	:	1 person
o Others	:	5 persons
Total	:	8 persons

FILE: 021
ISIC 3819

Pipe Fittings Making Plant

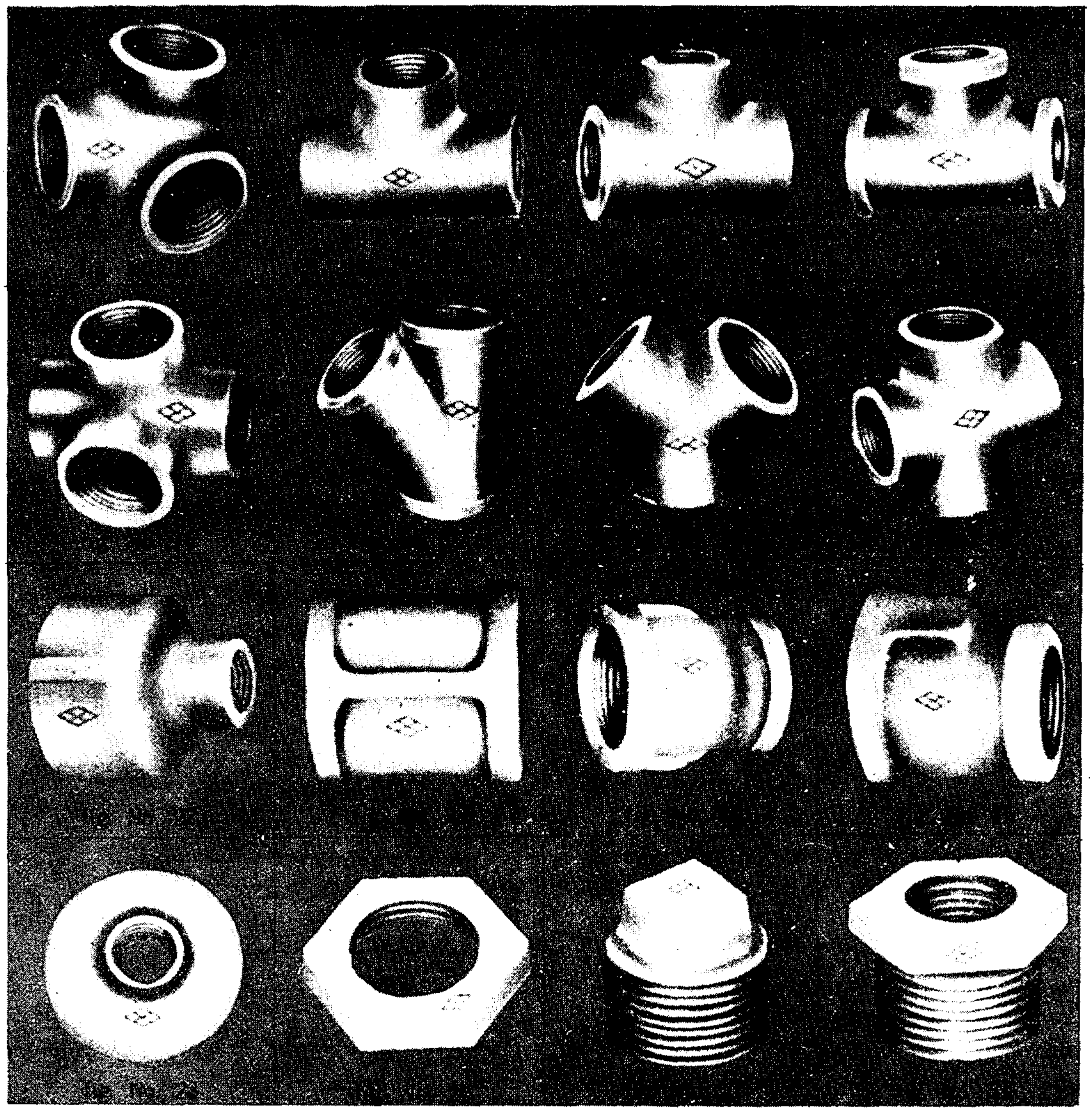
Pipe fittings are very important parts which are essentially required for the development of related industries as well as improvement of our daily life.

They have many uses including changing directions and prolonging the transport of air or liquid through fitted pipes in a wide range of industrial fields and even kitchen plumbing in a house.

In recent years, high-pressure pipe fittings are much in demand but ordinary cast products have difficulties meeting the requirements. Therefore, the consumption of malleable cast iron, best suiting the iron casting for the pipe fittings, has been on an increase year by year, with black heart malleable cast iron proved to be most suiting among the materials.

The melting method described here is based on the use of water cooling shower type hot-blast cupola, which can reduce the cokes ratio by using hot air and also extend (up to 12 hours) the operation by water cooling.

Generally, grey cast iron and scrap iron are used in manufacturing the molten metal of malleable cast iron by making use of the melting heat of cokes.



View of Products

Products and Specifications

With a wide scope of use, there are many kins of fittings such as elbows, tees, Y branches, caps, crosses, plugs, nipples, lock-nuts, conical joints, etc.

The total variety of kinds and sizes comes approximately 1,500. But usually 50-60 kinds are commonly employed.

Material
  Tensile strength : min. 28 Kg/mm^2 (4,000 psi)
  Elongation : min. 5%

Working pressure
  Water pressure of 25 Kg/cm^2 (300 psi)

Contents of Technology

1) Process Description

First, raw materials such as scrap iron, cokes and Fe-Si are weighed and charged into a cupola. When melting, some 17% of the cokes cost is substituted by using its waste heat for hot blast. Chemical and mechanical properties of the castings are improved by the high-pressure melting, while the castings are brought to the state of white cast iron (Fe_3C).

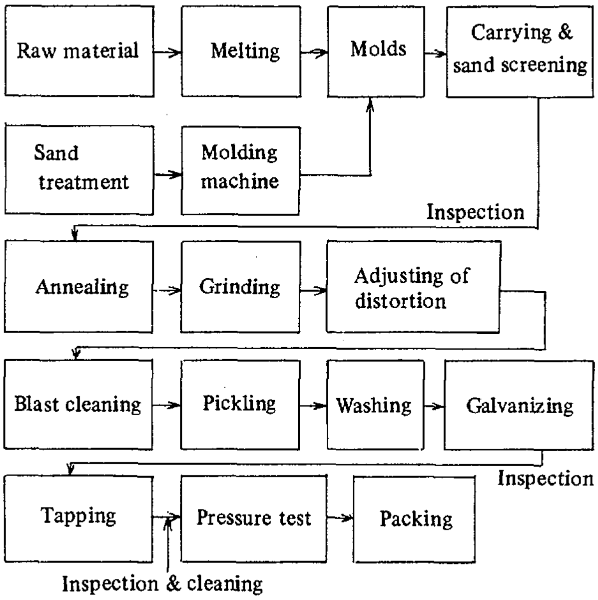
In the meantime, the molding sand is blended depending upon the form and characteristics of the casting, and then the molding is done by a manual type molding machine (F-2A) using green sand, while resin-coated silica sand shell cores are used.

The molten metal, adjusted in chemical composition, is tapped with a ladle and poured into prepared sand molds. The castings are separatd from sand after cooling for five to 10 minutes. The as-cast products removed of sand are separated from sprues, runners and gates by hammering.

The products are treated in a shot blast prior to inspection. The removed sprues, runners and gates are remelted for use. After inspection, the products are sealed in a annealing pot and charged into the annealing furnace.

Bunker-C oil is used for the annealing furnace in a continuous heat treatment, and the length of its heat treatment is shortened to the level of 30 hours by making use of hot blast method. One ton of the product consumes 90 liters of Bunker-C oil. The distortion of the castings is corrected in a deformation corrector to be followed by shot-blast cleaning and pickling for galvanizing. Then the castings are machined and threaded as final products. The products are subjected to pressure tests and coated with anti-corrosive oil for packing and delivery.

Pipe Fitting Manufacturing Process Block Diagram



2) Equipment and Machinery

Melting shop
  Induction furnace or cupola
  Holding furnace
Sand treating shop
  Sand mill
  Screw conveyor or water tank
  Belt conveyor
  Bucket elevator
  Overhead belt conveyor
  Magnet seperator
  Breaker screen
  Dust collector
  Control panel
Molding shop
  Automatic molding machine or jolt squeeze type moulding machine
  Pallet conveyor
  Oscillating conveyor
Rear treatment line
  Cooling tumbler
  Apron conveyor
  Chain bucket elevator
  Apron type shot machine
  Oscillating conveyor
  Sizing hopper and conveyor
Continuous annealing
  Furnace
  Oil burner
  Pump unit
  Oil tank
  Recuperator
Abrasive grinding shop

Oscillating conveyor
Grinder (high speed)
Dust collector
Sizing hopper
Mono rail and hoist
Cutting machine
Galvanizing shop
Apron type shot machine
Pickling line
Suspension crane
Tapping shop
Tapping machine
Jig and fixture
Cutting oil pump unit
Cutting oil tank
Washing machine
Chain bucket elevator
Machine shop
Union lathe
Bench lathe
Belt conveyor
Washing drum machine
Shell blowing machine line
Air compressor line
Pattern shop
High speed lathe
Milling machine
Electric welder
Maintanance shop
High speed lathe
Shaper
Radial drilling machine
Milling machine
Laboratory
Waste water treatment
Precipitation vessel
Electric system
Cold meter
Flow meter
Spectrometer
PH meter

3) Raw Materials and Utilities

Raw materials and utilities	Requirement (per ton of product)
Scrap	1,150 kg
Cokes	440 kg
Fe - Si	40 kg
Bentonite	114 kg
Seacoal	40 kg
Limestone	100 kg
Bunker-C	90 ℓ

Example of Plant Capacity and Construction Cost

1) Plant capacity : 3,600 m/t/year

2) Estimated construction (as of 1983)

- Equipment and machinery : US$3,000,000
- Installation cost : US$ 600,000

Total : US$3,600,000

3) Required space

- Site area : 10,000 m²
- Building area : 6,000 m²

4) Personnel requirement

- Manager : 10 persons
- Engineer : 5 persons
- Operator : 150 persons
- Others : 15 persons

Total : 180 persons

Table 4. Uses of Product

Dia. (mm)	Uses
0.20 - 0.30	Small bulbs and lamps, LED lamp
0.35 - 0.55	Large size and fluorescent lamp, Lead (in) wire
0.60 - 1.00	Diode, TV picture tube and neon tube

Contents of Technology

1) Process Description

Melting

Iron and nickel are melted in a high-frequency induction melting furnace for alloying and subsequently casting into an ingot of appropriate size.

Rolling

The ingot is hot-rolled to make the core metal of 14-mm rod.

Surface abrasion

The surface of core metal is completely removed of scale and the like by abrasion.

Copper tube reduction

The oxygen-free copper tube (16.2mm x 13.9mm x 1.5m) is heat-treated in the reducing atmosphere to get rid of oxide on the surface of copper tube.

Copper tube reduction

The core metal, completely removed of surface oxide and scale, is inserted into the copper tube for mechanical bonding.

Hot drawing

The mechanically bonded composite metal material is heated in the oxidation-proof atmosphere for hot drawing, whereby the perfect cladding of copper tube and wire metal is achieved by the copper tube expansion phenomenon.

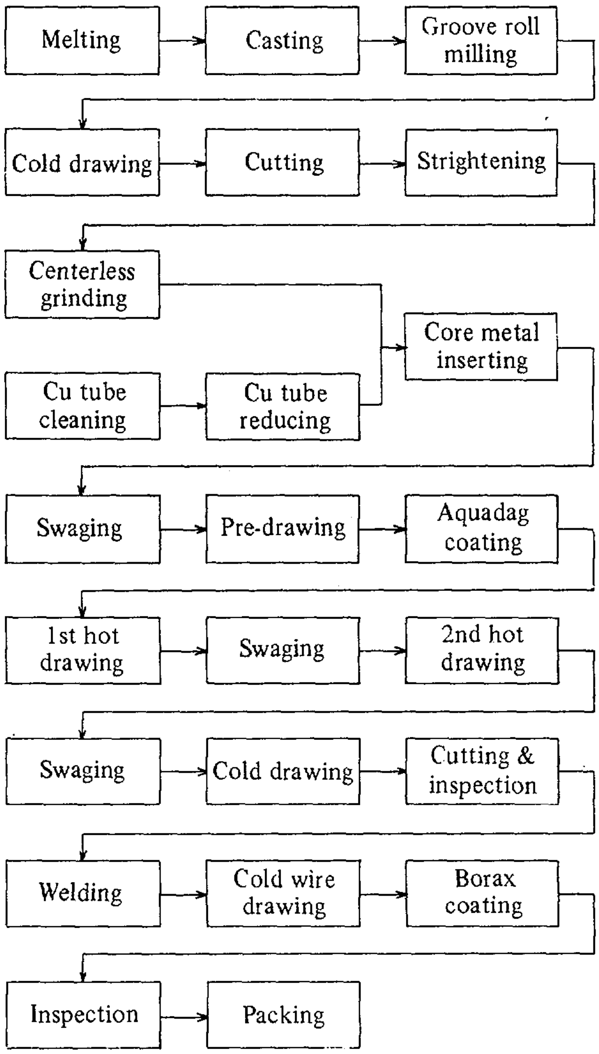
Cold drawing

The perfectly clad composite metal material is repeatedly treated in the drawing and wire drawing processes up to the final product specification.

Borax film formation

Borax is coated by fusing on the surface of the copper-coated alloy wire to improve its workability when sealing with glass.

Dumet Wire Manufacturing Process Block Diagram



2) Equipment and Machinery

High frequency induction melting furnace
Hydraulic draw bench machine
NH_3 gas cracking furnace
H_2 gas or NH_3 cracking gas atmosphere annealing furnace
N_2 gas atmosphere annealing furnace
Roll straightening machine
Centerless grinding machine
Swaging machine
Butt welding machine
Non-slip accumulation drawing machine
Cone type continuous drawing machine
Borax coating machine
Rewinding machine
Circular swaging machine
Tensile strength testing machine

3) Raw Materials

Raw materials	Requirement (per ton of product)
Electrolytic iron	580 kg
Electrolytic nickel	420 kg
Deoxidizer	2 kg
Flux	31 kg
Hot top	31 kg
Crucible	0.67 ea
Cutting oil	0.6 g/ℓ
Grinder wheel	0.6 ea
Diamond dresser	0.2 ea
Trichloroethylene	7 bottle
Graphite	5 sack
NH_3 gas	150 kg
N_2 gas	420 m^3
Dies	4 ea
Lubricant	1 kg
LPG gas	1,000 kg
Borax	1.5 kg

Example of Plant Capacity and Construction Cost

1) Plant capacity : 3 m/t/month
   * Basis : 8 hours/day, 25 days/month

2) Estimated construction cost (as of 1983)
   - Equipment and machinery : US$256,000
   - Utilities : US$ 66,000
   - Installation cost : US$ 26,000

   Total : US$348,000

3) Required space
   - Site area : 1,620m^2
   - Building area : 810m^2

4) Personnel requirement
   - Plant manager : 1 person
   - Engineer : 1 person
   - Operator : 7 persons
   - Others : 1 person

   Total : 10 persons

Any inquiry about the information contained should be sent to:
IO/COOP, Registry file No. ID/562/12, UNIDO, P.O. Box 300, A-1400 Vienna, Austria

Dumet Wire Making Plant

The dumet wire (or glass sealing copper-coated alloy wire) is the name of Fe+Ni alloy wire combined with copper. The wire is fabricated in accordance with the advanced brassless hot drawing process developed by the Korea Advanced Institute of Science and Technology (KAIST).

The glass sealing copper-coated alloy wire is a glass sealing electric conductor which is particularly essential in the manufacture of electric bulbs. With an increasing demand for such bulbs in extensive electrification projects for farm and fishing villages in developing countries, the production of electric bulbs, one of the labor-intensive type products, is in the trend of gradually shifting to these countries from advanced nations. It is mandatory to domestically produce this glass sealing copper-coated alloy wire which is a basic material for manufacturing electric bulbs.

This technology does not necessarily require highly sophisticated skills but can be effectively employed with relative ease depending upon increase and decrease in requirements.

It is also possible to make good use of this technology and plant facilities to produce other composite metal materials because advanced countries are not willing to provide their technical know-hows.

Products and Specifications

The dumet wire is produced in a variety of sizes (from 10 to 15mm) and types to meet the specific needs for soft glass sealing, television picture tubes, LED lamps and diodes which require a degree of expansion rate closely resembling the glass.

Table 1. Chemical Composition of Product

o Ni-Fe alloy (core metal) (%)

Ni	C	Mn	Si	S	P	Fe
41.5 ~42.0	Max 0.05	Max 0.02	Max 0.03	Max 0.02	Max 0.02	Bal

o Copper (%)

Cu	P	S	Pb
Min 99.00	Max 0.018	Max 0.02	Max 0.018

Table 2. Physical Properties of Product

Dia. (mm)	Electric specific resistance	Tensile strength	Elongation	Stiffness (20°C)
0.20–0.30	7–9 $\mu\Omega$m	Max 60Kg/cm^2	Min 15%	48g–cm
0.35–0.55	10–12 $\mu\Omega$m	Max 60Kg/cm^2	Min 15%	91g–cm
0.60–1.00	13–15 $\mu\Omega$m	Max 60Kg/cm^2	Min 20%	708g–cm

Table 3. Length and Weight of Product

Dia (mm)	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.70	0.80	0.90	1.00
Kg/Km	0.256	0.415	0.595	0.792	1.032	1.308	1.614	1.953	2.265	3.081	4.028	5.099	6.293
Km/Kg	3.766	2.417	1.678	1.260	0.958	0.763	0.619	0.511	0.440	0.323	0.248	0.195	0.159

Table 4. Uses of Product

Dia. (mm)	Uses
0.20 - 0.30	Small bulbs and lamps, LED lamp
0.35 - 0.55	Large size and fluorescent lamp, Lead (in) wire
0.60 - 1.00	Diode, TV picture tube and neon tube

Contents of Technology

1) Process Description

Melting

Iron and nickel are melted in a high-frequency induction melting furnace for alloying and subsequently casting into an ingot of appropriate size.

Rolling

The ingot is hot-rolled to make the core metal of 14-mm rod.

Surface abrasion

The surface of core metal is completely removed of scale and the like by abrasion.

Copper tube reduction

The oxygen-free copper tube (16.2mm x 13.9mm x 1.5m) is heat-treated in the reducing atmosphere to get rid of oxide on the surface of copper tube.

Copper tube reduction

The core metal, completely removed of surface oxide and scale, is inserted into the copper tube for mechanical bonding.

Hot drawing

The mechanically bonded composite metal material is heated in the oxidation-proof atmosphere for hot drawing, whereby the perfect cladding of copper tube and wire metal is achieved by the copper tube expansion phenomenon.

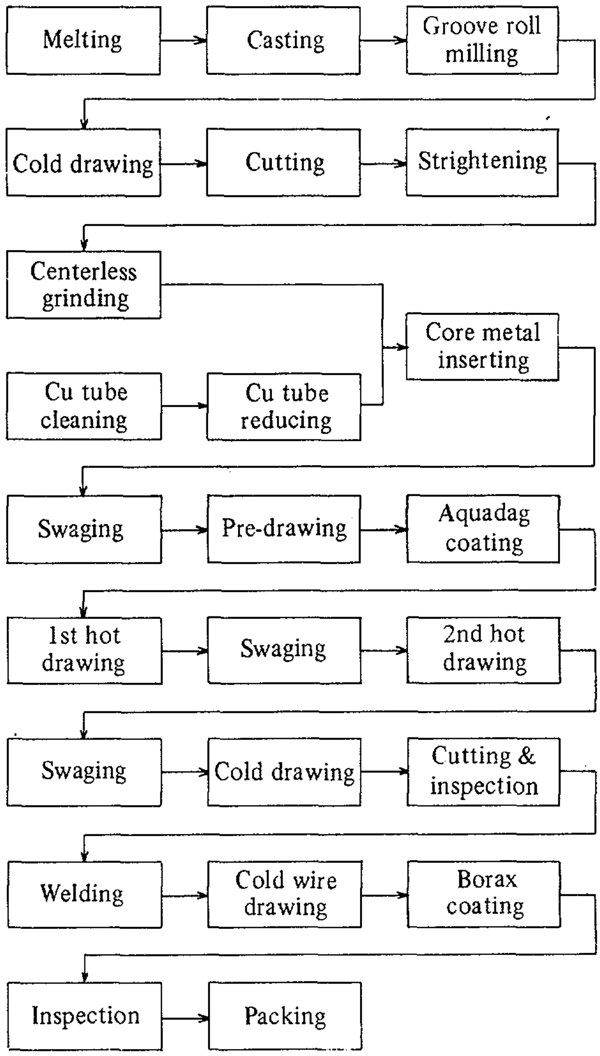
Cold drawing

The perfectly clad composite metal material is repeatedly treated in the drawing and wire drawing processes up to the final product specification.

Borax film formation

Borax is coated by fusing on the surface of the copper-coated alloy wire to improve its workability when sealing with glass.

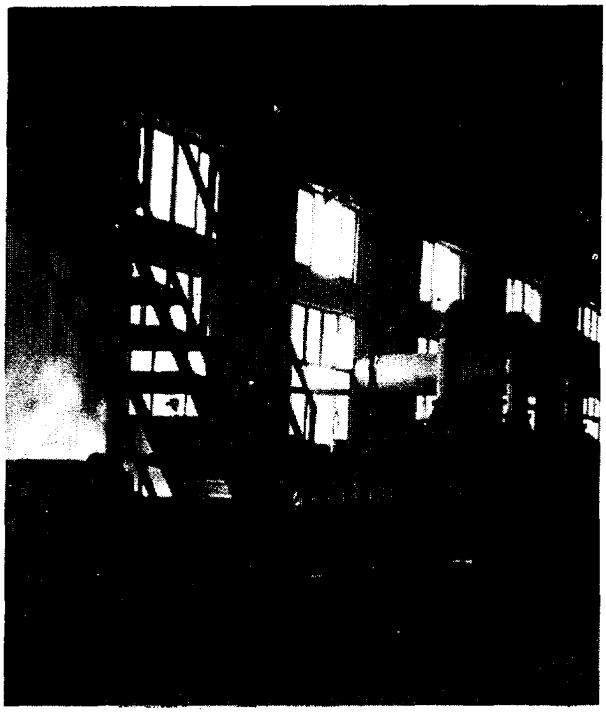
Dumet Wire Manufacturing Process Block Diagram



2) Equipment and Machinery

High frequency induction melting furnace
Hydraulic draw bench machine
NH_3 gas cracking furnace
H_2 gas or NH_3 cracking gas atmosphere annealing furnace
N_2 gas atmosphere annealing furnace
Roll straightening machine
Centerless grinding machine
Swaging machine
Butt welding machine
Non-slip accumulation drawing machine
Cone type continuous drawing machine
Borax coating machine
Rewinding machine
Circular swaging machine
Tensile strength testing machine

Wire Rope Making Plant



View of Patenting Facility

The technology and plant introduced here are related to the secondary product using the wire rod as its raw material. Labor-intensive instead of being technology-intensive, it is already a declining industry in many of the advanced nations due to the difficulty in securing labor as well as the weight of labor costs.

Though inferior in its workability to other industries, it is not subject to encouragement of plastics or synthetic fibers because of its characteristics. Therefore, it is the type of business having an increasing demand, which can be quite competitive if relatively cheap labor is utilized to advantage in developing countries where sufficient manpower is available.

Furthermore, characterized by the difficulty of making use of robots or automation, it will enable to turn out the product even with a relatively low degree of skills when well equipped with production facilities. In this plant, the following secondary products making use of the wire rod as basic raw materials are produced: PC wire and strand, hard drawn wire, carbon dioxide wire, bead wire, wire rope, G.A.C, belt cord, steel cord, guy strand and ACSR and Ulbon P.C. However, the description will be focused on the wire rope here.

Products and Specifications

Very versatile in types, the rope differs in construction, strand form, strand direction, diameter and material depending upon its purpose of use.

The rope is divided into the strand rope and spiral rope depending upon its construction. Bundled in single-layer or multi-layer strands, the strand rope is referred to what is usually called a rope of such a construction.

The strand rope breaks down to the round strand rope, bundled by round strands such as 6 x 7, 6 x 19, the triangle strand rope, bundled with triangular strands such as 6 x F(△ + 7) or 6 x F (3 x 2 + 3) + 12 + 12 designed to give a smooth surface, and the flat strand rope bundled by flat strands like the sinking rope or concentric rope. There is also the flattened strand rope.

The spiral rope is the rope having a single strand bundled by a single layer or several layers of side coil around the core coil such as 1 x 7 and 1 x 19. The locked coil is also a kind of the spiral rope, while there is the tiller rope bundled with strand ropes. It is also called the cable lay rope. In this case, the strand rope as a component element is called a shank (Schenkel).

With the exception of special ones, the strand form of the rope breaks down to two kinds of ordinary lay and lang's lay, with ordinary lay specifications as shown in table 1.

Contents of Technology

1) Process description

Wire rod

The wire which makes up a rope is a wire rod made of higher grade carbon steel. The wire rods used conform to hard steel wire rods or piano wire rods of the Korean Industrial Standards with chemical composition prescribed. Carbon contents are generally 0.55-0.85%, but hard steel wire rods or piano wire rods having 0.35-0.45% carbon contents can also be used depending upon uses. The wire rods are subjected to appearance and dimension inspections, microscopic inspection, chemical inspection and performance inspection.

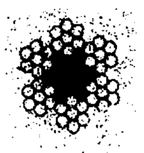
Patenting

After inspection when received, the wire rods are heat treated at the quenching plant. In this process, the wire rods are heated in the continuous heating furnace automatically controlled at predetermined temperatures, and then cooled in the molten lead or air to produce a suitable metal structure. This very important heat treatment is carried out to obtain physical properties required for the wire rope or other steel wire products in drawing and processing the wire rods. On completion of the heat treatment, a test piece is sampled from the bundle of wire rods for measuring physical properties.

Pickling

The hard oxidation film produced on the surface when the wire rods are subjected to the quenching treatment, it needs to be removed for the drawing treatment. The bundle of quenching-treated wire rods is first immersed in a dilute hydrochloric acid for a uniform length of time for removing the oxidation film, follwed by water washing and neutralization. It is immersed again in a chemical vessel for a special surface treatment. Coated with the film having excellent drawing property, the wire rods are dried with hot air in a drying oven.

Table 1. Specification of Wire Rope



6 x 7 (KS No. 1)	
Constitution	Fiber core, 6 x (1 + 6)
Strand	General / Lang } Z or S
Use	Mines, elevators, cables chair lift, forestry, marine

Rope diameter mm	Upper layer wire diameter mm	Calculated cross section area	Cutting load (t) AG	BG & A	B	C	Unit weight kg/m
3.15	0.35	4.06	0.53	0.60	0.66	0.71	0.037
4	0.44	6.54	0.85	0.97	1.06	1.15	0.059
5	0.55	10.2	1.34	1.52	1.65	1.79	0.093
6	0.66	14.7	1.92	2.18	2.38	2.58	0.134
6.3	0.69	16.2	2.12	2.41	2.62	2.84	0.147
8	0.87	26.2	3.42	3.88	4.23	4.58	0.237
9	0.99	33.1	4.33	4.91	5.35	5.80	0.300
10	1.10	40.9	5.34	6.06	6.61	7.16	0.371
11.2	1.24	51.3	6.70	7.60	8.29	8.98	0.465
12	1.32	58.9	7.69	8.73	9.52	10.3	0.534
12.5	1.36	63.9	8.34	9.47	10.3	11.2	0.579
14	1.55	80.1	10.5	11.9	13.0	14.0	0.727
16	1.75	105	13.7	15.5	16.9	18.3	0.950
18	1.93	132	17.3	19.6	21.4	23.2	1.20
20	2.20	163	21.4	24.2	26.4	28.6	1.48
22.4	2.47	205	26.8	30.4	33.2	35.9	1.86
24	2.65	235	30.8	34.9	38.1	41.3	2.14
25	2.75	255	33.4	37.9	41.3	44.8	2.32
26	2.85	276	36.1	41.0	44.7	48.4	2.51
28	3.07	320	41.9	47.5	51.8	56.2	2.94
30	3.25	368	48.1	54.5	59.5	64.5	3.34
31.5	3.45	406	53.0	60.1	65.6	71.1	3.68
32	3.55	419	54.7	62.1	67.7	73.3	3.80
33.5	3.70	459	59.9	68.0	74.2	80.4	4.16
34	3.75	472	61.7	70.1	76.4	82.8	4.29
35.5	3.93	515	67.3	76.4	83.3	90.3	4.67
36	4.00	530	69.2	78.5	85.7	92.8	4.81
37.5	4.12	575	75.1	85.2	93.0	–	5.21
38	4.25	590	77.1	87.5	95.5	–	5.36
40	4.43	654	85.5	97.0	106	–	5.93

Drawing

Following the pickling and surface treatment, the bundle of wire rods is drawn in the drawing process by using cemented carbide dies in series to produce fiber-like steel wire having mechanical properties required for the product. With the drawing treatment, the steel wire increases in its tensile strength and hardness, whereas the toughness decreases when overtreated to a certain extent, requiring repeated pickling and drawing processes after the first drawing in the event of thin wires.

Galvanizing

Galvanized steel wires are used for such uses as vessels, fishery, suspension bridge, ocean development, underground electric cables and overhead wires, which are liable to be corroded by brine water or exposed to winds and rains.

Intermediate inspection

Test pieces are sampled from each of the bundles when steel wires have been finished through drawing and electroplating processes for confirming the product quality by conducting such tests as the measurement of wire diameter, elongation test, stranding test and unwinding test.

Microscopic testing

The performance of steel wire can be indicated by its mechanical properties, including the tensile strength, but its quality depends on the microscopic metallography after quenching treatment or drawing.

Stranding

The element steel wire, which has passed the intermediate inspection, is produced as ropes with fiber core in the stranding process as the final step. The stranding process is generally subdivided into two different processes of stranding and closing.

First, the element steel wires are wound in required length onto a stranding bobbins with a winder for stranding by a strander. The strander breaks down to the high-speed tubular type and low-speed planetary type. In this process, rope grease is sufficiently applied to the strand in accordance with the unique interval oiling method developed by the company offering this technology, while preforming to provide uniform and well-twisted strands.

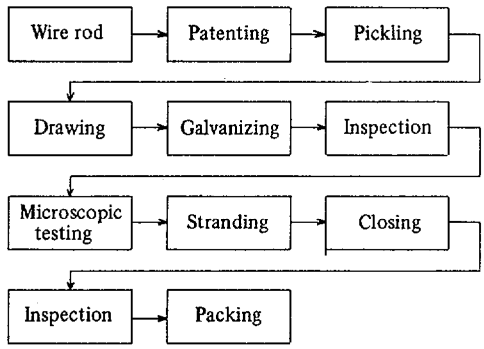
Closing

The produced strand is wound again onto the closing bobbin for closing with a closer. Its principle is suitable to stranding but the correction of form and elimination of internal stress are carried out by preforming and postforming, thus producing a superior wire rope of uniform quality.

Inspection

The finished wire rope undergoes external appearance and weighing inspections prior to test piece sampling for product inspection. The test piece is measured with regard to its diameter and pitch, followed by breaking load test. The rope is also disassembled for the confirmation of its uniform quality by fiber core construction check, element wire diameter measurement, twisting test, elongation test and unwinding test.

Wire Rope Manufacturing Process Block Diagram



2) Equipment and Machinery

- Wire pickling equipment
- Wire patenting furnace
- Wire take-up machine
- Continuous wire drawing machine
- Wire patenting & galvanizing combination equipment
- Fine wire drawing machine (wet, dry)
- Stranding & closing machine
- Packing & handling equipment
- Accessories for wire product

3) Raw Materials and Utilities

Raw materials and utilities	Requirement (per ton of product)
Wire rod (SWRH, SWRM, SWRS)	1003 kg
Zinc (99.5% Zn)	67 kg
Lead	1.55 kg
HCl (35%)	20 kg
Rust proofing oil	12 ℓ
Grease	44.6 kg
Borax	1.0 kg
Zinc ammonium chloride	1.73 kg
Bondelite	1.0 kg
Drawing lubricant compound	1.48 kg
Fiber core (P.P., manila rope, jute)	5.04 kg
Kerosene	18.5 ℓ
Electric power	450 kwh
Bunker-C oil	20 ℓ
Butane gas	21 kg

Example of Plant Capacity and Construction Cost

1) Plant capacity : Wire rod 1,300 m/t/month (13 ~ 32φ)
Hard drawn steel wire 1,200 m/t/month (0.33 ~ 12φ)

* Basis : 20 hours/day, 30 days/month

2) Estimated construction cost (as of 1979)

○ Equipment and machinery	:	US$7,514,000
○ Utilities	:	US$ 737,000
○ Installation cost	:	US$ 770,000
Total	:	US$9,021,000

3) Required space

○ Site area	:	49,500 m^2
○ Building area	:	20,000 m^2

4) Personnel requirement

○ Manager	:	12 persons
○ Engineer	:	8 persons
○ Operator	:	116 persons
○ Others	:	12 persons
Total	:	148 persons

P

MACHINERY MAINTENANCE AND REPAIR SHOP

1. PREFACE

The machinery maintenance and repair shop is mainly a workshop for mechanical repairs, whose services include repairing machine tools and similar machines, regardless of their make, overhauling small-scale plant, modernizing machine tools, carrying out construction steel work, doing maintenance and assembly work and carrying out small production series for different kinds of metal component.

These machinery maintenance and repair shops should be designed and equipped for repairing, overhauling, modernizing and construction work, as well as maintenance, assembly and production, and also jobbing work, mainly on metal cutting machines and connected with surface preparation, sand blasting, rust elimination, surface treatment preparation, the production of various surface patterns, metal spraying using the wire and powder spray methods, anti-corrosion metal coating with zinc, aluminum, copper, steel, Babbitt metal, molybdenum, brass, powdered metal alloys (e.g. Cr.,Ni and many others) and improving and repairing components of machinery.

Repairs on many machines can be carried out partly in the repair shop and partly at the customer's factory.

2. CAPACITY OF THE PLANT

The capacity of the machinery maintenance and repair shop depends entirely on the mix of components and machines which are repaired there.

That means that its capacity cannot be stated with precision.

3. BRIEF DESCRIPTION OF THE PROCESS

Maintenance and repairing are individual processes which vary according to what is being maintained, repaired, overhauled, modernized or produced.

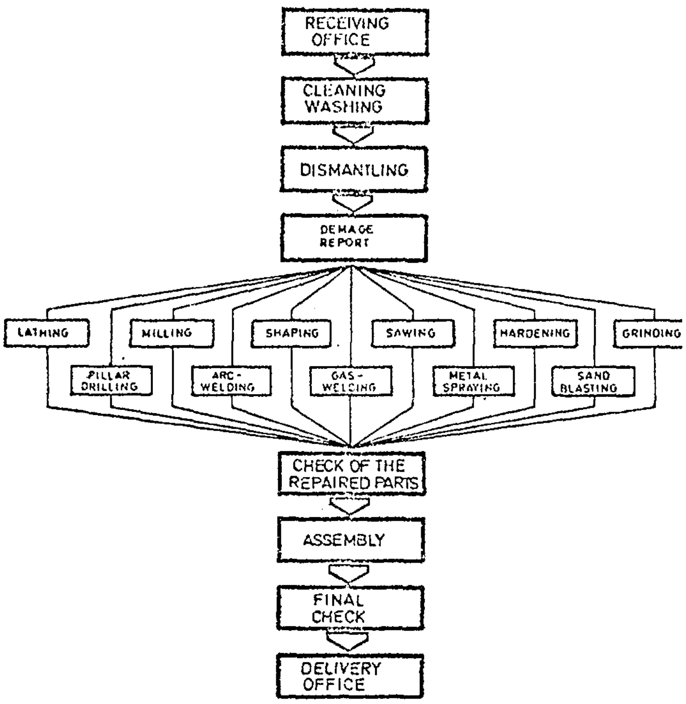
After the equipment has been received, cleaned and dismantled, an initial report is prepared prior to further action.

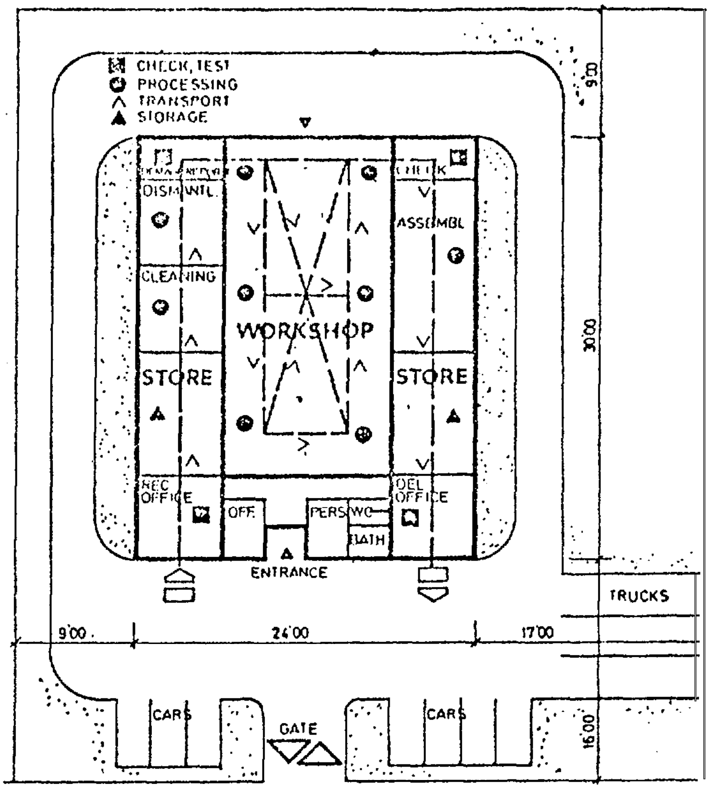
In the machining shop, the parts which require repair are machined by lathing, milling, shaping, sawing, hardening, grinding, pillar drilling, arc-welding, gas-welding, metal-spraying and sand blasting until the repair is completed.

They are then checked and tested and assembled by the assembly section, completing repairs to the machine.

The repaired equipment is taken to the storage area, from where it is either delivered straight away to the customer or put into final storage.

PROCESS FLOW SHEET





4. REQUIRED BASIC AND AUXILIARY MATERIALS

The quantity of the various materials depends on the nature of the equipment which is repaired and maintained and on the methods used.

Below are the approximate material requirements of the plant for one year's operation:

- Electrodes	200 boxes
- Welding wire	10 rolls
- Protective gas	10 bottles
- Oxygen	10 bottles
- Acetylene gas	20 bottles
- Bearing grease	100 kgs
- Multi-grease	100 kgs
- Gear oil	400 l
- Anticorrosive paint	300 kgs
- Cleaning chemicals	200 kgs
- Various additional materials	

5. AREA REQUIREMENTS

Required site area: 2,915 m^2

Required building area

Production hangar	684 m^2
Storage hangar	108 m^2
Office building	108 m^2

Structural

Production hangar, storage hangar, office building

Columns and beams	- prefabricated concrete or steel construction
Walls	- corrugated iron sheets; office building brick-lined
Floors	- concrete paved with PVC
Roof	- metal sheets

6. MACHINERY AND EQUIPMENT

Description:	Quantity:	Description:	Quantity:
Universal lathe	3	Tempering furnace	1
Universal milling machine	2	Hand fork lift	3
Framed saw	1	Diesel fork lift	1
Shaper	1	Workbench	10
Grinding machine	2	Metal worker's tool kit	6
Pillar drill	2	Mechanic's tool kit	4
MIG/MAG welding unit	1	Electrician's tool kit	1
Arc welding unit	1	Welding tool kit	3
Gas welding unit	1	Portable tool box	6
Hand-drilling unit	5	Tool cabinet	6
Right angle grinder	3	Shelf unit	4
Air compressor	1	Assembly bench	4
Steam jet unit	1	First aid box	2
Sand blasting unit	1	Cupboard	5
		Metal spraying unit	1

7. POWER REQUIREMENTS

Power type:	3 x 380 V, 50 Hz
Built-in capacity:	72 kW
Total power consumption during simultaneous use:	45 kW
Power consumption/year:	90,000 kWh

8. PERSONNEL REQUIREMENTS

Production staff

- Master technicians	2
- Master skilled workers	10
- Skilled workers	4
- Semi-skilled workers	2
- Unskilled workers	2

Management and administrative staff

- Plant managers	1
- Technicians	2
- Clerical staff	2

Work-time base

Number of shifts taken into consideration:	1 shift per day
Work-time taken into consideration:	8 hours per day
Number of work-days:	250 days per year

The plant is also suitable for operation in more shifts.

This information has been prepared for UNIDO by Horst Langbauer, Austria. Any inquiry about the information contained should be sent to: IO/COOP, Registry file No. ID/562/12, UNIDO, P.O. Box 300, A-1400 Vienna, Austria.

FILE: P3
ISIC 3824

SMALL-SCALE REPAIR WORKSHOP

1. PREFACE

The small-scale repair workshop is mainly a workshop for mechanical repairs, whose services include repairing machine tools and similar machines, regardless of their make, overhauling small scale plant, modernizing machine tools, carrying out constructional steel work, doing maintenance and assembly work and carrying out small production series for different kinds of metal components.

These small-scale repair workshops should be designed and equipped for repairing, overhauling, modernizing and construction work, as well as maintenance, assembly and production, and also jobbing work, mainly on metal cutting machines and connected with surface preparation, sand blasting, rust elimination, surface treatment preparation, the production of various surface patterns, metal spraying using the wire and powder spray methods, anti-corrosion metal coating with zinc, aluminum, copper, steel, Babbitt metal, molybdenum, brass and powdered metal alloys (e.g. Cr, Ni and many others) and improving and repairing components of machinery.

Repairs on many machines can be carried out partly in the repair workshop and partly at the customer's factory.

2. CAPACITY OF THE PLANT

The capacity of the small-scale repair workshop depends entirely on the mix of components and machines which are repaired there.

This means that its capacity cannot be stated with precision.

3. BRIEF DESCRIPTION OF THE PROCESS

Repairing is an individual process which varies according to what is being repaired, overhauled, modernized or produced.

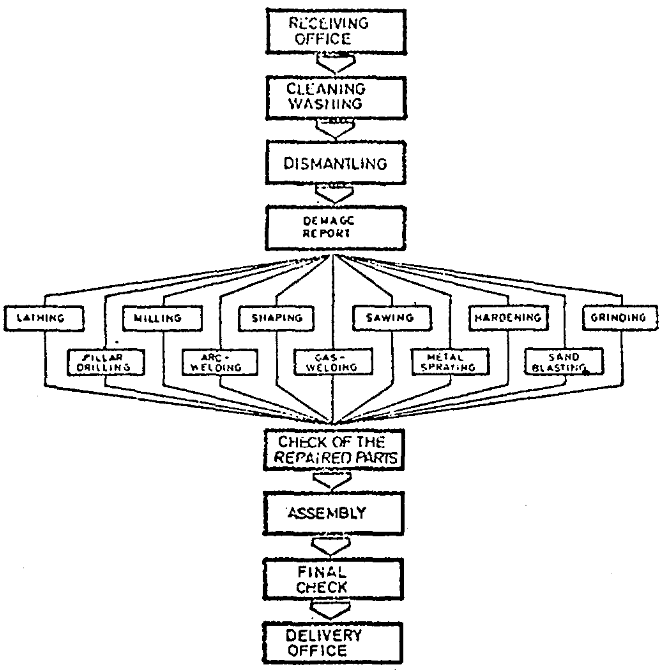
After the equipment has been received, cleaned and dismantled, an initial report is prepared prior to further action.

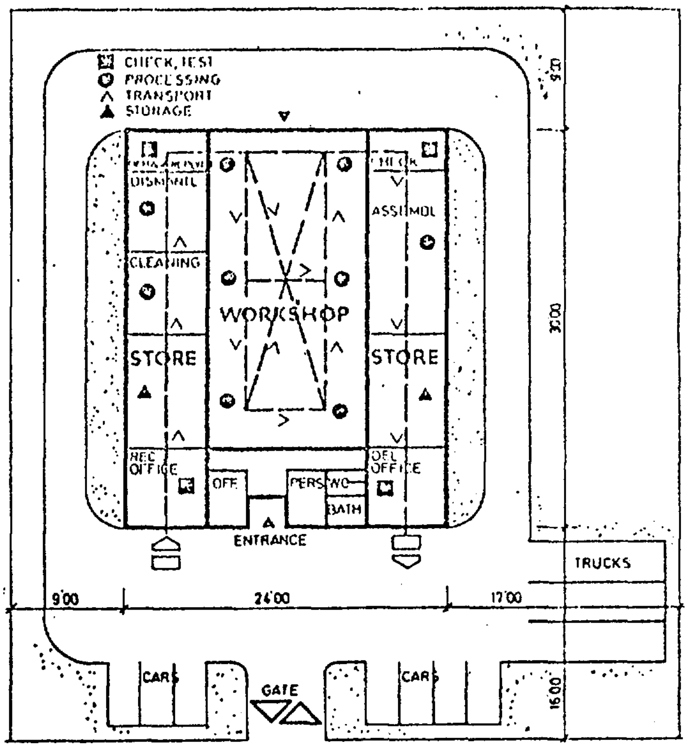
In the machining shop, the parts which require repair are machined by lathing, milling, shaping, sawing, hardening, grinding, pillar drilling, arc welding, gas welding, metal spraying and sand blasting until the repair is completed.

They are then checked and tested and assembled by the assembly section, completing repairs to the machine.

The repaired equipment is taken to the storage area, from where it is either delivered straight away to the customer or put into final storage.

PROCESS FLOW SHEET





4. REQUIRED BASIC AND AUXILIARY MATERIALS

The quantity of the various materials depends on the nature of the equipment which is repaired and on the methods used.

Below are the approximate material requirements of the plant for one year's operation:

- Electrodes	100 boxes
- Welding wire	5 rolls
- Protective gas	5 rolls
- Oxygen	5 bottles
- Acetylene	10 bottles
- Bearing grease	50 kgs
- Multi-grease	50 kgs
- Gear oil	200 l

- Anticorrosive paint 150 kgs
- Cleaning chemicals 100 kgs
- Various additional materials

5. AREA REQUIREMENTS

Required site area: 2,750 m^2

Required building area

Production hangar:	468 m2
Storage hangar	162 m^2
Office building	72 m^2

Structural:
Production hangar, storage hangar, office building

Columns and beams	- prefabricated concrete or steel construction
Walls	- corrugated iron sheets; office building brick-lined
Floors	- concrete, PVC-paved
Roof	- metal sheets

6. MACHINERY AND EQUIPMENT (Estimated total FOB price:approx. US$ 210,000)

Description:	Quantity:	Description:	Quantity:
Universal lathe	1	Tempering furnace	1
Universal milling machine	1	Hand fork lift	1
Framed saw	1	Diesel fork lift	1
Shaper	1	Workbench	5
Grinding machine	1	Metalworker's tool kit	4
Pillar drill	1	Mechanic's tool kit	2
MIG/MAG welding unit	1	Electrician's tool kit	1
Arc welding unit	1	Welding tool kit	3
Gas welding unit	1	Portable tool box	3
Hand-drilling unit	3	Tool cabinet	3
Right angle grinder	2	Shelf unit	2
Air compressor	1	Assembly bench	2
Steam jet equipment	1	First aid box	1
Sand blasting unit	1	Cupboards	3
Metal spraying unit	1		

7. POWER REQUIREMENTS

Power type:	3 x 380 V, 50 Hz
Built-in capacity	52 kW
Total power consumption during simultaneous use:	35 kW
Power consumption/year	70,000 kWh

8. PERSONNEL REQUIREMENTS

Production staff

- Master technicians	1
- Master skilled workers	5
- Skilled workers	2
- Unskilled workers	1

Management and administrative staff

- Plant managers	1
- Technicians	1
- Clerical staff	1

Work-time base

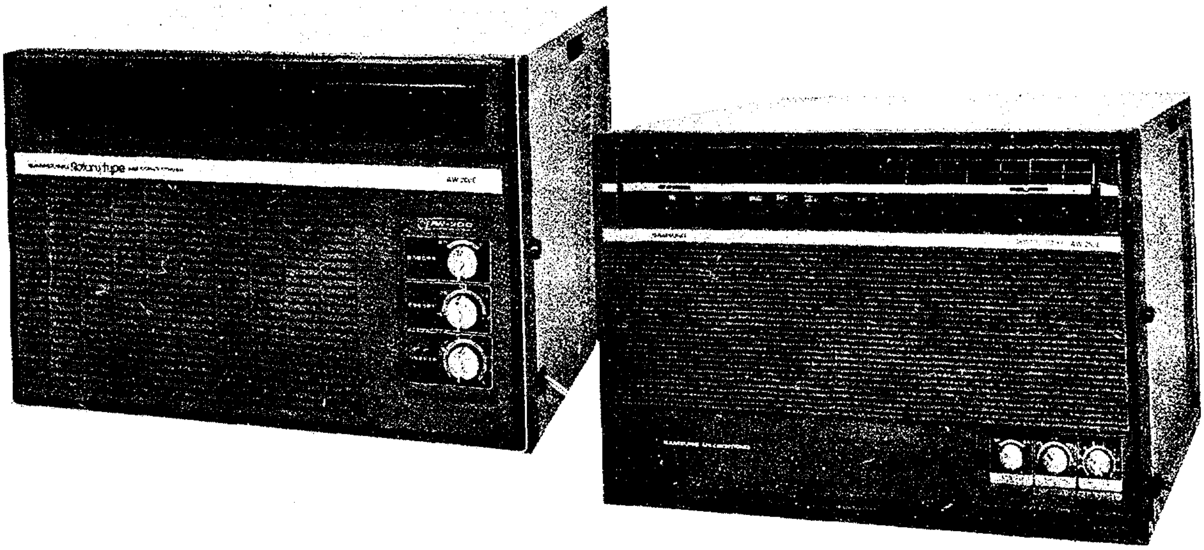
Number of shifts taken into consideration:	1 shift per day
Work-time taken into consideration:	8 hours per day
Number of work-days:	250 days per year

The plant is also suitable for operation in more shifts.

This information has been prepared for UNIDO by Horst Langbauer, Austria. Any inquiry about the information contained should be sent to: IO/COOP, Registry file No. ID/562/12, UNIDO, P.O. Box 300, A-1400 Vienna, Austria.

FILE: P4
ISIC 3829

Air Conditioner Making Plant



View of Products

Though limited in its use depending upon regions and seasons, the room air conditioner is can be used anywhere in tropical and subtropical areas. With the improvement in the living standard, the demand for adjusting the room temperature to an agreeable extent suitable for human activities is gradually increasing. Furthermore, places of its use include not only public places and offices but also automobiles, living rooms, resting rooms and places of amusement.

When reviewing the actuating principle of a room air conditioner, it simultaneously performs actions of cooling, dehumidification, dust removal and air suction and discharge. First of all, its cooling system is almost identical to that of a refrigerator but the compressor motor is much larger and the air suction is carried out by the fan, with the dust in the air removed by the air filter in the front part of the room air conditioner. The cooling takes place when the vapor passes through the space of cooler. The temperature of moisture in vapor falls below the dew point and condenses into water droplets, which are discharged into atmosphere by a fan through the back side of the cooler.

This type of room air conditioner can be advantageously manufactured with relatively simple assembly lines in developing countries.

Products and Specifications

Characteristics of the products manufactured in this plant are as follows:

- The use of a high-powered compressor and large capacity cooling coils enable to induce a pleasant, quiet cooling rapidly.
- Highly conductive coils are in use for a quick cooling and moisture removal.
- A permanent washable air filter is in use.
- An automatic temperature control is provided for a cooling suitable for human health.

The type of room air conditioner breaks down into the window type and split type with models of cooling capacity ranging from 5,830 to 22,000 Btu/hr and air circulation volume ranging from 5.5 to 13m^3/min. Detail specifications are shown in table 1.

Contents of Technology

1) Process Description

In the manufacturing process, the base fan is first assembled and then the barrier is assembled. As can be seen from the block diagram, the compressor, evaporator and control box are attached, with necessary refrigerant and oil filled, for tests prior to further attaching to the cabinet.

2) Equipment and Machinery

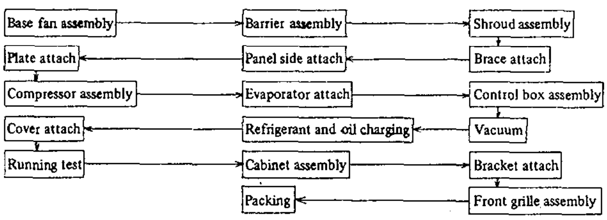
Slot conveyor
Endless conveyor
Roller conveyor

Table 1. Specifications of Room Air Conditioner

Type		Window Type						Split Type	
Model		AW-2000E		AW-250E		AW-500E		AS-250T	
		50Hz	60Hz	50Hz	60Hz	50Hz	60Hz	50Hz	60Hz
Power source		220	220	220	220	220	220	220	220
Phase		Single	Single	Single	Single	Single	Single	Single	Single
Running current	A	3.4	4.1	6	7	13	16	4.4	5
Power consumption	W	733	880	1,210	1,480	1,790	3,350	890	1,170
Cooling capacity	Btu/h	5,830	7,000	10,000	12,000	20,000	22,000	7,500	9,000
	Kcal/h	1,470	1,800	2,520	3,020	5,040	5,600	1,870	2,240
Moisture removal	Pints/h	2.1	2.3	4.3	5.1	6.4	7.7	2.6	3.0
	Liters/h	1.0	1.1	2.0	2.4	3.0	3.6	1.2	1.4
Air circulation	CBM	207	224	323	388	382	459	283	329
	m^3/min	5.9	6.3	10.8	13	9.1	11	8	9.3
Automatic temperature control		yes		yes		yes		yes	
Air exhaust system		yes		yes		yes		yes	
4-way air deflection		yes		yes		yes		yes	
Weight	Lbs	79		137		234		117	
	Kgs	36		62		90		53	
Dimensions (W x H x D)	Inches	20 9/16 x 13 14/16 x 19 13/32		26 3/8 x 17 23/32 x 25 1/16		26 3/8 x 17 23/32 x 30 11/16		31 3/32 x 15 21/32 x 5 11/16 (in) (790 x 398 x 145)	
	mm	522x353x493		670x450x637		670x450x781		26 21/32 x 19 12/16 x 18 4/16 (out) (677x502x464)	
Stuffing Q'ty	20'	135		84		63		72	
	40'	300		180		126		168	

Tow conveyor
Belt conveyor
Trolley conveyor
Ball caster
Oil and gas charging machine
Free balancer
Auto-packing machine
Vacuum pump and motor
Cal tester
Tangent bender
Spot welder
Portable spot welder
Dehydrator
Dry oven
Fork lifter

Room Air Conditioner Assembling Process Block Diagram



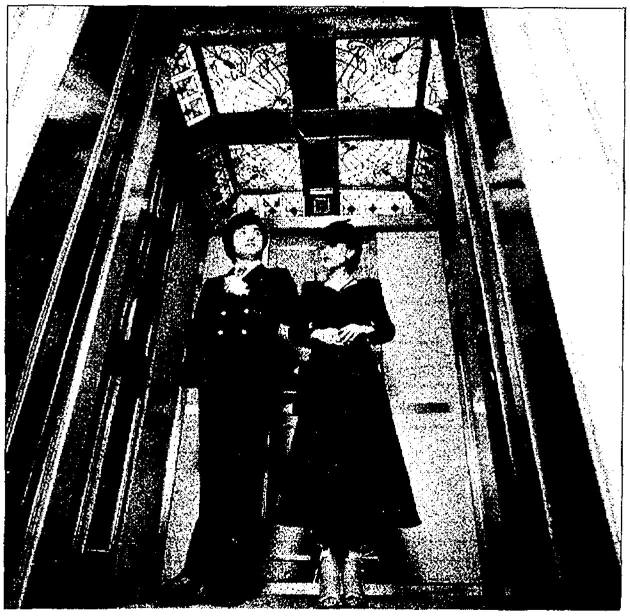
Example of Plant Capacity and Construction Cost

1) Plant capacity : 200 sets/day
   * Basis : 8 hours/day
2) Estimated assembling equipment cost (as of July, 1982) : US$2,000,000
3) Required space
   - Site area : 770 m^2
   - Building area : 470 m^2
4) Personnel requirement: 150 persons

Any inquiry about the information contained should be sent to:

IO/COOP, Registry file No. ID/562/12, UNIDO, P.O. Box 300, A-1400 Vienna, Austria

Elevator/Escalator Making Plant



View of Products

With the recent trend of high-rise buildings, it is almost impossible for man to directly walk up and down many stairs, because one is physically strained not to speak of much time it takes. More difficult is to bring up one's heavy freights to higher floors. An elevator was devised to cope with the situation.

However, in the case of single floor and not higher floors, that is to say, an escalator is designed for use in frequent transportation of men and freights between 2 or 3 floors or in narrow stairs at one time.

Such elevators and escalators are used in many fields including office building, subway, hospital, department store and apartment house, further increasing in demand due to higher buildings as a result of the social development and rapid urbanization.

Such an elevator and escalator plant occupies an important position as the basic conveying machine industry in developing countries, with the advantage of easily manufacturing products by relatively simple mechanical assembly.

Products and Specifications

The characteristics of elevators and escalators manufactured in this plant are that they are diversified in the load capacity and speed and equipped with thyristor control system in consideration of the safety, reliability and economy.

First of all, the elevator capacity is from 450kg (6 persons) to 1,600kg (24 persons) with the speed ranging from 45 to 300m/min. In the control system, the most important part of the elevator, the thyristorized feedback system is employed for over 75m/min and AC-2 speed control method for 45-60m/min.

This thristorized feedback control is characterized by its stepless speed pattern providing the sense of comfort from the start to arrival. It enables the elevator to stop at safe and accurate places at all times regardless of load, voltage temperature and other possible factors.

In the case of below 60m/min speed, it is actuated by AC-2 speed control system. The motive power is provided by a three-phase induction motor with two sets of windings for both low and high speeds.

The elevator uses the high-speed winding in starting, and resistance is applied to minimize the shock. In stopping, conversion is made to the low-speed winding at some predetermined distance before floor levels. The car proceeds at low speed to a point just before floor level, at which point a magnetic brake is activated to bring the car to a stop, aligned with the floor.

The scalator is featued by 30m/min speed at the inclination of 30 degrees, with two maximum rises of 12,000mm and 7,700mm. Detailed specifications of the elevator and escalator explained above are as shown in table 1 and table 2 with reference to fig. 1 and fig. 2.

Table 1. Specifications of Elevator

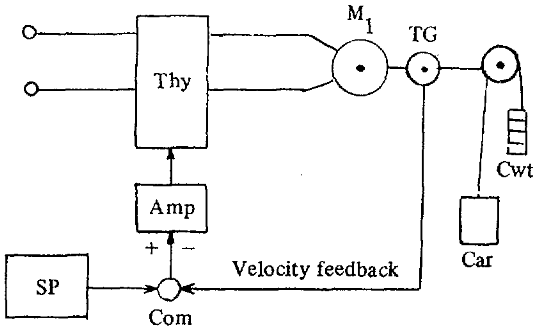
Code		P6-CO	P8-CO	P9-CO	P10-CO	P11-CO	P13-CO	P15-CO	P17-CO	P20-CO	P24-CO
Capacity	Rated load	450kg	550kg	600kg	680kg	750kg	900kg	1000kg	1150kg	1350kg	1600kg
	Persons	6	8	9	10	11	13	15	17	20	24
Speed		45, 60, 75, 90, 105, 120, 150, 180, 210, 240, 300mpm									
Max. travel		120mpm and above: 100-200m, 60-105mpm: 60m, 45mpm: 40m									
Control systems		75mpm and above: Thyristorized feedback,45-60mpm: AC-2 speed control									
Operation systems		For 1 or 2 cars: Selective collective For 3 or more cars: OS-75E (speed 90mpm and above)									
Car designs	Ceiling	Type C-202									
	Walls	Painted steel sheet in color selected									
	Doors	Painted steel sheet in color selected									
Entrance designs	Door frame	Type E-102									
	Hoistway doors	Painted steel sheet in color selected									
Car-position indicator		Horizontal type, mounted above the car doors									
Hall indicator and call buttons	For 1-car operation (DC or 2BC)	For main floor: Type PIR-B-110 For other floors: Type PIR-B910									
	For 2-car operation (2C-DC or 2C-2BC)	*15 stops or less*	For main floor: Type PIR-B120 (with two-column position indicators, two-*column directional arrows and call button(s))* For other floors: Type PIR-B920 (with two-column directional arrows and call button(s))								
		15 stops or more	For main floor : Type PIR-B110 (two per floor) For other floors: Type PIR-B920								
	For 3 or more car operation (OS-75E)	Hall lanterns: Type HLH-501 Call button(s): Type HBN-121									
Faceplate of signal equipment		Silver-colored anodized aluminum									

* Calculated on the basis of an average weight of 65kg.

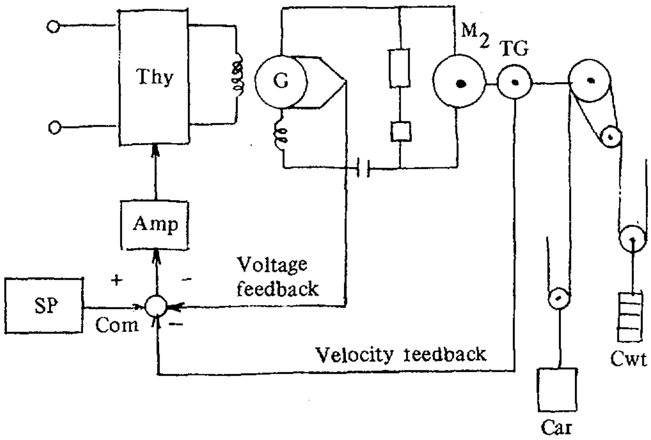
Table 2. Specifications of Escalator

Type		800	1200
Effective width between balustrades (mm)		800	1200
Step width (mm)		604	1004
Carrying capacity (person/hour)		6000	9000
Speed (m/min)		30	
Inclination		30°	
Maximum rise (mm)		12000	7700
Power source	Main drive	3-phase 50 or 60Hz	
	Lighting	Single-phase 50 or 60Hz	

Fig 1. The Control System of AC-SL Geared and DC Gearless Elevator



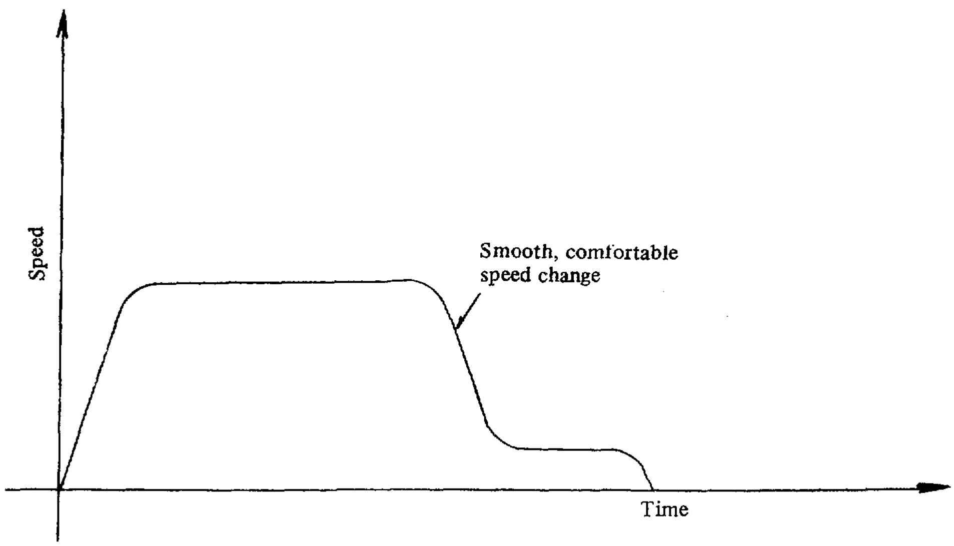
For 75 and 90mpm elevators and 105mpm (except 1600kg-capacity) elevators



For 120mpm and above speed elevators

* Basis;				
	Amp	Amplifier	M_2	DC motor
	Com	Comparator	SP	Speed-pattern generator
	Cwt	Counterweight		
	G	Generator	TG	Tachogenerator
	M_1	AC motor	Thy	Main thyristor

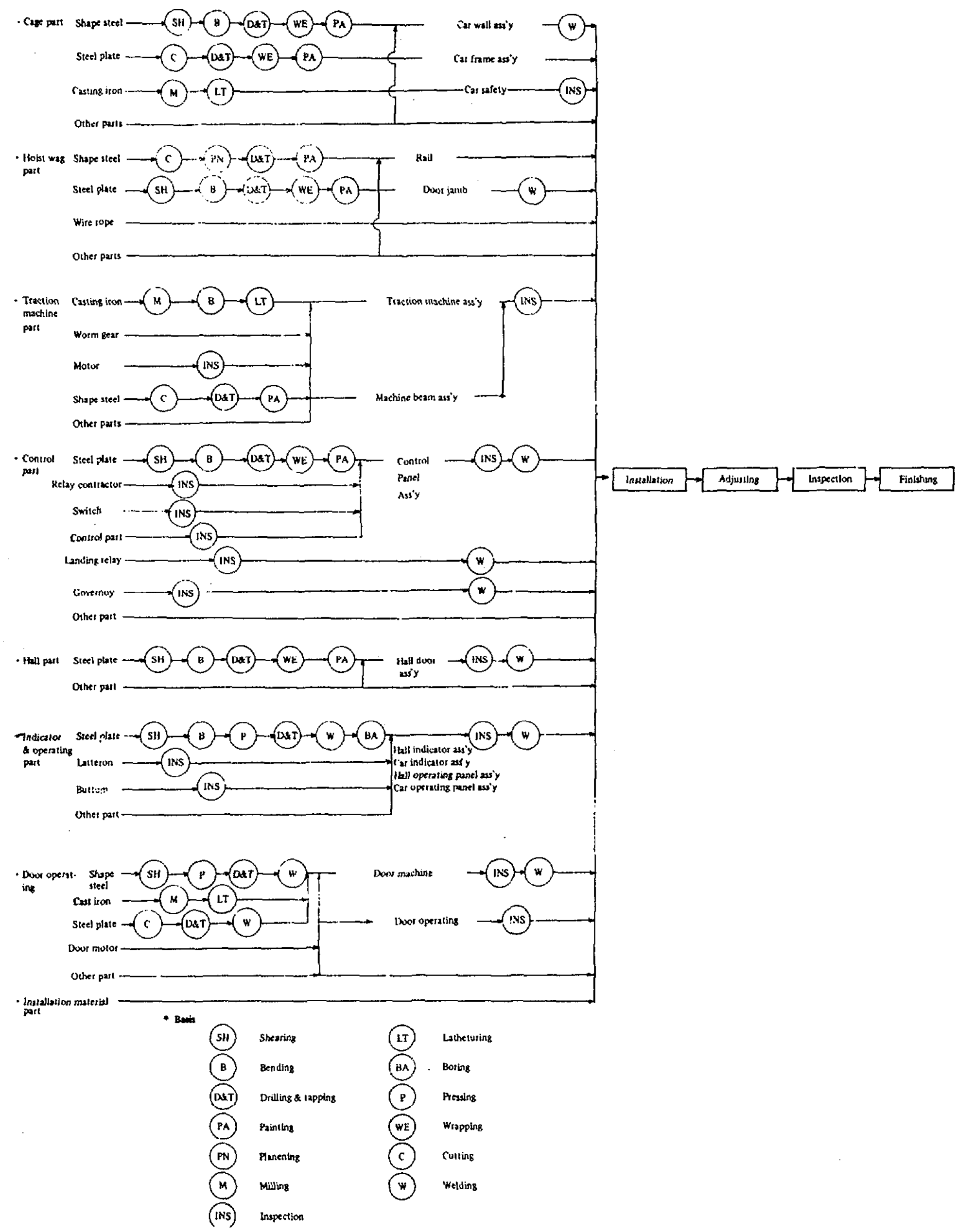
Fig 2. AC-2 Speed-Time Curve



Contents of Technology

1) Process Description

Of the elevator and escalator, brief explanations are made only on the elevator, referring to the flow chart regarding other details. By unit, respective component parts are welded after processes of shearing, bending, drilling and tapping, boring, pressing, cutting and machining. The welded component parts are assembled together to make finished products prior to adjustment, painting, final inspection and delivery.



Example of Plant Capacity and Construction Cost

1) Plant capacity : 700 sets/year
   * Basis : 8 hours/day, 25 days/month

2) Example of estimated assembling equipment cost: US$1,460,000

3) Required space
   - Site area : 29,000 m^2
   - Building area : 7,205 m^2

4) Personnel requirement: 300 persons

Any inquiry about the information contained should be sent to:

IO/COOP, Registry file No. ID/562/12, UNIDO, P.O. Box 300, A-1400 Vienna, Austria

Pump Assembling Plant

With the increase in population centered around cities and improvement in living standard, there has been a considerable upsurging in the consumption of water, which necessarily calls for extension of facilities for its treatment and distribution.

On the other hand, facilities are required for control of floods which occur in heavy rains, for supply of industrial water which is indispensable for expanding industry, as well as for discharge of waste water from plants and treatment of such water. No undertaking relating to water, which is direcuy connected to human life, can be achieved without pumps. Centrifugal pumps have been used in waterworks in Korea for drawing water from the lower reaches of rivers or under-ground, and pressure-feeding of water to reservoirs at higher levels. Among water pumps, the small-type centrifugal pumps enjoy a large demand being extensively used, in the fields of agriculture, civil engineering, chemical industry, water works, minding and air-conditoning, and for many other industrial purposes.

Products and Specifications

Pumps can be classified into various types but explanations given here relate only to the centrifugal pump being produced in this plant, which is now most universally used.

A centrifugal pump has two main parts: a rotating element, including an impeller and a shaft, and a stationary element made up of a casing, stuffing box, and bearings. In a centrifugal pump the liquid is forced, by atmospheric or other pressure, into a set of rotating vanes. These vanes constitute on impeller

Table 1. Specifications of Pump

Description	Bore(mm)	Capacity (m^3/min)	Head(m)
Single suction volute pump	32-300	30	
Double suction volute pump	150-800	2.5-200	
Single suction multi-stage turbine pump	50-250	0.3-4.5	30-200
Gear pump	40-150	0.1-1.5	10-100
Horizontal mixed flow pump	300-2,000	12-500	3-8
Vertical turbine pump	80-700	0.3-55	1.8-150

View of Assembling Plant

which discharges the liquid at its periphery at a higher velocity. This velocity is converted into pressure energy by means of a volute or by a set of stationary diffusion vanes, surrounding the impeller periphery. Pumps with volute casings are generally called volute pumps, while those with diffusion vanes are called diffuser pumps. Diffuser pumps were once quite commonly called turbine pumps.

First of all, the single suction volute pump among volute pumps is in use mainly for industrial water, civil work, agricultural irrigation, drainage and circulation of both cold and hot water in a building. It is of high efficiency, of simple but study construction, and of long life and high reliability.

The double suction volute pump is widely used in urban water supply, long distance irrigation in rural areas, industrial water in various plants, large vessels and tanks. This double suction volute pump is also characterized by its high efficiency, simple but sturdy construction, and long life and high reliability.

Besides, there are also the single suction multi-stage turbine pump, gear pump, horizontal mixed flow pump and vertical turbine pump. Detail specifications are shown in table 1.

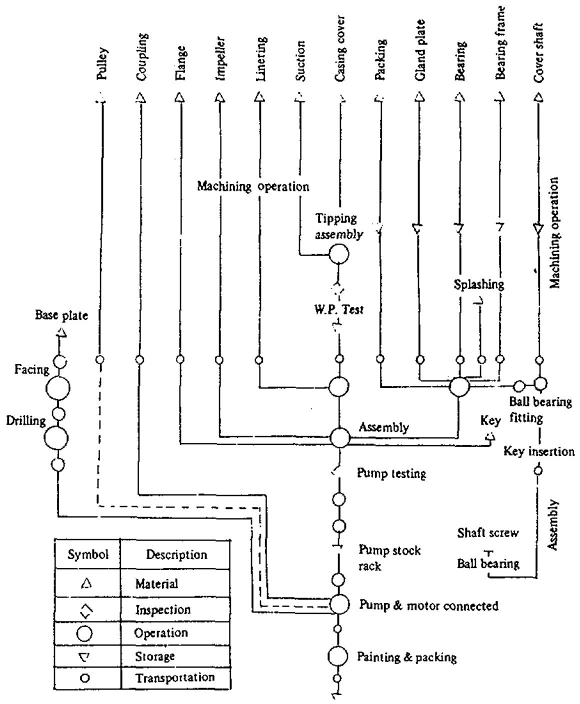
Contents of Technology

1) Process Description

Wooden pattern and casting

Cast iron, cast steel, stainless steel, bronze, etc. are

Pump Assembling Process Diagram



used as materials of casing, impeller, bearing bracket and bed. Wooden patterns are manufactured after due consideration of materials of parts and cast a statue in material to use electric furnace and cupola.

Machining and assembling

The machining process uses lathe, milling machine, drilling machine and broing machine, and all parts are asssembled after static and dynamic balance tests of impeller and rotating parts. The center of pump and motor coupling is regulated by a dial gauge.

Inspection and test

All products are inspected by an inspector during the manufacturing and testing. The following inspections are performed at the factory:

- Appearance inspection and dimensions inspection
- Hydrostatic pressure inspection
- Operating inspection
- Performance inspection
- Net positive suction head (NPSH) inspection
- Materials inspection
- Manufacturing inspection
- Balance and vibration inspection

2) Equipment and Machinery

Cupola
Wooden pattern machine
Boring machine
Turning machine
Lathe
Planen miller
Radial drilling machine
Bending roller

Example of Plant Capacity and Construction Cost

1) Plant capacity : 150 unit/month
   * Basis : 8 hours/day, 25 days/month
     Model – ϕ 150mm
2) Estimated manufacturing equipment cost: US$1,100,000
3) Required space: 2,000 m^2

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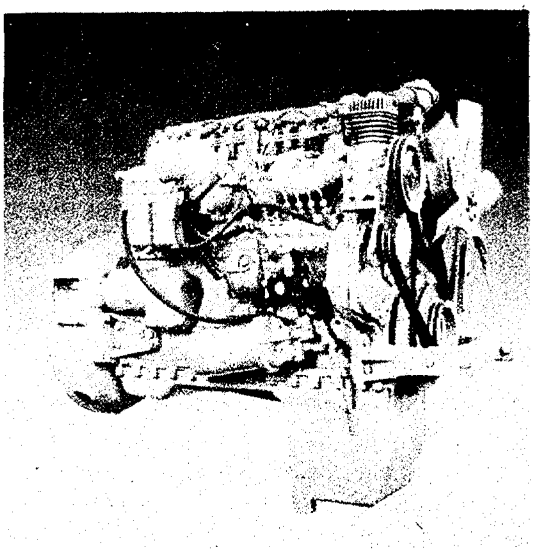
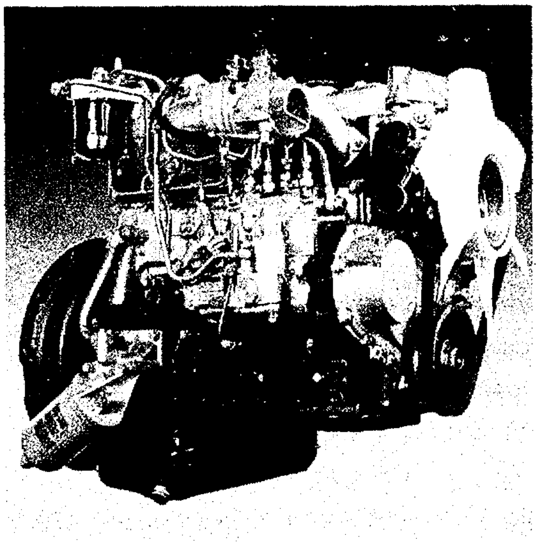
Diesel Engine Assembly Plant



(D0846M)



(4BAI)

View of Diegel Engine

Diesel engines are used as power source for vehicles, heavy construction equipment, vessels, generators and other industrial equipment, with the general advantage of being favorable in terms of fuel economy for their high thermal efficiency and of excellent durability.

In particular, the MAN diesel engines referred to belong to one of the most outstanding engines (NA 165g/ps.h, TA 158g/ps.h) boasting of enduring 500,000km with no necessity of boring.

The uses cover buses, trucks and other heavy equipment like fork lift, excavator and bulldozer as well as generators and vessel engines.

Since the production and machining of such important diesel engine parts as cylinder block, cylinder head, crank shaft, cam shaft and connection rod are difficult to undertake at early stages, the diesel engine assembly plant externally purchases these parts to assemble the engines. This description being concerned with the construction of such an assembly plant and related technology licensed.

Products and Specifications

MAN diesel engine

This engine incorporates the M (HM) combustion system developed by MAN company of Germany characterized by the smooth and quiet running, high flexibility over the entire speed range, high fuel economy, high power and long service life.

ISUZU diesel engine

This minimum stroke/bore ratio engine provides the

Table 1. Specifications of Diesel Engine

Spec. \ Model	D0846M	D2156HM	D2156MT	4BAI	6BBI
Cycle	4	4	4	4	4
Type	Vertical, In-line	Vertical, In-line	Vertical In-line	Vertical In-line	Vertical In-line
No. of cylinders	6	6	6	4	6
Bore (mm)	108	121	121	98	102
Stroke (mm)	132	150	150	92	110
Sweep volume (cc)	7,255	10,350	10,350	2,775	5,393
Compression ratio	17:1	17:1	17:1	19:1	17.5:1
Weight, dry abt.(kg)	620	850	900	300	480
Max. horse power (DIN)	145HP/2,500r.p.m.	215HP/2,200r.p.m.	256HP/2,200r.p.m.	85PS/4,000r.p.m. (JIS)	145PS/3,200r.p.m. (JIS)
Max. horse power (SAE)	160HP/2,500r.p.m.	236HP/2,200r.p.m.	281HP/2,200r.p.m.		
Max. torque(DIN)	45mkg/1,600r.p.m.	76mkg/1,400r.p.m.	91.5mkg/1,400r.p.m.	18.5kgm/2,200r.p.m. (JIS)	35kgm/2,000r.p.m. (JIS)
Max. torque(SAE)	50mkg/1,600r.p.m.	84mkg/1,400r.p.m.	101mkg/1,400r.p.m.		
Fuel consumption (g/HP-h)	160	162	158	187	170
Length (mm)	1,110	1,205	1,250	773	1,145
Width (mm)	720	745	825	595	791
Height (mm)	995	1,185	1,275	666	805

features of high speed performance with durability, low cost per horse power, no air pollution, quick operation and easy starting.

Contents of Technology

1) Process Description

1. The important parts like the cylinder block, crank shaft, cylinder head, flywheel, cam shaft, bearing cap and flywheel housing are cleaned.
2. Crank shaft is assembled to cylinder block.
3. Water chamber cover and push rod chamber cover are assembled.
4. Flywheel housing and cam shaft are assembled to cylinder block.
5. Flywheel is assembled.
6. Timing gear case is assembled.
7. Injection pump is assembled.
8. Cam shaft gear and idle gear are assembled.
9. Timing gear case is assembled.
10. After assembling mounting bracket, the engine is mounted on a truck.
11. Engine number is engraved on cylinder block.
12. Connecting rod, piston and piston ring are subassembled.
13. The subassembled piston is assembled.
14. The injection time of injection pump is adjusted.
15. Oil suction pipe in oil pan and oil pump are assembled.
16. Oil pan is assembled.
17. Oil filter and oil cooler are assembled.
18. Valve and valve spring are assembled to cylinder head.
19. The subassembled cylinder head is assembled.
20. Rocker arm and rocker arm shaft are assembled with valve clearance adjusted.
21. Cylinder head cover is assembled.
22. Intake and exhaust manifold are assembled.
23. Nozzle and injection pipe are assembled.
24. Water pump is assembled.
25. Cooling fan is assembled.
26. Fuel filter is assembled.
27. Alternator and starter are assembled.
28. Air compressor is assembled.
29. Engine test
30. Painting
31. Delivery

2) Equipment and Machinery

Washing machine
Dynamo tester
Paint booth
Conveyor
Tool
Special tool
Rack
Fork lift (battery)
Jib crane
Hand lift

Example of Plant Capacity and Construction Cost

1) Plant capacity : 10,000 units/year

* Basis: 300 days/year (D08 series)

2) Example of estimated construction cost (as of 1982)

o Equipment and machinery	:	US$ 637,000
o Utilities	:	US$ 382,000
o Installation cost	:	US$ 127,000
Total	:	US$ 1,146,000

3) Required space

o Site area	:	4,860m^2
o Building area	:	3,888m^2
o Others	:	324m^2
Total	:	9,072m^2

4) Personnel requirement

o Plant manager	:	2 persons
o Engineer	:	5 persons
o Operator	:	55 persons
o Others	:	15 persons
Total	:	77 persons

Any inquiry about the information contained should be sent to:

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Ball Joint Making Plant

Among the FRT suspensions for small cars, the ball joint becomes the rotating shaft, when tires on both sides rotate, as rotating and oscillating part subject to tensile strength as well as compressive strength along its vertical direction.

Here, the power is determined by the rotating torque or oscillating torque of the socket and ball stud, with the ball joint made of spring and rubber or synthetic resin. It in particular maintains the cushion of ball itself and enhances the feeling of car-riding by keeping a fixed clearance against the impact.

As to the type, there are the tensile type and compressive type, this product being an important component part for safety directly linked to human lives should it break.

This plant can extend satisfying guarantees with respect to heat treatment against its breakage due to crack and shortened life due to the abrasion caused by repeated load as well as inspection of crack, selection of material of construction and size. Particularly, best efforts are being made to assure its quality by conducting the endurance test in accordance with specifications.

Products and Specifications

This plant produced both tensile type ball joints and depressive type ball joints. Types and specifications are determined by types of cars.

Table 1. Specifications of Ball Joint

Car name	Part No.	Model	Position
Hyundai	71BB 3263 BC	Cortina (T/C) Mark-IV	Upper
	71BB 3395 AD	Cortina (T/C) Mark-IV	Lower
	54520 11000	Pony	R & L
	71BB-3263-BD	Cortina (T/C) Mark-V	Upper
	71BB-3395-AE	Cortina (T/C) Mark-V	Lower
Kia	0062 34550C	Brisa Pick Up	Upper
	0662 34510A	(S1000P, 1300P)	Lower
	0305 34550A	S-1000, 1300 (Sedan)	R & L
	0866-99-356A	Brisa-II 1300 (Sedan)	
Seahan	8964969	Rekord 1900cc (Old type)	Upper
	8967252	Rekord 1900cc (Old type)	Lower
	352821	Rekord Royal (New type)	
	8942003200	Gemini (Sedan)	Upper
	8942003160	Gemini (Sedan)	Lower

View of Ball Joint Plant

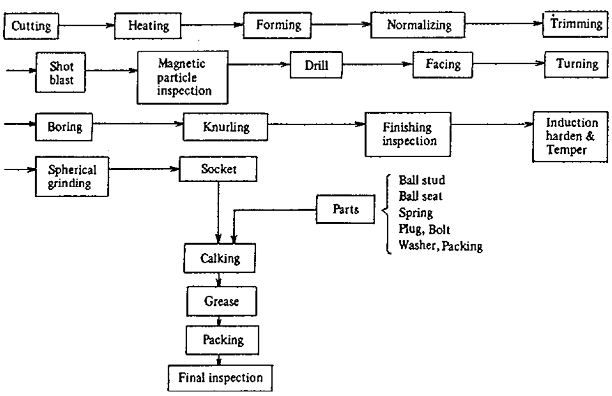
Contents of Technology

1) Process Description

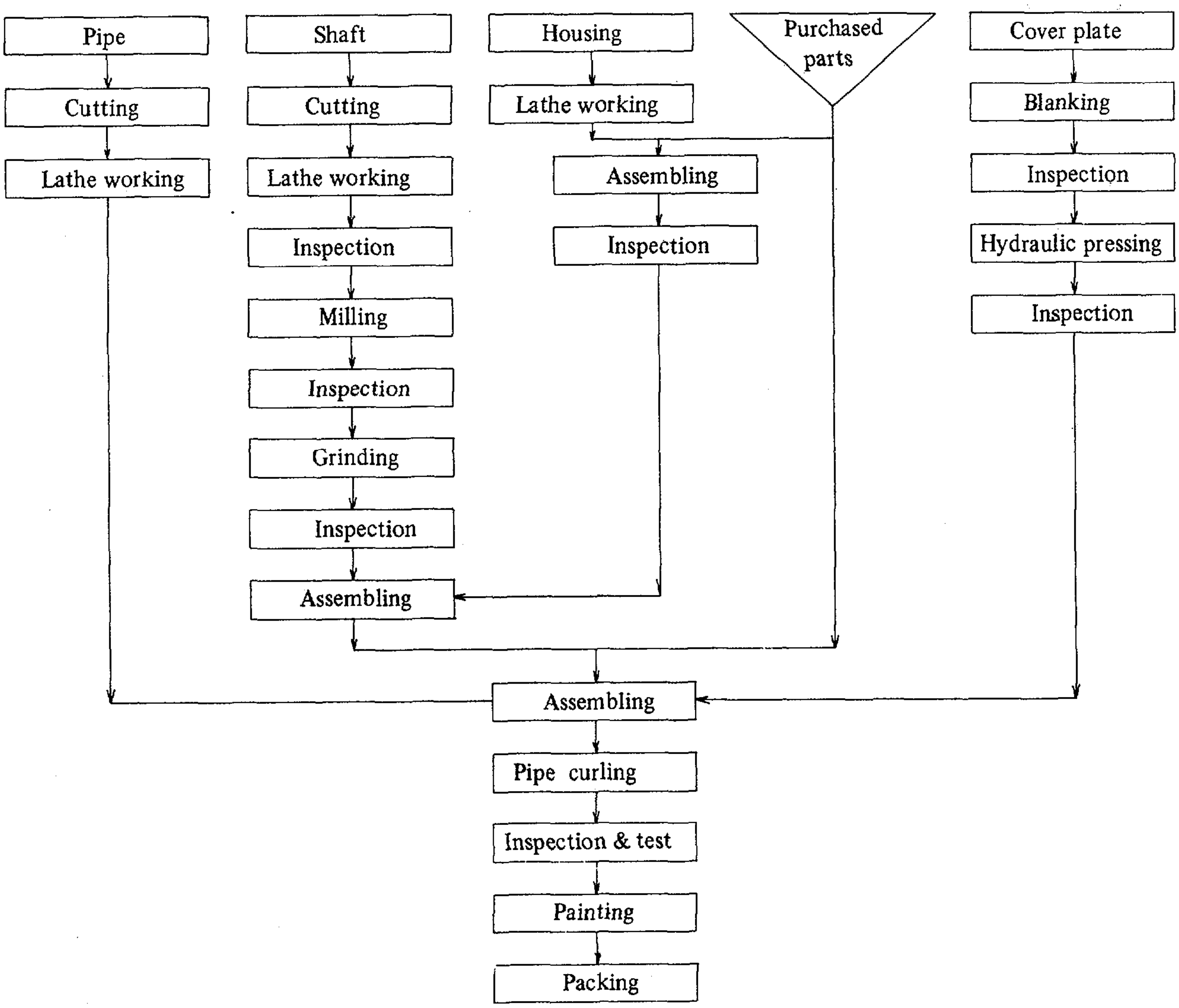
The manufacturing process largely consists of preparation of raw materials, forging, machining, heat treatment, grinding and assembling. The material is first cut, formed by cold rolling press, normalized by heat treatment and then machined.

Of the above steps, critical points are heat treatment, clearance and torque subject to particular inspections in quality control, with other individual processes also requiring frequent inspections by test jigs. In order to prevent the danger of breakage, special crack

Ball Joint Manufacturing Process Block Diagram



Roller Manufacturing Process Flow Diagram



2) Equipment and Machinery

- Engine lathe
- Turret lathe
- Hydraulic auto press
- Horizontal milling machine
- Vertical milling machine
- Universal milling machine
- Horizontal boring and milling machine
- Shaper
- Band sawing machine
- Universal grinding machine
- Outer centerless grinding machine
- Universal cutter and tool grinder
- Center hole grinder
- Radial drilling machine
- Bench drilling machine
- Crank press
- Roll bender
- Press braker
- Shearing machine
- Cutter master
- Automatic gas cutting machine
- Copy cutting machine
- Arc welder
- Argon welder
- Overhead crane

3) Raw Materials and Utilities

Raw materials	Specifications	Requirement (per set of product)
4″ pipe	4″	8.1kg
Round bar (SS41)	ϕ20	1.7kg
Bearing housing (FC20)	BH 501-04	2 ea
Bearing (SUJ2)	6204	2 ea
Labyrinth seal (Nylon)	NLS-04	2 ea
Corer (SPC-D)	SC-4	2 ea
snap ring (SK-5M)	SRH-04	4 ea

Example of Plant Capacity and Construction Cost

1) Plant capacity : 8,400 m/t/year

2) Estimated construction cost (as of 1983)

o Equipment and machinery	:	US$ 250,000
o Utilities	:	US$ 70,000
o Installation cost	:	US$ 800,000
Total	:	US$1,120,000

3) Required space

o Site area	:	$30{,}000m^2$
o Building area	:	$8{,}000m^2$

4) Personnel requirement

o Manager	:	14 persons
o Engineer	:	39 persons
o Speciallist	:	60 persons
Total	:	113 persons

Any inquiry about the information contained should be sent to:

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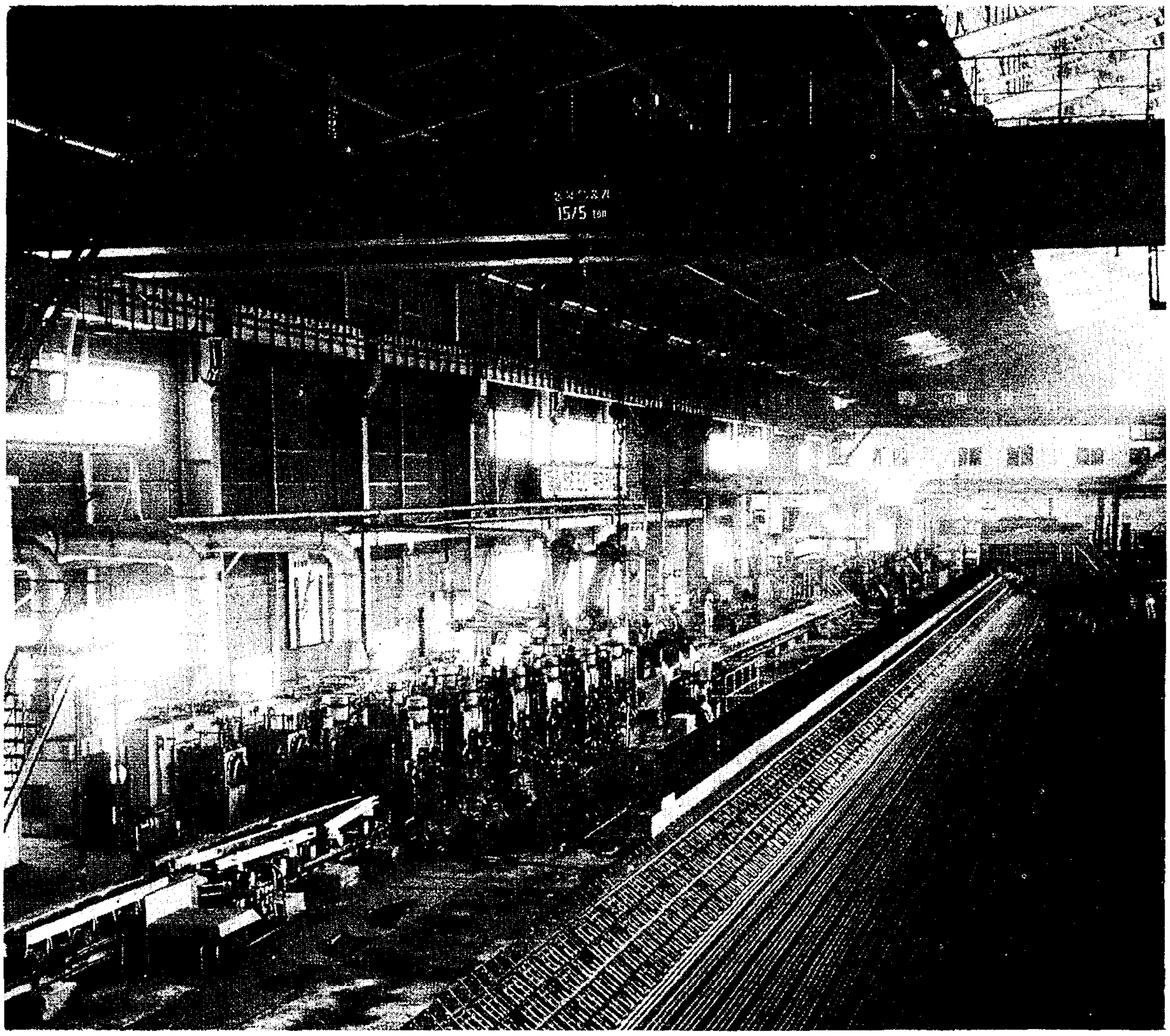
Rolling Mill Plant



View of Rolling Mill Plant

The steel industry is one of the fundamental industries which supplies basic raw materials essential to the production activities in other industries. In particular, it is the industry having the greatest relative effects with such other businesses as the machinery industry, construction industry and metal industry.

It is said that one nation's level of industrialization can be measured by fluctuations in the production and consumption of the steel products.

Annually producing some 700,000 metric tons of deformed or round reinforcing bars, angles ane channels, the rolling mill plant described here is a medium-scale plant equipped with reasonably-priced but fully automated rolling machines providing high productivity and returns on the investment.

It is also specially designed with ease of maintenance in mind. A similar wire making plant was already exported to Kuwait in May 1977 with good reputation.

Products and Specifications

The kind, specifications and sizes of the products which can be produced are as shown in table 1.

Table 1. Product Specifications

Products	Specification	Size	Application
Deformed/round reinforcing bar	ASTM A615 JIS G3112 G3111 BS 44401	Dia: 3/8"~ 15/8" Length : 20' - 40'	Construction
Angle and channel	ASTM A36 VIS G3101	L50xT4/5/6 L65xT 6/8 L75 x T 6/9 L90xT7/9/10 Length: 20' - 40'	Construction, Industrial

Contents of Technology

1) Process description

Billet shearing in billet handling bay

Purchased billets should be cut into pieces by the torch at the billet handling bay, at the length of 4.0 meter, a suitable size for reheating furnace.

Billet reheating in the reheating furnace

The cut billet will be loaded on the billet charging conveyor by a crane and transferred to furnace charging roller table in order to be carried to pusher. Billet charging pusher will he used to charge the billets into reheating furnace in which about 60 tons/hour of the billets shall be heated up to about 1,250°C so as to be pliable for next rolling prcess.

Billet being pushed out from the reheating furnace after reheating slides down on the chute installed at the furnace exit onto the furnace delivery-side roller table. Billet taken out onto the furnace delivery-side roller table. Billet taken out onto the furnace delivery-side roller table is transported one by one onto the approaching roller table located between the furnace and the Kant table of the roughing mill.

Rolling in the roughing mill

The billet of 130 x 130mm, being transported on the approaching roller table, is reduced to 75 x 75mm by 3 Hi-stand roughing mill and reversible Kant table. As is clear from the attached pass schedule, seven passes for rough rolling are required.

Rolling in the intermediate mill.

The elongated billet leaving the roughing mill, is transported on the No. 2 approaching roller table between roughing & intermediate mill, and fed into the No. 2 stand on the intermediate mill, where the billet will become thinner once again.

A flying crop shear shall be installed between No. 3 and No. 4 stand for cutting the nose and tail ends produced during the rolling.

This cutting at this point is very useful to increase the actual operating efficiency.

The independent driving in the last stand, one motor per stand, is adopted to permit the rolling of a veriety of products.

Rolling in the finishing mill

The rolled bars leaving the No. 6 stand, the last stand of the intermediate mill, are fed into the finishing mill through an up-looper. Up-loopers are also provided in order to control the free tension during rolling between No. 7 and No. 8 and between No. 9 and No. 10.

The final size of products will be accomplished at the final stand of finishing mill.

Cooling on the cooling bed

On the basis of its long experience, we have developed a multi-capacity cooling bed which is capable of handling a wide range of products.

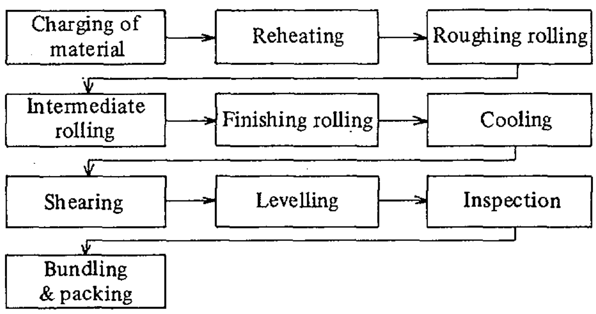
Cooling bed run-in roller table connected to run-in trough will move the hot products onto straightening grid. Products taken out from this through are cooled to suitable temperature on the straightening grid, then sufficiently cooled down while being conveyed in an inclined position on the skew roller type cooling bed which is most suitable for cooling a wide range of products without loss. Cooled products on rollers are taken by walking beams onto the cooling bed run-out roller table.

Finishing in the cold shear and leveler

Cooled products onto the cooling bed run-out table are transported to shear gauge.

At this point, they are cut to required length by a cold shear. Products cut-to-length are loaded on the shear run-out table and then transferred onto the take-out equipment. On this take-out equipment, they are again put in order and taken out onto a leveler run-in table connected to leveler. Products transferred on leveler run-in table are fed into the leveler to be straightened and leveled. Straightened products are transferred onto bundling bed by overhead crane.

Rolling Mill Process Block Diagram



2) Equipment and Machinery

Reheating furnace
- Torch cutter
- Billet charging conveyor
- Furnace charging roller table
- Pusher
- Reheating furnace
- Reheating furnace delivery side roller table
- Approaching roller table

Rough mill
- Roughing mill stand
- Kant table
- Approaching roller table

Intermediate mill
- Intermediate mill stand
- Gear and pinion stand for mill stand
- Flying crop shear
- Run-in table

Finishing mill
- Finishing mill stand
- Gear and pinion stand for mill stand
- Run-in table

Cooling bed
- Cooling bed run-in table
- Straightening grid
- Skew roller table
- Cooling bed run-out table

Finishing facilities
- Cold shear
- Shear gauge
- Shear run-out table
- Take-out device
- Leveller
- Bundling Bed

Auxiliary
- Cooling water system
- Forced circulating oiling system
- Centralized greasing system

3) Raw Materials and Utilities

Raw materials and utilities	Requirement (per ton of product)
Billet (115mm, 130mm)	1,065 t
Electric power	110 kwh
Fuel (bunker-C oil)	45 ℓ

Example of Plant Capacity and Construction Cost

1) Plant capacity : 7,000 m/t/year
   * Basis : 1 shift/8 hours

2) Estimated construction cost
   - o Equipment and machinery : US$ 8,500,000
   - o Utility : US$ 2,500,000
   - o Installation cost : US$12,000,000

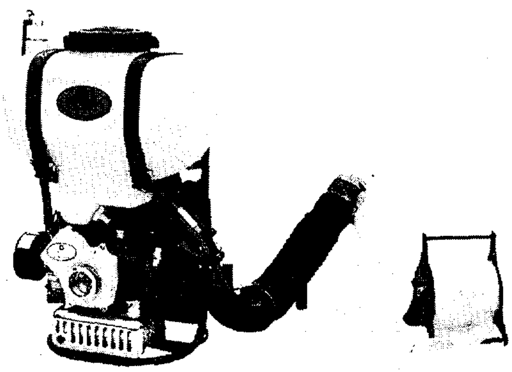
   Total : US$23,000,000

3) Required area
   - o Site area : 100,000 m^2
   - o Building area : 25,000 m^2

4) Personnel requirement
   - o Manager : 13 persons
   - o Engineer : 12 persons
   - o Operator : 42 persons
   - o Others : 5 persons

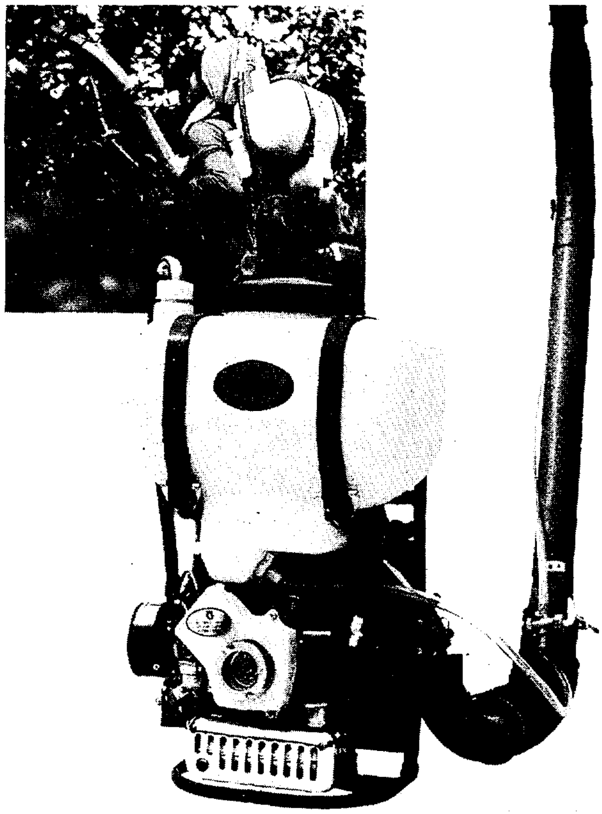
   Total : 72 persons

Power Duster and Mist Blower Plant



View of Power Duster

Dusting Operation with Power Duster



View of Mist Blower and Its Operation

Since the dawn of history, mankind has developed and utilized a number of implements for more harvests and more effective farming in the same acreage of cultivated lands. However, since the latter half of the 20th century in particular, the mechanization of farming has been inevitably required due to the labor shortage, rise in labor costs and large-scale cultivation.

The power duster and mist blower are machines spraying various insecticides for the prevention of damages by blight and harmful insects, which best suit the place too small to make use of an airplane but too large to resort to human labor, capable of uniformly spraying insecticides in the intended area in a short period of time.

It is also highly effective when only small orchards, roadside trees along the street and other particular areas are in mind. Moreover, these products are one of the essential items for the farmers, because they can simply change the insecticide when desiring to exterminate particular insects.

The power duster and mist blower produced in this plant are portable machines which can be used by carrying on the back of men, requiring sophisticated designing and manufacturing skills, because these need to be safe in terms of somatological engineering and relatively free from vibration and noise from the standpoint of mechanical engineering. Therefore, these products are one of the items with significant spillover effects in the field of precision machine industry despite the small scale of the plant, with the following features:

- Compact, light weight and easy operation
- Powerful small two-stroke engine
- Free from lubrication
- Powerful blower and uniform blowing system
- Smart and art-of-the-state design

Also very low in the plant construction costs and reasonable in its product prices, as well as deeply related to the precision machine industry, this plant is definitely one of the indispensable plants in developing countries.

Products and Specifications

Types of the products produced in this plant are as follows:

- Mist blower: Capable of using both liquid and powder insecticides and operated by one man.
- Power duster: Using liquid insecticides, even a vast area can be dusted in a short period of time by a two-man team.

Specifications of the power duster and mist blower are as shown in table 1.

Table 1. Specifications of Products

Name	Power duster	Mist blower
Weight	10.5 kg	10.3 kg
Tank capacity	14ℓ (10.5kg)	14ℓ
Dimension L x W x H(mm)	612x475x330	635x475x330
Discharging rate	1.7kg/min	3ℓ/min
Effective range	15m	10m
Engine	Gasoline engine (2-cycle, 37.7cc, 3.3 Hp)	
Fuel	Mixing oil 20-25:1 (Gasoline 20-25:2 cycle Engine oil 1)	
Revolutions	6,000 - 8,000 rpm	
Fuel tank capacity	1ℓ	
Blowing volume	20m^3/min	
Blowing speed	96m/sec.	
Blowing pressure	720 mmH_2O	

Contents of Technology

1) Process Description

Injection molding

Insecticide tanks are injection-molded with PVC while caps, hoses and connecting parts are injection-molded with polypropylene. After cleaning oils and other impurities caused in the molding, the respective parts are subjected to hydraulic tests for detecting possible abnormalities.

Machining

A round bar or square bar is cut to required length and bent to desired forms by hydraulic press working. These are then made into a basic frame of the product by arc welding, milling and grinding.

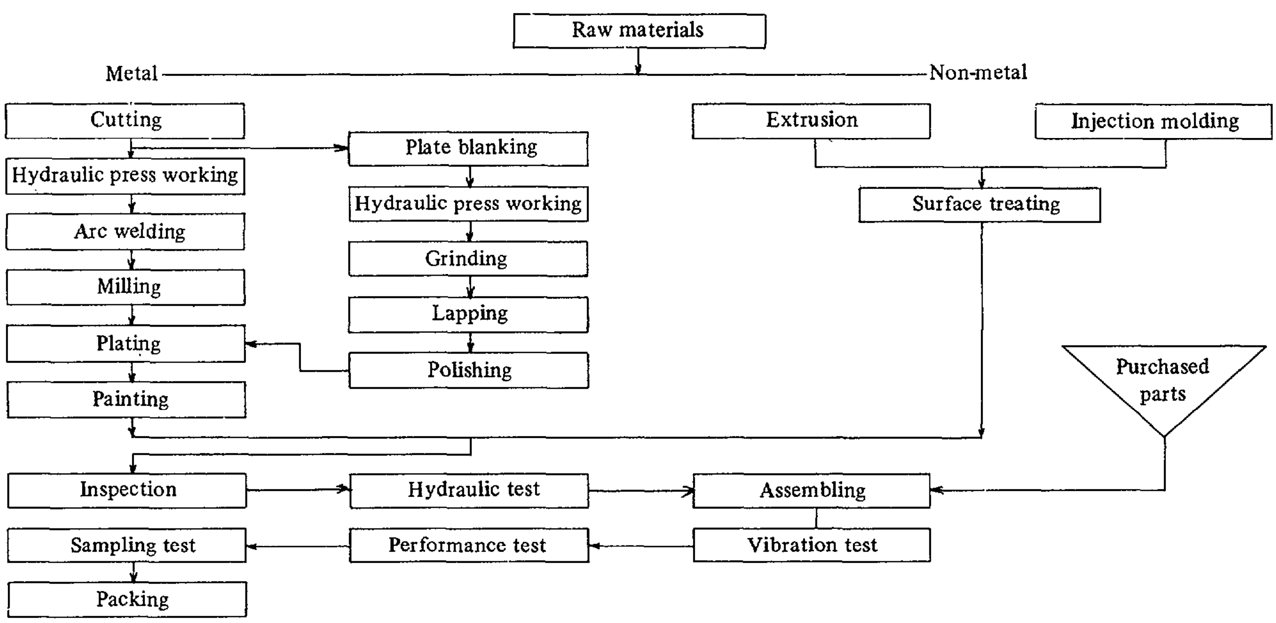
In order to minimize the vibration in actual operation, the power transmission elements between engine and blower are polished after grinding and lapping. After precision measurement with 3-D CNC measuring machine, only the component parts below 0.01 mm in precision are regarded as passed, followed by Rockwell hardness tests.

The fuel tank, tank cover, blower, blower cover, engine support and start-up part are machined into desired forms by blanking and hydraulic-press-working hot coils having different thicknesses and then subjected to grinding, plating and painting when necessitated.

Assembling and test

Engine and blower parts are first assembled to the frame to undergo vibration tests. The product is completed by assembling the remaining parts, followed by performance test, inspection and packing.

Power Duster and Mist Blower Manufacturing Process Flow Diagram



2) Equipment and Machinery

Lathe
Milling machine
Drilling machine
Tapping device
Arc welder
Hydraulic press
Head grinder
Lapping device
Conveyor
Hoist
Air compressor
Air horse
Spray gun
Spray booth
Dry oven
Cleaner
Washing machine
Work bench
Bench vise (4″, 6″)
Wheel assembly machine
Vibrometer
Hydrometer
Profile projector
3-D CNC measuring machine
Universal test machine
Rockwell hardness device

3) Raw Materials

Raw materials	Specifications	Units	Requirement (per unit)
Hot coil (SBC 1)	0.6^t	ea	0.0226
Hot coil (SBC 1)	1.0^t	ea	0.058
Hot coil (SBC 1)	1.2^t	ea	0.035
Round bar (MSWR 10)	5ϕ	m	0.58
Round bar (MSWR 10)	3ϕ	m	0.17
Square bar (MBs BE_1)	6 x 6″	m	0.68
Square bar (SPC 41)	15.9^{OD} x 1.2^t	m	0.265
Pipe (SPCN4)	22.3^{OD} x 2^t	m	0.1
Pipe (PVC)	10ϕ x 1.5^t	m	0.213
Pipe (PVC)	8ϕ x 1.5^t	m	0.21
Synthetic rubber	25ϕ	m	0.112
Casting		kg	3.214

Example of Plant Capacity and Construction Cost

1) Plant capacity : 30,000 set/year

2) Estimated construction cost (as of 1983)

- Equipment and machinery : US$120,000
- Installation cost : US$100,000

Total : US$220,000

3) Required space

- Site area : 9,000 m^2
- Building area : 3,000m^2

4) Personnel requirement

- Manager : 3 persons
- Engineer : 5 persons
- Speciallist : 20 persons
- Others : 5 persons

Total : 33 persons

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Q

FILE: Q4
ISIC 3831

How To Start Manufacturing Industries

AUTOMOTIVE STARTER AND GENERATOR REBUILD PLANT

Generators are devices which employ the principal of electromagnetic induction to convert mechanical energy into electrical energy. A generator utilizes mechanical power from an operating engine to restore the electrical charge in the vehicle's battery. The battery, in turn, powers the starter motor for cranking the engine and other vehicle electrical systems. There are two basic types of generators; one type produces a direct current (DC) and the other type produces an alternating current (AC) and is more commonly called an alternator. Alternators are lighter and more compact than DC generators, and are better at charging a battery at lower speeds. Most modern cars have been built with alternators but generators are still found on older cars and trucks.

Starter motors are constructed in basically the same way as generators. Starters use electrical energy from the battery to produce mechanical energy in order to crank the engine.

The breakdown of the generator or starter motor is a common problem with all types of trucks and cars, and can be caused by dirt or worn parts. Repair of the unit at a garage, by a trained mechanic, is difficult and expensive since the necessary tools and spare parts are not usually on hand. A garage cannot afford to stock all the component parts for the many different makes and models of starters and generators and the vehicle is out of service while parts are ordered from the manufacturer. Therefore, the garage will normally order a new or rebuilt starter or generator.

A starter and generator rebuilding operation involves the repair of worn units on a production basis. The quality of a rebuilt starter or generator, generally, is as good as a new unit. The rebuilt product can be guaranteed and sold at about 35 percent to 50 percent of the cost of a new unit because the most expensive parts of the unit, the metal castings, can be salvaged.

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The appropriate scale of a starter and generator rebuild operation depends on the vehicle population in the market area being considered. Given an automotive population of one million vehicles, then approximately 100,000 starters and 75,000 generators will require rebuilding each year. A rebuild plant becomes economical given a market of about 30,000 starters and generators per year. Requiring only a low level of capital investment, a starter and generator rebuild plant may reduce foreign imports and also provide interesting industrial jobs, contributing to the development of industrial skills in the labour force.

To initiate this type of rebuild operation, a stock of worn starters and generators is required. Such a stock called 'cores' must match the components required to repair the popular models of automobiles and trucks in the market area to be served by the rebuilder. The rebuilder must make up a catalogue of starters and generators he will supply, cross-referenced to the model numbers of the vehicles he wishes to be able to repair.

This initial stock of used cores can either be purchased from dealers who supply established rebuild operations in a number of countries, or it can be accumulated from the local market area at local service stations and scrap yards. Once operations begin, then the initial stock is replaced by 'cores' taken in trade for rebuilt parts delivered to the garages and service stations in the area.

Process Description

1. Identification and storage. When starter and generator cores are received at the plant, each part is identified and stored according to model type.

2. Dismantling. Dismantling is the beginning of the production run. A batch of 75 to 125 units of the same model number are drawn from storage and dismantled to their various component parts.

3. Cleaning and inspection. All component parts are degreased in a vibrator degreasing machine. Some parts are further cleaned using a sandblaster or a wheelabrator machine. The cleaned parts are then inspected and some can be used to rebuild the component, while other parts may be rejected and replaced by new parts.

4. Sub-assembly and testing of component parts. Sub-assembly operations include: rewinding operation for 'wire coils or rotor bobbins and solenoid coils; assembly and test of solenoids and solenoid switches; assembly and test of regulation units; assembly and test of armature coils.

5. Rotor insulating. All rotor assemblies are varnished and baked to restore their electrical insulation properties.

6. Reassembly operation. Starter and generator component parts, after sub-assembly operations, are brought to an assembly bench equipped with part storage bins, air tools, and test equipment. Here the rebuilt sub-assemblies are assembled and the completed unit is tested using a special machine.

   A separate assembly bench is used for those less popular models with short production runs. Here, some sub-assembly operations, as well as final assembly and test operations, are performed.

7. Packaging and Storage. All reassembled units are packaged in die-cut, foldable cardboard boxes, labelled and stored ready for delivery. As well, component parts such as solenoids, and regulators from the sub-assembly lines are packaged for distribution for the more simple repair work done by garages and service stations.

Outline Of The Plant Operation

For a production operation capable of rebuilding 30,000 units per year, the following plant facility, machinery and equipment, labour, and materials are required.

1. Plant Facility. A 1,000m² plant facility will be required. Included will be offices requiring about 100m² and inventory space requiring about 300 to 400m². Production operations will occupy the remaining 500 to 600m² of space. A typical plant layout is outlined in Figure 1.

2. Machinery And Equipment. Initial capital investment in machinery and equipment will be approximately $133,500 (U.S.). The types of machinery required are listed in Table 1.

3. Labour. The plant operation is labour intensive and will require a total of 40 employees to operate on a one shift per day basis. Staffing requirements include one production manager/ purchasing agent, one sales manager, five skilled workers and 33 semi-skilled workers. Staffing requirements are outlined in Table 2.

4. Materials. The operation will require three types of materials. First, an inventory of 5,000 used cores (approximately a 2-month supply) must be maintained. Typically, about 200 part numbers would account for 75 percent of the core inventory value depending on the mix of cars in the local market. Secondly, an inventory of various new parts must also be maintained including brushes, insulated wires, leads, bushings, etc. Finally, a variety of operating supplies will also be required including rewinding wire, packaging material, cleaning materials, etc.

Figure 1

Typical Plant Layout

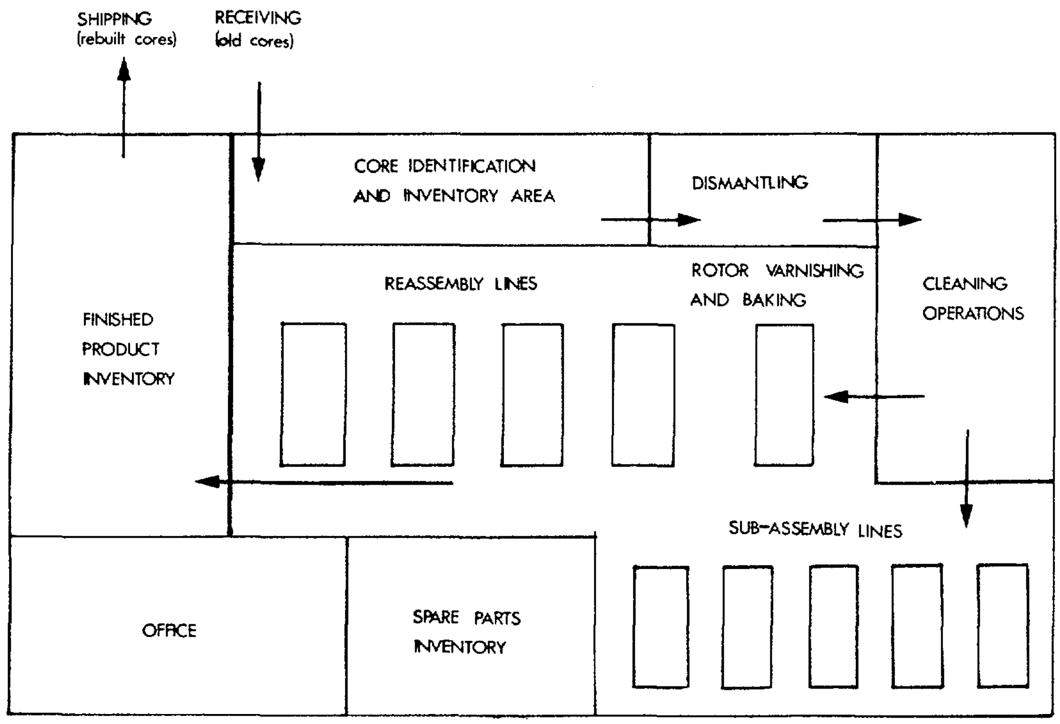


TABLE 1

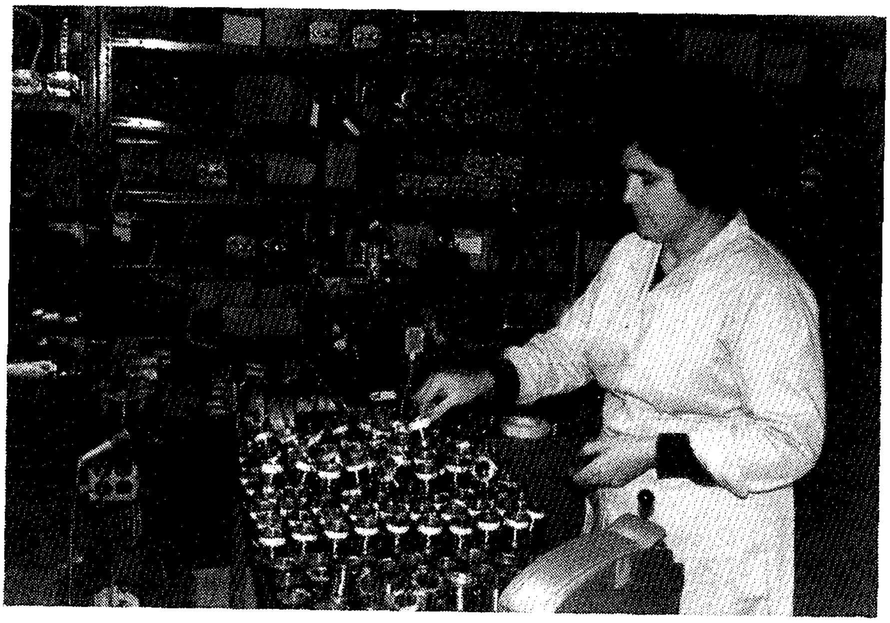
MACHINERY AND EQUIPMENT REQUIREMENTS

	COST (U.S.)
25 h.p. air compressor	$ 5,000
Vibrator degreasing unit	5,000
Wheelabrator and dust collector	9,000
Sandblaster	1,500
Batch oven for varnish baking	3,000
Rewinding machine for rotor bobbins and solenoid coils	5,000
Rewinding machine for armatures	20,000
Solenoid assembly bench including testing equipment and air tools	7,000
Regulator bench including testing equipment and air tools	3,000
Starter drive bench including testing equipment and air tools	2,000
Starter reassembly bench including testing equipment and air tools	5,000
Generator reassembly bench including testing equipment and air tools	5,000
Alternator reassembly bench including testing equipment and air tools	5,000
Short-run bench including testing equipment and air tools	5,000
Inventory shelving	8,000
2 light-duty delivery trucks	20,000
Miscellaneous machinery, equipment and storage racks	25,000
TOTAL	$133,500

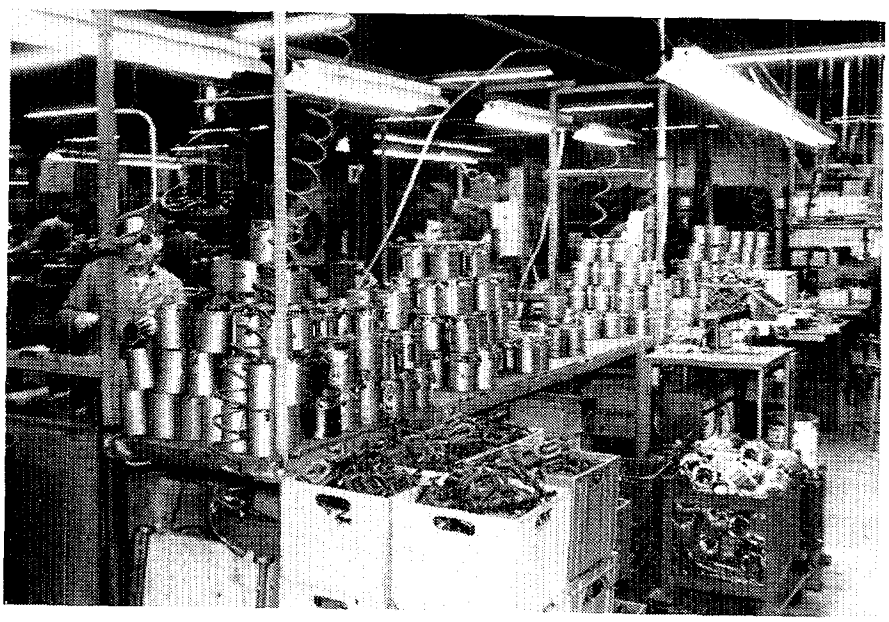
TABLE 2

STAFFING REQUIREMENTS

	NUMBER
Production Manager/Purchasing Agent	1
Sales Manager	1
Office operations	4
Core dismantling and cleaning	5
Sub-assembly lines	13
Reassembly lines	13
Inventory areas	3
TOTAL	40



Coil Winding Operation



Assembly Bench

FILE: Q5
ISIC 3843

How To Start Manufacturing Industries

ENGINE BLOCK, ENGINE HEAD, WATER PUMP REBUILDING

Automobile and truck engines often wear out before the useful life of the vehicle is over. Rather than purchase a new engine, it is possible to have the old engine rebuilt or have it replaced with another rebuilt engine of the same type.

The rebuilding of a vehicle engine at a garage by a trained mechanic is often difficult and expensive since the necessary machinery may not be on hand. Also, a garage cannot afford to stock the many different and expensive engine parts that may be required in rebuilding the engine and the vehicle will be out of service while new parts are ordered. Therefore, the garage will normally send the engine to a specialized engine rebuilder for repair or exchange with another rebuilt unit.

While engine rebuilding plants are production operations, they will also custom rebuild engines for vehicle owners or garages. Truck engines are more often rebuilt on a custom basis than are car engines because the demand for any one type of truck engine is more limited. To serve customers on a custom basis, rebuilding operations will often have a number of service bays for removing and installing engines.

The quality of a rebuilt engine normally is as good as a new engine if all the rebuilding operations are done properly. The rebuilt engine can be guaranteed and sold at about 35 to 50 percent of the cost of a new unit because the most expensive parts of the unit, the metal castings, can normally be salvaged.

The appropriate scale of the engine rebuilding operation depends on the vehicle population in the market area being considered. Given an automotive population of 1 million vehicles, then approximately 10,000 to 12,000 engines will require rebuilding each year. An engine rebuild plant becomes economical given a market of about 2,500 engines per year or a vehicle population of approximately 200,000 to 250,000.

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Engine rebuilding operations usually start out as custom shops and then develop into production operations as a stock of worn out engines is accumulated. Such a stock, called 'cores', must match the engines required by the popular models of cars and trucks in the market area served by the rebuilder.

The initial stock of used cores can either be purchased from dealers who supply established rebuild operations in a number of countries, or it can be accumulated from the local market area at service stations and scrap yards. Once production operations begin, the initial stock is replaced by cores taken in trade for rebuilt engines delivered to the garages and service stations in the area.

Process Description

1. Dismantling, cleaning, and inspection. Dismantling is the beginning of the rebuilding operation. Each engine and all component parts are fully dismantled before cleaning. Large castings, such as engine blocks and cylinder heads, are cleaned with high-pressure steam in a special cleaning machine. Smaller parts, such as water pump housings and pistons, are cleaned in a hot tank with a degreasing agent and are rinsed in a special rinsing booth with clean water. All parts are then inspected to determine if they are irreparably damaged.

2. Engine block reconditioning. Using a block honing machine, the cylinder bores of the engine block are honed oversize to eliminate any imperfections. The block face may also be resurfaced to eliminate any warpage or flaws. Main bearing bores are realigned using a special line honing machine.

3. Cylinder head reconditioning. Cylinder heads may be resurfaced to eliminate warpage and any other imperfections. A special cylinder head grinding machine is used for this purpose. Air intakes, exhaust ports, and combustion chambers are ground smooth using grinding stones attached to electric hand tools. Valve guides are replaced and valve seats are reamed with an electric hand tool to the correct angle to ensure a good seal with valves.

4. Valve grinding. The face and stem of each valve is resurfaced using a special grinding machine. The valve face is ground to an angle to match the valve seat on the cylinder head.

5. Piston and connecting rod reconditioning. Using a ring expander, piston rings are removed from the piston and the ring groves and piston face are cleaned. Connecting rods are also removed from the piston and are reamed at both ends using a special honing machine. Connecting rods are reinstalled using new oversize piston pins. New oversize piston rings are also installed to match the honed cylinder bore.

6. Camshaft and crankshaft grinding. Using specialized grinding machines, the wearing surfaces of camshafts and crankshafts are ground smooth. New bearings may be installed on both camshafts and crankshafts and oil seals will also be replaced.

7. Water pump rebuilding. After all parts have been cleaned, the water pump component is reassembled at a special bench using new bearings, bushings, and gaskets.

8. Reassembly and testing. The engine is then fully reassembled on a bench equipped with the necessary hand tools and new parts. A variety of new parts may be required during reassembly, including gaskets, bearings, bushings, valve springs, rocker arm parts, timing chain, etc. The reassembled engine is tested for correct oil pressure and compression on a special testing machine.

Outline Of The Plant Operation

For a production operation capable of rebuilding 2,500 units per year, the following plant facility, machinery and equipment, labour, and materials are required.

1. Plant facility. A 1,500m² plant facility will be required. Included will be offices requiring about 80m² and inventory spaces requiring about 200m². Three service bays will take up about 125m² and

production operations will take up the remaining space. A typical plant layout is outlined in Figure 1.

2. Machinery and equipment. Initial capital investment in machinery and equipment will be approximately U.S. $229,600. The types of machinery required are listed in Table 1.

3. Labour. The plant operation will require a total of 25 employees to operate on a 1-shift per day basis. Staffing requirements include 1 production manager/purchasing agent, 1 sales manager, 5 skilled mechanics, and 18 semi-skilled workers who can be trained by the skilled mechanics. Staffing requirements are outlined in Table 2.

4. Materials. The operation will require 3 types of materials. First, an inventory of about 40-50 old engines must be maintained (approximately a 2-month supply) for production operations. Secondly, an inventory of various new engine parts of all types must be maintained. Finally, a variety of operating supplies will also be required, including honing oil, cleaning materials, spare honing stones, etc. An engine core and new parts inventory and a 1-year's supply of operating materials will cost approximately $75,000 to $100,000 U.S.

Figure 1

Typical Plant Layout

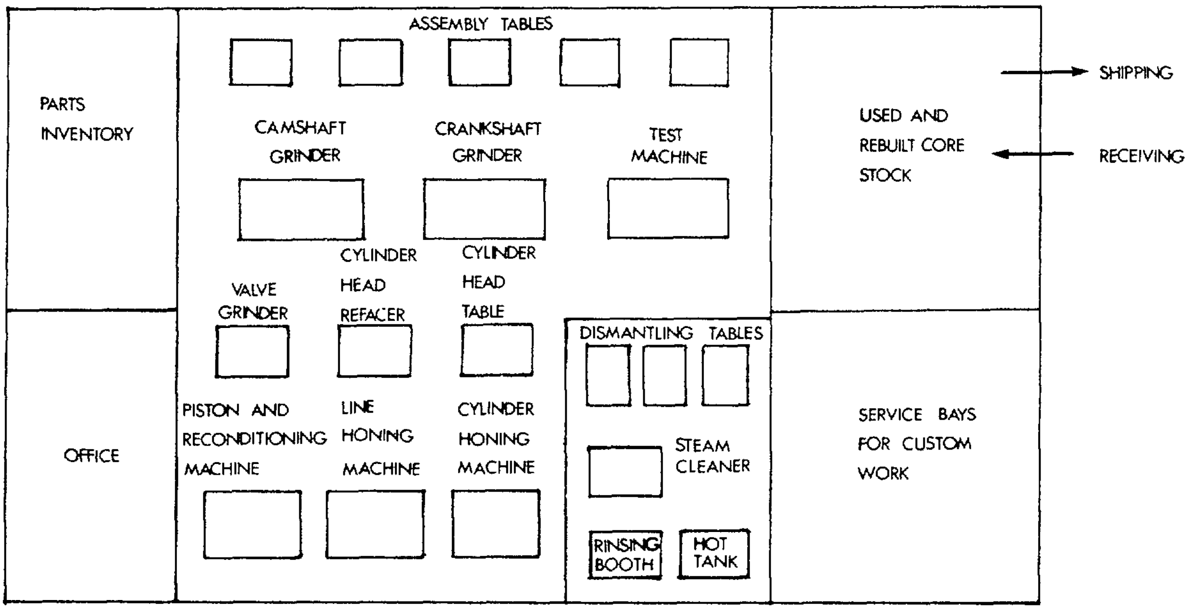


TABLE 1

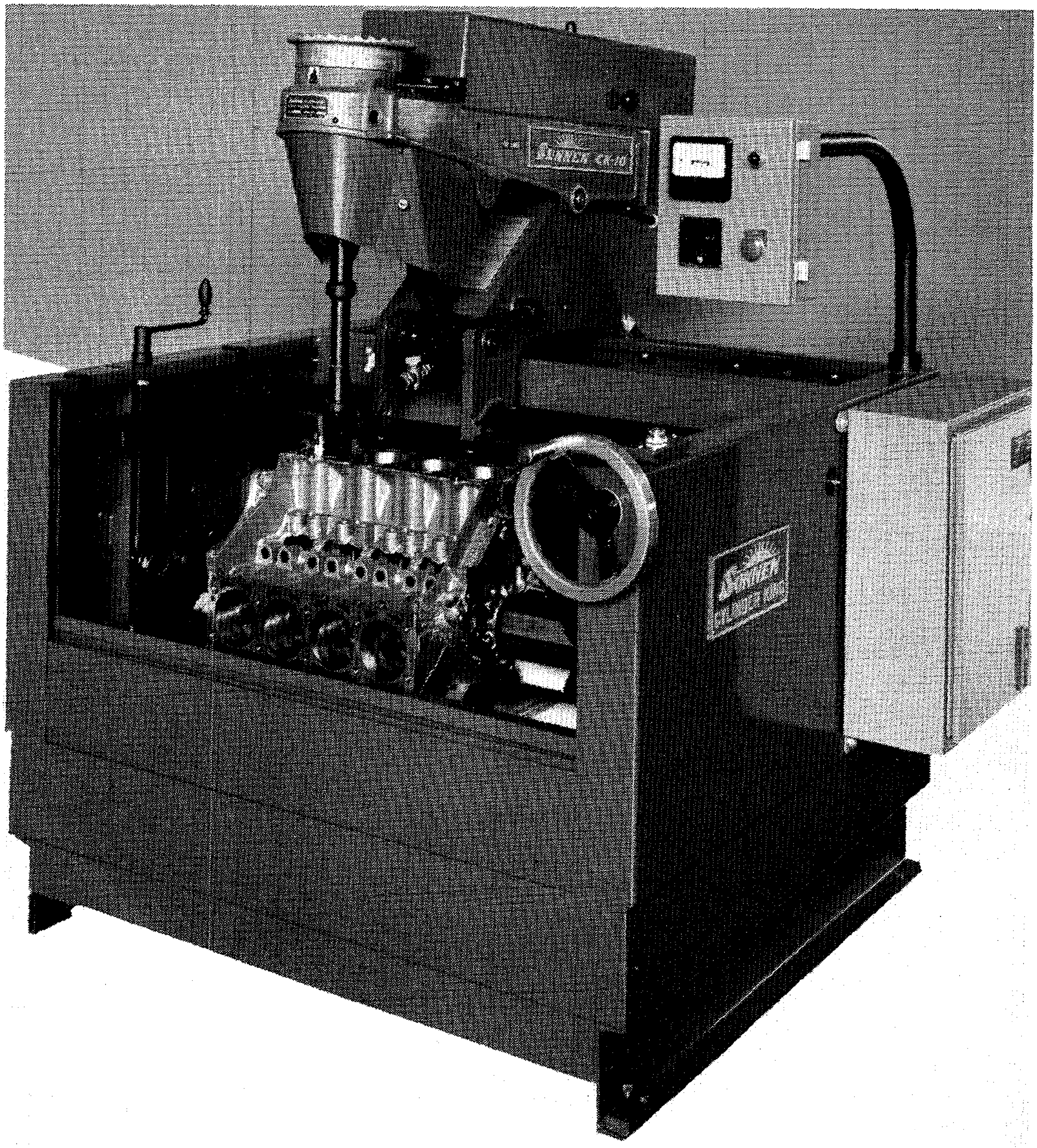
MACHINERY AND EQUIPMENT REQUIREMENTS

	COST ($U.S.)
Typhoon steam cleaning machine	$ 5,000
Degreasing hot tank and rinsing booth	5,000
Wheelabrator and dust collector	9,000
Cylinder honing machine with complete tooling	25,000
Line honing machine for main bearing bores	18,000
Valve grinding machine	15,000
Cylinder head refacer	7,000
Seat cutting machine	15,000
Piston pin fitting and connecting rod sizing machine	20,000
Crankshaft grinder	25,000
Camshaft grinder	25,000
2-ton hydraulic press	2,500
Small drill press	1,000
5 h.p. air compressor	1,000
Overhead crane installation	10,000
Handtools	8,000
Small lathe	2,000
Test machine	2,000
1 light-duty truck	10,000
Inventory shelving	2,000
3 hand trucks	600
Miscellaneous machinery and equipment	20,000
TOTAL	$228,100

TABLE 2

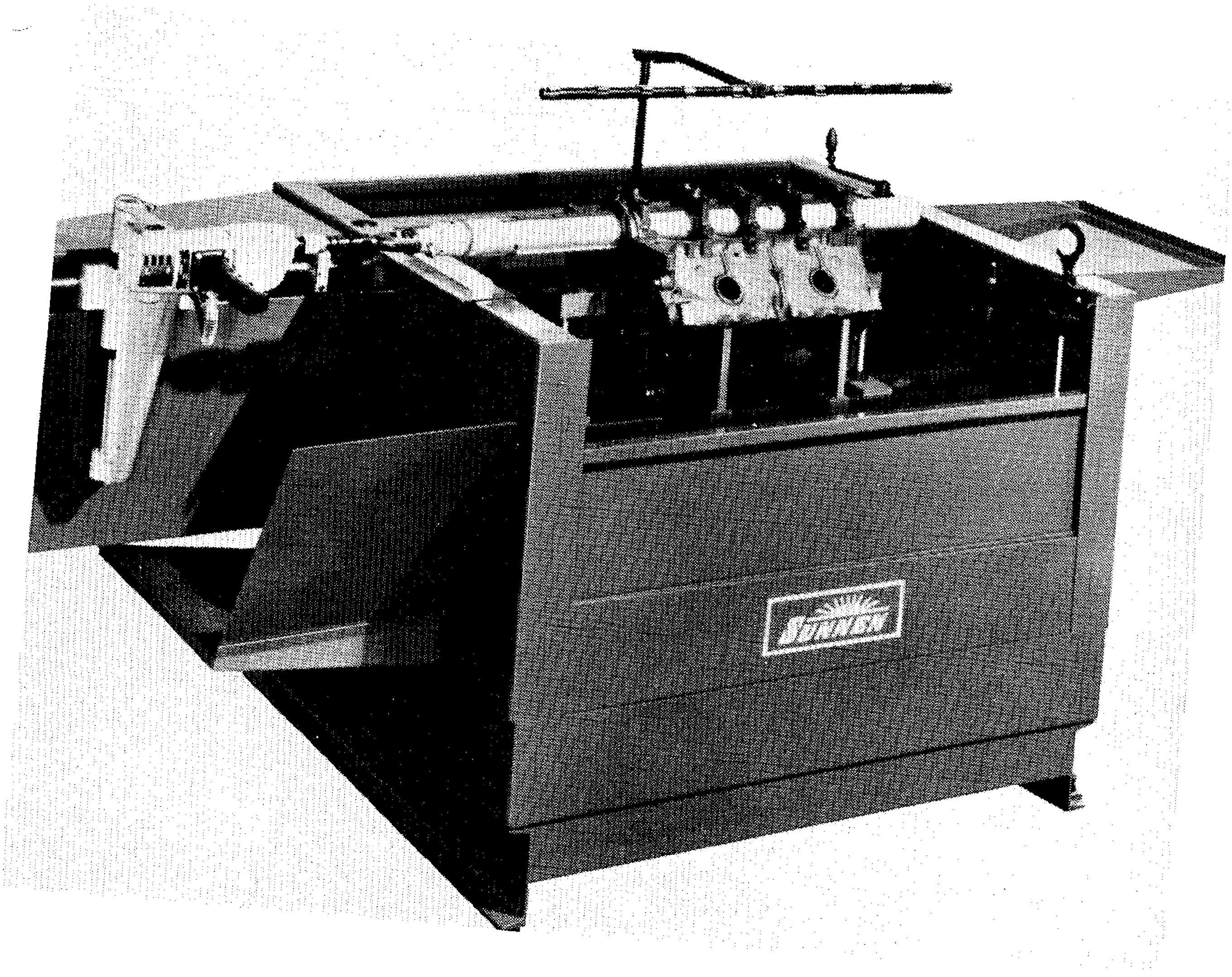
STAFFING REQUIREMENTS

	NUMBER
Production Manager/Purchasing Agent	1
Sales Manager	1
Office operations	2
Dismantling, cleaning, and inspection	3
Cylinder head and valve reconditioning	3
Engine Block and piston reconditioning	3
Water pump reassembly	1
Camshaft grinding	1
Crankshaft grinding	1
Engine reassembly operations	5
Shipping, receiving, and inventory	2
General mechanics	2
TOTAL	25



Cylinder Resizing Machine

FILE: Q5



Line Hone Machine

How To Start Manufacturing Industries

TRUCK BRAKE RELINING PLANT

Truck brake relining is a simple type of automotive rebuilding that involves the cleaning and stripping of worn brake shoes and the installation of new brake linings using a riveting machine. While it is possible to reline truck brakes using hand tools, there are specialized machines which permit this type of automotive repair work to be done on a more efficient production rebuilding basis. A garage or service station will not usually have the volume of relining work necessary to justify the purchase of relining machinery, thus, a specialized truck brake relining operation becomes possible.

Quality control is critical in this type of automotive rebuild operation because the product can affect vehicle safety. If a truck brake relining operation is properly set up with the necessary machinery and equipment, then the quality of the relined brake shoe should be just as good as a new shoe. The rebuilt product can be guaranteed and sold at about 35 to 50 percent of the cost of a new unit because the most expensive parts of brake units, the cast metal shoes, can be salvaged.

The appropriate scale of a truck brake relining operation depends on the vehicle population in the market area being considered. A small but economical operation would have the capacity to reline approximately 150,000 brake shoes per year. A market area with about 200,000 to 300,000 trucks should be able to support this production capacity.

To initiate this type of rebuild operation, a stock of worn brake shoes is required. Such a stock called 'cores', must match the components used on the popular models of trucks in the market area to be served by the rebuilder. The initial stock of used cores can either be purchased from dealers who supply established rebuild operations in a number of countries, or it can be accumulated from the local market area at service stations and scrap yards. Once operations begin, then

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the initial stock is replaced by cores taken in trade for rebuilt parts delivered to the garages and service stations in the area.

Process Description

1. Identification and storage. When brake shoes are received at the plant, each part is identified and stored according to model type.

2. Degreasing. Degreasing is the beginning of the production run. Shoes are placed in a tumbler degreaser which leaves the shoes wet, reducing flying asbestos dust when the worn brake linings are stripped from the shoes. A batch of at least 80 to 100 shoes of the same type is processed at one time to reduce machinery adjustments (however, smaller runs of less popular models may also be accommodated).

3. Brake stripping. Brake shoes are then placed on a heavy duty brake stripping machine which is designed to strip rivets and bolts from truck brake shoes. The brake shoe is placed on a mandrel, then a hydraulic cylinder coupled to a rack and pinion moves the shoe past a shearing blade. After the lining has been stripped, some of the remaining rivets may need to be manually knocked out of the shoe using an electric hand tool.

4. Sandblasting. Stripped brake shoes are placed in a sandblaster to remove any paint scale or rust.

5. Inspection. Fully cleaned brake shoes are inspected to see if they have maintained their original shape. Special instruments are used to test concavity, radius, and surface warpage. If the shoe is damaged, it is discarded. This inspection operation is critical to the quality and safety of the rebuilt product.

6. Paint dipping. Shoes are then painted in an automatic dip tank before new linings are riveted in place.

7. Brake relining. Special riveting machines are used to attach new brake linings to the brake shoes.

8. Packaging and storage. All relined brake shoes are packaged in die-cut foldable cardboard boxes, labelled, and stored ready for delivery.

Outline Of The Plant Operation

For a production operation capable of rebuilding 150,000 units per year, the following plant facility, machinery and equipment, labour, and materials are required.

1. Plant facility. A 600m² plant facility will be required. Included will be offices requiring about 80m² and inventory space requiring about 200m². Production operations will occupy the remaining 320m². A typical plant layout is illustrated in Figure 1.

2. Machinery and equipment. Initial capital investment in machinery and equipment will be approximately $93,000 U.S. The types of machinery required are listed in Table 1.

3. Labour. The plant operation requires a staff of only 12 employees to operate on a 1-shift per day basis. Staffing requirements include 1 production manager/purchasing agent, 1 sales manager, 2 clerical staff, and 8 semi-skilled production workers. Staffing requirements are listed in Table 2.

4. Materials. The operation will require 3 types of materials. First, an inventory of 12,000 cores (approximately a 1-month supply) must be maintained. Secondly, an inventory of new brake linings will be required. Finally, a variety of operating supplies will also be needed, including rivets, paint, cleaning materials, etc.

Figure 1

Typical Plant Layout

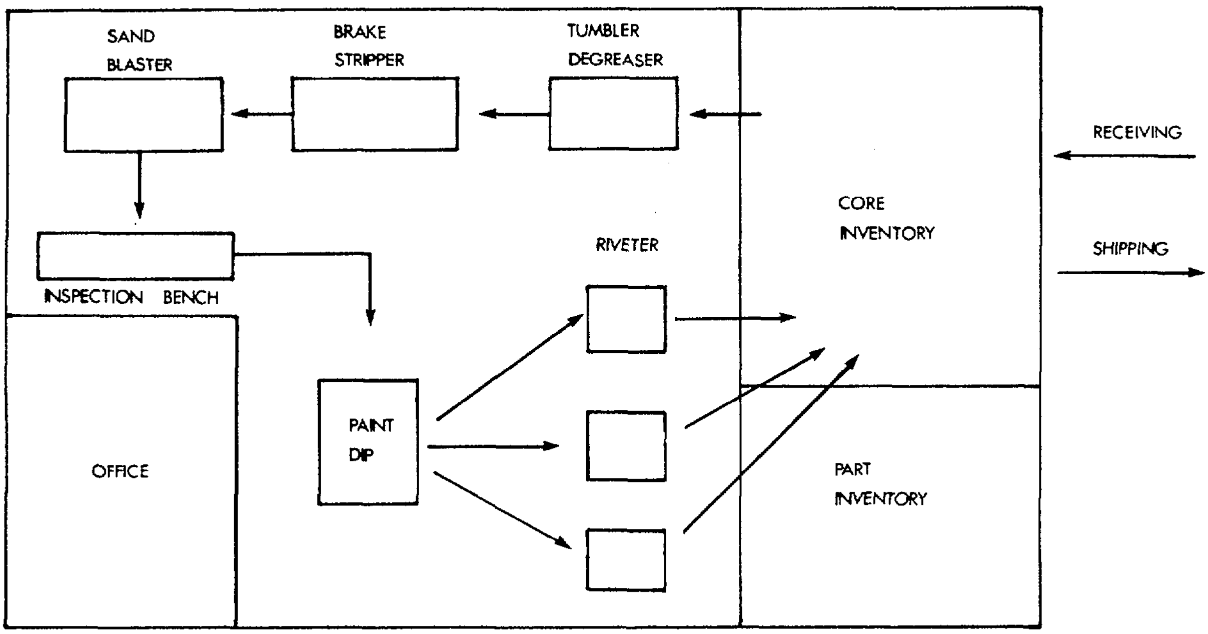

TABLE 1

MACHINERY AND EQUIPMENT

	COST (U.S.)
Inventory shelving and bins	$ 5,000
Tumbler degreasing unit	7,000
Brake stripper	9,000
Hand tools	1,000
Sand blaster and dust collector	8,000
Testing equipment and bench	1,000
Paint dip tank	800
3 Riveting machines	15,000
Air ventilation equipment	25,000
6 light-duty hand trucks	1,200
1 light-duty delivery truck	10,000
Miscellaneous machinery and equipment	10,000
	$93,000

TABLE 2

STAFFING REQUIREMENTS

	NUMBER
Production Manager/Purchasing Agent	1
Sales Manager	1
Office operations	2
Cleaning and stripping	2
Inspection and paint dip	2
Riveting	3
Packaging and shipping/receiving	1
TOTAL	12

How To Start Manufacturing Industries

CARBURETOR AND FUEL PUMP REBUILD PLANT

The fuel pump is a device which sucks gasoline out of the gasoline tank and forces it into the carburetor by utilizing mechanical power from the camshaft. The carburetor is a device which mixes air with gasoline spray to make an explosive mixture in an internal combustion engine. When carburetors and fuel pumps get old, they can become clogged and various parts such as gaskets and springs can become worn and lose their effectiveness.

The rebuilding of carburetors is a relatively complex type of automotive rebuilding, complicated by the large number of small parts which are involved. Carburetors may have upwards of 100 parts, some of which can be reused or rebuilt while others must be replace. In contrast, fuel pump rebuilding is a relatively simple operation that involves the cleaning or replacement of only about 20 parts.

The rebuilding of carburetors and fuel pumps requires some specialized and expensive machinery and equipment. As a result, most garages and service stations do not have the capability for complete rebuilding jobs for these engine parts. Also, a garage cannot afford to stock all the component parts for the many different makes and models of carburetors and fuel pumps, and the vehicle is out of service while parts are ordered from the manufacturer. (For North American passenger cars alone, there are close to 2,000 different carburetor models currently in use.) Therefore, the garage will normally install a new or rebuilt unit.

The quality of a rebuilt carburetor or fuel pump generally is as good as a new unit. The rebuilt product can be guaranteed and sold at about 35 percent to 50 percent of the cost of a new unit because the most expensive parts of the unit, the metal castings, can be salvaged.

The appropriate scale of a carburetor and fuel pump rebuild operation depends on the vehicle population in the market area being considered. The automotive market

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required to support a carburetor and fuel pump rebuild operation depends largely on the age and type of vehicle in the market area. However, a vehicle population of at least 1 million cars and trucks would be necessary to support an economical plant which would be capable of rebuilding 75,000 carburetors and 8,000 fuel pumps per year. This market is required to support the major capital investment in machinery and equipment required to start the plant.

To initiate this type of rebuild operation, a stock of worn carburetors and fuel pumps is required. Such a stock called 'cores' must match the components required to repair the popular models of automobiles and trucks in the market area served by the rebuilder.

The initial stock of used cores can either be purchased from dealers who supply established rebuild operations in a number of countries, or it can be accumulated from the local market at service stations and scrap yards. Once operations begin, then the initial stock is replaced by cores taken in trade for rebuilt parts delivered to the garages and service stations in the area.

Process Description

1. Identification and storage. When carburetor and fuel pump cores are received at the plant, each unit is identified and stored according to model type (Figure 1).

2. Stripping. Stripping is the beginning of the production run. A batch of approximately 100 carburetor or fuel pump units of the same model type are drawn from storage and dismantled to their various component parts. Custom-built machines are commonly used to open both fuel pump and carburetor castings. At this stage, a variety of non-salvageble parts are discarded.

3. Cleaning. All metal carburetor and fuel pump parts are degreased using a spray washing machine with a 50 percent caustic degreasing agent. Fuel pump casings are further cleaned using a wheelabrator machine. Small fuel pump and carburetor parts are

cleaned in a sandblast machine. Larger carburetor parts go through a complex chemical cleaning and treatment process. These parts are placed in metal screen containers and then dipped in a series of ten, 600 litre stainless steel, or chemical resistant plastic tanks. The system utilizes a light-duty overhead winch and rail system which dips the parts in sequence into the following solutions: caustic cleaning solution; flowing rinse; chromic solution; static rinse; flowing rinse; acidtron solution; flowing rinse; phosphating solution; hot rinse; oil dip.

4. Fuel pump reassembly and testing. Following cleaning, fuel pumps are reassembled using all new gaskets, diaphragms, and check valves. A special press machine is used to close the fuel pump casings and the units are then tested with an inexpensive, electric motor-operated test machine.

5. Carburetor repair operation. Carburetor castings are repaired in a special area equipped with 3 work benches, a variety of electric and manual handtools including a drill press, taping head, and a small lathe. The casting repair operation includes the rethreading of throttle shafts and the insertion of brass bushings, the rethreading of fuel inlets, casting plate resurfacing to eliminate any flaws or warpage, and a variety of other repair operations depending on the condition of the castings.

6. Small carburetor parts sorting and inspection. In an area equipped with two benches and a variety of small bins, small carburetor parts are sorted and inspected. All reusable parts are salvaged and any damaged or worn parts are discarded and replaced with new parts. The small parts sorting area is normally located next to the stockroom which would include an extensive new part inventory.

7. Reassembly and testing. Carburetor castings and small parts are reassembled on a single large bench equipped with numerous small part bins and air-operated hand tools. Reassembled carburetors are then tested on an expensive testing machine which simulates a vehicle engine.

8. Packaging and storage. All reassembled carburetors and fuel pumps are packaged in die-cut foldable cardboard boxes, labeled, and stored ready for delivery.

Outline of the Plant Operation

For a production operation capable of rebuilding approximately 75,000 carburetors and 25,000 fuel pumps per year, the following plant facility, machinery and equipment, labour, and materials are required.

1. Plant facility. A 2,000m^2 plant facility will be required. Included will be offices requiring 150m^2 and inventory space requiring about 500 to 600 m^2. Production operations will occupy the remaining 1,250 to 1,350m^2 of space.

2. Machinery and equipment. Initial capital investment in machinery and equipment will be approximately U.S. $271,350. The types of machinery required are listed in Table 1.

3. Labour. The plant operation is labour intensive and will require a total of 33 employees to operate on a 1-shift per day basis. Staffing requirements include 1 production manager/purchasing agent, 1 sales manager, 5 skilled workers and 26 semi-skilled workers.

4. Materials. The operation will require 3 types of materials. First, an inventory of 12,500 carburetor cores and 4,000 fuel pump cores (approximately a 2-month supply) must be maintained. Secondly, a large inventory of new carburetor and fuel pump parts must be maintained. Finally, a variety of operating supplies will be required including cleaning chemicals, oil, packaging materials, etc. Altogether, an initial core and new parts inventory, and operating supplies for 1 year would cost approximately $200,000 to $250,000 U.S.

Figure 1

Process Flow For Carburetor and Fuel Pump Rebuilding

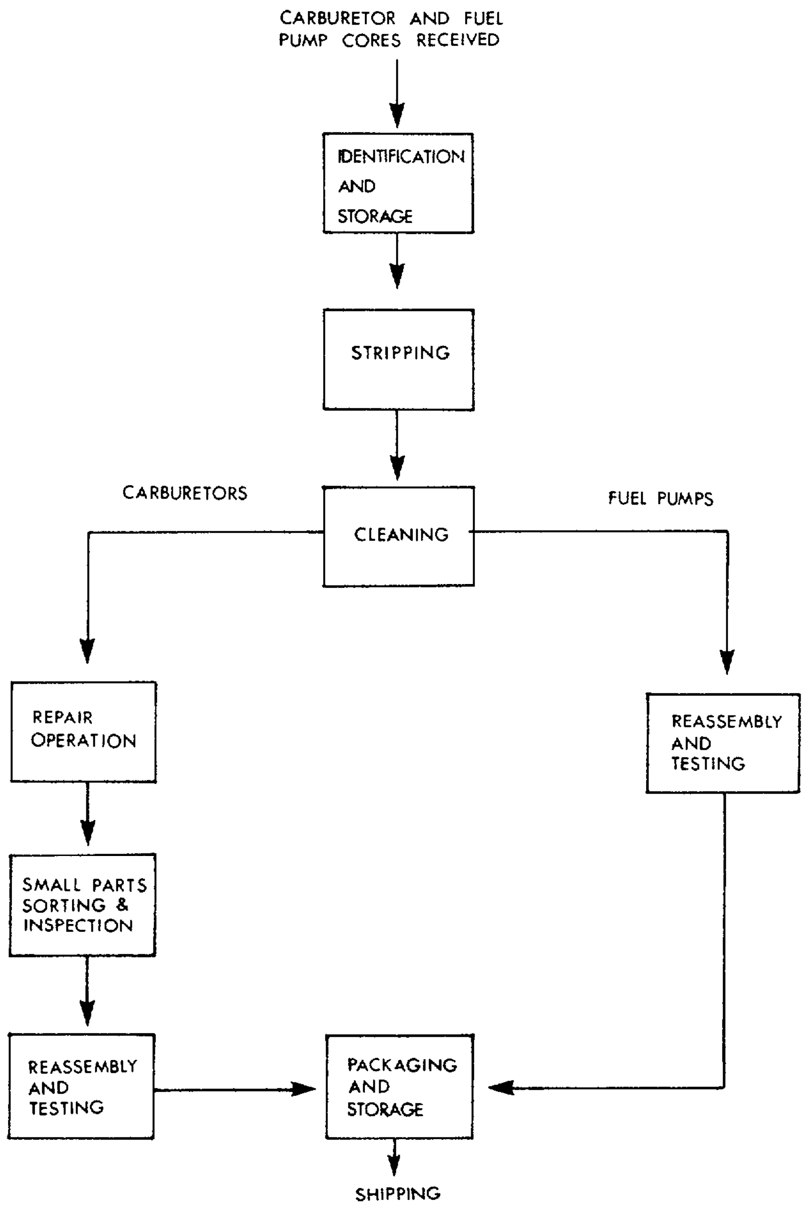


TABLE 1

MACHINERY AND EQUIPMENT REQUIREMENTS

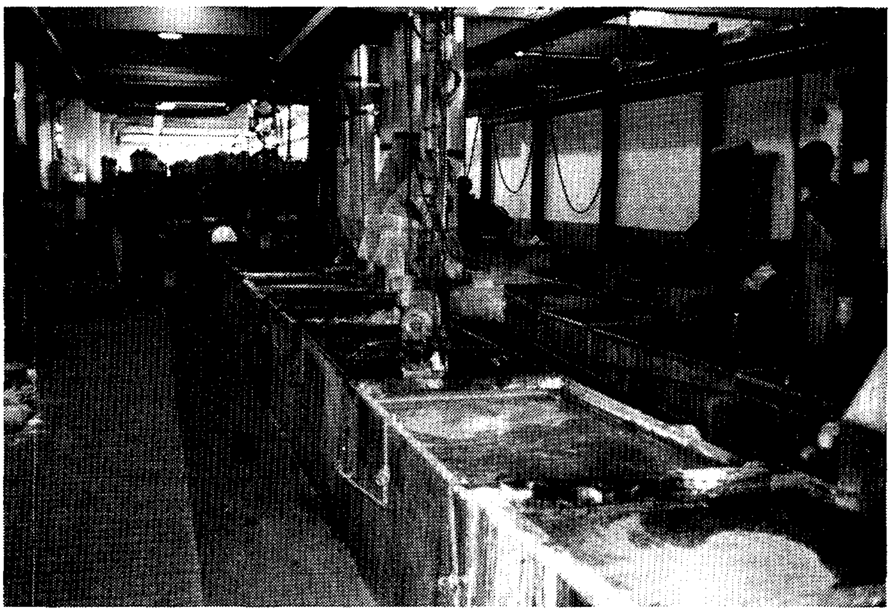
	AMOUNT ($U.S.)
Inventory shelving and storage bins for cores and parts	$ 10,000
High-pressure spray degreaser	5,000
3 stripping tables and benches for carburetors	2,500
2 fuel pump opening machines	1,400
Sandblast machine for small parts	800
Wheelabrator and dust collector for water pump housings	9,000
10 stainless steel 600 litre tanks and plumbing system	100,000
3 overhead hoists and rail system	8,000
3 carburetor repair benches and handtools	10,000
Drill press	1,500
Taping head	250
Small Lathe	2,000
2 small parts sorting benches and bins	1,000
Carburetor assembly bench and air tools	8,000
2 carburetor test machines	30,000
Fuel pump assembly bench and air tools	2,000
2 fuel pump closing machines	1,000
Fuel pump test machine	100
25 h.p. air compressor	5,000
2 light-duty delivery trucks	20,000
10 light-duty hand trucks	2,000
3 hand pump trucks	1,800
Miscellaneous machinery, equipment and tools	50,000
TOTAL	$271,350

TABLE 2

STAFFING REQUIREMENTS

	NUMBER
Production Manager/Purchasing Agent	1
Sales Manager	1
Office operations	3
Identification and storage	1
Stripping operation	4
Cleaning operation	4
Fuel pump reassembly and testing	2
Carburetor repair operation	3
Small carburetor parts sorting and inspection	2
Reassembly and testing	9
Packaging and storage	7
Inventory and shipping	1
TOTAL	33

Disassembly Bench



Carburetor Cleaning Line

ELECTRICAL SWITCHES, SOCKETS AND PLUGS

1. PREFACE

The plant produces flip switches and sockets as well as earthed right angled plugs.

In addition to the devices named above, another 10 to 15 items can be manufactured on the machines using special tools.

The products are made of thermosetting plastic and electroplated metal.

The plant is designed for use as a specialized plant which can be adapted to suit market conditions.

The equipment and the plant can be easily tailored to suit different requirements, ranging from plants using production methods which require a high proportion of manual work to others equipped with automatic machinery lines which require a relatively small amount of labor.

2. CAPACITY OF THE PLANT

The capacity of the plant for manufacturing the electrical products mentioned (flip switches, sockets and earthed right angled plugs).

This profile describes a plant with a manufacturing capacity of 1,000,000 electrical items per year.

The capacity of the plant can be increased by a third shift.

3. BRIEF DESCRIPTION OF THE PROCESS

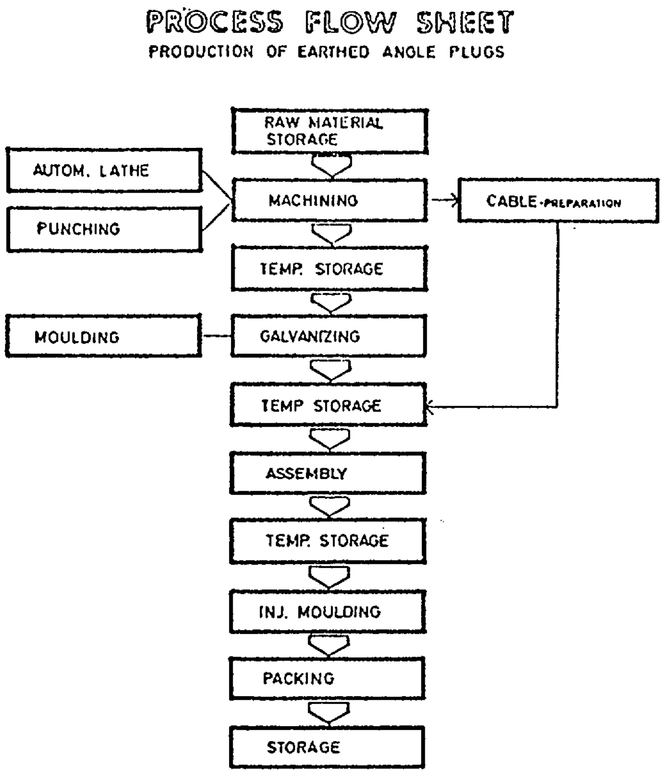
The basic materials are stored according to type in the materials store, whence they are taken to the machining shop by hand or machine-powered materials handling equipment.

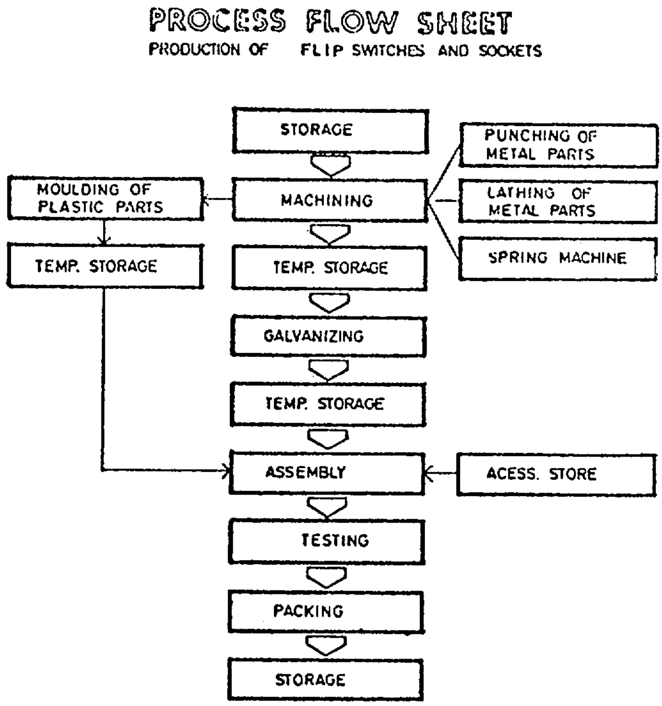
The manufacturing process is made up of the machining stage, the galvanizing and molding stage, the assembly stage and the injection molding stage.

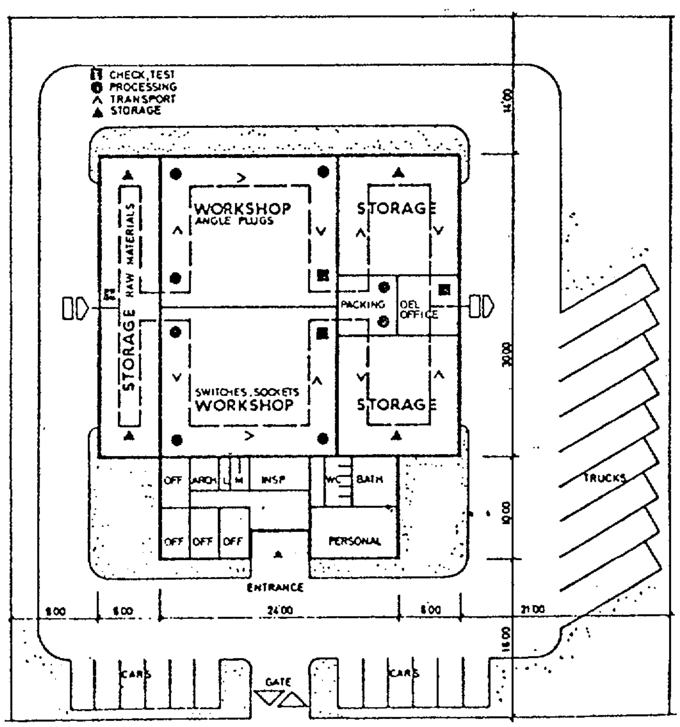
In the machining stage, the metal parts are prepared by punching, lathing, and spring machines for further processing in the galvanizing stage, whence the semi-finished products pass to the assembly stage.

In the assembly stage, the semi-finished products are put together to become finished flip switches, sockets or earthed right angled plugs.

After assembly, the finished products are taken to the packing section. From there, they are either delivered straight to the customer or stored in the final storage yard.







4. REQUIRED BASIC AND AUXILIARY MATERIALS

The quantities of the various materials used depend on the particular product mix and the methods used.

Below are the approximate materials requirements of the plant for one year's production:

- Plastics	30 tons
- Metal sheeting	1 ton
- Other	200 kgs
- Nickel dip	500 l
- Zinc dip	500 l
- Degreasing mixture	2,400 l
- Water	2,500 m^3
- Cleaning chemicals	
- Various additional materials	

5. AREA REQUIREMENTS

Required site area:	4,690 m^2

Required building area

Production hangar:	540 m^2
Storage hangar	540 m^2
Office building:	225 m^2

Structural:

Production hangar, storage hangar

Columns and beams	- prefabricated concrete or steel construction
Walls	- corrugated iron sheets
Floors	- concrete
Roof	- metal sheets on a sawtooth construction

Office building

Columns and beams	- prefabricated concrete or steel construction
Walls	- brick-lined, plastered
Floors	- PVC-paved
Roof	- concrete ceiling with metal sheets

6. MACHINERY AND EQUIPMENT (Estimated total FOB cost: approx. US$ 750,000)

Description:	Quantity:	Description:	Quantity:
Hydraulic press	4	Tempering furnace	1
Trimming machine	4	Mounting table	10
Automatic eccentric press	2	Vise bench	5
Tiltable eccentric press	2	Tool locker	4
Tiltable eccentric press	1	Frame stand for storage	20
Plate shearing device	1	Materials transportation carriage	10
Scouring barrel	1		
Bench drill	7	Mobile storage boxes	850
Bench tap	6	Operator's board	8

Pedestal grinder	2	Frame stand for sheet storage	8
Bench lathe	1	Electro-plating device	1
Plane grinder	1	Air compressor	1
Milling machine	1	Injection molding machine	2

7. POWER REQUIREMENTS

Power type:	3 x 380 V, 50 Hz
Built-in capacity:	150 kW
Total power consumption during simultaneous operation:	115 kW
Power consumption per year:	460,000 kWh

7. PERSONNEL REQUIREMENTS

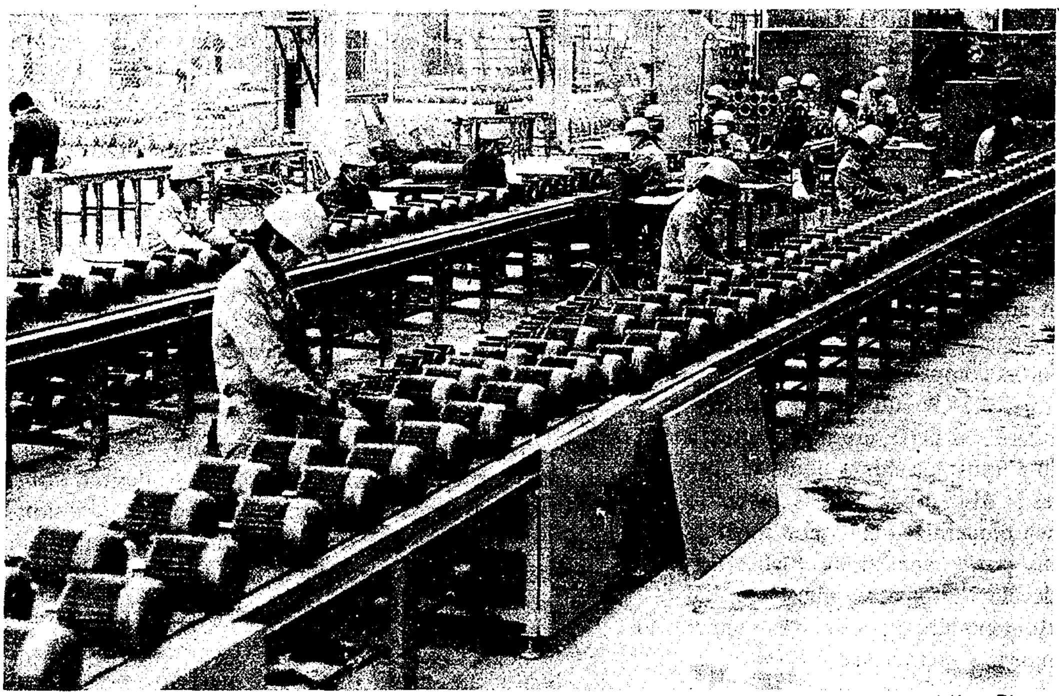
Production staff	First Shift	Second Shift
- Skilled workers	7	5
- Semi-skilled workers	28	28
- Unskilled workers	9	7
- Storeroom workers	2	2
Management and administration staff		
- Plant managers	1	
- Workshop managers	3	3
- Technicians	2	2
- Workshop clerks	5	2

Work-time base

Number of shifts taken into consideration:	2 shifts per day
Work-time taken into consideration:	16 hours per day
Number of work-days:	250 days per year

This information has been prepared for UNIDO by Horst Langbauer, Austria. Any inquiry about the information contained should be sent to: IO/COOP, Registry file No. ID/562/12, UNIDO, P.O. Box 300, A-1400 Vienna, Austria.

Electric Motor Assembling Plant



View of Electric Motor Assembling Plant

Electric motors have been used as power sources in the full range of industries since the directed motor was invented by Ja Cobi in 1834 and the induction motor by Ferraris in 1835.

Particularly, the motors are used for the transport and washing in chemical industries and such industrial items as a continuous rolling mill in iron and steel works, printing machine, weaving machine, machine tools and crane as well as for an electric fan, pump, elevator, escalator and the like. The motors have been important tools to the extent that the life in modern times cannot be managed without them.

Such electric motors break down into direct current motors and alternating current motors. In direct current motors, they are so selected as to have arbitrary speed and torque and are therefore convenient in speed control, while in alternating current motors, induction motors are mostly used.

The electric motor industry is a type business which is more labor-intensive and higher in added value along with other machine industries than the rest industries, playing a leading part in the development of electrical machinery and equipment.

In particular, the electric motor industry is one of the key industries in developing countries and no doubt occupies an important position in the development of the national economy.

Products and Specifications

Explanations here relate to only induction motors being manufactured in this plant. First of all, three-phase induction motors are widely used ranging from large capacity motors to smaller motors.

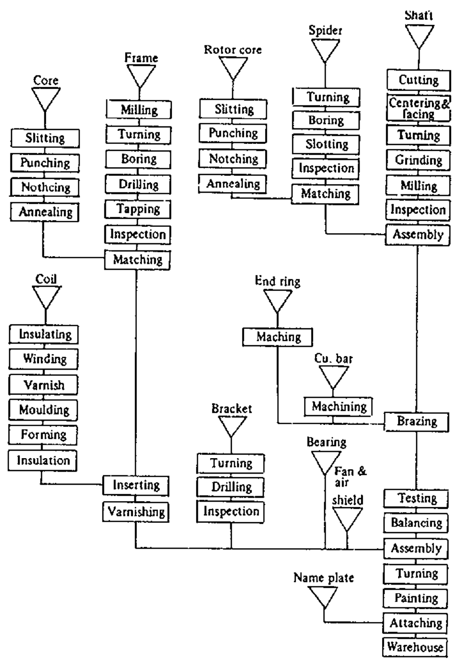
What should be taken into consideration in selecting electric motors are such factors as the load torque speed curve, load time curve, type of power source, axial direction and environment of the place where it is to be installed.

The squirrel cage rotor type is for use when the speed variation rate is relatively small, while the wound rotor type is used for the purpose of speed control. Characteristics of electric motors produced in this plant are as follows:

- Winding is insulated mainly with mica and glass, and treated with complete permeation and coating of synthetic varnish. It withstands mechanical abuse and has high dielectric strength with excellent moisture resistive qualities.

- Grease replacing system extremely simplifies maintenance and enables grease to be fed or replaced during operation. The special design grease valve and its guide for proper lubrication ensures trouble free operation.
- Frames are made of cast iron or special steel plate with rust resisting and stabilizing treatment. Precision machining of assemblies provides a uniform concentric air gap with resulting low magnetic noise and quiet operation.
- All rotors are dynamically balanced to close limit. Especially the balance test is conducted for large wound type and high speed rotor under full running condition after the final assembly.
- In either open or closed type, special design cooling fan for ventilation and heat transmission results in very effective cooling, lowering temperature rise, and making the motors compact and light.
- The standard motors, 3.7KW and smaller capacity, designed with standardized parts, are manufactured by precision mono-purpose machines under quality control procedures. Also every care is taken to make its appearance modernized and good looking.
- Considering various power conditions, high efficiency motors are developed for economical use, and high maximum output enables them to be run under overload condition or low line voltage.

Electric Motor Assembling Process Diagram



Contents of Technology

1) Process Description

Stator frame

Stator frames are made of welded steel plate or cast iron for a sufficient mechanical strength. Rolled steel plates are processed by punching, roll forming, drilling, boring, milling and turning to welded structures. And cast frames are drilled, bored, milled and finished to desired shape and dimensions.

Stator and rotor core

Cores are constructed with laminated silicate steel plate of good quality to decrease core losses. Sheet cores are slitted, punched and slotted to desired shape and dimensions for fabrication in stator frame, assembly to shaft and coil inserting.

Stator and rotor winding

Windings are made of insulated wires except cage rotor windings. Anealed bare copper stripes are double glass covered and enameled wires are also used for insulation. Insulated wires are wound, varnished and formed (except random wound coils) to desired turns, size and hexagonal shape, then inserted into core slots, with each wire connected and vacuum impregnated. In the case of cage rotor, windingsare bare copper stripes or cast aluminium.

Shaft

Shafts are made of forged steel for a sufficient mechanical strength and also for centrifugal force and power transmission. Forged steel bars are processed by cutting, turning, grinding and milling into a desired dimensions and shape. And then, rotor cores and rotor windings are assembled and dynamically balanced.

Miscellaneous

Also other parts of motors are made of proper materials and suitably treated for desired purposes and performance.

Assembly

Stators, rotors, brackets and all other parts are assembled into motors.

Inspection and test

After assembly, motors are inspected and tested for dimensions, materials, workmanship, painting and performances.

2) Equipment and Machinery

Notching press
Annealing furnace
Lathe
Boring machine
Balancing machine
Drying chamber
Core press
Bending rolling machine

Press brake
Cupola
Coil mounting machine
Sand mill
Moulding machine
Die casting machine
Compressor
Milling machine
Shot-blaster

Example of Plant Capacity and Construction Cost

1) Plant capacity

Case A : 10,000 sets/month
* Basis : 3.7KW-4p, totally enclosed fan-cooled type. 8 hours/day, 25 days/month

Case B : 500 sets/month
* Basis : 22kw-4p, totally enclosed fan cooled type. 8 hours/day, 25 days/month

2) Estimated manufacturing equipment cost: (as of July, 1982)

Case A : US$3,200,000
Case B : US$1,600,000

3) Required space

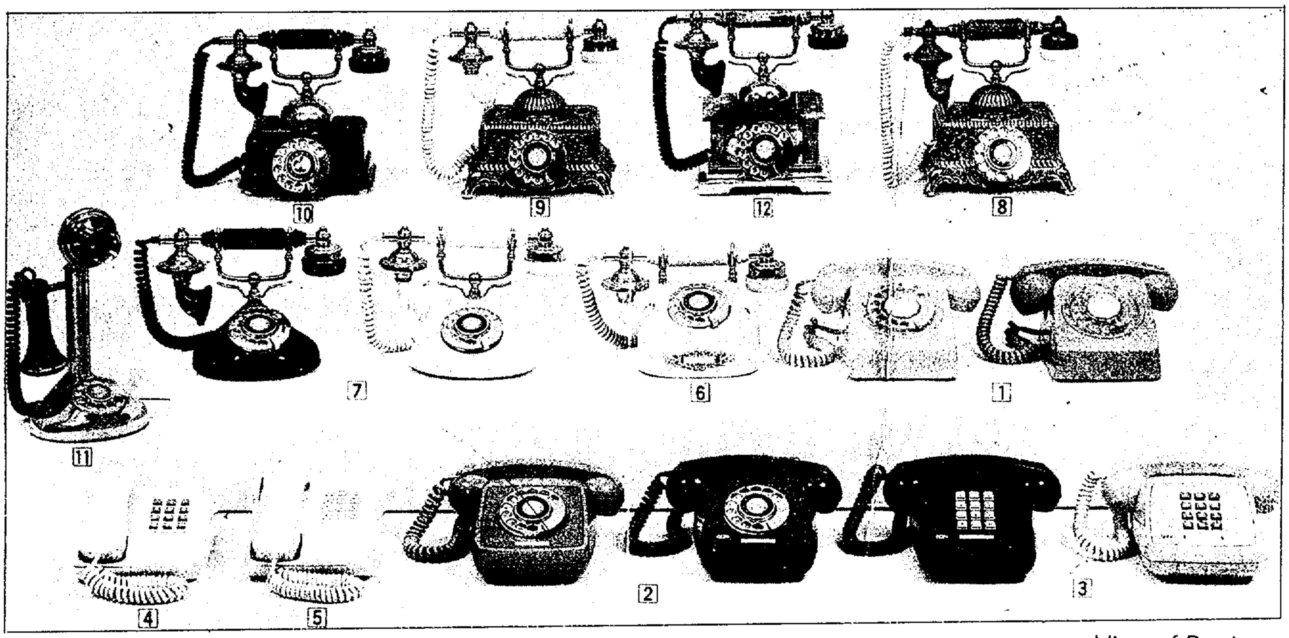
Case A : ○ Site area : 9,000 m^2
○ Building area : 6,000 m^2

Case B : ○ Site area : 3,000 m^2
○ Building area : 2,000 m^2

4) Personnel requirement

Case A : 150 persons
Case B : 60 persons

Telephone Assembling Plant



View of Products

Man first used the postal service in conveying an intention or information, and then contrived the electric communication. However, the cable needed subsequent translations on both sides and also entailed difficulties in its use due to limits in contents of communication and other defects.

Accordingly, it was necessary to convert the human voice into an electric signal, directly transmit it and talk each other by changing the electric signal back to the voice on the part of a recipient. Such a means of long distance conversations was invented by A.G. Bell in 1870.

The telephone thus came into being has now become one of the most essential tools in modern life one cannot do without. In a telephone, the receiver and transmitter are most important component parts and should be able to faithfully regenerate electric signals into voices.

The human voice generates frequencies over a wide range of 16 to 20,000Hz but its conversion is not without difficulty, because it is regenerated in the receiver or transmitter in a limited range of 300 to 3,000Hz. However, the regeneration is almost 95 percent and sufficiently servces the original purpose of transmitting information with little limitation in daily dialogues.

The dial, vital to functions of the receiver and transmitter, is a component used in calling out the man to talk to. Such a telephone is now an absolutely necessary item in the communication system with the improvement of people's living standard, playing an important part in the development of the national economy.

This type of industry, involving the fabrication of relatively simple component parts, is a labor-intensive business requring technologies suitable for developing countries.

Products and Specifications

This description relates to the government designated model-70 telephone which is produced in diverse types based on both dialing and push-botton systems. Light and semi-permanent with the use of ABS resin, decorative telephones in particular are well-balanced with dignity and practicability matching any environment. Characteristics of the products manufactured in this plant are as follows:

- Transmitter unit sensitivity is 52 ± 6 db at 1khz.
- Dynamic impedence of transmitter is 20-60 ohms at 1khz.

- Continuous noise of transmitter is less than -90 db.
- Receiver unit sensitivity is 71 ± 6 db at 1 khz.
- Impedanee of receiver is 160 ± 50 ohms.
- Instantaneous resistance of receiver between coil terminal and protective grip panel is more than 50 meg-ohms.
- Average impulse speed is 10 ± 0.8 pulse per second.

Contents of Technology

1) Process Description

As can be seen in the flow sheet, such externally ordered items as induction coils and springs are lined up in line (1), houseings, handles and rubber foot items made of respectively thermoplastic resin and thermosetting resin by means of pelletizing, molding and finishing are lined up in line (2) and such other items as levers, base plates, terminals and pin parts made of the raw metal by heat treatment, plating and painting are finished at the assembly section in line (3). Important manufacturing processes are as follows:

Injection molding

Housing and handle

ABS resin is formed into these components by a screw type injection molding machine with the use of single cavity injection mold. The adjustment of time, temperature and pressure is the most important factor for working conditions.

The working conditions prescribe the cooling time of 50-80 seconds, temperature of 180-190°C at the middle of screw and primary injection pressure of 70-80kg/cm^2. The color is separately determined.

Rubber foot

PVC resin is formed into this component by means of a screw type injection molding machine with the use of 8-cavity injection mold. The adjustment of time, temperature and pressure is the most important factor for working conditions. The work is done under conditions of the cooling time of 15-18 seconds, temperature of 100-120°C at the middle of screw and primary injection pressure of 50-60kg/cm^2.

Hook switch body

ABS resin is formed into this component by means of a screw type injection molding machine. The adjustment of time, temperature and pressure is an important factor. The working conditions prescribe the cooling time of 20-30 seconds, temperature of 190-210°C at the middle of screw and primary injection pressure of 90-100kg/cm^2.

Die casting

Lever A-1, Lever A-2

An aluminum ingot is melted as a primary work in the furnace at 650-670°C. As a secondary work, the molten aluminum is formed into this component by a plunger type die casting machine with the use of 4-cavity die casting mold. The temperature, time and pressure are important factors for working conditions. The working conditions prescribe the aluminum filling temperature of 645-655°C, cooling time of 40-50 seconds and casting pressure of 650-670kg/cm^2

Press work

Base plate

Mild steel is used as raw material and processing equipment are 3.3mm shearing machine and 12.5-75 ton eccentric press performing the cutting, shearing, boring, drawing and embossing. The second grade mold is used for a single work.

Terminal and pin parts

The material used is copper plate or copper alloy plate designated to conform to charracteristics of the component part. The processing equipment is 55-12.5 ton high speed press simultaneously performing the shearing, cutting and boring. The first grade precision progressive mold is used to punch 1 to 3 pieces at one time depending upon the form of respective component parts.

Gong A, Gong B

The material used is copper plate. The processing equipment include 3.3mm shearing machine, 12.5-ton eccentfic press and 55-ton eccentric press respectively performing the cutting, shearing and boring. The second grade mold is used for each separate work.

Machining

Iron core

The material used is 8mm diameter genuine iron bar. The processing equipment are circular sawing machine and bench automatic lathe respectively performing the cutting, drilling, milling and tapping. The bite, 3mm diameter drill and 0.9mm pitch knur M3P05 tap are used.

Heat treatment

Genuine iron product (Heelpiece core amateur)

Products are placed in a stainless steel box of appropriate standard and kept at 850°C for 3 hours in a chamber furnace (21 KVA) to be stabilized of its structure by cooling to 350°C in the furnace. After cooling in the furnace, the products are taken out for sir cooling to room temperature. Care should be taken not to cause the occurrence of oxidized film on the surface of the product while working.

Surface treatment process

Half-dull nickel plating (Heelpiece core amateur)

A rigid rubber or PVC lined tank is used in this process. The plating liquid is prepared by blending in an appropriate ratio $NiSO_4$, $NiCl_2$ and H_3BO_3. Such working conditions as reaction temperature, pH and

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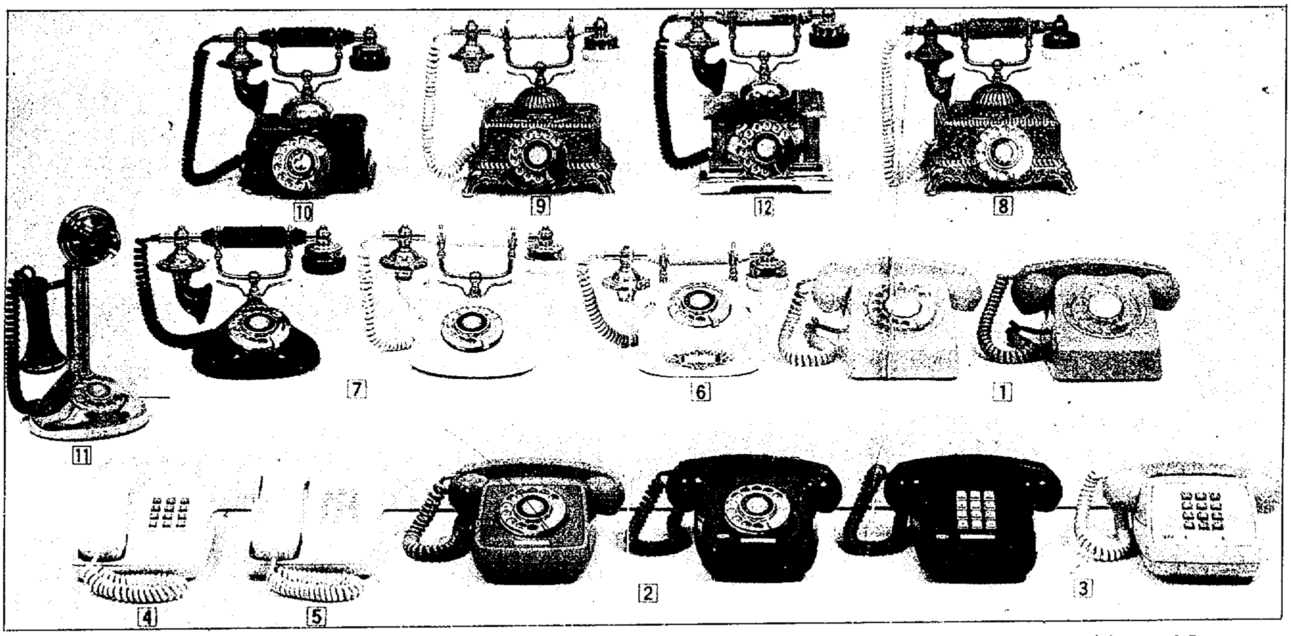
Telephone Assembling Plant



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ABS resin is formed into these components by a screw type injection molding machine with the use of single cavity injection mold. The adjustment of time, temperature and pressure is the most important factor for working conditions.

The working conditions prescribe the cooling time of 50-80 seconds, temperature of 180-190°C at the middle of screw and primary injection pressure of 70-80kg/cm^2. The color is separately determined.

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PVC resin is formed into this component by means of a screw type injection molding machine with the use of 8-cavity injection mold. The adjustment of time, temperature and pressure is the most important factor for working conditions. The work is done under conditions of the cooling time of 15-18 seconds, temperature of 100-120°C at the middle of screw and primary injection pressure of 50-60kg/cm^2.

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Surface treatment process

Half-dull nickel plating (Heelpiece core amateur)

A rigid rubber or PVC lined tank is used in this process. The plating liquid is prepared by blending in an appropriate ratio $NiSO_4$, $NiCl_2$ and H_3BO_3. Such working conditions as reaction temperature, pH and electric currents at cathode and anode are important factors. The process including degreasing, hydrochloric acid treatment, electrolytic degreasing, strike copper plating and half-dull nickel plating is completed with the hot water drying.

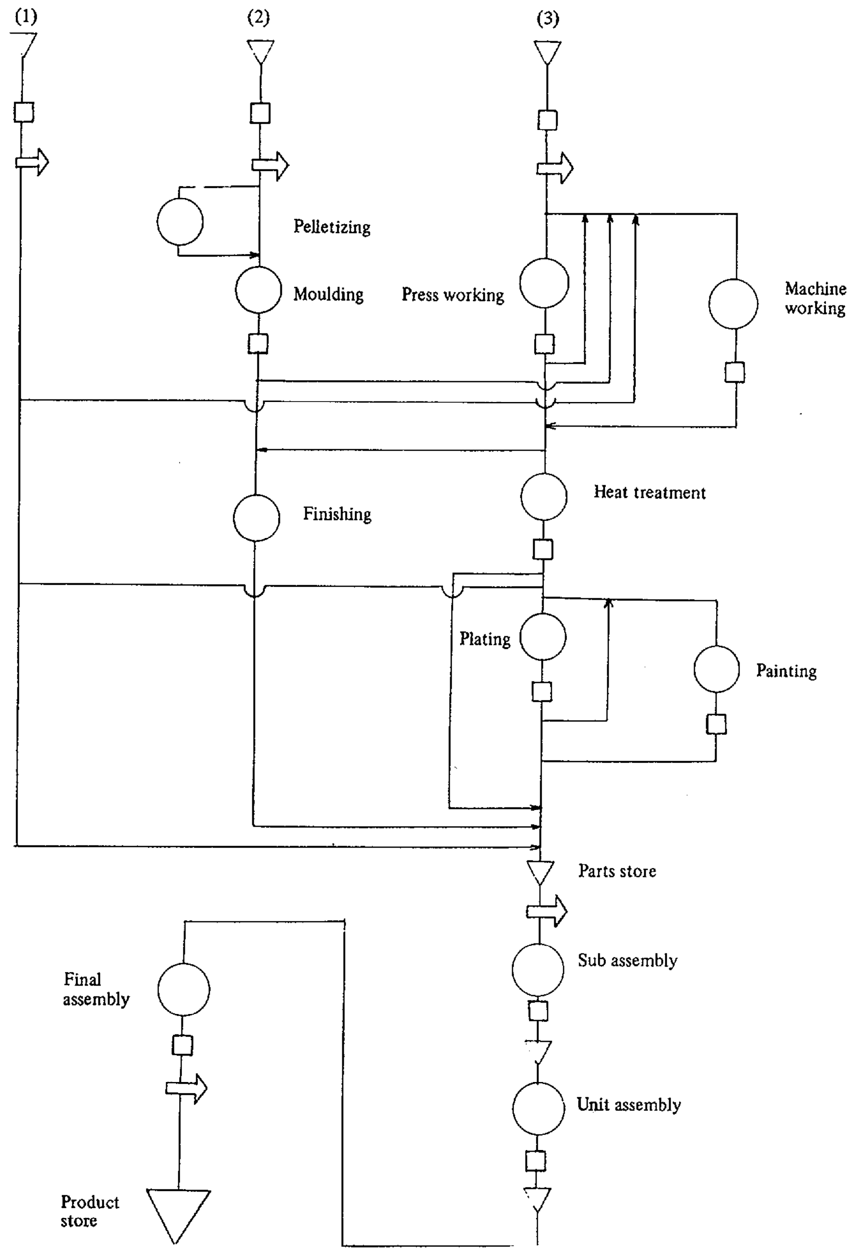
Spot welding

An automatic spot welding machine with the production capacity of 28,000 pieces per day is used. The material used is 1.6mm diameter alloy wire for the process of cutting, spot welding and forming into an appropriate spot size at one-cycle time. Products are automatically transferred by means of the first grade precision turning table.

Winding

The product is fixed onto a winding jig holder and the counter is set at an appropriate number of turns, with the resistance meter set at required 1,000-1,500 ohms. After winding, the coil resistance is measured by an ohm meter (Wheatstone bridge) and changes in the resistance value depending upon the temperature difference is figured out by the conversion table.

Telephone Assembling Process Diagram



2) Equipment Machinery

Production equipment

- Injecting moulding machine
- Crusher machine
- Shearing machine
- Econtric press (5 ton–100ton)
- Drilling machine (db ϕ 13)
- Tapping machine (dtp ϕ 6)
- Bench lathe (230 ϕ x 260)
- Engine lathe (550)
- Chamber furnace (30kw, 250°c)
- Sawing machine (ϕ 300)
- Rectifier (500-1,500 a, 15v)
- Air press (7kg/m^2)
- Waste water treatment
- Hoffing machine
- Diecasting machine
- Transformer (250 kwh)

Test & inspection equipment

- Automatic telephone test set (at 7301)
- Side tone attenuation tester (au-7713 a)
- Tension gauge
- Ring tower supply equipment (type, 3w)
- Air driver
- T-60 sensitivity tester
- R-60 sensitivity tester
- R-60 mognet tester
- T-60 & R-60 resonent frequency tester
- R-60 maxwell meter
- Braks-down voltage tester

Tool equipment

- TR unit
- Dial unit
- Bell unit
- Hand set
- Casing & others
- PM manufacturing
- Cabling

Example of Plant Capacity and Construction Cost

1) Plant capacity : 240,000 sets/year
   * Basis : 8 hours/day, 25 days/month

2) Example of estimated consturction cost (as of 1980)

o Assembling machinery	:	US$1,100,000
o Other equipment	:	US$ 170,000
Total	:	US$1,270,000

3) Required space

- o Site area : 5,000m^2
- o Building area : 4,000m^2

4) Personnel requirement

o Assembly line	:	64 persons
o Moulding process line	:	29 persons
o Painting & plating line	:	19 persons
o Inspection line	:	10 persons
Total	:	122 persons

Electric Lamp Making Plant

This plant produces various electric lamps which are basic items for all household electric appliances. Essentially used as daily necessisties anywhere in the world regardless whether for household or industrial uses, the electric lamps are enormous in quantity and require considerably large facilities for manfuacturing.

Moreover. despite a long history and great demand at present, production facilities still lag far behind in most countries in the Middle East, Africa, Southeast Asia and south America except for several advanced nations, and those countries depend on the advanced nations for imports of electric lamps.

However, the recent trend is that they seek to modernize the existing facilities or domestically produce electric lamps on a gradual basis. Therefore, this type of plant offers good opportunities for the developing countries to start the production should it be economically feasible. The plant has an advantage of quick effects and results even with relatively small initial investments.

Products and Specifications

The following electric lamps in varied types are manufactured in this plant:

- Decorative lamp
- Fluorescent lamp
- Automotive lamp
- Household lamp
- Glow starter
- Miniature lamp
- Other industrial lamp

Contents of Technology

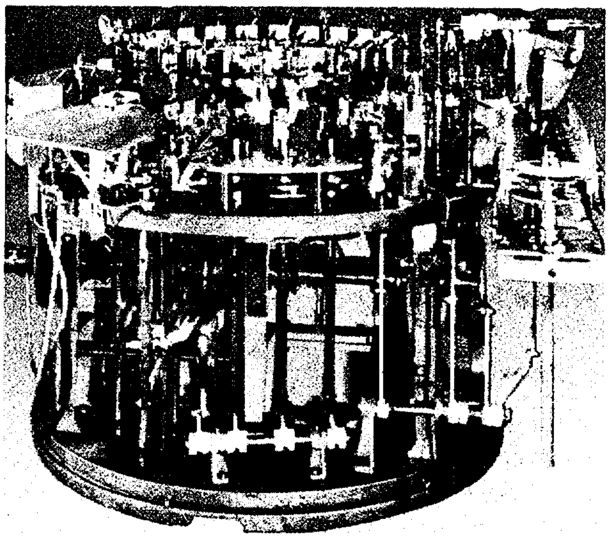
1) Process Description

As can be seen in the flow sheet blow, the process is relatively simple and automatic to a large extent. This helps reduce personnel as well as plant and labor costs helped by ease of its operations. Other characteristics of this plant are that it is so constructed as to conform to diverse standard specifications and not bound by specific standards.

2) Equipment and Machinery

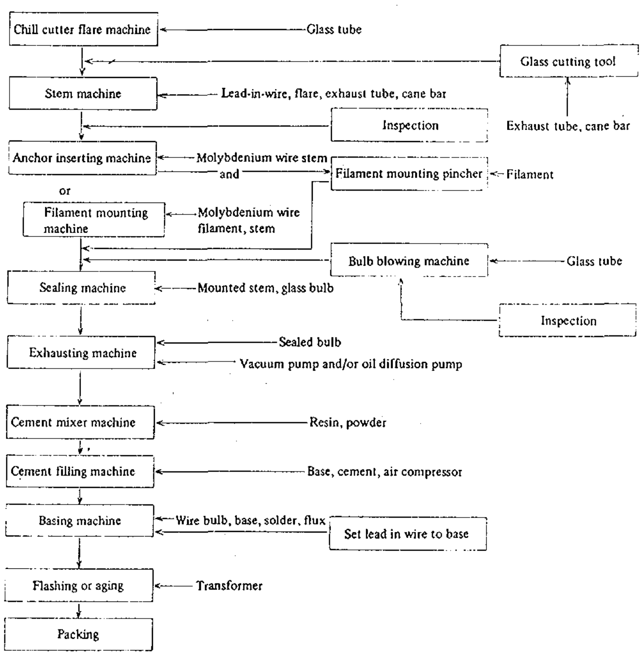
Manufacturing equipment

12 Heads automatic chill cutter flare machine
20 Heads automatic stem making machine



24 Heads automatic filament mounting machine
16 Heads automatic sealing machine
32 Heads automatic exhausting machine
Vacuum pump set

Electric Lamp Manufacturing Process Block Diagram



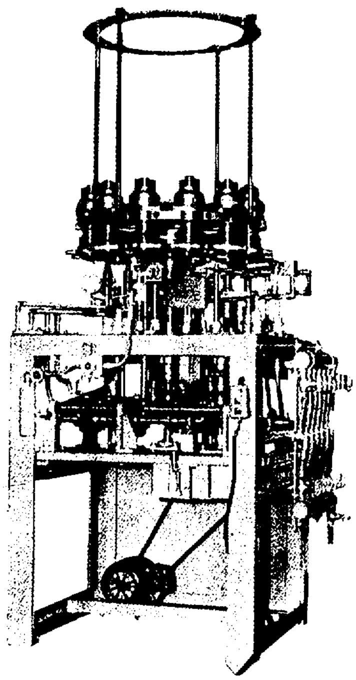
Cement mixer
10 Heads automatic cement filling machine
40 Heads automatic basing machine
30 Heads automatic aging machine
96 Heads automatic bulb froct machine
Air blower
Ball mill

Laboratory equipment

Strain viewer
Ampere & volt meter
Globe photometer
L.P. gas detector
Aging tester
Transformer
Slidac
Automatic voltage regulator

3) Raw Materials

Raw materials	Requirement (per1000 pcs of product)	
Ex-tube (3.8ϕ)	4	kg
Stem-tube (11.7ϕ)	4.65	kg
Lead-in wire	2,540	ea
Molybdenum wire(5mm)	31.31	mm
Getter (barium)	11.5	g
Filament (60 watt)	1,180	ea
Glass bulb (55ϕ)	1,156	ea
Base (E-26)	1,065	ea
Cement (powder and resin)	1,413	kg
Solder (20%)	300	g
Flux (B.T)	21	g
Individual box	1,020	ea



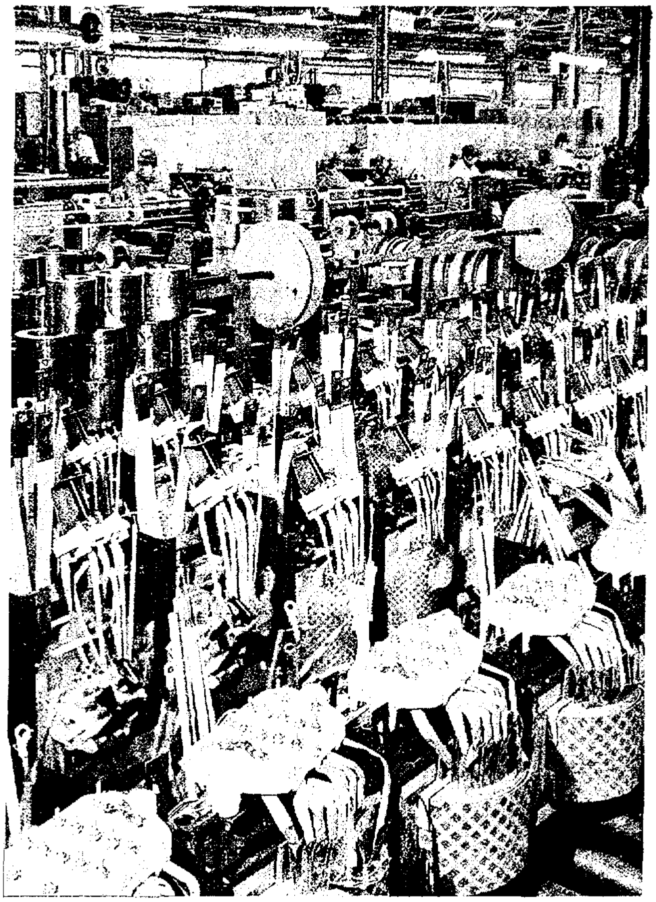
Example of Plant Capacity and Construction Cost

1) Plant capacity : 8,000 pcs/day
   * Basis : 8 hours/day
2) Estimated equipment cost (as of July, 1982)
   - Manufacturing machinery : US$170,000
   - Spare parts for 1 year : US$ 8,000
   - Testing machinery : US$ 45,000
   - Gas and air piping, gas station : US$ 20,000

   Total(FOB) : US$243,000
3) Required space
   - Building area : 112 m^2/line
4) Personnel requirement
   - Chief engineer : 1
   - Sub engineer : 1
   - Worker :
     W/O bulb blowing machine : 13
     Adopted mounting machine : 10
   - Inspector : 1

   Total : 26 persons

Transformer Assembling Plant



View of Assembling Line

The transrormer was first produced by Varley in 1856 by making a bundle of iron wires and then winding insulated copper wires around it. It is now produced in capacity up to 800KV class for use in the alternating current transmission. The transformer is an essential electrical equipment in power transmission and distribution, with its demand steadily increasing as industries expand in respective scales and the demand for power in general households also increase.

The transformer industry has been rapidly growing, particularly with the development of large-capacity generators (100,000KW) and electric motors since around 1910 when such related element industries as the metal and machine industries began to advance. However, with the development of the electronics industry in the 1960s, emphasis has been placed in the electric equipment industry on such new system industrial equipment as computers and other ultra-precision electric control equipment for use in both nuclear energy and space industries. Accordingly, the transformer manufacturing is slowly being transferred to semi-developed or developing countries, while developed nations concentrate mainly on the technology centering around transformers of several hundred thousand KW class and ultra-precision electric control equipment.

From the standpoint that the transformer is an essential product with an increase in the requirement of electric power, and it is a technology being shifted to semi-developed and developing countries, the transformer manufacturing industry is an inevitable key industry with the feature of being highly value-additive in developing nations.

Products and Specifications

The classification of transformers varies depending upon their uses and inner structure. When classified in

Table 1. Specifications of LL-130 Pole Distribution Transformer

Capacity	Voltage	Cu loss	Fe loss	Copper	Iron	Oil	Radiation area
10KVA	6.3/3.15KV	141W	65W	25 L/b	92.6 L/b	10 G/A	870 SQ. in
20KVA	6.3/3.15KV	202W	80W	34.6 L/b	123 L/b	14 G/A	1,000SQ. in
30KVA	6.3/3.15KV	257W	103W	45 L/b	153.5 L/b	16 G/A	1,200SQ. in

Table 2. **Specifications of LL-130 Pole Distribution Transformer in Over Load Time Allowance**

Load (%)	250	200	120
Total loss (W)	945	629	522
Time (H)	1.96	4	6.5

* An LL-130 pole distribution transformer can be stand for 4 hours at 200% overload.

accordance with the method of power transmission, they are generally divided into a distribution transformer and power transformer. To the distribution transformer usually belong a pole distribution transformer installed in the power distribution line, while the power transformer is a transformer installed in the high-voltage power transmission line.

Explanations here relate to the usual pole distribution transformer being produced in this plant.

First of all, LL-130 type 10KVA, 15KVA and 20KVA transformers are designed for the temperature of 65°C with the use of "Insuldur", the latest insulator, while the coil temperature rise is permissible up to 130°C. As a result of reduced cooling surface area, the cost saved that much is invested on copper wires to reduce the load loss. It is therefore so designed as to provide a pertinent average load by minimizing the ratio of copper loss to iron loss. Detail specifications are as shown in tables.

Contents of Technology

1) Process Description

Insulating oil

Filtration

Insulating oil is received and transferred into the storage tank through the oil filter.

Inspection

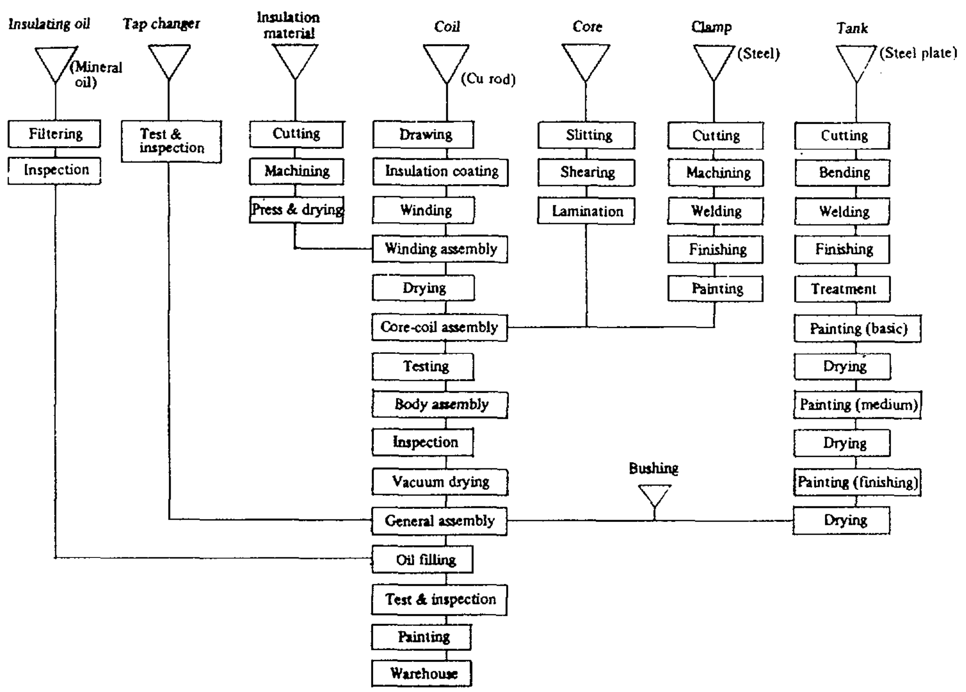
The sampling oil is collected from the bottom valve of the storage tank. The inspection of oil is carried out in accordance with the procedure specified by the applicable standard (KS, IES, BS etc). If the quality of oil is worse than the required value, the storage tank oil should be circulated through the oil degasing equipment until the required value is obtained.

Insulation material

Cutting

The insulating material is cut for use by the vertical

Transformer Manufacturing Process Block Diagram



cutter.

Machining

The insulating material is processed to adequate size by cycle machine, machine saw or plane.

Press and drying

The insulation material processed is pressed and dried to remove the bending surface.

Core

Shearing

Each sheet is cut off into an accurate rectangular size, whose direction is lengthwise to be in line with the rolling direction of sheet to increase the permeability of the cutting machine.

Lamination

The section of core is divided into several steps, each of which has different width so that each limb inscribes a circle. The core limbs are interleaved into the top and bottom by yoke, whose laminations being clamped with heavy clamping structures, insulated from core except at earthing point to reduce stray loss. The contact parts of yoke and core are penetrated by bolts, which is sufficiently insulated.

Coil

Drawing

The copper conductor is drawn into the size as designed.

Insulation coat

Both high and low tension coils are wound with cotton, paper on PVF covered silverless high conductivity annealed electrolytic copper wire of circular or rectangular cross section.

Winding

The insulated copper conduction is wound in cylindrical type, continuous disc type, helical type, etc.

Winding assembling

Windings are laminated one by one and interleaved with press board ducts and then connected together at the outer siac.

Drying

The coil is given vacuum drying and stabilizing treatment in a vacuum oven, and is impregnated with degassed and is impregnated with degassed and dehydrated oil, which makes it possible to ensure very strong dielectric strength.

Core-coil assembling

The high and low voltage windings are assembled concentrically on the core.

Core-coil test

The test of core and coils is carried out as below.

i) Insulation resistance between windings and the earth.

ii) Polarity and phase relation between windings.

iii) Ratio for each tap.

Inspection test

The transformer is tested according to purchasers standard specifications (JEC, KS, IEC, BS, ANSI, etc.)

Painting

The painting of the transformer is carried out to form a tough, moisture-and abrasion-resistant coating as below.

Absorption of oil – Short blast– Phosphate coating – Drying – Intermediate coating – Baking – Final coating – Baking.

2) Equipment and Machinery

Paper slitter
Coil winding machine
Shearing machine
Paper taping machine
Dryer
Hydraulic press
Filter
Oil purifier
Vacuum tank
Expansion machine

Example of Plant Capacity and Construction Cost

1) Plant capacity : 300 sets /month
   * Basis : 1ϕ 50 kva, 8 hours/day, 25 days/month

2) Estimated manufacturing equipment cost: US$2,100,000

3) Required space
   - Site area : 6,000 m^2
   - Building area : 3,000 m^2

4) Personnel requirement: 80 persons

Any inquiry about the information contained should be sent to:

IO/COOP, Registry file No. ID/562/12, UNIDO, P.O. Box 300, A-1400 Vienna, Austria

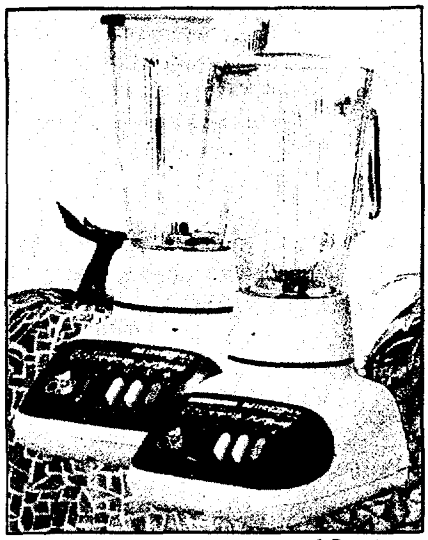
FILE: Q13
ISIC 3833

Mixer Making Plant

The mixer is a household kitchen appliance widely used along with such items as rice cooker, refrigerator, washing machine and electronic range. With the improvement of the living standard and requirement of varied culinary dishes, it is significantly used in cooking vegetables and fruits.

The principle of the mixer is to cut foodstuffs finely in the cup connected to a rotating rod of the motor for agitation and mixing. The cutter is of stainless steel and mostly attached with four blades assembled crosswise in two each in both upper and lower parts. Some mixers have six blades with the addition of two more and rotate at the high speed of 5,000 rpm.

The manufacturing plant of such mixers is simple in facilities and relatively monotonous in technology, being an industry capable of sufficiently manufacturing products in quantities as a small and medium type business.



View of Products

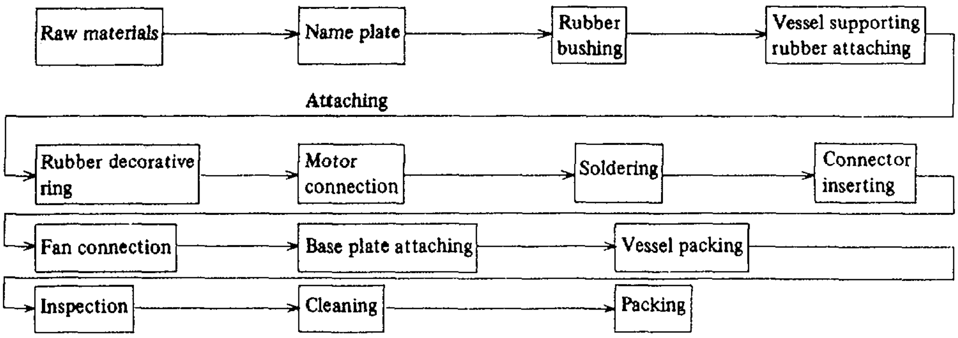
Products and Specifications

Products manufactured in this plant can use both 110 and 220 volts as power source, and the revolution per minute is adjustable by the varied speed controller between 5,000 and 9,000. The capacity is fixed at 1,200cc and characterized by definitely less power consumption than other products. The motor is also special and produces strong power equipped with a varied speed controller. It is characteristic of a low temperature motor. The stainless alloy steel cutting

Table 1. Specifications of Mixer

Model	V	Hz	r.p.m.	Watt	CC	Kg
DWM 401	100	60	5,000–9,000	250	1,200	5.3
DWM 401W	100/220	60	5,000–9,000	270	1,200	5.3
DWM 402	100	60	5,000–9,000	250	1,200	4.5
DWM 402W	110/220	60	5,000–9,000	270	1,200	4.5
DWM 403	100	60	5,000–9,000	250	1,200	4.5
DWM 403W	110/220	60	5,000–9,000	270	1,200	4.5

Mixer Manufacturing Process Block Diagram



blades are rustproof and resistant to breakage. The cup is provided with double covers. Detail specifications are shown in table 1.

Contents of Technology

1) Process Description

Component parts are conveyed and a nameplate is inserted in a groove at the front of the body, and bush rubber is also inserted in the attached groove to prevent a transmission of vibration when the motor is working. The vessel supporting rubber is accurately inserted in the groove to reduce the vibration of vessel and maintain the overall level when in use. A decorative ring for the vessel is so attached as to cause no damage to the outer appearance, and washers are inserted in fixing holes of the motor. Bolts are lightened and the motor is fixed on the body. The wiring in the power supply source is thoroughly checked and connected by soldering. Connectors are pressed and the fan is connected to the motor shaft. The base plate is attached to prevent a motion of the body and inclusion of dust. Damages in outer appearance and switch buttons are minutely inspected, cleaned and packed not to be separable.

2) Equipment and Machinery

Core press machine
Shaft grinder
Press
Kotor winder
Fusing machine (spot)
Automatic lathe
Balancing machine
Stator winder
Conveyor
Plastic moulding machine
Coil tester
Volt, watt, ampere meter
Insulation resistance tester
Tachometer
Wheatstone bridge
Mullitester

3) Raw Materials

Raw materials	Requirement (per unit of product)
Silicon steel plate	1.3 kg
A.B.S.	0.3 kg
Polyester copper wire	0.3 kg

Example of Plant Capacity and Construction Cost

1) Plant Capacity: 250,000 units/year
   * Basis: 8 hours/days, 25 days/month
2) Estimated equipment cost (as of Sep., 1981)
   - *Assembling equipment*: US$200,000
3) Required space
   - Site area : 650 m^2
   - Building area : 370 m^2
4) Personnel requirement: 120-160 persons

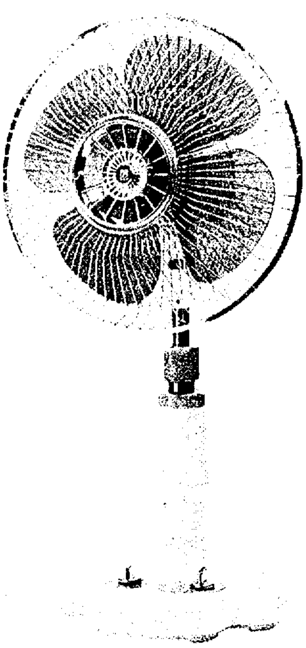
FILE: Q14
ISIC 3833

Electric Fan Assembling Plant

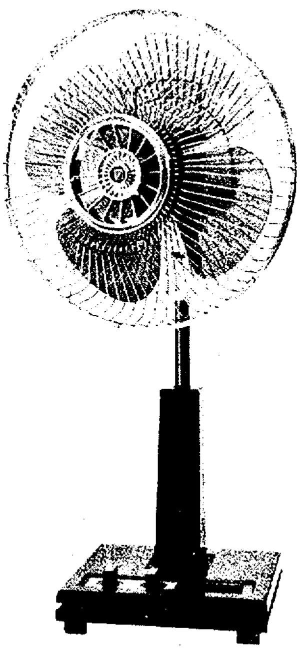
In many places including an ordinary house, factory, resting place and the like where men spend part of their time, an electric fan makes them feel cool and refreshed. It is primarily used for controlling the air in a room or ventilating. In particular, during the season of high temperature, it is an important appliance men cannot do without in daily life.

The electric fan consists of four main parts; fan, guard, motor and stand. The fan is usually of plastic screw type but sirocco fans are also used. The motor is usually of induction type but a condenser motor is also used. The electric fan is characterized by the rotation of a swinging device, which is converted to the reciprocating motion by a worm gear and crank rod, making the entire fanning device to swing from one side to the other with a fulcrum located in the stand.

Though electric fans are limited in use depending upon regions and seasons, they are most suitable for small and medium businesses which can be established relatively easily with small investments on the foothold of universal technology.



SIF-350EHD (14")



SIF-350BSD (14")

View of Products

Table 1. Specifications of Electric Fan

Size (inch)	Model	Diameter (cm)	Voltage (V)	Frequency (Hz)	Watt (W)	Rotation (r.p.m.)	Wind speed (m/min)	Wind quantity (m^3/m)	Weight (kg)	Volume (m^3)
9"	238MS	23	100	60	35	1,500	150	16	2.4	0.04
12"	304HFD	30	110/220V	60	51	1,300	209	38	4.3	0.117
12"	309PJD	30	110/220V	60	51	1,300	200	38	4.6	0.087
14"	359RT	35	100	60	60	1,300	240	52	4.9	0.114
14"	366SID	35	110/220V	60	59	1,300	215	53	5.9	0.114
14"	366SJD	35	110/220V	60	57	1,250	230	48	6.1	0.114
14"	36ATD	35	110/220V	60	57	1,250	230	48	7.2	0.155
14"	363TPD	35	110/220V.	50	50	1,300	220	58	6.3	0.19
16"	403TUD	40	110/220V	60	60	1,300	220	58	6.9	0.19
14"	359ITD	35	110/220V	60	57	1,250	230	48	5.9	0.094
14"	359POD	35	110/220V	60	57	1,250	230	48	5.9	0.094
14"	359TFD	35	110/220V	60	57	1,250	230	48	5.8	0.094
14"	359TTD	35	110/220V	60	57	1,250	230	48	5.8	0.101
14"	358TOD	35	110/220V	60	57	1,250	230	48	5.8	0.114
14"	358SP	35	100	60	60	1,300	240	52	7.8	0.096
14"	358SND	35	110/220V	60	57	1,250	230	48	5.6	0.12
14"	358SQD	35	110/220V	60	57	1,250	230	48	5.9	0.124
14"	365NGD	35	110/220V	60	57	1,250	230	48	6.1	0.114
14"	358TMD	35	110/220V	60	57	1,250	230	48	6.0	0.114
14"	359WHD	35	110/220V	60	59	1,300	215	53	4.6	0.127
16"	403WAD	40	110/220V	60	65	1,300	220	58	5.6	0.127
16"	405FAD	40	110/220V	60	60	1,300	220	60	15.5	0.256
16"	402CTD	40	110/220V	60	65	1,300	230	60	6.7	0.093
16"	903CSD	90	110/220V	60	115	490	170	180	7.0	0.037
16"	140CF	140	100	60	115	270	150	210	13.0	0.095
36"	903CSD	90	110/220V	60	115	490	170	180	7.0	0.037
55"	140CF	140	100	60	115	270	150	210	13.0	0.095
14"	3500ND	35	110/220V	60	57	1,250	230	48	6.0	0.114
14"	352FLD	35	110/220V	60	57	1,250	230	48	6.0	0.114
14"	365SFD	35	110/220V	60	57	1,250	230	48	6.0	0.114
14"	350EHD	35	110/220V	60	57	1,250	230	48	8.0	0.134
14"	350CAD	35	110/220V	60	57	1,250	230	48	6.0	0.114
14"	350BSD	35	110/220V	60	57	1,250	230	48	6.2	0.114

Products and Specifications

Electric fan diameters range from 12 to 16 inches with 1,150-1,380 rpm and 40-75 watts in power consumption, being manufactured in varied types with the table 1.

Contents of Technology

1) Process Description

As can be seen in the flow sheet, various component parts are first supplied by means of a conveyor to assemble the spring supporting and plate. The timer switch, helix spring and stand cap are also assembled. Lead coil is soldered and then neck and motor assemblies are fabricated. Following an inspection of the completed base assembly, other rigging components like rubber foot, base and cover fan are fabricated with a decoration plate fixed prior to the final inspection.

Example of Plant Capacity and Construction Cost

1) Plant capacity : 30,000 pcs /month
   * Basis : 8 hours/day, 25 days/month,

2) Estimated equipment cost (as of July, 1982)

o Assembling machinery	: US$ 62,000
o Plastic injection moulding machine	: US$544,000
o Plastic mounting die	: US$ 36,000
Total (FOB)	: US$642,000

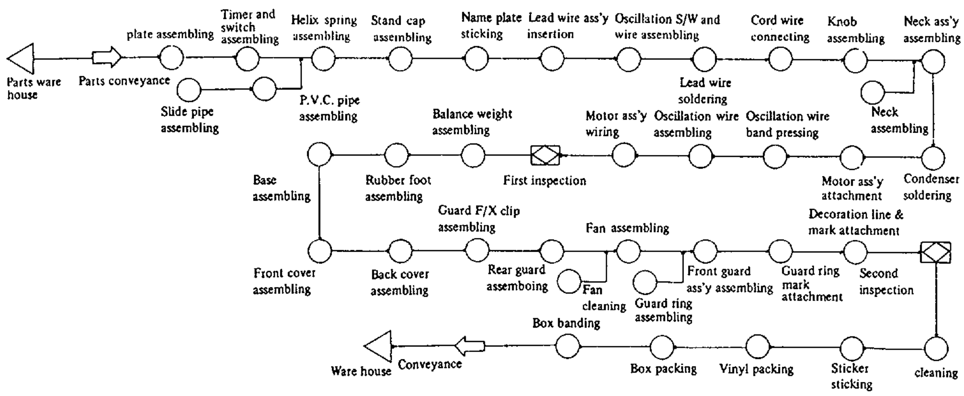
3) Required space
   - o Site area : 2,200 m^2
   - o Building area: 2,136 m^2

4) Personnel requirement: 50 persons

2) Equipment and Machinery

Power press (1 ton)
Drilling machine
Impect pench
Air driver
Low speed air driver
Resin pulverizer
Chin block
Tapping machine
Belt conveyer
Auto packing machine
Solder (60w)
+ Hand driver
- Hand driver
Nipper
Long nose plier
Oil gun
Plastic hammer
Sub conveyer (I)
Sub conveyer (II)
Cooling system

Electric Fan Assembling Process Diagram



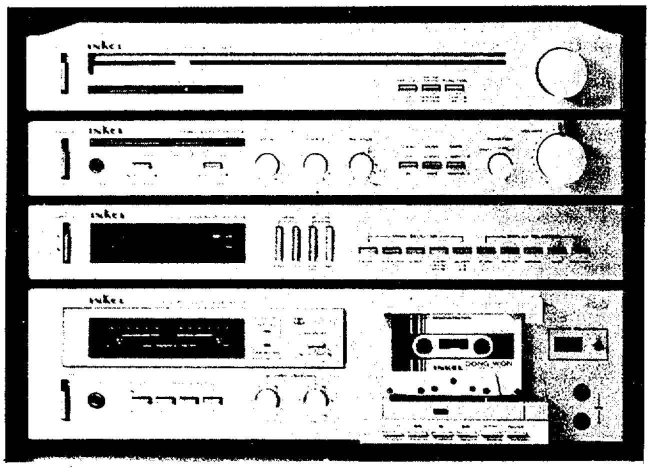
3) Raw Materials

Raw materials	Requirement (per unit of product)
ABS	1 kg
AS	0.25 kg
EPS	0.35 kg
S-60 steel piece coil	1.303kg
Galvanized steel plate	0.636kg

Any inquiry about the information contained should be sent to:

IO/COOP, Registry file No. ID/562/12, UNIDO, P.O. Box 300, A-1400 Vienna, Austria

Stereo Phonograph Making Plant



View of Products

With the progress in its manufacturing technology, a stereo is not only combined merely with radio and record player but also with cassette tape deck.

One step beyond the mere radio and record player reproducing the sound with the progress in manufacturing technology, the stereo is combined even with a cassette tape deck. It is an electronic home appliance anybody requiring a cultural life would like to have in his or her home.

As the living standards steadily improve, people want to directly listen to the high-quality sound, that is to say, the sound quite similar to the original sound track at their homes, work places and other resting lounges.

In the case of radio, they want to listen to AM as well as FM in stereo sound, requiring an amplifier equipped with highly reliable sound quality in case of a turntable. In the case of cassette tape deck, they also want to listen to the unspoiled, reverberating sound in terms of original one based on taped signal.

With the development in the electronic circuit design technology, multi-functional switches are also in use, with the stereo characterized by quickly changing models. Such stereos are used not only in houses but also in such places as an office, plant, school, hotel and other resting lounges where people find themselves.

Though one step behind the color television industry which is called the flower of the electronics industry, such stereos belong to an industry required to pass through in developing one nation's electronics industry coupled with the realization of cultural life.

Highly technology-intensive and also labor-intensive, this industry requires many electronic component parts with the characteristics of significantly contributing to the development of related electronic component parts industry.

Products and Specifications

Constituents of a stereo is a tuner, amplifier, cassette tape deck, turntable, mixer, timer and speaker. When these component parts are in harmony one another with respective characteristics, an excellent stereo is produced. The tuner is characterized by a signal to noise ratio of 75-79db for FM mono and 65-70db for FM stereo. Five segments of LED are in use as signal strength meters and three other segments of LED are also used to serve as indicators for the ease of tuning.

In the case of amplifier, its power output channel ranges from 25 to 90 watts with the frequency response of 50 to 450KHz. The cassette tape deck has the total harmonic distortion of 1 to 1.2 percent at 1 KHz. The noise reduction circuit is licensed from Dolby Laboratories. The digital tape counter is up to 999, and the damped door as well as mechanical soft touch botton are employed for the quiet operation.

With the compact design in appearance, it superbly suits a living room, bed room, family room and study room. Detailed specifications are as shown in table 1.

Contents of Technology

Explanations are restricted to manufacturing processes of tuner, amplifier and cassette tape deck here. As shown in the flow chart, the tuner process includes the insertion of such electronic components as R, L, C, Tr and the like into the PCB (printed circuit board) in body line process and automatic soldering.

Deflective soldered parts are rectified to be attached with necessary accessories. In preparatory process, the wire cutting work is carried out by a wire cutting machine for wiring various components. At the processing table, painting of back chassis and silk work

Table 1. Specifications of Tuner, Amplifier and Cassette Tape Deck

○ TUNER

	TD1000	TD 910	TD 900	TD 1	TD 10
FM SECTION					
IHFSensitivity, 30db quieting	1.8μv(10.3dbf)	1.7μv(9.8dbf)	1.9μv(10.8dbf)	1.9μv(10.8dbf)	1.9μv(10.8dbf)
50dB quieting sensitivity					
Mono	3.0μv(15.0dbf)	2.8μv(14.1dbf)	3.0μv(15.0dbf)	3.0μv(15.0dbf)	3.0μv(15.0dbf)
Stereo	40μv(37.2dbf)	36μv(36.3dbf)	40μv(37.2dbf)	40μv(37.2dbf)	40μv(37.2dbf)
Signal to noise ratio					
Mono	78db	79db	77db	75db	75db
Stereo	70db	70db	68db	65db	68db
Total harmonic distortion					
Mono	0.05%	0.08%	0.15%	0.15%	0.15%
Stereo	0.08%	0.1%	0.25%	0.25%	0.25%
Capture ratio	1.0db	1.0db	1.5db	1.5db	1.5db
Alternate channel selectivity	80db	80db	60db	60db	60db
Stereo separation at 1khz	50db	55db	50db	48db	50db
AM SECTION					
Sensitivity 20db S/N, Bar ANT	600μv/m	200μv/m	300μv/m	300μv/m	600μv/m
Signal to noise ratio	40db	45db	45db	45db	45db
Selectivity, ± 10 khz	30db	40db	25db	25db	25db
Spurious response rejection	50db	55db	45db	45db	45db
GENERAL					
Unit dimension (WxHxD) mm	440 x 70 x 300	440 x 125 x 345	440 x 125 x 345	440 x 55 x 263	440 x 55 x 300
Unit weight	4.8 kg	7.3 kg	6.5 kg	5 kg	4.2 kg

○ AMPLIFIERS

	MD1200	PD1100	AD970	AD950	AD2	AD20
AMPLIFIER SECTION						
Power output/ch. into 8 ohms,						
min. rms from 20hz to 20khz	90 watts	10v rms (Max.)	60 watts	40 watts	25 watts	25 watts
min. rms at 1khz	100 watts		70 watts	50 watts	30 watts	30 watts
With THD no more than						
Frequency response of aux	DC-150khz	DC-450khz	DC-100khz	5hz-100khz	8hz-50khz	10hz-50khz
Input sensitivity, aux & tape		150mv	150mv	150mv	150mv	150mv
Phono		2.5mv	2.5mv	2.5mv	2.5mv	2.5mv
Mic						
S/N ratio, IHF A wtd/unwtd						
Aux & tape	115db/100db	100db/92db	100db/90db	100db/90db	100db/90db	100db/90db
Phono	–	89db/78db	85db/75db	85db/75db	80db/70db	83db/75db
Mic	–	–	90db/80db			
Phono input overload at 1khz	–	250mv	240mv	180mv	140mv	140mv
GENERAL						
Unit dimension(WxHxD)mm	440x125x300	440x70x300	440x125x345	440x125x345	440x55x263	440x55x300
Unit weight	13 kg	5.2 kg	9.9 kg	8.8 kg	6.4 kg	7.7 kg

○ CASSETTE TAPE DECKS

	CD1300	CD980	CD3	CD-30
Wow and flutter (wrms)	0.04%	0.04%	0.04%	0.05%
Frequency response, ±3db, at -20db				
Level normal	25hz-15khz	25hz-15khz	25hz-15khz	25hz-15khz
Chrome	*25hz-17khz*	*25hz-16khz*	*25hz-15khz*	*25hz-16khz*
Metal	25hz-19khz	25hz-18khz	25hz-15khz	25hz-18khz
Fe-Cr	25hz-17khz	25hz-16khz	–	–
Signal to noise, dolby NR ON				
Normal	62db	62db	62db	62db
Chrome	65db	65db	65db	65db
Metal	65db	65db	65db	65db
Dolby NR OFF normal	*53db*	*53db*	53db	*53db*
Chrome	56db	56db	56db	56db
Metal	56db	56db	56db	56db
Total harmonic distortion at 1khz, metal	1.0%	1.0%	1.2%	1.0%
Input sensitivity impedance,				
Mic	0.3mv/0.6-5.7 kohm	0.3mv/0.6-10 kbhm	0.3mv/0.6-10 kohm	0.3mv/0.6-10 kohm
DIN	*1.5mv/15 kohm*	*1.8mv/18 kohm*		
Line	70mv/47 kohm	70mv/47 kohm	70mv/47 kohm	70mv/47 kohm
Output level/impedance,				
Line	500mv/47 kohm	500mv/47 kohm	740mv/47 kohm	550mv/27 kohm
Headphone	50mv/47 kohm	55mv/48 kohm	64mv/8 ohm	
Crosstalk at 1 khz	40db	40db	40db	40db
Erase ratio with 1khz band pass filter	*68db*	65db	65db	65db
Bias oscillator frequency	95 khz	85 khz	95 khz	95 khz
Deviation of tape speed	0.5%	0.5%	0.5%	0.5%
GENERAL				
Unit dimensions, (WxHXD)mm	440 x 125 x 300	440 x 125 x 345	440 x 110 x 263	440 x 100 x 300
Unit weight	8 kg	7.5 kg	6 kg	5.6 kg

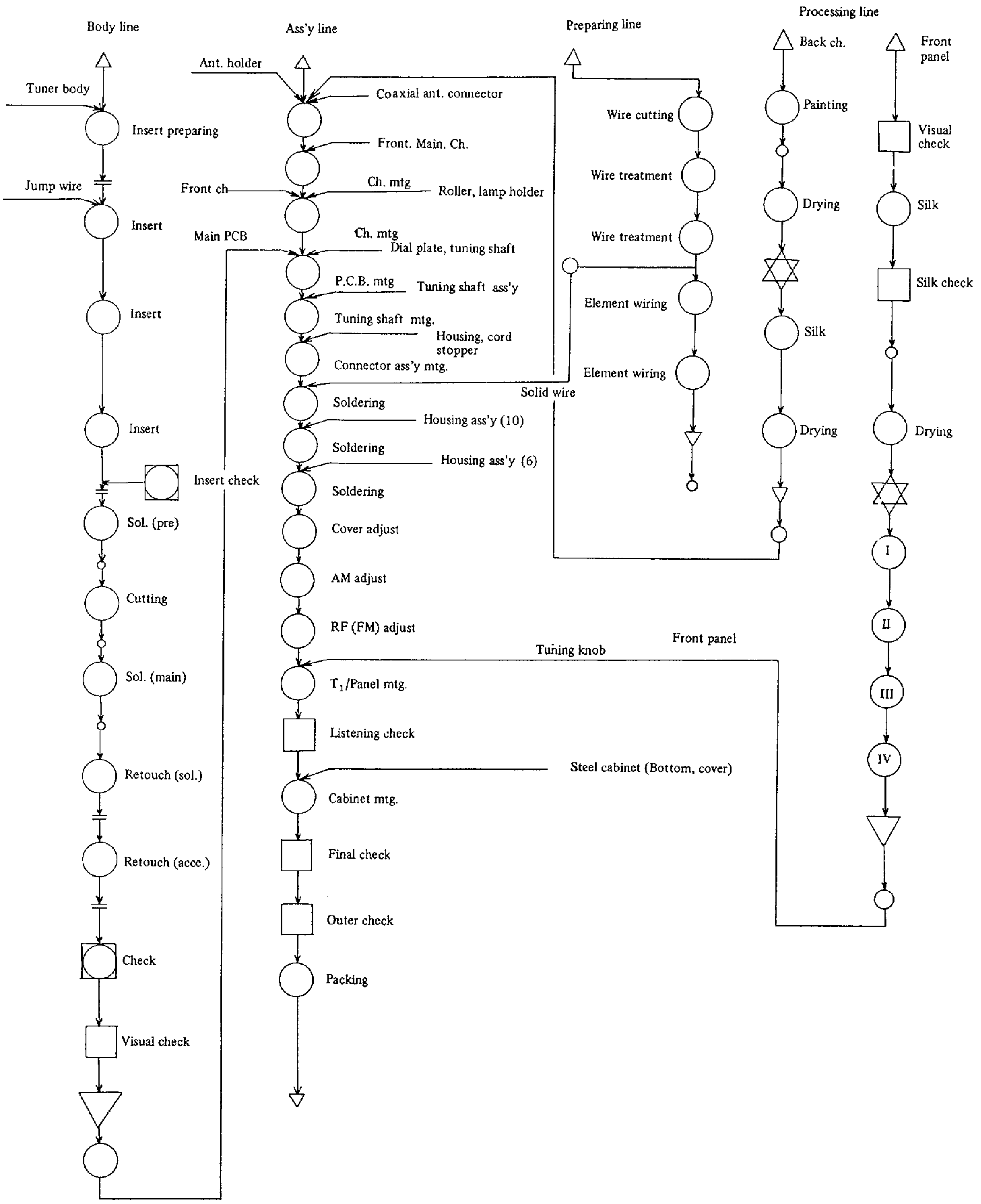
are done, with the front panel attached with other accessories.

Respective parts thus completed are assembled, wired, checked and inspected in the assembly line prior to casing as finished tuner.

As in the above tuner process, the amplifier and cassette tape deck manufacturing processes consist of body line, preparation process and assembly line, and the work is separately performed and delivered as finished products.

Such other units as turntable, mixer, timer and speaker have also similar manufacturing processes. Respective units thus finished are combined to make a complete stereo.

Tuner Assembling Process Diagram



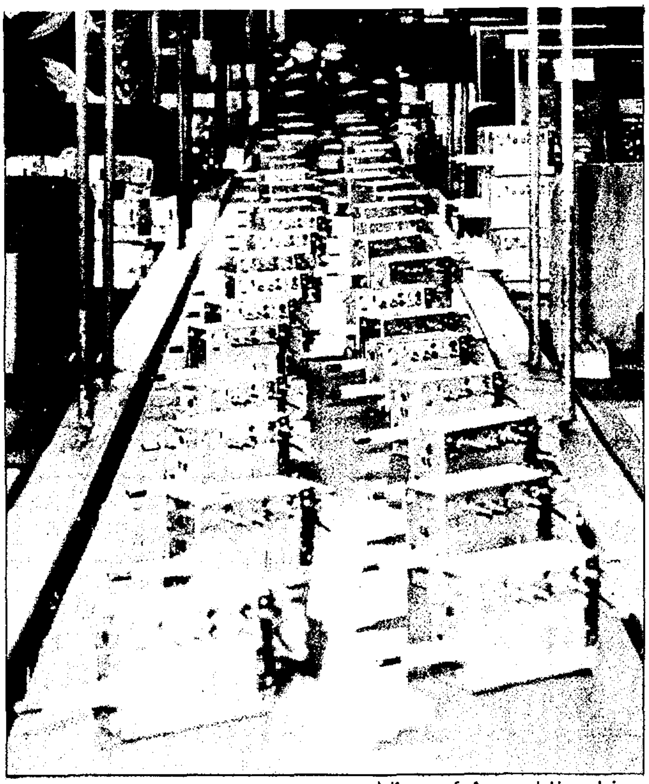
2) Equipment and Machinery

Automatic soldering system machine
Table belt conveyor
Wire cutting machine
Signal generator
Lead cutter one shoot system
Graphic recorder
Round pallet conveyor
Sweep generator
Wire twisting machine
Distorsion measurement machine
Digital multi meter
Low frequency spectrum analyser
O.S.C.
Instrument for measuring quantity of sound

Example of Plant Capacity and Construction Cost

1) Plant capacity : 50,000 towers/year
   * Basis : 8 hours/day, 25 days/month
2) Example of estimated equipment cost (as of 1982) : US$4,000,000
3) Required space
   - Site area : 100,000 ft^2
   - Building area : 65,000 ft^2
4) Personnel requirement: 800 persons.

TV Tuner Making Plant



View of Assembling Line

Seen from the television receiver, the tuner is the first stage for the electric wave received by an antenna in selecting necessary electric waves.

As can be seen in fig. 1, the tuner is divided into very high frequency (VHF) and ultra high frequency (UHF), amplifying respectively received signals into high frequency. The received signal is mixed with the signal at the local oscillator and sent to IF amplifier circuit.

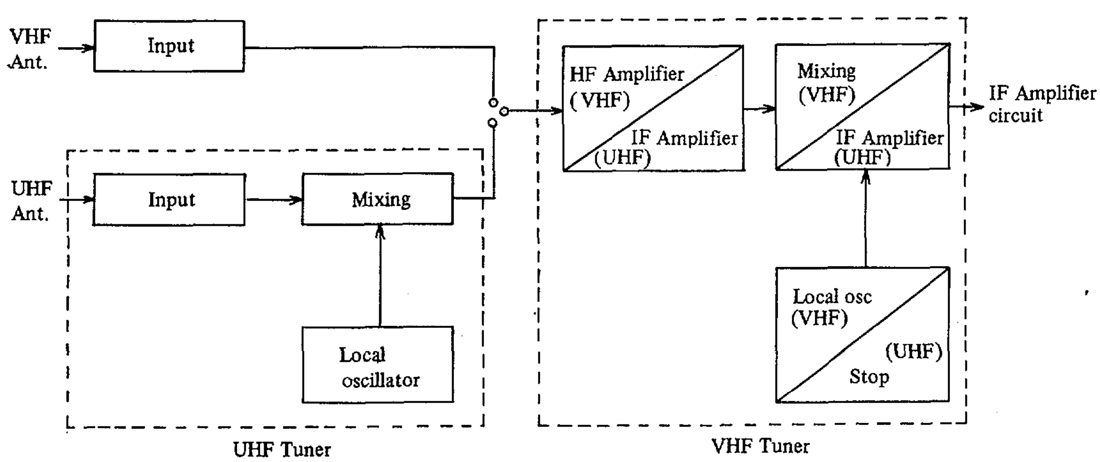
The feature of tuner is that the input impedance of tuner should be matched with that of the feeder supplying signals from atenna. Unless matched, there arises a reflection of signal, producing multiple images (overlapping of images) in the case of black and white television and no color in color television.

Such a tuner manufacturing is an essential industry in the manufacture of television component parts.

Products and Specifications

The tuner is used in VHF band by switching the coil on rotating switch. In the UHF band, the channel is selected by turning the varicon as a mechanical tuner, and the other is one-touch method of converting to signal the minute induced current flowing in the human body upon contacting the sensor electrode by hand. There is the remote controller method attached with an ultrasonic receiver of 40KHz and also the

Fig 1. The Function of Tuner



voice-controlled remocon. In this plant are produced the most universal and fundamental mechanical tuners and electronic tuners for both black and white television and color television matching diversified types.

Table 1. Specification of Mechanical Tuner

Model No.	Receiving system	Input impedance (Ω)	Supply voltage (V)	AGC voltage (V)	Number of position	Receiving channel
VCP-1880 + +	Color VHF	75	16.5	Reverse 8.0	13 detents	US
VCP-2880 + +	Color VHF	75	16.5	Reverse 8.0	13 detents	CCIR
VBM-1325 + +	B/W VHF	300	11.0	Forward 1.4	14 detents	US
VBM-2720 + +	B/W VHF	75	11.0	Forward 1.4	14 detents	CCIR
UCD-1400 + +	Color UHF	300	11.0		70 detents	US
UBS-2400 + +	B/W UHF	300	11.0		One speed	CCIR
UBS-2801 + +	B/W UHF	75	11.0		One speed	CCIR
UBS-2824 + +	B/W UHF	75	11.0	Forward 1.4	One speed	UK

Table 2. Specification of Electronical Tuner

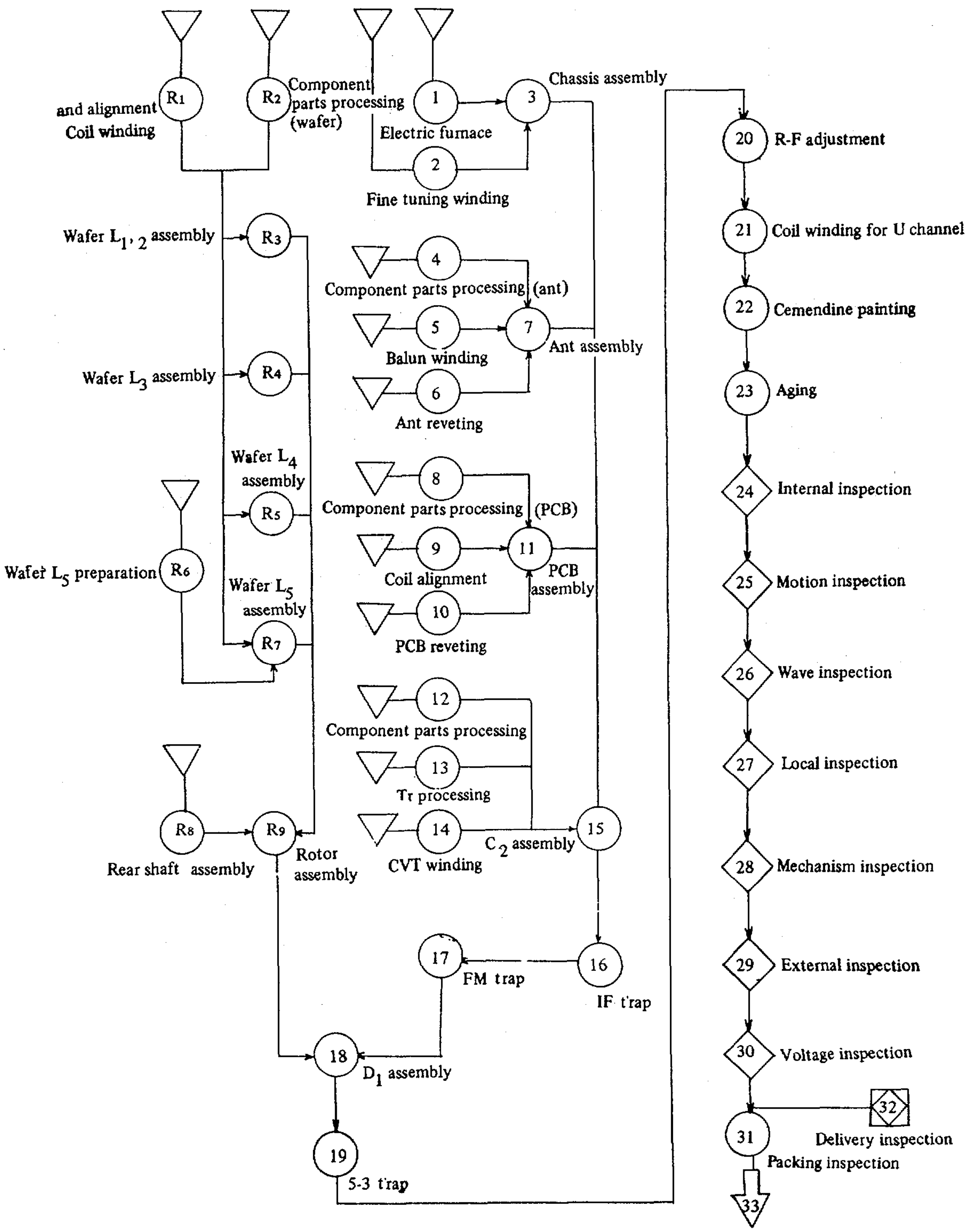
Model No.	Receiving system	Input impedance(Ω)	Supply voltage(V)				Size(mm) LxWxT	Receiving channel
			B+	AGC	V/H	V/L		
ECC-1582 + +	Color VHF/UHF COMBI	VHF 75 UHF 300	15	Reverse 8	0	30	100x82x26	US
ECC-1582C +	Color VHF/UHF COMBI CHIP TUNER	VHF 75 UHF 300	15	Reverse 8	0	30	85x65x17	US
EBC-2725 + +	B/W VHF/UHF COMBI	VHF 75 UHF 75	11	Forward 1.4	11	Off	74x56x24.5	CCIR
EBV-1745 + +	B/W VHF only	75	9	Forward 1.8	9	Off	62x57x23	US
EBU-1745 + +	B/W UHF only	75	9	Forward 1.8	9	Off	62x57x23	US
EBC-1725B +	B/W VHF/UHF COMBI Chip tuner	VHF 75 UHF 75	11	Forward 1.4	11	Off	72x47.5x14.5	US

Contents of Technology

1) Process Description

In this process, manufacturing processes of only VHF and UHF tuners among mechanical tuners are first explained. As can be seen in the flow chart, the VHF tuner manufacturing process on the right covers the component parts from the electric furnace and the fine tuning coil first pass the chassis assembling process for solder mounting. An antenna from the antenna assembly process (7) and other transistor, resistor and

TV Tuner Assembling Process Diagram



capacitor are mounted on the printed circuit board (PCB) for assemblying. It further moves through converting, IF trap and FM trap processes.

On the left, the concentric coil is wound by means of magnetic wire to form each channel, which is the formation of a wafer for the tuning and local oscillation between RF-input, RF-amp and mixer to be assembled to the rotor shaft.

The rotor shaft thus completed and the printed circuit board in the process on the right are further assembled of driving parts in the process (18) and undergo R-F adjustment, coil adjustment for UHF channel, aging, wave testing, local oscillation inspection and internal and external inspections prior to final packing.

The assemblying process of a UHF tuner is quite similar, and particularly that of an electronic tuner is much simpler involving the assembly of respective component parts on the printed circuit board with no need of description.

2) Equipment and Machinery

Alignment scope
Oscilloscope
VHF swemar generator
UHF swemar generator
UHF channel controla
Plug in unit
Power supply
NF check meter
Balun
Conveyer
Tracking meter
Auto soldering machine
Electric furnace
AVR
Torque meter
PCB contact spring inserting machine
Shaft inserting machine

3) Raw materials

Raw materials	Requirement (per set of mechanical tuner)
Steel plate	
Dura con	4.0 gr
P.C.B.	1 pcs
Transistor	3 pcs
Registor	15 pcs
Capacitor	23 pcs
Magnetic wire	5 gr

Example of Plant Capacity and Construction Cost

1) Plant capacity : 100,000 sets/month
  * Basis : 8 hrs/day, 25 days/month

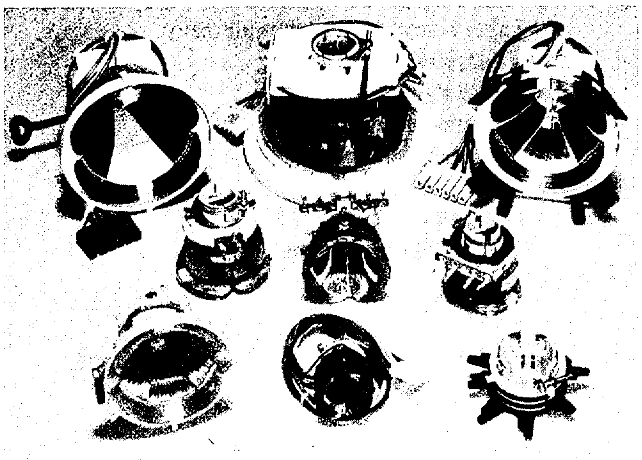
2) Example of estimated manufacturing machine cost (as of 1982) : US$140,000

3) Required space
  - Building area : 60m x 30mx 4 = 7,200m^2
  - Site area : 7,200m^2 x 2 = 14,400m^2

4) Personnel requirement

○ Prepare and assembling line	:	150 persons
○ Adjusting and testing	:	25 persons
○ Others	:	25 persons
Total	:	200 persons

Deflection Yoke Making Plant



View of Products

A deflection yoke plays the role of hitting the screen of picture tube by vertical and horizontal convergence of electron beams from electron guns. Particularly, in color television rather than black and white sėt, electron beams from three electron guns are supposed to pass through a shadow mask and converge upon a screen. For the simultaneous convergence of three electron beams, the magnetic field must be uniform, otherwise there will arise a great convergence error.

In recent years, there has been the trend of reducing the thickness of picture tube, making its neck narrower. Accordingly, two lines of thin coil are usually wound in parallel to be subjected to high voltage at the neck. Generally, 0.4mm polyester coated adhesive coil is wound in a way as to reduce the resistance loss by increasing the current capacity.

In the meantime, thermistors are contained in series in the vertical coil to offset an increase in resistance caused by the coil temperature rise, while the condenser contained in parallel in the horizontal coil compensates for the unbalance of distribution capacity.

Such a deflection yoke is one of the essentially important components in the manufacture of television, significantly influencing its performance, particularly in the color television. This kind of component of assembling industries including the television.

Table 1. Specifications of Deflection Yoke

Model No.	Applicable CRT	Horizontal		Vertical		Geometric distortion
		L(mH)	R(ohm)	L(mH)	R(ohm)	
DID-1992 + +	29ϕ 90° 19″ In-line gun, color	1.95 ±3.2%	2.14 ±10%	90 ±5%	47±5%	Less than 2.5%
DID-1492 + +	29ϕ 90° 14″ In-line gun, color	1.80 ±3.2%	1.83 ±10%	137 ±5%	6.3±5%	Less than 2.5%
DID-1272 + +	29ϕ 76° 12″ In-line gun, color	3.85 ±4%	3.7 ±10%	124 ±7%	45±7%	Less than 2.5%
DBB-0554 + +	20ϕ 55° 5″, b/w	0.32 ±5%	max. 0.75	37.7 ±7%	32±7%	Less than 2%
DBF-0994 + +	20ϕ 90° 9″–14″, b/w	0.245 ±5%	max. 68	5.2 ±5%	2.8±7%	Less than 2%
DBB-1294 + +	20ϕ 90° 9″–14″, b/w	0.16 ±5%	max. 0.4	40 ±5%	20±5%	Less than 2%
DBB-1708 + +	20ϕ 110° 12″–17″, b/w	0.18 ±5%	max. 0.47	53 ±5%	22.5±7%	Less than 2%
DBC-1701 + +	29ϕ 110° (114°) 17″–20″, b/w	2.05 ±5%	max. 4	108 ±10%	41±10%	Less than 2%
DMB-1294 + +	20ϕ 90° 12″ Monitor display	0.115 ±5%	max. 0.35	88 ±7%	47±7%	Less than 2%

Products and Specifications

Deflection yokes produced in this plant are 20 – 29mm in neck size, 50-114 degrees in deflection angle and 9-19 inches in screen size in diversified models for both black and white and color televisions.

The horizontal inductance is 0.115 to 3.85mH with plus-minus 3.2-5 percent error in various types. In the vertical inductance, the model ranges between 5.2mH and 137mH.

This plant is equipped with facilities capable of also producing other models to meet customer's requirements. Detailed specifications are as shown in table 1.

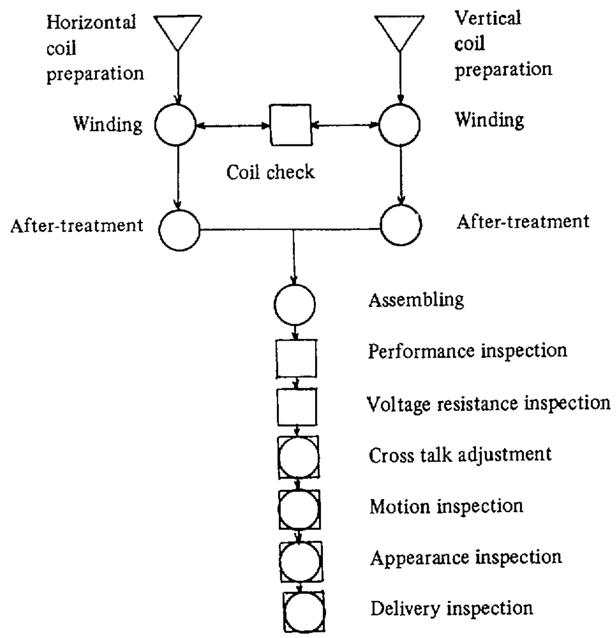
Contents of Technology

1) Process Description

Both horizontal and vertical coils are first prepared and checked for soldering and assembling. The assembled coil is inspected as to its inductance to be followed by the inspection of appearance and voltage resistance at the time of its assembly. When passed standards, the yoke is adjusted of its cross talk and then directly inspected by actuation.

Following the assembly and inspection, it is labeled and delivered. There is practically no difference in the manufacture of deflection yokes for color television and black and white television.

Deflection Yoke Assembling Process Diagram



2) Equipment and Machinery

- Winding frame
- Horizontal coil winding machine
- Vertical coil winding machine
- Cross talk meter
- Pattern generator
- Wire brush
- Motion inspection equipment
- Layer short inspection equipment
- Voltage resistange meter
- Bridge meter
- Inductance tester
- Degaussing coil
- Memory board
- Microscope
- Magic soldering machine

Example of Plant Capacity and Construction Cost

1) Plant capacity : 100,000 sets/month
   * Basis : 8 hours/ day, 25days/month

2) Example of estimated equipment cost : US$330,000

3) Required space
   - o Site are : 60m x 30m x 4 = 7,200m^2
   - o Building area : 7,200m^2 x 2 = 14,400m^2

4) Personnel requirement
   - o Engineer : 15 persons
   - o Worker : 120 persons

   Total : 135 persons

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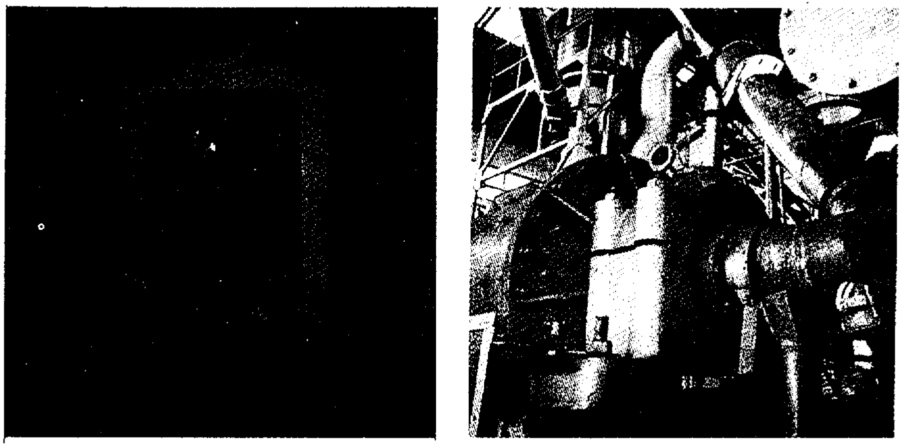
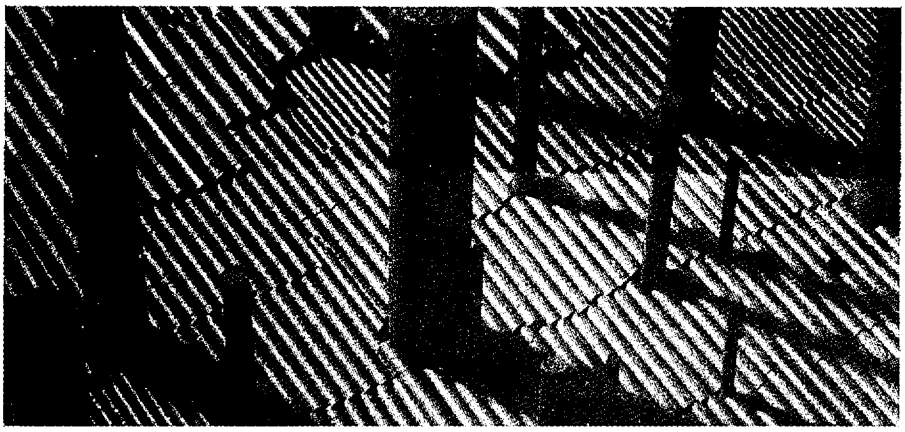
Carbon Rod Making Plant



View of Kiln & Crusher



View of Products

The carbon electrode put into the moist ammonium chloride is a carbon rod. The carbon rod serves as a conductor passing an electric current from the interior of a dry cell to the external anode terminal. Therefore, the quality of the carbon rod exerts an important influence on the characteristics of the dry cell, acquiring the most vital position among the items for a dry battery.

The demand for such carbon rods is closely related to that for dry bateries. In the case of Korea, it is on the increase in proportion to an increase in the demand for electric and electronics products. In particular, an explosive demand for the household consumer electronics, including tape recorders, transistor radios and flash lights, is greatly accelerating the demand for dry batteries along with carbon rods.

Furthermore, the dry battery industry, with its great scale merit in terms of products, has begun to expand in size for improving competitiveness, also increasing the demand for carbon rods on a large scale.

Generally, it is customary in developing nations to start the dry battery manufacturing industry with the assembly production system requiring relatively small scale in investment. The local production of component parts is realized on a gradual basis as the demand for dry cells increases. Consequently, the production of carbon rods contributes to the domestic production of component parts in the dry battery industry.

The carbon rod can also be developed into an export-oriented strategic items for invigorating the export industry, since its large-scale export to other countries merely with the assembly production system can be seen in the example of Korea.

Products and Specifications

This plant produces the carbon rods for use by zinc-carbon dry cells of various specifications well balanced in the quality and economy of the products. General physical and chemical properties of the products are as shown in table 1.

Table 1. Property and Size of Carbon Rod

o **Physical and chemical property**

Test item	Specifications
Pure carbon	Over 70%
Impurities Fe	Under 0.8%
Ash	Under 12%
Degree of wax impregnation	7-11
Shear stress	Over 280 Kg/cm^2
Electric resistance	Under $5 \times 10^{-3}\ \Omega \cdot cm$

o **Size of carbon rod**

Product	Diameter (mm)	Length (mm)
DM	7.98 ± 0.03	58.3 ± 0.2
CM	6.08 ± 0.03	46.8 ± 0.2
AAM	4.0 ± 0.03	47.35±0.15
TR	4.0 ± 0.03	47.65±0.15
FM	7.98 ± 0.03	85.5 ± 0.4
DB	7.98 ± 0.03	58.3 ± 0.2
BM	4.0 ± 0.03	57.0 ± 0.2
6M	25.02 ± 0.1	143.0 ± 0.5

Contents of Technology

1) Process Description

This carbon rod manufacturing process consists of seven unit processes, including the kneading, extruding, baking, cutting, impregnating, grinding and packing, with the following description.

Kneading

This is a process in which appropriate quantities of various raw materials, including graphite, binder, sulfur and blending agent, are weighed and mixed in a kneader with heating. The quality of carbon rods is directly influenced by this process. Therefore, all conditions in this process require to be so particularly adjusted as to ensure uniform weights of respective raw materials, as well as uniform mixing, mixing temperature, volume and softening point of binder, and mixing time.

Extruding

This is the process in which the mixture of raw materials is formed by a press to conform to the sizes of desired products. It is extruded through dies of fixed sizes to be cooled and cut. In this forming process, particularly the working conditions including the forming speed, temperature and pressure have to be precisely adjusted because of the frequent occurrence of cracks.

Baking

The formed semi-finished carbon rod products are piled in rows on a truck and then covered with sand and cokes to prevent the products from oxidation. Pushed into the kiln already preheated to a proper temperature, the formed carbon rods are calcined at the temperatures controlled by each zone.

Cutting

On completion of the calcination, the carbon rods are sufficiently cooled and cut to prescribed sizes (already marked when formed).

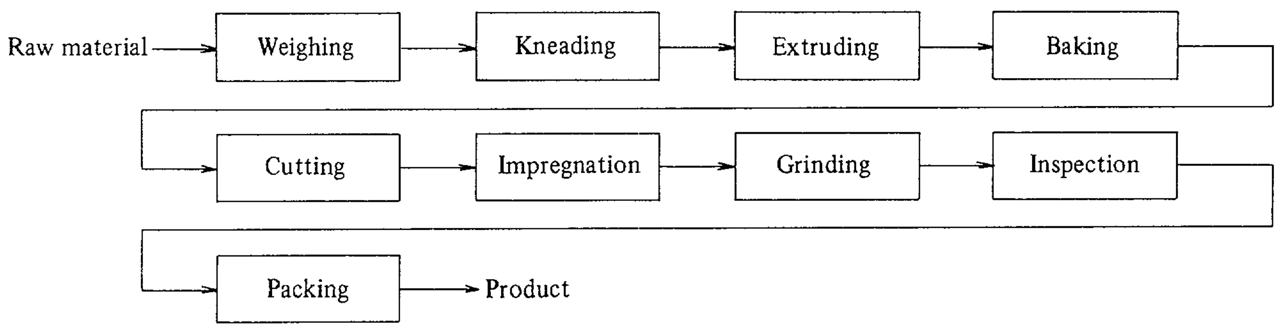
Impregnating

This is the process in which the carbon rods are given a waterproofing treatment to prevent the occurrence of solution leakage caused by the permeation of electrolytic solution into them. There are two methods of directly impregnating the carbon rods with paraffin wax, and dissolving solid paraffin in a solvent to impregnate them at proper temperatures, followed by the removal of the solvent.

Grinding

On completion of the impregnation, the carbon rods are ground and finished so that the sizes are in confor-

Carbon Rod Manufacturing Process Block Diagram



mity to specifications.

Inspection and packing

Following the grinding, the carbon rods are inspected as to dimensions, including the diameter and length as well as the condition of sectional grinding prior to packing in carton boxes for delivery.

2) Equipment and Machinery

- Crushing section
  - Hammer mill
  - Dust collector
  - Blower
- Kneading section
  - Kneader
  - Tar storage tank
  - Tar dehydration tank
  - Gear pump
  - Pitch dissolving tank
  - Binder mixing tank
- Extruding section
  - Extruder
  - Rotary cutter
  - Water tank
  - Transfer conveyor
- Baking unit
  - Tunnel kiln
  - Oil burner
  - Blower
  - Oil tank
  - Heavy oil preheating system
  - Subsidiary kiln
  - Dust collecting system
  - Carbon plate
  - Truck
  - Pusher
- Impregnation section
  - Impregnation tank
  - Chiller
  - Cooling tower
  - Solvent recovery system
  - Auto impregnator
- Grinding section
  - Feeding machine
  - Finishing facility
  - Dust collecting system

3) Raw Materials and Utilities

Raw materials and utilities	Requirement (per ton of product)
Graphite raw materials	680 kg
Binder	690 kg
Sulfur	28 kg
Others	6 kg
Electric power	560 kwh
Fuel	500 ℓ
Water	35 m^3

Example of Plant Capacity and Construction Cost

1) Plant capacity : 125 m/t/year
   * Basis : 24 hrs/day, 25 days/month

2) Estimated equipment cost (as of 1983)
   - Manufacturing equipment : US$1,600,000
   - Utility equipment : US$ 80,000

   Total : US$1,680,000

3) Required space
   - Site area : 5,100m^2
   - Building area : 1,800m^2

4) Personnel requirement
   - Manager : 13 persons
   - Engineer : 7 persons
   - Operator : 40 persons

   Total : 60 persons

Electronic Ballast for Fluorescent Lamp

Though the history of lamps are almost as long as that of electricity and various kinds of lamps have been developed, those with high efficiency have not been invented yet.

Among others, the fluorescent lamp is in the limelight due to its relatively reasonable efficiency and, thus, is most widely used nowadays. The fluorescent lamps, however, require high voltages at the beginning of the lighting instant as in the cases of the other discharge tubes, and maintain almost constant voltages during the lighted interval, which makes it difficult to light the lamps with good efficiency.

Many approaches have been developed to light the fluorescent lamps with good efficiency since the invention of lamps. However, the conventional choke ballasts developed in early days are still considered to be the most popular ones nowadays in spite of their many shortcomings for reasons of technical difficulties and economics of other methods.

As high voltage and high speed transistors are available with low cost, the development of highly effcient and reliable electronic ballasts using semiconductor devices can be considered nowadays.

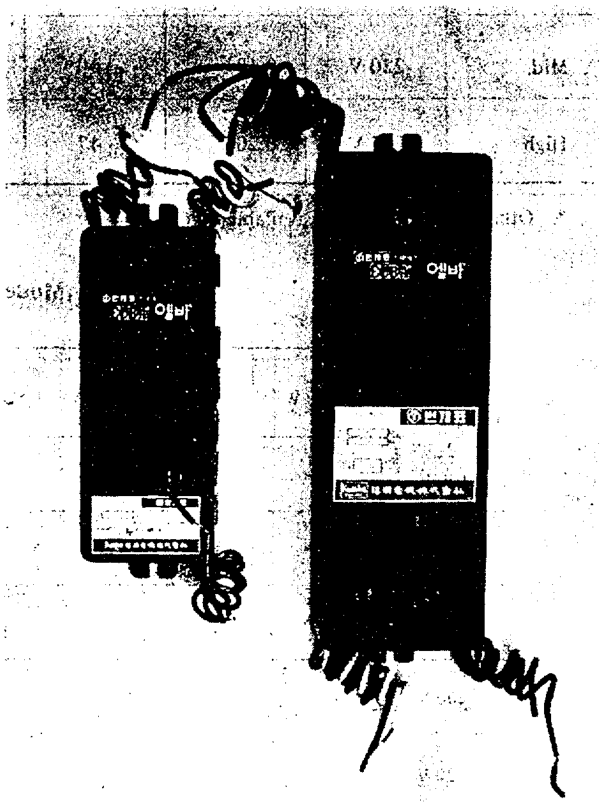
Furthermore, the need for such electronic ballasts with better efficiency has been ever increasing as the cost of energy increases day by day.

Therefore the present invention relates to a transistor inverter for lighting the fluorescent lamp with very good efficiency.

Firstly, we will briefly examine the characteristics of the invention below in comparison with the conventional choke ballasts.

Several modified configurations are possible, but the characteristics are almost the same with all of those using choke ballasts. The major demerits of the method are as follows:

- Power loss of the choke which can be classified into the following two cases :
  One is the resistance loss of the copper wire so-called "copper loss", and the other is the hysterisis loss of the iron core so-called "hysterisis loss". It generally becomes 25 percent or more of the total power due to the above two factors.
- The weight of the choke ballast is very heavy due to the existence of the iron core.



View of Electronic Ballast

- Audible noise (60Hz hum) is generated due to the vibration of the iron core.
- Line power factor which causes redundant power loss in the transimission line becomes low if not compensated by inserting external capacitors, resulting additional loss.

These demerits can be eliminated by using transistor inverter instead of the conventional choke ballast.

Products and Specifications

In this plant, almost every kind of ballasts for fluorescent lamps are produced including those for buses, trains and airplanes.

Specifications of current products are as shown in table 1 and types of the ballasts produced are as shown in table 2.

Table 1. Specifications of FLX-40SF

Line condition	Input voltage(V)	Input current(A)	Input power(W)	Power factor(%)	Lamp voltage (V)	Lamp current (A)	Light output (Lumen)	Freq. (KHz)
Low	198 V	0.186	35	95.2	102	0.302	2.050	28.8
Mid.	220 V	0.191	40	95.0	99	0:371	2.450	28.6
High	242 V	0.205	47	94.7	96	0.441	2.750	27.7

* Other specifications are available on order.

Table 2. Models of Electronic Ballast

Watt / Voltage	10 W	15 W	20 W	20 W x 2	30 W	40 W	40W x 2	110 W	110 W x 2
100 V	*	*	*	*	*	*	*	*	*
110 V	*	*	*	*	*	*	*	*	*
120 V	*	*	*	*	*	*	*	*	*
200 V			*	*	*	*	*	*	*
220 V			*	*	*	*	*	*	*
254 V				*		*	*	*	*
12V (DC)	*	*	*						
24V (DC)	*	*	*						

* The asterisk means available products.

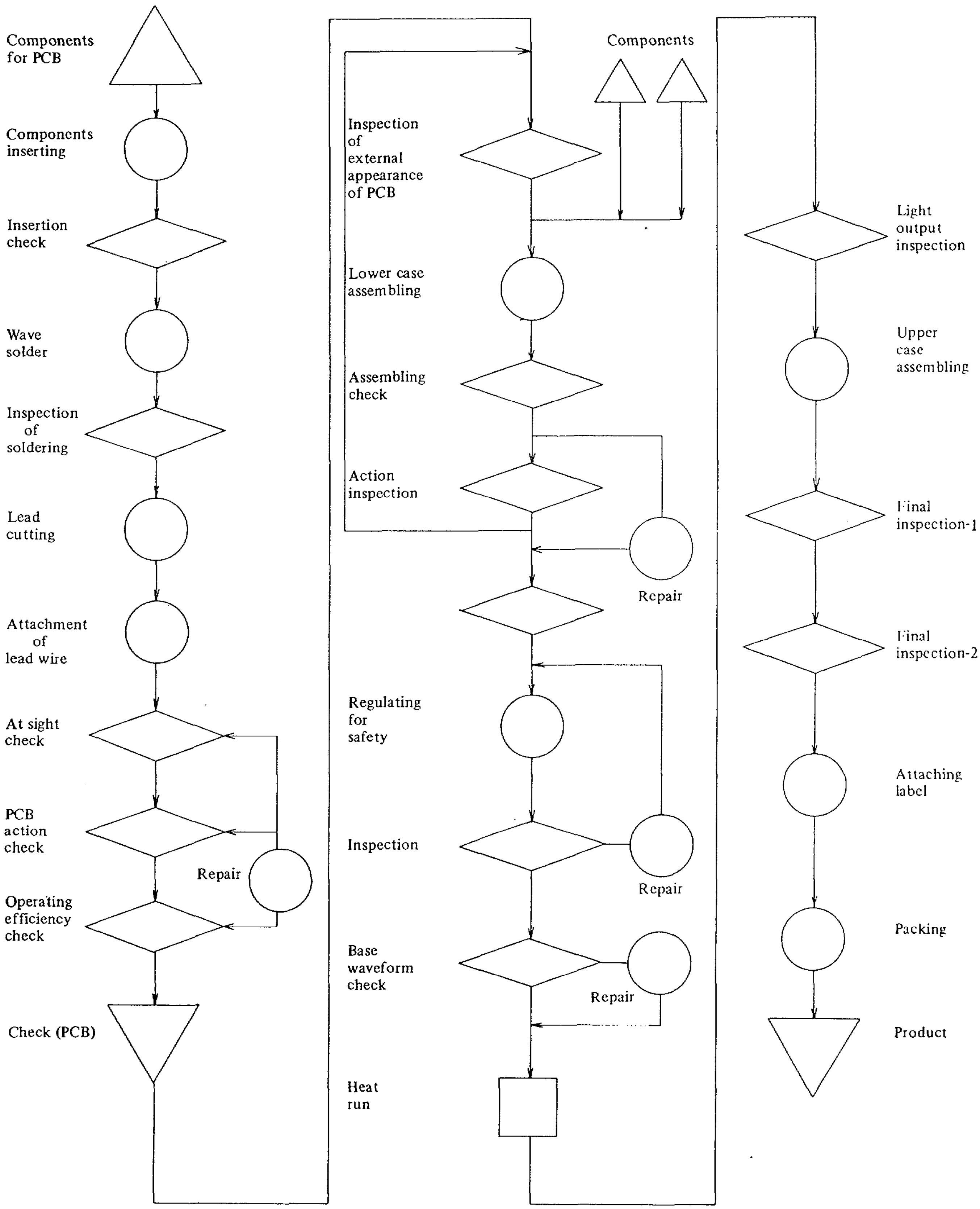
Contents of Technology

1) Process Description

An extremely efficient and low cost resonant self-ocillated electronic ballast especially suitable for a fluorescent lamp load is achieved by employing a small ferrite core transformer for an isolated base power of the high frequency transistor inverter. Both the exact compensation of the turn-off time delay originating from the storage time of the transistor and the sustained self-oscillation of the inverter are achieved by controlling the magnetization of the current transformer of which the primary winding is connected in series with the series resonant circuit.

Base currents of the transistors are controlled in synchronization with the circuit resonant current with a proper conducting interval adjusted by the externally controlled magnetization of the small ferrite core transformer, resulting in minimum switching losses in the transistors.

Electronic Ballast Assembling Process Flow Diagram



2) Equipment and Machinery

Manufacturing equipment
- Automatic inserting machine
- Automatic soldering machine
- Lead cutting machine
- Conveyor
- Varnishing equipment
- Temperature controller chamber
- Air driver

Test equipment
- Signal generator
- Freq. counter
- Temperature check meter
- True RMS volt meter
- True RMS ampere meter
- True RMS digital watt meter
- Vector impedance meter
- Power factor meter
- Total lumen check system
- Power supplier
- Spectrum analyzer

Example of Plant Capacity and Construction Cost

1) Plant capacity : 3,600,000 pcs/year
   * Basis : 8 hours/day, 330 days/year

2) Estimated equipment cost (as of 1983)

o Equipment for manufacturing	:	US$ 500,000
o Utility facility	:	US$ 250,000
Total	:	US$ 750,000

3) Required space
- o Site area : 16,281 m^2
- o Building area : 4,340 m^2

4) Personnel requirement

o Manager	:	5	persons
o Engineer	:	10	persons
o Technician	:	20	persons
o Others	:	100	persons
Total	:	135	persons

Any inquiry about the information contained should be sent to:
IO/COOP, Registry file No. ID/562/12, UNIDO, P.O. Box 300, A-1400 Vienna, Austria

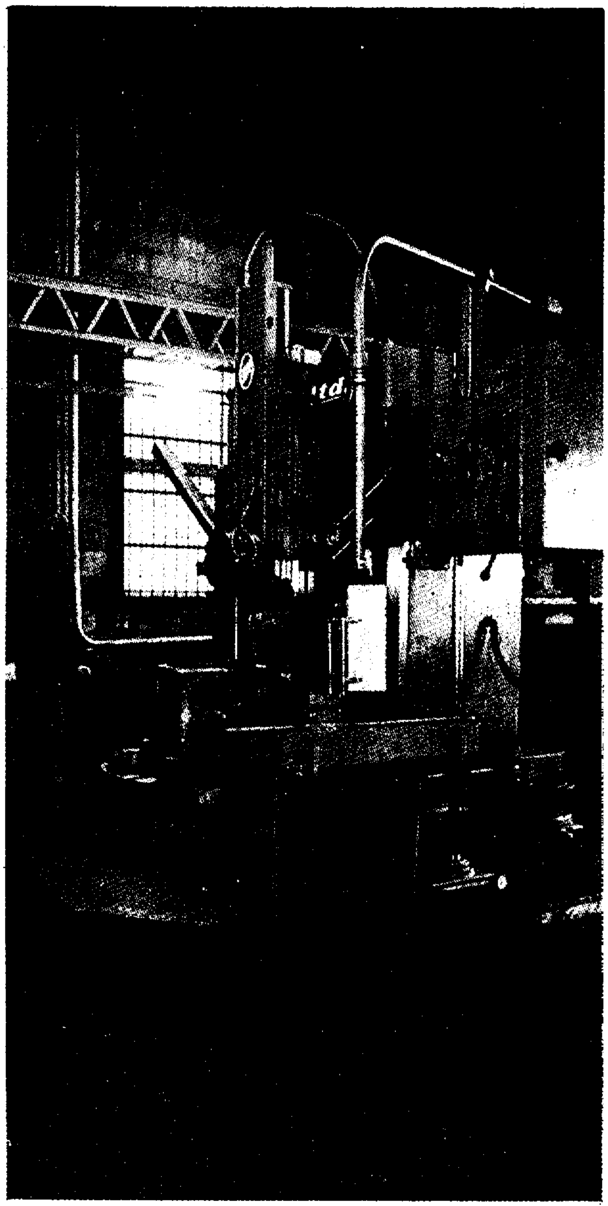
V. S. Motor Assembling Plant

As the industries develop and diversify, rather than the motors with fixed revolution, the variable speed motors of large variable speed ratio and easy maintenance and operation have been in greater demand. The V.S. motor is largely divided into the induction motor part which is a driving motor, the V.S. coupling part consisting of the fixed speed rotating part directly connected to the driving motor and the accelerating part connected to the load side, and the speed controlling part, which serves the purpose of ensuring that a deviating voltage is fed back to the input of an amplifier by comparing at all times the detected voltage fed back from the tacho-generator and proportional with the voltage and loaded speed set by the control board.

Such a V.S. motor displays the function quite different from ordinary motors in the controlling part. When the set voltage is larger than the detected voltage, namely the detected voltage is smaller than the set voltage, the amplifier dimnishes or amplifies its magnitude and then generates the pulse for controlling the phase in combination with the phase shifter.

If this pulse signal is amplified and the SCR (silicon controlled rectifier), which is a semiconductor for controlling the electric current of the excitation coil, is turned on with an appropriate phase angle, the excitation current is controlled. The degree of torque transmission changes depending upon the excitation current. The change of rotation on the load side changes the detected voltage, leading to the comparison with the set voltage. It is the principle of controlling the speed of V.S. motors to ensure the stabilization of loaded speed through such continuous feedback controls.

The V.S. motors have a variety of uses not only in independent variable speed operations but also in such industries as cement, paper making, textile, electric wire and steel making.

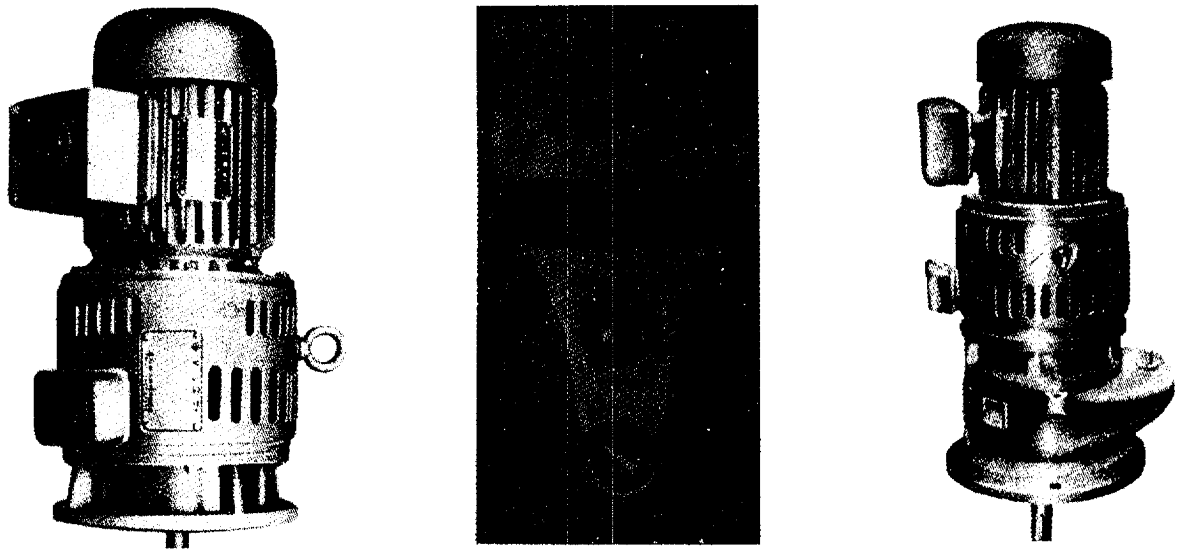


View of Vertical Turret Lathe

Products and Specifications

This plant is capable of manufacturing on order a variety of models ranging from 0.4 kw to 75 kw in capacity to suit uses and places, with the following characteristics:

- Electronically connected in operation, it has no part subject to wear and tear, coupled with long service life and ease of maintenance and inspection.
- Wide-ranging in the speed ratio (1:10), it has good variable characteristic both at low speed and high speed.
- Almost 100% in the driving torque transmission efficiency of the driving motor, its output also



View of Products

exhibits a positive troque.

- Its speed fluctuation is well within 2% in case of ordinary type and 1% in case of special type.
- The control board requires insignificant control current.
- Diversified in uses depending upon the selection of control board, the VS motor is simple and substantial in structure and easy of handling.

Table 1. Specification of V.S. Motor

Model	• Water-cooled type: Above 150 HP • Self-cooled type: Below 125 HP
Scope of speed control	• 10 : 1 General type : 150-1,500 rpm Low speed type : 100-1,000 rpm High speed type: 330-3,300 rpm
Speed fluctuation rate	1%: When V type control board is in use 2%: When F type control board is in use * In case the loaded torque varies between 100% and 10%
Driving motor	General type : 4-pole Low speed type : 6-pole High speed type: 2-pole
Tacho-generator	720-cycle, 48-pole: Above 19 Kw 360-cycle, 24-pole: Below 19 Kw

Contents of Technology

1) Process Description

Such component parts of the motors as brackets, drums, frames and inductors are inspected as to appearance and dimensions and conveyed to the lathe. These parts are machined in the first process by the CNC lathe and undergo intermediate inspections not to allow the occurrence of any defective parts.

After inspections, the parts are machined for bolt holes by drilling and taping machines, followed by the broaching of key grooves and removing of rust prior to balancing. On completion of these machinings, the parts are subjected to the final intermediate inspection.

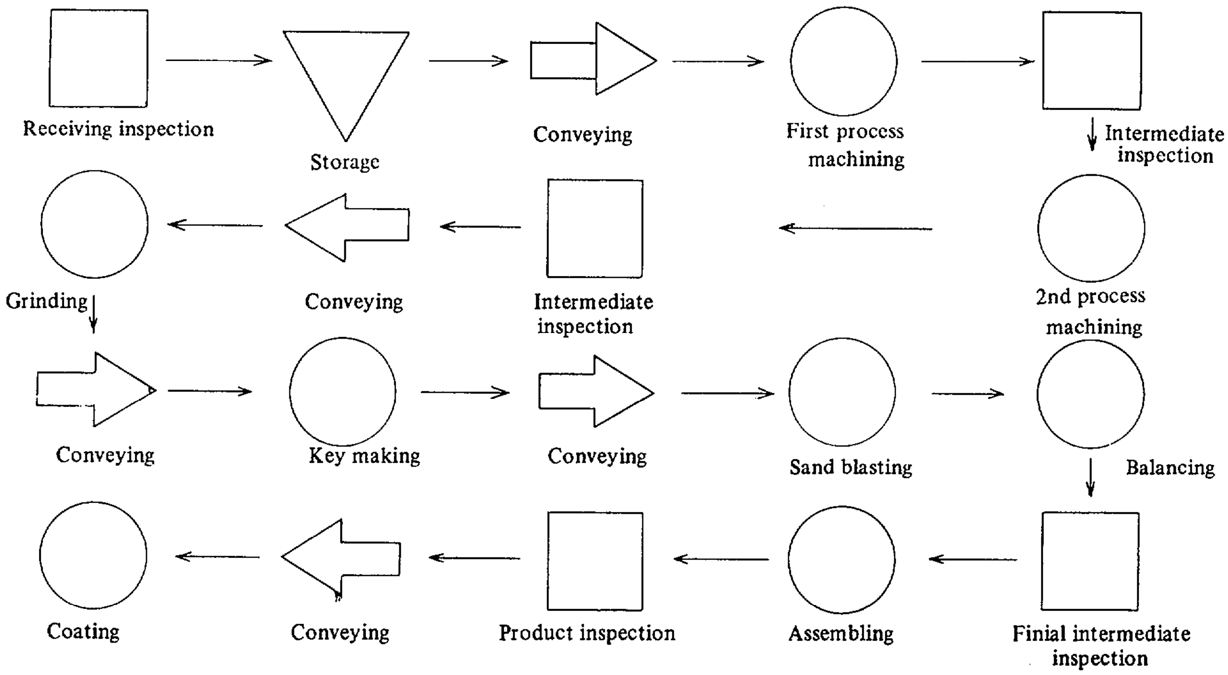
Respective parts (bracket, drum, frame and inductor) are assembled for the final inspection and coating by spray gun prior to delivery. Thus the motors, which are relatively simple in manufacturing process but display sufficient performances, are produced.

With respect to controllers, such products with diverse uses and functions as the half-wave control for 100 HP and below and large-capacity full-wave control 100 HP and above, as well as proportionate control for running two machines at the same speed and optical detection control for controlling the motor speed at will by amplifying the light beam are produced.

2) Equipment and Machinery

CNC Machining center
CNC Lathe
NC Lathe
Automatic cylindrical grinder
Plane grinder
Slotter
Vertical lathe
Rivetting machine
Milling machine
Shaper
Universal tool grinder
Multi spindle drilling machine
Tapping machine

V.S. Motor Assembling Process Flow Diagram



Example of Plant Capacity and Construction Cost

1) Plant capacity : 1,000 set/month
   * Basis : 20 hrs/day

2) Estimated equipment cost (as of 1982)

○ Equipment & machinery	: US$ 500,000
○ Utility	: US$ 250,000
Total	: US$ 750,000

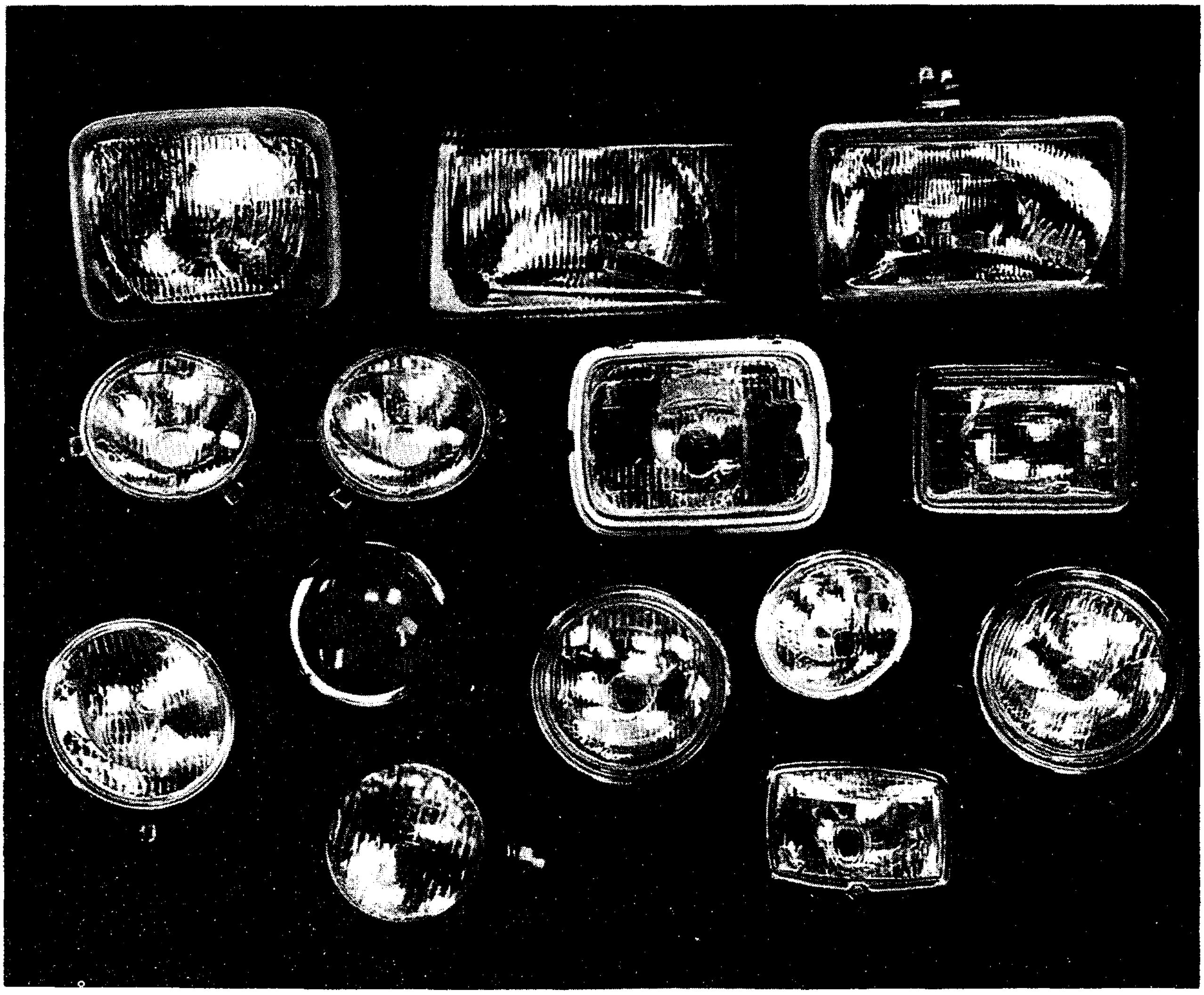
3) Required space

○ Site area	: 2,300 m^2
○ Building area	: 990 m^2

4) Personnel requirement

○ Plant manager	: 1 person
○ Engineer	: 10 persons
○ Specialist	: 40 persons
○ Others	: 10 persons
Total	: 61 persons

Head Lamp Making Plant



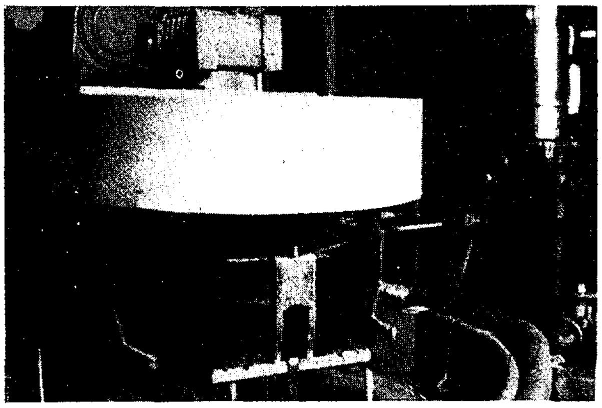
View of Products

The company introduced here has been producing various types of head lamps for use by automobiles since early 1954 and has a capacity of annually producing some 700,000 sets of this item as of the end of 1982.

It is a specialized head lamp maker in Korea with manufacturing technologies based on respective specifications of the KS (Korean Industrial Standards), SAE and EEC, currently supplying most of the head lamps for assembling domestic automobiles.

Enjoying higher added values than other ordinary automotive parts, the head lamp manufacturing field has an excellent marketability in terms of already guaranteed after-sales service markets. However, it is one of the technology-intensive industries involving difficulties in learning its manufacturing technology, requiring to introduce advanced technical know-how for doing so in a short span of time.

The semi-sealed beam head lamps being produced by this company are basically of the economical bulb-replacing type. Producing diverse items in many required types depending upon the model of automobiles, this company can also quickly respond to any market demand under the circumstances.



View of Facilities

Products and Specifications

This company can produce semi-sealed beam head lamps for both automobiles and motorcycles. Various model types and specifications are as shown below.

Table 1. Product Specifications

Model No.	Type	Dimension	Lens (F)
HL–02–182	Rectangular	200 x 142 x 130mm	F = 28.5 mm
HL–01–181	Rectangular	264.1 x 182.8mm	F = 28.5 mm
SSB–16	Round	178.6 diam.x 120mm	F = 26 mm
SSB–13	Round	142.7 diam.x 103mm	F = 30mm
FL–1001	Rectangular clear fog	163.5 x 88.5 x 62mm	F = 27 mm Replacement lens
FL–1001	Round clear fog	136 diam.x 60mm	F = 32 mm Replacement lens
FL–1021	Rectangular amber fog	163.5 x 88.5 x 62mm	F = 27mm Replacement lens
FL–1031	Round amber fog	136 diam.x 60mm	F = 32 mm Replacement lens
PL–1081	Rectangular passing	163.5 x 88.5 x 62mm	F = 27 mm Replacement lens
PL–1091	Round passing	136 diam.x 60mm	F = 32 mm Replacement lens
SL–1041, 1051	Round spot	136 diam.x 60mm	F = 27 mm Colori clean, amber
DL–1061	Rectangular driving	163.5 x 88.5 x 62mm	F = 27 mm Replacement lens
DL–1071	Round driving	136 diam.x 60mm	F = 32 mm Replacement lens

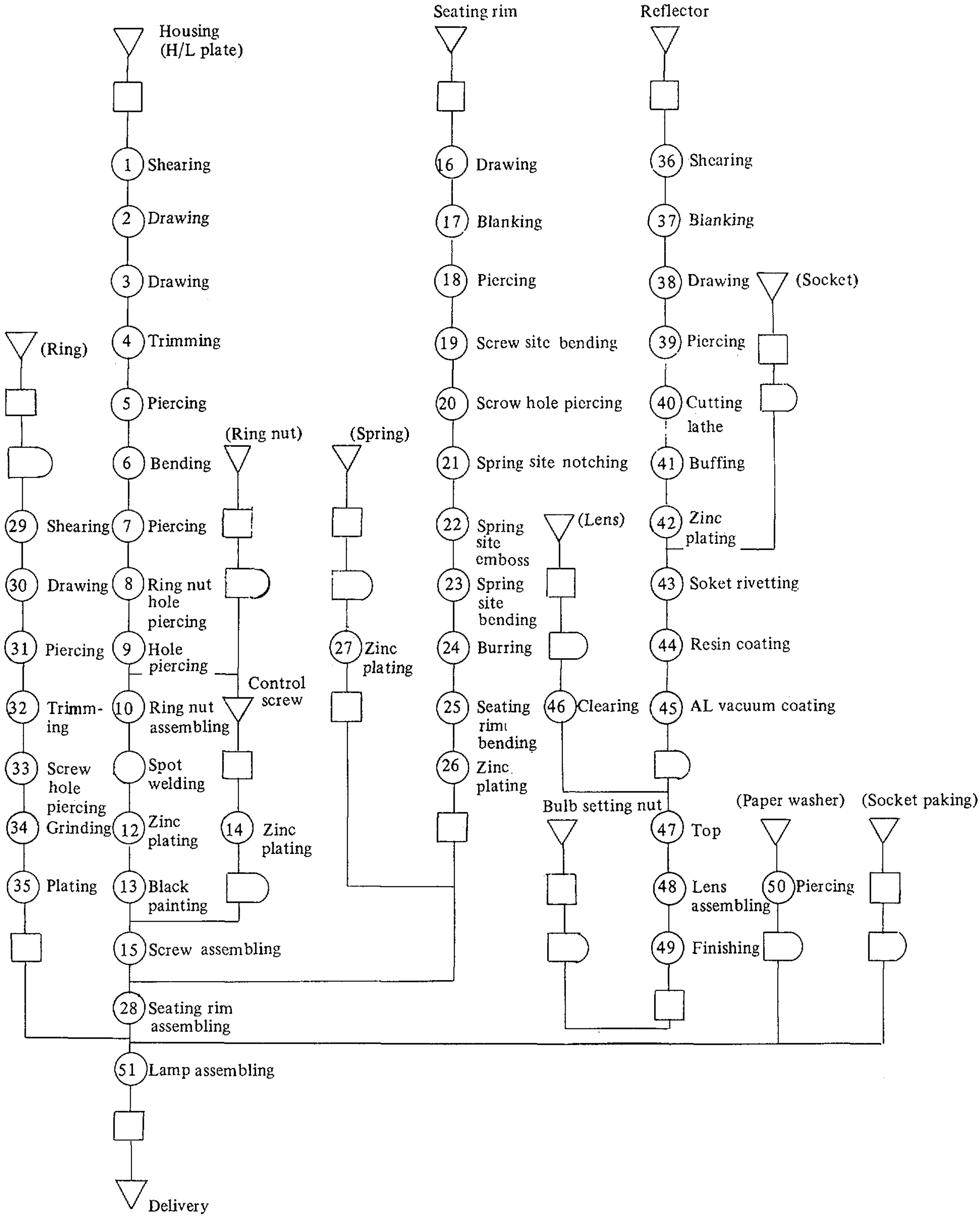
Contents of Technology

1) Process description

The raw materials for housing, seating rim and deflector are first cut by a shearing machine to the requirement of respective sizes and then machined in drawing, trimming, piercing and bending by a pressing machine.

Where necessary, the parts are adhered together by spot welding and undergo buffing for subsequent surface treatment by zinc plating and aluminum vacuum coating. After fitting and assembling the housing, seating rim and reflector, the finished head lamp is subjected to light distribution, water-tightness and vibration tests prior to packing for delivery.

Head Lamp Assembling Process Flow Diagram



2) Equipment and Machinery

Cutter
Hydraulic and power press
Spot welding machine
Plating equipment
Buffing machine
Vacuum coating machine
Drying furnace
Assembling equipment

3) Raw Materials and Utilities

- Automobile head lamp

Raw materials and utilities	Requirement (per ea of product)
Steel plate (0.6mm)	500 g
Lens	600 g
Epoxy resin	25 g
PE resin	15 g
Paint	30 g
Electric power	400 w
Bunker-C oil	30 cc
Water	5 ℓ

Example of Plant Capacity and Construction Cost

1) Plant capacity : 20 ,000 set/year

2) Estimated construction cost (as of 1982)

- Equipment and machinery : US$666,000
- Utilities : US$ 66,000
- Installation cost : US$ 66,000

Total : US$798,000

3) Required space

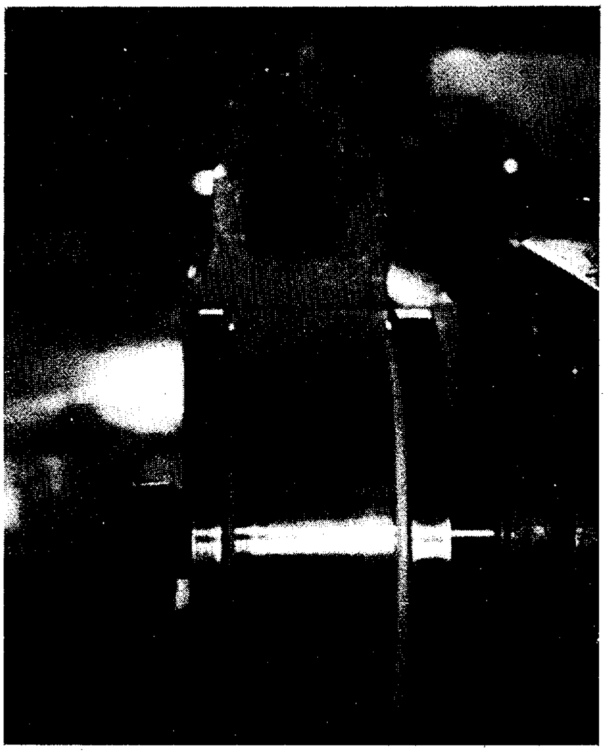
- Site area : 9,720 m^2
- Building area : 3,240 m^2

4) Personnel requirement

- Plant manager : 10 persons
- Engineer : 5 persons
- Operator : 30 persons
- Others : 20 persons

Total : 65 persons

Arc Welding Electrode Making Plant



View of Arc Welding Wire

It is generally known that the quantity of steel consumed in a country can be utilized as a barometer for judging the economic growth or level of development of that country. In other words, this means that the iron and steel industry makes a great contribution to the economy of a country.

In a wide range of related industries, the welding materials manufacturing is one of the most important sectors and indispensable for the industry since many welded steel products are used for household appliances, bridges, machines, pipelines, automobiles, railroad equipment, buildings and so forth.

From this point of view, it is especially recommended to developing countries to construct an arc welding electrode making plant and consolidate their industrial foundation.

Of about 40 different welding processes being used today, the arc welding process is most versatile.

Shown here is a minimum yet highly efficient plant for 150 metric tons per month of arc welding electrodes. (working hours: 8 hour/day x 25 days/month= 200 hours/month)

Products and Specifications

○ For welding steel plates (KR-3000)

Application

- Excellent slag fluidity.
- Shallow penetration and excellent operational characteristics in the welding of thin plates.
- Easy regeneration.
- Beautiful bead appearance.
- Stable and concentration.

Characteristics in use

- KR-3000 is titania type electrode for or positions and suitable for the welding of sheets and light gauge steel plates with complicated form and curved joints.
- The electrode below 3.2mm in diameter can be easily used for vertical downward welding.

○ For highly efficient butt and fillet welding (K-7014)

Application

- All position fillet welding of ship structures, bridges, structural steels for buildings and general structures.

Characteristics in use

- K-7014 is an iron powder rutile type electrode which is designed to attain high efficiency in single pass and multi-layer welding.

○ For highly efficient welding of 50kg/mm^2 class high tensile steel (K-7018)

Application

- Welding of industrial machinery and mining machinery.
- Welding of mild steel and 50kg/mm^2 class high tensile steel of ships, bridges, tanks and buildings.

Characteristics in use

- K-7018 is an iron powder low hydrogen type electrode which has been designed for the use on heavy duty structures in all positions.
- Its usability is also good with direct current applications. Dry the electrodes at 300-350°C for 30-60 minutes befor use.
- Keep the arc as short as possible.

○ For highly efficient fillet welding (K-7024)

Application

- Horizontal and flat fillet welding of ship structures, bridges, structural steels for buildings and general structures.

Characteristics in use

- K-7024 is an iron powder rutile type electrode which is designed to attain high efficiency in single pass horizontal and flat welding.
- Its arc is quiet and stable. Its slag removes of itself. Apperance of weld metal is extremely good.
- No under-cuts form. It is also applicable to gravity welding.
- In the case of horizontal fillet welding, keep the optimum speed ratio at 1.0 - 1.5.
- Dry electrodes at 70 - 100°C for 30 - 60 minutes before use, because excessive moisture absorption causes undercut and irregular beads.

○ For highly efficient welding of 50kg/mm^2 class high tensile steel (K-7028)

Application

- Flat and horizontal fillet welding of 50kg/mm^2 class high tensile steel structures, large size steel coatings and strength members of ship hulls.

Characteristics in use

- K-7028 is an iron powder low hydrogen type electrode for exclusive use in flat and horizontal fillet welding.
- Its deposition rate is extremely high and its slag removability is also good. Therefore, working hour is shortened and it is very efficient.
- Further efficiency is also improved by auto-contact and gravity welding.
- Dry electrodes at 300-350°C for 30-60 minutes befor use.
- Keep the arc short.

○ For 50kg/mm^2 class high tensile steel (KK-50)

Application

- Welding of 50kg/mm^2 class high tensile steel for ships, bridges, buildings and pressure vessels.

Characteristics in use

- KK-50 is the most popular electrode for 50 kg/mm^2 high tensile steel.
- Its usability is good in all positions and it deposits weld metal of high quality.
- Dry electrodes at 300°C-350°C for 30-60 minutes befor use.
- It has excellent crack resistance because of extremely low diffusible hydrogen content of deposited metal and remarkably decreases the preheat temperature required for prevention of cracks.

Table 1. Typical Chemical Composition of Weld Metal (%)

Items \ Elements	C	Mn	Si	P	S
KR-3000	0.07	0.43	0.32	0.014	0.008
K -7014	0.08	0.60	0.35	0.017	0.010
K-7018	0.07	1.06	0.57	0.012	0.011
K-7024	0.08	0.60	0.35	0.019	0.014
K-7028	0.07	0.81	0.58	0.012	0.01
KK-50	0.08	1.03	0.62	0.011	0.009

Table 2. Typical Mechanical Properties of Weld Metal

Items \ Properties	YP (Kg/mm^2)	TS (Kg/mm^2)	EL (%)	2mm V-notch (Kg-m) (0°C)
KR-3000	42.6	46.3	29.7	6.5
K-7014	48.0	54.0	28.0	8.0
K-7018	50.0	59.0	31.0	8.2(-29°C)
K-7024	48.0	54.0	28.0	7.0
K-7028	45.1	55.3	31.2	10.5(-18°C)
KK-50	48.0	57.3	32.6	8.6(-29°C)

Contents of Technology

1) Process description

Descaling

Mechanical descaler is used for descaling.

Wire drawing

Wire rod is drawn to a required diameter after descaling.

Straightening and cutting

Drawn wire is straightened and cut into a length of 350mm or 400mm generally.

Flux annealing

Premixed flux is annealed with a binder (sodium silicate or potassium silicate).

Molding

Annealed flux is pressed and molded into a cylindrical shape to make easier flux charging into extruder at a coating shop.

Coating

Cut wire is fed from wire feeder and coated with pressed flux in the extruder. After pressing through the coating die the coated electrodes are placed on the conveyor. While the coated electrode is running on the transfer conveyor, the coated flux is removed to make contact with a holder and are end permitting easy arc striking when start welding thus the electrodes shaped are taken out by hand at the end of conveyor with frames.

Drying

The frames are mounted on a cart. The cart is put into the drying oven where hot air circulates and vaporizes the moisture in thd binder.

Inspecting

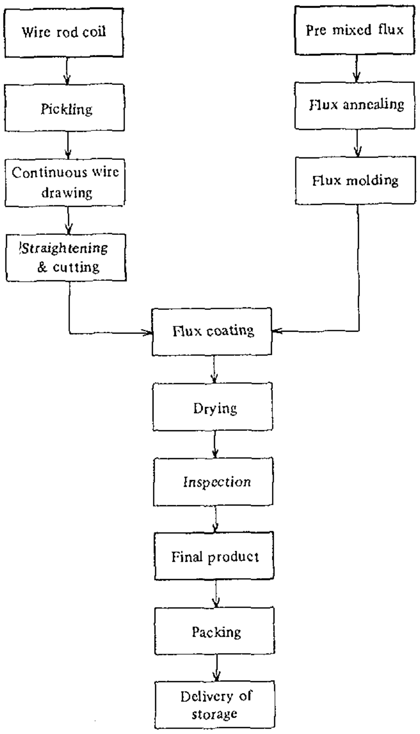
Final products are subject to the visual inspection and other specific inspections (actual welding test, etc).

Packing and shipping

Table 3. Size Available and Recommended Currents

KR–3000	Dia (mm)		2.6	3.2	4.0	5.0	6.0	–	AC or DC±	Approved by: KR, ABS, LR, NV, NK, BV, KS.
	L (mm)		350	350	400	400	450	–		
	A	F	50-100	80-130	140-180	180-230	260-320	–		
		V & O	50-90	60-110	110-160	120-160	–	–		
K–7014	Dia (mm)		3.2	4.0	5.0	5.5	6.0	–	AC or DC –	Approved by: ABS, LR, NK
	L (mm)		400	450	450	450	450	–		
	A	F	90-140	150-210	200-240	220-270	250-320	–		
		V & O	60-90	110-160	120-160	–	–	–		
K–7018	Dia (mm)		3.2	4.0	5.0	5.5	6.0	–	AC or DC ±	Approved by: KR, ABS, LR, NK, NV.
	L (mm)		400	450	450	450	450	–		
	A	F	90-140	130-185	190-250	230-285	250-320	–		
		V & O	80-120	110-180	160-210	–	–	–		
K–7024	Dia (mm)		4.0	4.5	5.0	5.5	6.0	7.0	AC or DC –	Approved by: KR, ABS, LR, NK, NV.
	L (mm)		450 550	450 550	450 550 700	450 550 700	450 550 700	450 550 700		
	A		150-210	180-230	240-290	260-320	280-380	350-400		
K–7028	Dia (mm)		4.0	5.0	5.5	6.0	6.4	7.0	AC or DC +	Approved by: ABS, LR, NV.
	L (mm)		450	450-500	450 550 700	450 550 700	450 550 700	450 550 700		
	A	F	160-220	200-250	220-270	270-320	290-340	310-360		
	Leg Length		5.5-6.5	6.0-7.0	6.5-7.5	7.0-8.0	7.5-8.5	8.0-9.0		
KK–50	Dia (mm)		3.2	4.0	5.0	6.0	7.0	–	AC or DC +	Approved by: KR, ABS, BV, GL, LR, NK, NV.
	L (mm)		350	400	400	450	450	–		
	A	F	70-130	150-190	210-250	250-300	270-400	–		
		V & O	70-100	120-160	130-180	–	–	–		

Arc Welding Electrode Manufacturing Process Flow Diagram



2) Equipment and Machinery

Drawing
- Supply stand
- Mechanical descaler
- Wire washing unit
- Degreaser
- Drying room
- Drying machine
- Pointer
- Butt welder

Straightening and cutting
- Supply stand
- Straightening and cutting machine

Flux annealing
- Annealer (Wet mixer)
- Binder tank

Flux moulding slag press

Coating
- Extruder
- Wire feeder
- Transfer conveyor
- Brushing conveyor

Drying
- Drying oven
- Combustion chamber
- Eccentricity tester
- 1T hoist crane
- Forklift
- 1,000 KV transformer
- Piping and wiring materials

3) Raw Materials and Utilities

Raw materials and utilities	Requirement (per ton of product)
Wire rod	0.77 ton
Pre-mixed (flux)	0.23 ton
Flux binder	0.03 ton
Electric power	250 kw
Water	1.67 m^3
Kerosene	22.7 ℓ

Example of Plant Capacity and Construction Cost

1) Plant capacity : 300 m/t/month
 * Basis : 8 hours/day, 25 days/month

2) Estimated construction cost (as of 1983)

- o Equipment and machinery : US$636,000
- o Utility facility : US$133,000
- o Installation cost : US$ 63,000

Total : US$832,000

3) Required space

- o Site area : 6,400m^2
- o Building area : 3,240m^2

4) Personnel requirement

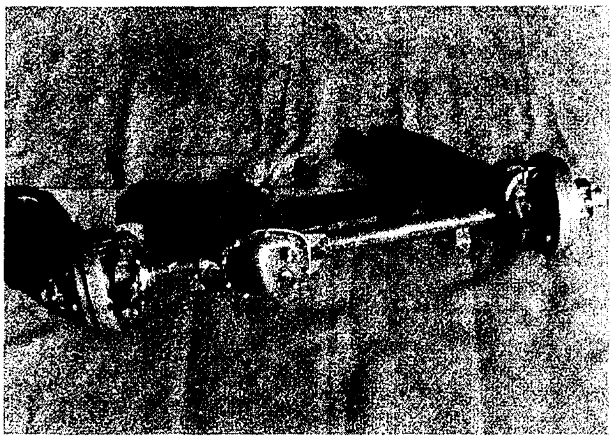
- o Manager : 4 persons
- o Engineer : 6 persons
- o Operator : 28 persons

Total : 38 persons

Any inquiry about the information contained should be sent to:

IO/COOP, Registry file No. ID/562/12, UNIDO, P.O. Box 300, A-1400 Vienna, Austria

Front & Rear Axle Making Plant



View of Product

The products to be produced under the technology license are the front and rear axles of respectively 4-wheel driven cars and front axles of 2-wheel driven vehicles.

Characteristics of this product are that the safety is outstanding when driving because of the use of Birfield joint as driving axle in the front, requiring no repair in addition to its light weight and accuracy in braking power.

The prospective licensor has a long-time experience along with the know-how related to the machining, heat treatment and assembling required for the manufacture of the product, as well as exclusive and general-purpose facilities, layout of manufacturing facilities, inspection and testing equipment and design and draft capabilities.

Products and Specifications

Product	Type	Specification
Front axle	• Total floating type • Birfield joint or U-joint	Engine 1,000-5,000cc, front axle and rear axle
Rear axle	• Internal expansion type drum, oil brake • Dead axle	

Contents of Technology

1) Process Description

As to the manufacturing process of this product, it is different for each component part, but explanations will be made by largely grouping similar parts or typical parts. The typical parts break down into the carrier, knuckle and arm, and yoke.

Manufacturing process for the carrier

Such component parts as case, gears and seal are necessary for the carrier but explanations will be mainly on the carrier as typical part.

Following the milling, the triplex head boring is carried out with the milled surface as the base. Securing of the base level is important as a matter of course, and the concentricity between the two boring holes as well as the degree of right angle of the three boring holes are also extremely important. Therefore, the machining is performed by the special triplex head boring machine.

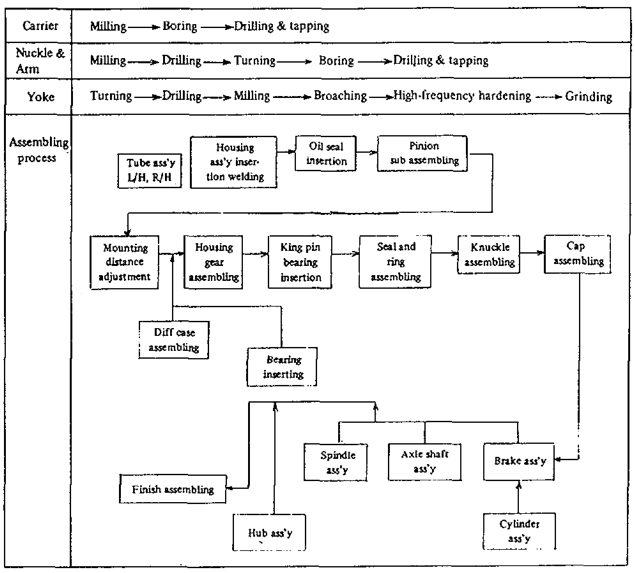
Knuckle and arm

The manufacturing process includes the milling, drilling, tapping and boring.

Yoke

Following the turning, there follow such works as drilling, milling, broaching, high-frequency hardening and grinding, requiring sufficient experience and technology for the manufacture of special tools and management of concentricity and precision.

Front Axle and Rear Axle Manufacturing Process Flow Sheet



2) Equipment and Machinery

Radial drilling m/c
Upright drilling m/c
Vertical milling m/c
Horizontal milling m/c
Broaching m/c
Universal grinding m/c
Turret lathe
Boring m/c
Copy lathe
Lathe
Grinding m/c

Example of Plant Capacity and Construction Cost

1) Plant capacity: 12,000 set/year

2) Example of estimated construction cost (as of 1982)

o Equipment and machinery	:	US$ 2,500,000
o Utilities	:	US$ 500,000
o Installation cost	:	US$ 60,000
Total	:	US$ 3,060,000

3) Required space

o Site area	:	15,000m^2
o Building area	:	5,000m^2

4) Personnel requirement

o Plant manager	:	20 persons
o Engineer	:	30 persons
o Operator	:	100 persons
o Others	:	20 persons
Total	:	170 persons

Shock Absorber Making Plant

View of Shock Absorber Ass'y Line

It is the front and rear cushions that determine the smartness of motorcycle and pleasure of its riding. In particular, the built-in type (containing the cushion spring inside the fork pipe) making a good use of the function of front cushion constitutes its mainstream.

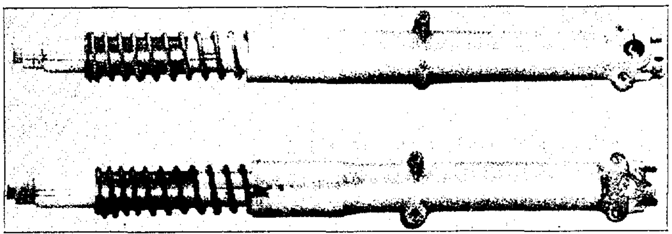
Moreover, based on the aluminum gravity casting, the front cushion cylinder is technically far ahead of other casting methods in terms of the stabilized product quality, its machining method also suiting the production of many different types in small numbers.

It is not only suitable for motorcycle manufacturers of developing and middle developing nations but also facilitates its export to third countries, being considerably worth the investment in such respects.

Products and Specifications

Table 1. Specifications of Shock Absorber

Product	Type	Specification
Front cushion	Strut	50-250cc motorcycle
Rear cushion	Shell	50-250cc motorcycle



View of Product

Contents of Technology

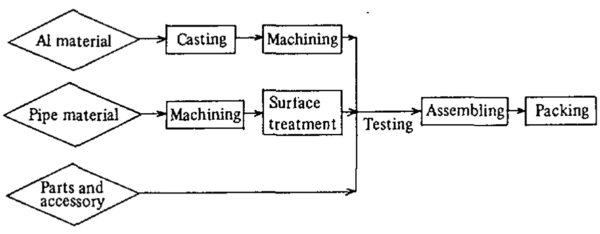
1) Process Description

Consisting of the machining, assembling and inspection in the production line, its machining breaks down into the cylinderical bottom case of cast aluminum and fork pipe as basic material, with other built-in materials supplied by specialized manufacturers.

The casting is of the gravity casting method, while the deep-hole boring method is used in machining. The machining of fork pipes includes the hard chrome coating and polishing work designed to prolong its service life.

The assembly section consists of the cleaning line, painting line and assembly conveyer line, while the inspection line consists of damping force test, endurance test and other tests of its characteristics, making a steady manufacturing work flow possible.

Shock Absorber Manufacturing Process Block Diagram



2) Equipment and Machinery

Shell core forming machine
Gravity casting machine
Welding machine

- Automatic lathe
- Polishing machine
- Chrome plating machine
- Ultrasonic cleaning machine
- Painting shop
- Baking shop
- Assembly machine
- Damping force tester
- Endurance tester
- Function tester
- Special tools

3) Raw Materials and Utilities

Raw materials and utilities	Requirement (per ea of product)
Al	4 kg
Pipe	8 kg
Wire	1 kg
Rubber	0.5 kg
Oil	1 kg
Plate	0.5 kg
Grease	0.1 kg
Air	1 m^3
Fuel	0.1 ℓ
Water	0.2 ℓ
Electric power	30 kwh

Example of Plant Capacity and Construction Cost

1) Plant capacity: 20,000 unit/month
   * Basis : 8 hr x 25 day

2) Example of estimated construction cost (as of 1982)

o Equipment and machinery	:	US$ 3,846,000
o Utilities	:	US$ 256,000
o Installation cost	:	US$ 641,000
Total	:	US$ 4,743,000

3) Required space

o Site area	:	9,720m^2
o Building area	:	3,240m^2

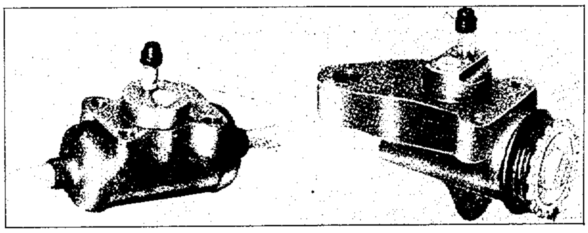
4) Personnel requirement

o Plant manager	:	1 person
o Engineer	:	10 persons
o Operator	:	50 persons
Total	:	61 persons

Any inquiry about the information contained should be sent to:
IO/COOP, Registry file No. ID/562/12, UNIDO, P.O. Box 300, A-1400 Vienna, Austria

FILE: Q25
ISIC 3843

Brake Cylinder Making Plant



View of Product

Brake cylinders for automobiles are divided into:
1. Brake master cylinder (tandem or single type)
2. Clutch master cylinder
3. Wheel cylinder
4. Release cylinder
5. Load sensing proportioning valve (for truck)

The brake cylinder requirement per specific type of automobile varies, that is the brake cylinder manufacturing technology requires adopting the method of producing many different types in small numbers, with each readily applicable manufacturing method also desirable when producing in quantities.

Accordingly, the system of manufacturing many different types of cylinders with small investments is absolutely necessary in middle developing automobile producing countries.

Products and Specifications

Master cylinder Wheel cylinder Release cylinder Load sensing proportioning valve	17.46-31.75mm in diameter

Contents of Technology

1) Process Description

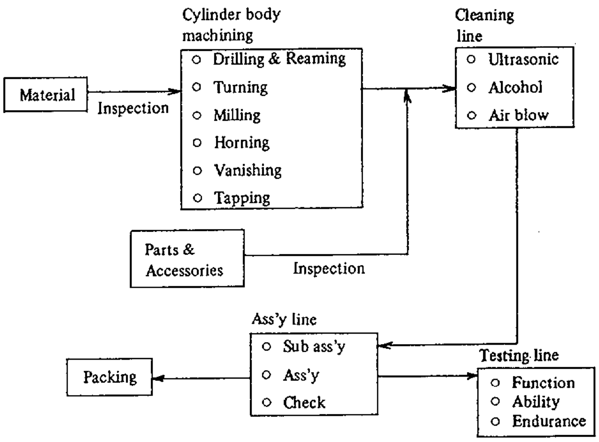
In this manufacutirng technology, basic materials. are supposed to be produced and supplied by specialized plants, while functional parts are supplied by other plants specializing in springs, rubbers, pistons and other special surface treatments, including the machining, assembling, inspection and performance test.

With respect to the machining, exclusive facilities suitable for machining mainly cast iron and aluminum products consist of an appropriate line for the production of many different types of brake cylinders in small numbers, including inspection in the machining process to detect inferior products.

The special horning work for inner accuracy and roughness as well as the special brushing technique with very inexpensive manufacturing cost requirement are also included.

In assembling, the process should include the ultrasonic washing, alcohol washing and inspection for thorough quality assurances, with various lines for testing its function and performance also included.

Brake Cylinder Manufacturing Process Block Diagram



2) Equipment & Machinery

Drilling & Reaming machine
Auto lathe
Milling machine
Tapping machine
Drilling & tapping machine
Turret drilling machine
Honing machine
Brushing machine
Ultrasonic cleaner
Assembling machine

Function tester
Endurance tester
Special tool

3) Raw Material and Utilities

Raw materials and utilities	Requirement (per ea of product)
Cast iron (FC25)	1.5 kg
Bar (S25C)	1.0 kg
Wire (SWPA)	0.5 kg
Steel sheet (SS41)	0.5 kg
Rubber	0.5 kg
Plastic (6-6 Nylon)	0.1 kg
Oil	20 cc
Air	0.5 lube
Water	0.1 ℓ
Electric power	20 kwh

Example of Plant Capacity and Construction Cost

1) Plant capacity: 50,000pcs/month
   * Basis: 8hr x 25 day

2) Example of estimated construction cost (as of 1982)

o Equipment and machinery	:	US$ 4,000,000
o Utilities	:	US$ 266,000
o Installation cost	:	US$ 666,000
Total	:	US$ 4,932,000

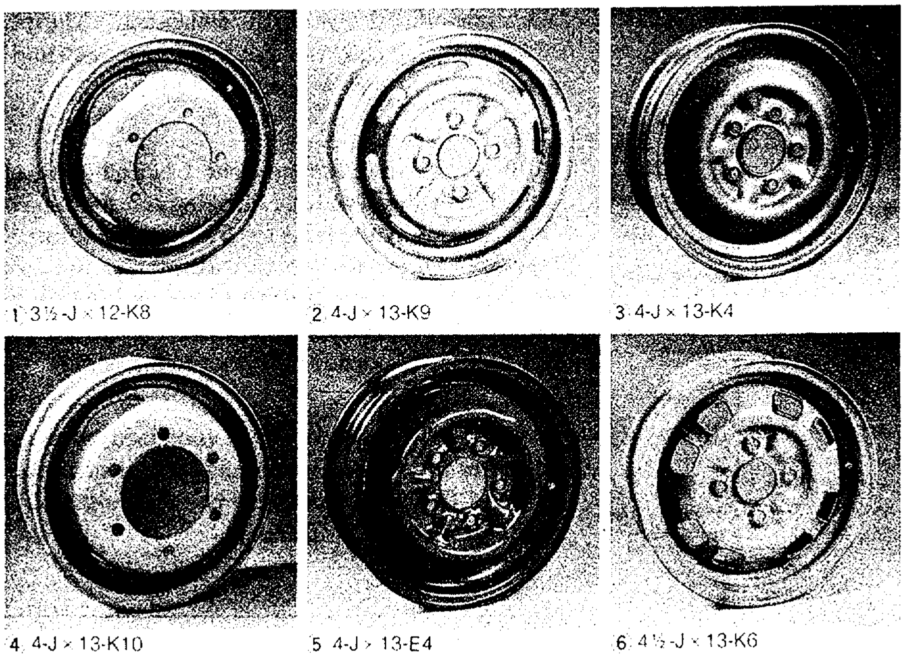
3) Required space

o Site	:	$9{,}720m^2$
o Building	:	$3{,}240m^2$

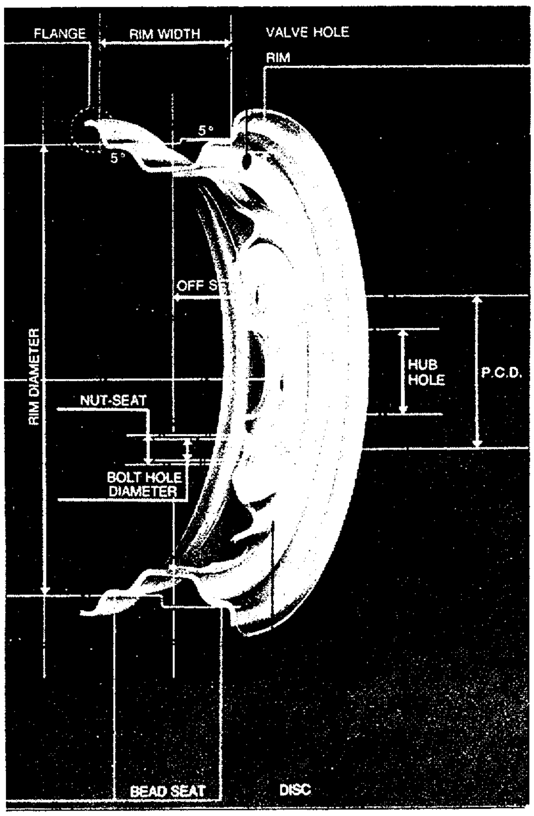
4) Personel requirement

o Plant manager	:	1 person
o Engineer	:	10 persons
o Operator	:	50 persons
Total	:	61 persons

Wheel Disc Making Plant



View of Products



View of Wheel Spec. Sheet

The wheel disc generally breaks down into the following three types:

1) Complete with tire
2) Rim only
3) Rim and disc

Here, explanations will be made on the case 3) of assembled rim and disc.

As specialized plant designated by the government in 1975, this company has concentratedly developed the wheel disc, expanding its market both at home and abroad. It can now license the technology for facilities, metallic molds, product design, process design and manufacturing technology related to the manufacture of wheel discs.

Products and Specifications

Rim type (wide base drop center)

This type of rim has the deeply dropped rim center section for easier tire mounting. In order to prevent the tire from being separated from the bead due to skidding at a curve or in an unexpected accident such as its puncture while running at high speed, most wide base drop center rims have humps on the bead portion as safety precaution. This type of rim is widely used for passenger cars and light commercial vehicles.

Table 1. Specifications of Rim Type (Wide Base Drop Center)

Rim size	Wheel grouping	Bolt holes				Hub hole dia (mm)	Off set (mm)	Weight (Approx. kg)	Remark
		No.	Dia (mm)	P.C.D (mm)	Type				
3½ x 12	3½-Jx12-K8	5	13	140		113.5	87	7.15	*Mazda, kia bongo 1Twide* low (rear)
4 x 13	4-Jx13-K9	4	15	110	F	59.5	40	6.65	Mazda, kia, bongo 1T wide low (front)
4 x 13	4-Jx13-K4	5	15	110	E	70	30	5.7	*Mazda, familia truck kia* pick-up
4 x 13	4-Jx13-K10	6	17.5	170	I	134	85	9.3	Mazea, kia titan 1.4T wide low (rear)
4 x 13	4-Jx13-E4	5	15	114.3	F	73	40	7.18	*Mitsubushi selica, Galant* (export)
4½ x 13	4½x-Jx13-K6	4	15	110	E	60	30	6.75	Mazda Familia kia, Brisa K-303
4½ x 14	4½-Jx14-E9	5	16.7	114.3	E	71.5	7	6.7	A.M.G. Pottal vehicle
5 x 13	5-Jx13-K14	5	17.5	170	I	134	48	10.5	Mazda, kia bongo 1T high
5 x 13	5-JBx13-E5	4	16	100	E	57	40	6.9	Chrysler
5½ x 14	5½-Jx14-K7	4	13.5	98	F	44	25	8.8	Fiat 132 (Italy)
6 x 15	6-Lx15-E3	5	15	139.7	E	109.6	12.7	9.3	A M C CJ-5
7 x 15	7-Lx15-E6	6	14	139.7	E	111	-5	12	Toyota. Landcruiser

Rim type (drop center):

This type of rim is featured by the deeply dropped rim center for easy tire mounting and chiefly used for jeeps.

Table 2. Specifications of Rim Type (Drop Center)

Rim size	Wheel grouping	Bolt holes				Hub hole dia (mm)	Off set (mm)	Weight (Approx. kg)	Remark
		No.	Dia (mm)	P.C.D. (mm)	Type				
4.00x12	4.00Ex12-D1	4	15	150	D	80	55	5.6	Agricultural daedong Tractor
4.50x16	4.50Ex15-A1	5	14.6	139.7	D	100	46.9	9.85	A.M.G. Kennedy jeep
4.50x16	4.50Ex16-D2	5	15.5	139.7	D	102	20	8.7	Agricultural daedong trailer
4.50x16	4.50Ex16-K13	6	20	180	I	140	30	10.8	Mazda, kia titan 1.4T high
4.50x16	4.50Ex16-K5	5	16.4	139.7	E	107.2	19	9.6	Mitsubushi jeep asia jeep

Contents of Technology

1) Process Description

Rim making process

The steel sheet or coil with tensile strength of about 32kg/mm^2 is cut in required dimension and the company name or standard is marked on the material to be coiled by a coiler.

Connecting parts of coiled materials are jointed by flash butt welding, and the trimming and side cutting work are performed to eliminate welding beads. The welded material is first flared by flaring machine to be formed. The required form is produced by the primary and secondary rollings with the roll forming machine.

It is then subject to expanding by expander for the removal of its stress and at the same time for the adjustment of the material dimension. The rim is finished by pircing the valve hole for inserting the valve.

Disc making process

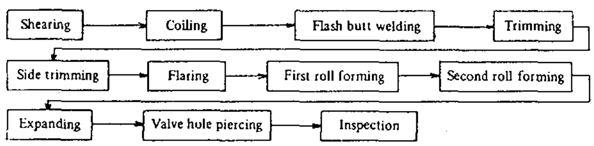
In case of disc, the steel sheet or coil is cut in required dimension, and the blanking and drawing work is carried out by the press to give necessary forms. The bolt hole boring for the bolt assembling and coining work to give 60-degree slope to the bolt hole are performed. The piercing work is also done to bore the hub hole as well as side hole prior to inspection.

Assembling process

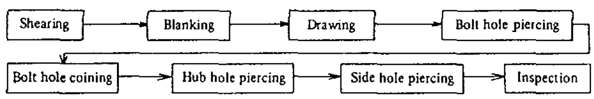
The rim and disc are once assembled by the press and after the run-out test for adjusting its balance, the rim and disc are welded and put to the run-out test again. It is coated for delivery.

Wheel Disc Manufacturing Process Block Diagram

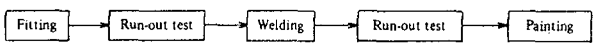
1) Rim



2) Disc



3) Assembly



2) Equipment and Machinery

Uncoiler
Leveller
Shearing machine
Hydraulic press
Crank press
Coiler
Flash butt welder
Trimming machine

Roll former
Expander
Assembly press
Carbon dioxide welder

3) Raw Materials and Utilities

Raw materials and utilities	Requirement (per ea of product)
Rim SAPH32 steel sheet & coil	6.46 kg
Disc SAPH38 steel sheet & coil	5.57 kg
Paint	165 g
Electric power	2.5 kwh

Example of Plant Capacity and Construction Cost

1) Plant capacity: 750,000 ea/year

2) Example of estimated construction costs (as of 1982)

o Equipment and machinery	:	US$ 1,975,000
o Utilities	:	US$ 374,300
o Installation cost	:	US$ 467,900
Total	:	US$ 2,817,200

3) Required space

- o Site area : $16{,}200 m^2$
- o Building area : $6{,}480 m^2$

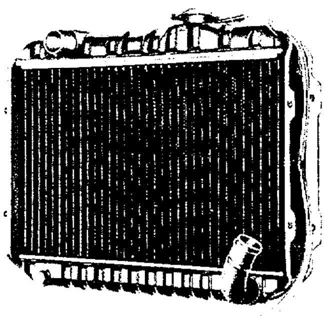
4) Personnel requirement

o Plant manager	:	10 persons
o Engineer	:	15 persons
o Operator	:	60 persons
o Others	:	10 persons
Total	:	95 persons

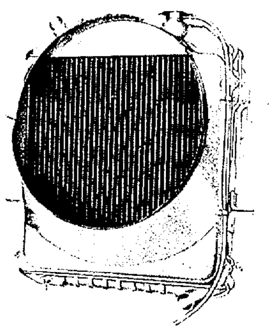
FILE: Q27
ISIC 3843

Radiator Making Plant

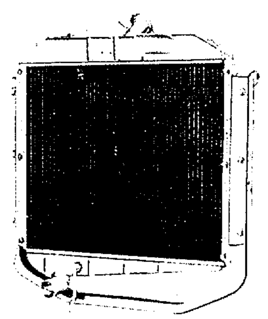
RADIATOR FOR PASSENGER



RADIATOR FOR BUS



RADIATOR FOR TRUCK



View of Products

The radiator has an important function of ensuring the safe operation of equipment and prolonging their life by subsequently preventing the engine from being overheated by cooling with water the combustion heat and friction heat generated by an automobile and combustion engine.

The radiation in the cooling system depends upon the discharge rate of water pump, air flow rate of cooling fan and radiator capacity. Among them, the most important part of the direct radiation is the core consisting of water tubes and cooling fans.

The principle of water circulation to cool an automobile engine is as shown in the following figure. The water to cool engine surrounding is forced into the radiator by pump, while the function of radiator is to achieve the cooling effect in the radiator core by making use of the air flow supplied by the fan and advancing motion of the car itself. Therefore, main factors of cooling efficiency are the water flow and air flow as well as the radiator and cooling system.

In general, essential factors of a quality radiator are as follows:

- Higher radiation capacity per unit area (cm^2)
- Light weight and small size
- Low resistance to air
- Low resistance to water

These factors are applicable not only to the water-cooled radiator but also to the oil-cooled or air-cooled radiator.

The water tube referred to in the foregoing is made of thin brass plate. It is liable to cause water leakage unless precisely manufactured by the folding machine of multi-stage forming roller capable of making lock seam type tubes.

The cleaning device for the after-treatment of finished products requires to be perfect because the quality and anti-corrosiveness depend largely on the equipment.

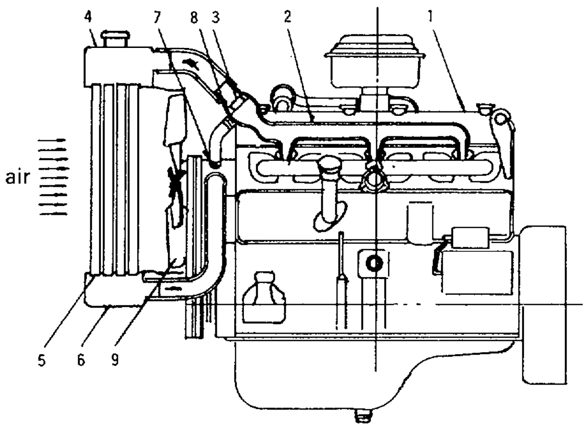


Illustration of cooling system.

1. Engine body
2. Water manifold
3. Thermostat
4. Top tank
5. Radiator core
6. Bottom tank
7. Water pump
8. Water pine
9. Cooling fan

Table 1. Specifications of Radiator

Model	Description	Original No. (Part No.)	Dimension of core			Tube			Fin			Dimension of header	
			Ht	Width	Th	Dimension	Qty	Row	Type	Pitch	Qty	Top	Bottom
AC-101	Hilux RN25	16400-3112	375	526	32	13 x 2	86	2	C - T	6.16	34	533.6 x 46.6	533.6 x 46.6
AC-102	Land crwser FJ46	16400-61020	435	490	66	13 x 2	160	4	C - T	5.37	41	497 x 76	497 x 76
AC-120	Royal diesel		475	444.5	49	19 x 2	92	2	C - T	1.8	47	451.3 x 64.3	451.3 x 64.3
AC-121	Royal diesel aircon		475	444.5	49	19 x 2	92	2	C - T	1.57	47	451.3 x 64.3	451.3 x 64.3
AC-140	RB 635		720	597.5	88	14 x 2.5	235	5	C - T	4.76	48	604.4 x 106.8	604.4 x 106.8
AC-141	CJ-5 (6 cyl.)		369.2	614	32	13 x 2	86	2	C - T	5.5	44	626.5 x 69.5	609.5 x 56.5
AC-180	5 T		714	600	73	19 x 2	166	4	P - T	2.3	304	626.8 x 151.8	607.8 x 76.8
AC-181	CK 10G		522	595.9	66.2	14 x 2.5	186	4	P - T	3.19	164	602 x 102	602 x 92
AC-182	FD 20-7		400	430	83	13 x 2	175	4	C - T	4.5	36	437 x 95.5	437 x 95.5
AC-210	SPM 710		588	635	70	14 x 2.5	192	4	C - T	3.5	51	646 x 146.5	646 x 119.5
AC-211	XD 2200		375	454	49	13 x 2	141	3	C - T	3.85	48	462 x 63	462 x 63
AC-212	HD 3 T		419.4	533.4	50	14 x 2.5	125	3	P - T	2.5	164	559.5 x 59.5	559.5 x 59.5
AC-270	ISUZU 6 T		625	640	100	14 x 2.5	292	5	P - T	2.5	247	645.5 x 139.5	645.5 x 111.5
AC-271	ISUZU 8 T		530	723.9	100	14 x 2.5	330	5	P - T	3	175	724.4 x 120	724.4 x 120
AC-272	HINO 8 T (RC420)		620	649	94	19 x 2.5	232	4	P - T	2.65	231	650 x 126	650 x 126
AC-290	M151		345.9	495	50	16 x 2.5	113	3	P - T	2.3	147	521.2 x 99.7	491.2 x 62.3
AC-291	M38		335	510	76	19 x 2	76	3	P - T	2.3	142	508.5 x 95.5	508.5 x 75.5
C-301	ER 6301		673	610	58	16 x 2.5	144	3	C - T	5.39	49	686.5 x 134.2	686.5 x 134.2
C-302	ER 6302		317.5	510	58	16 x 2.5	120	3	C - T	5.49	41	586.5 x 134.2	586.5 x 134.2
C-303	ER 6303		292	510	58	16 x 2.5	120	3	C - T	5.64	41	586.5 x 134.2	586.5 x 134.2
C-340	PEUGEOT 204		323	358	32	13 x 2	58	2	C - T	4.4	30	359 x 60	359 x 60
C-341	Datsun 160J		300	478	32	13 x 2	78	2	C - T	3.8	40	485 x 64	485 x 50
C-342	Datsun 160 SSS		359	478	32	13 x 2	78	2	C - T	3.9	40	485 x 64	485 x 50
C-380	Toyota 4		477	598	66	13 x 2	196	4	C - T	3.89	50	605 x 97	605 x 97
C-381	Subaru 1600		540	274	32	13 x 2	44	2	C - T	3.56	23	279 x 40	279 x 40
C-382	Grolia 2000cc		360	614	32	13 x 2	86	2	C - T	4.6	44	623 x 67	623 x 63
C-410	Toyota KE 20		332	418	32	13 x 2	68	2	C - T	4.15	35	425 x 65	425 x 47
C-411	R - 192		560	534.5	53	14 x 2.5	126	3	C - T	4.47	43	566 x 77	566 x 77
C-412	R - 192		560	538	66	13 x 2	176	4	C- T	5.4	45	566 x 77	566 x 77
C-421	Heavy equipment		1,070	1,030	94	19 x 2.5	372	4	P - T	3	3.53	1,250 x 230	1,250 x 230
C-422	"		1,015.7	155	58	22 x 2	36	2	P - T	3.19	3.17	150 x 70	150 x 70
C-423	"		894.8	580	130	12 x 2.5	115	7	P - T	3.19	278	615 x 190	615 x 190
C-424	"		768.3	760.5	100	14 x 2.5	347	5	P - T	3.19	238	812.8 x 152.4	812.8 x 152.4
C-425	Kolon truck		960	688.5	50	16 x 2.5	158	3	P - T	2.5	368	904 x 266.5	904 x 266.5

Products and Specifications

By design, there are two different types of radiator core; the corrugated-type core and plate-type core, while the radiator also breaks down into two different types of down-flow radiator and corss-flow radiator depending upon its cooling water flow and tank position.

Various kinds of highly efficient and durable radiator cores of the following specifications are available for use in cars, buses, trucks, locomotives and other heavy construction equipment

Contents of Technology

1) Process Description

Parts machining

The tube is solder-coated in streaks by the tinning machine and formed into the lock seam type by the multi-stage roller to be automatically cut in necessary length.

The fin fabrication breaks down into two different kinds of the corrugated-type fin, made by corrugating the copper foil, and the plate-type fin. The louver is fabricated to improve the radiation effect.

Assembling process

Fins and tubes are put together.

Heat treatment

It is heated in the continuous automatic furnace so that the solder coated on the tube surface can also solder the fins. The furnace breaks down into the flux spray zone, free heated zone and cooling zone. Hereby, the tube and fins are completely jointed.

Parts soldering

Jigs and automatic soldering system designed to improve the accuracy of dimension and productivity.

Leak test

In order to check the air tightness of the finished product, it is immersed in water, with compressed air filled in the radiator, for confirming the performance.

Cleaning

It is automatically cleaned while being conveyed by such mediums as hot water, acid, cooling water and hot water to remove various chemicals stained on the product surface.

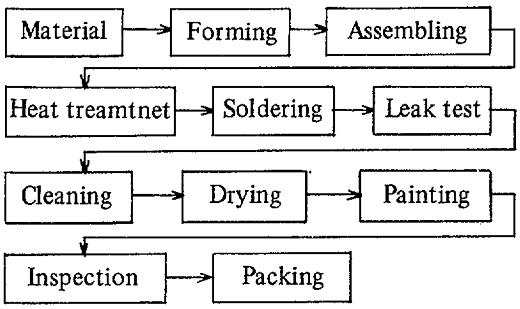
Drying

The moisture on the product surface is eliminated by passing the conveyor through the drying furnace.

Painting

The painting work is performed while being transfrred on the conveyor. The product is delivered after inspection.

Radiator Making Process Block Diagram



2) Equipment and Machinery

Strip tinning machine
Tube forming machine
Corrugate fin machine
Plate fin machine
Core assembling machine
Heat treatment furnace
Automatic tank soldering machine
Plate soldering equipment
Cleaning equipment
Leak tester
Drying furnace
Painting equipment
Press
Compressor

3) Raw materials

○ Radiator for PONY car

Raw materials	Requirement (per ea of product)
Cu	1.1085 kg
Brass	2.5176 kg
Solder	0.6 kg
SCP	1.0634 kg

Example of Plant Capacity and Construction Cost

1) Plant capacity: 500,000 ea/year

2) Example of estimated construction costs (as of 1982)

○ Equipment and machinery	:	US$ 4,710,000
○ Material cost	:	US$ 336,000
○ Installation cost	:	US$ 309,000
Total	:	US$ 5,355,000

3) Required space

○ Site area	:	48,600m^2
○ Building area	:	9,720m^2

4) Personnel requirement

○ Administrative personnel	:	120 persons
○ Engineer	:	50 persons
○ Operator	:	350 persons
Total	:	520 persons

Clutch Cover Ass'y Making Plant

View of Products

The recent development in clutch cover disc for automobiles has been very remarkable in terms of its improved durability, improved operationality, and quietness and maintenance of vehicles.

New requirements have made great strides towards its operational reliability, smooth engagement, reduced pedaling strength for smooth contact, pertinent vibration characteristics, anti-vibration and soundproofing effects and stabilized prices.

Further requirements will be its prolonged life, improved synchronization of transmission and design aiming at reducing weights of respective component parts for saving fuel.

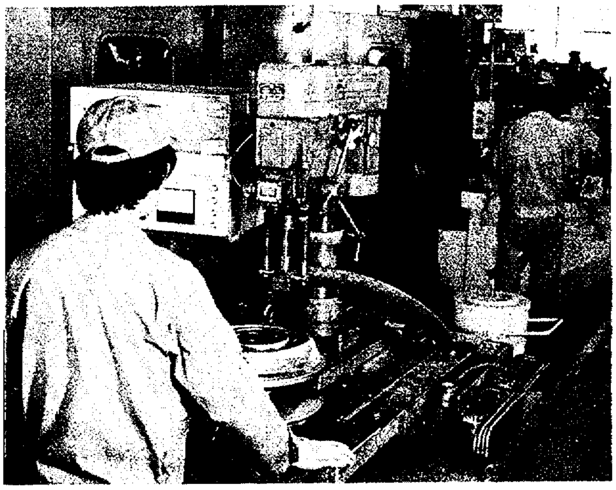
The coil spring was mainly used in keeping the clutch disc pressed down, but recently maximum use of the diaphragm spring has been made not only for cars but also for large-size buses and trucks.

In transmitting the engine torque to the clutch disc, the conventional lug drive method is also being replaced by the strap drive method of late.

At present, the prospective licensor of this technology is producing both the coil spring and diaphragm spring and also adopting both the lug drive and strap drive in its driving method.

Products and Specifications

No.	Spring type	Load method	Drive method	Flywheel type	Cover type	Called name
1	Coil spring	Direct type	Strap drive	Pot type	Out lever	CSP
2					Inner lever	
3				Flat type	Out lever	CSF
4					Inner lever	
5			Lug drive	Pot type	Out lever	CLP
6					Inner lever	
7				Flat type	Out lever	CLF
8					Inner lever	
9	Diaphragm spring	Direct type	Strap drive	Pot type	Out lever	DSP
10					Inner lever	
11				Flat type	Out lever	DSF
12					Inner lever	
13			Lug drive	Pot type	Out lever	DLP
14					Inner lever	
15				Flat type	Out lever	DLF
16					Inner lever	



Contents of Technology

1) Process Description

(A) Cover

- Shearing: Cutting to the size of 1219 x 340mm by shearing machine for subsequent blanking.
- Blanking: Blanking the cover plate with 200-ton crank press.
- Piercing: The center is pierced in 50mm diameter to serve as the base in subsequent press

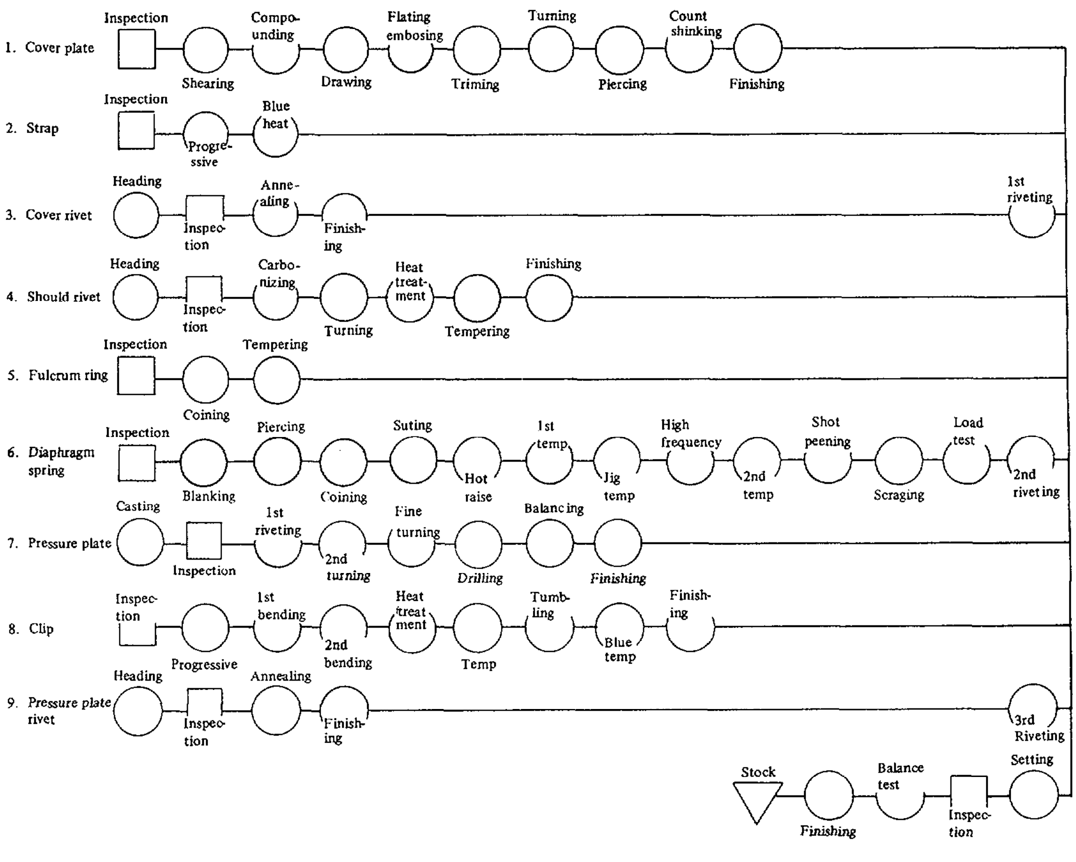
work.

- Drawing: Drawing work for cover depth and shape by means of hydraulic press.
- Center hole piercing: 50mm hole is finished as 90mm hole suiting the cover dimension.
- Restriking and burring: Incomplete cover shape is reshaped. Control points are inner diameter of the cover, cover depth and depth to strap fitting position. 500-ton crank press is in use.
- Trimming: Unnecessary portion of outer diameter is trimmed off to comply with the precribed dimension. Burr should be eliminated at this point.
- Piercing: The fitting hole, dowel hole and balancing control hole are pierced.
- Cutting of fitting and set rivet facings: Cover depth, fitting facing plane and parallel between fitting facing and set rivet are controlled (These are very important in view of characteristics of the clutch cover). High-speed lathe is in use.
- Parkerizing: A kind of coating treatment performed for rustproofing the cover exterior.
- Dowel hole drilling: When fitting (clutch cover plus flywheel), this hole becomes its base, requiring extremely precise common difference of diameter and also that of PCD. It is also called the knock hole. Upright drill is in use.
- Chamfer: Removal of burr from the drilled hole.

(B) P/plate

- Cutting of facing and inner and outer diameters: Automatic turning machine is in use.
- Cutting of boundary of dia. s/p and p/plate and strap position: Automatic turning machine is in use, with the finish machining allowance of 0.4-0.3.
- Strap hole drilling: Riveting holes of strap and p/plate are drilled by upright drill for connecting p/plate and cover.
- Finishing of facing: The workpiece cut and machined by the automatic turning machine is further machined by a kind of high-speed lathe for finishing in terms of controlling its roughness and dimension.

Clutch Cover Assembly Manufacturing Process Block Diagram



- Balancing: Designed to eliminate the unbalance of p/plate. The unbalance is a disturbing factor not allowable for the clutch cover in high-speed rotation.

(C) Dia. s/p

- Press work: Blanking, piercing, coining, slitting, center hole piercing.
- Heat treatment work: Cleaning, high-frequency hardening, high tempering, shot peening, billeting, setting.

(D) Assembling

- Set rivet riveting: Fifty-ton crank press is used, with the precision of jigs required. Component parts include one cover, one dia. s/p, two pivot rings and nine set rivets.
- Strap riveting: Fifty-ton hydraulic press is in use. Component parts include the above (a) plus one p/plate, three ret. s/p, six straps and six rivets.
- P/plate lifting: Clutch cover is fitted to flywheel with special device. The distance between p/plate facing and flywheel is checked when the clutch cover pedal is operated.
- Assembly balancing: Unbalance is rectified.
- Completion inspection: Inspections of clamp load, release load and burst strength.
- Marking: Date of manufacture is marked with indelible ink for metal.
- Packing: The finished product is packed to prevent the clutch cover from foreign matters. Rustproofing coating is also applied on the facing of p/plate.
- Storage: The products are stored in standby for delivery.

2) Equipment and Machinery

Clutch cover ass'y part
Crank press (250$)
Hydraulic press (800$)
Crank press (350$)
Duplicating lathe
Packerizing furnace
Crank press (5$)
Electric resistance furnace
Gas caburizing furnace
Salt bath furnace
Bench lathe
Crank press (200$)
Hydraulic press (150$)
Shot peening machine
Automatic gang drilling machine
Balance machine

3) Raw Materials and Utilities

Raw materials and utilities	Requirement (per ea of product)
SBC 1	2.0 kg
GC 25	2.0 kg
YK-50	0.57 kg
PW 1	0.07 kg
STC-5M	0.11 kg
SWRM	0.32 kg
Electric power	500 kwh
Water	20 m^3/day

* Basis : Pony clutch cover ass'y (7½" cover)

Example of Plant Capacity and Construction Cost

1) Plant capacity: 100,000 ea (ass'y)/year

2) Example of estimated construction cost (as of 1982)

- Equipment and utilities : US$ 670,000
- Installation cost : US$ 110,000

Total : US$ 780,000

3) Required space

- Site area : 12,000m^2
- Building area : 9,000m^2

4) Personnel requirement

- Plant manager : 11 persons
- Engineer : 10 persons
- Operator : 60 persons
- Others : 2 persons

Total : 83 persons

Any inquiry about the information contained should be sent to:

IO/COOP, Registry file No. ID/562/12, UNIDO, P.O. Box 300, A-1400 Vienna, Austria

Transmission & Transfer Making Plant

The prospective licensed products are transmission and transfer used for medium and small-size trucks and other 4-wheel driven vehicles.

The transmission is of forward 4-stage direct control type, while the transfer is also of high and low 2-stage direct control.

Particularly, the products manufactured on the basis of this technology are characterized by the extreme stability against the noise and vibration when running at high speed, with natural transmission of high impact coupled with light weight.

With a long experience in this field, the technology supplier can license the know-how related to the machining, heat treatment and assembling required for the manufacture of the products as well as engineering and production of exclusive and general-purpose facilities, layout of prduction facilities and other inspection and test facilities. The manufacturing technology has already been exported.

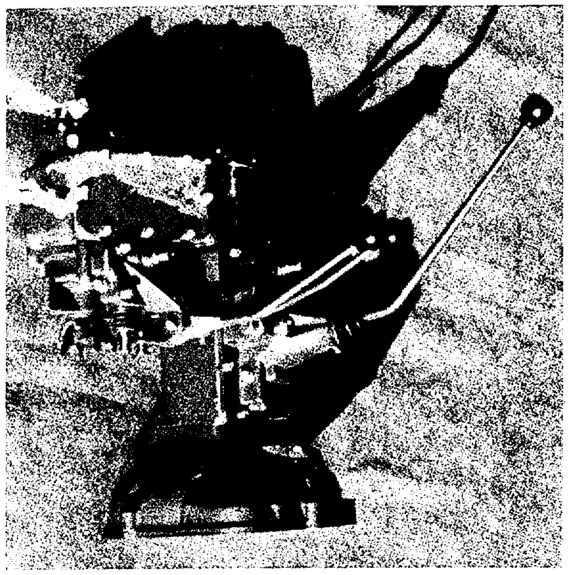
Table 1. Specifications of Transmission and Transfer

Product	Type	Specification
Transmission and transfer	• 4-stage forward, 1-stage backward • Type: geared type • Input revolution: max. 1,500 rpm • Input torque: 15kg. cm • Speed change method: flow change	Transmission and trasnfer for 1,000 to 5,000cc engine

Contents of Technology

1) Process Description

The manufacturing process of these products is different depending upon respective component parts, but explanations will be made by grouping similar parts. Typical products break down into cases and shafts.



Manufacturing process of transmission case and transfer case

After securing the base level by milling in order to fix it, location pin holes of the product are drilled, thus making further machining possible in all processes on the basis of this base. The acquisition of both the base level and base hole is significantly important, these being currently machined by the duplex head milling machine.

After the milling on both surfaces comes the boring. To keep the concentricity of the two boring holes, the special duplex head boring machine is also being used.

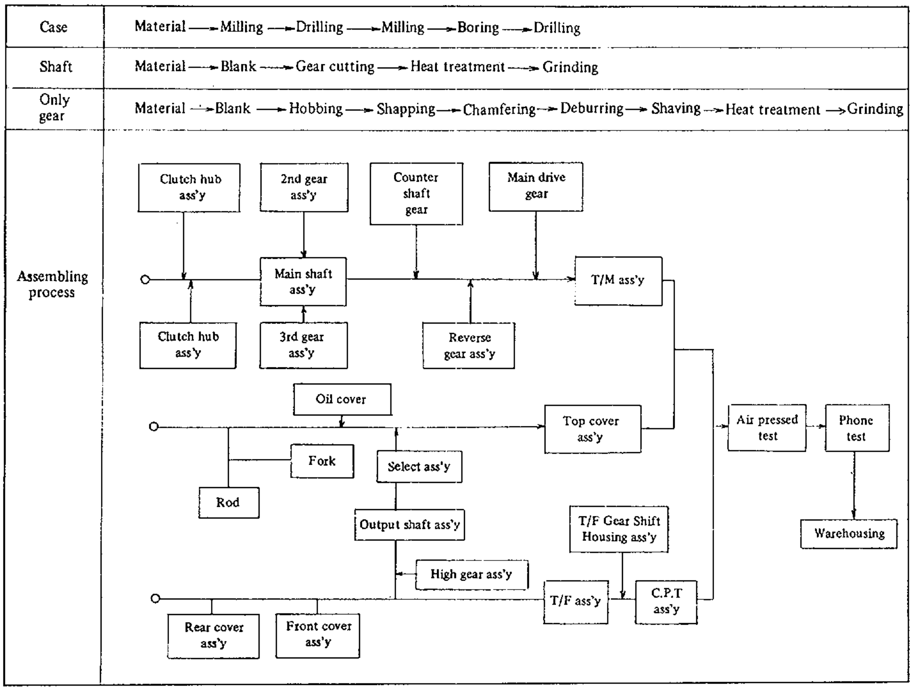
Shafts

The blanking (turning) is followed by gear cutting, heat treatment and grinding.

Gears

There follow the gear hobbing, gear shaving and broaching after blanking (turning), though slightly varying depending upon gears. In the work shaving the gear surface on completion of the gear cutting, the grade required of the gear is said to be influenced as much as 80 percent. Therefore, the technology of re-grinding the shaving cutter can be acquired through an experience of many years supported by theoretical aspects. After the shaving, the gear is turned over to heat treatment. Any deformation in the heat treatment can exert an influence on the possible occurrence

Transmission & Transfer Manufacturing Process Flow Sheet



of sound, which is another important matter for the transmission, with sufficient experience and skills also required.

2) Equipment and Machinery

Centering m/c
N.C. Lathe
Upright drilling m/c
Vertical milling m/c
Horizontal milling m/c
Gear hobbing m/c
Gear shaper m/c
Gear shaving m/c
Gear chambering m/c
Broaching m/c
Grinding m/c
Wheel slide cyclindrical grinding m/c
Shaving cutter regrinding m/c
Broach shaper m/c
Hob shaper
Pinion shaper
Angulal wheel slide cylinderical grinder
Milling m/c
Boring m/c
Drilling m/c

Example of Plant Capacity and Construction Cost

1) Plant capacity: 12,000 set/year

2) Example of estimated construction cost (as of 1982)

o Equipment and machinery	:	US$ 4,500,000
o Utilities	:	US$ 600,000
o Installation cost	:	US$ 120,000
Total	:	US$ 5,220,000

3) Required space

o Site area	:	20,000m^2
o Building area	:	6,000m^2

4) Personnel requirement

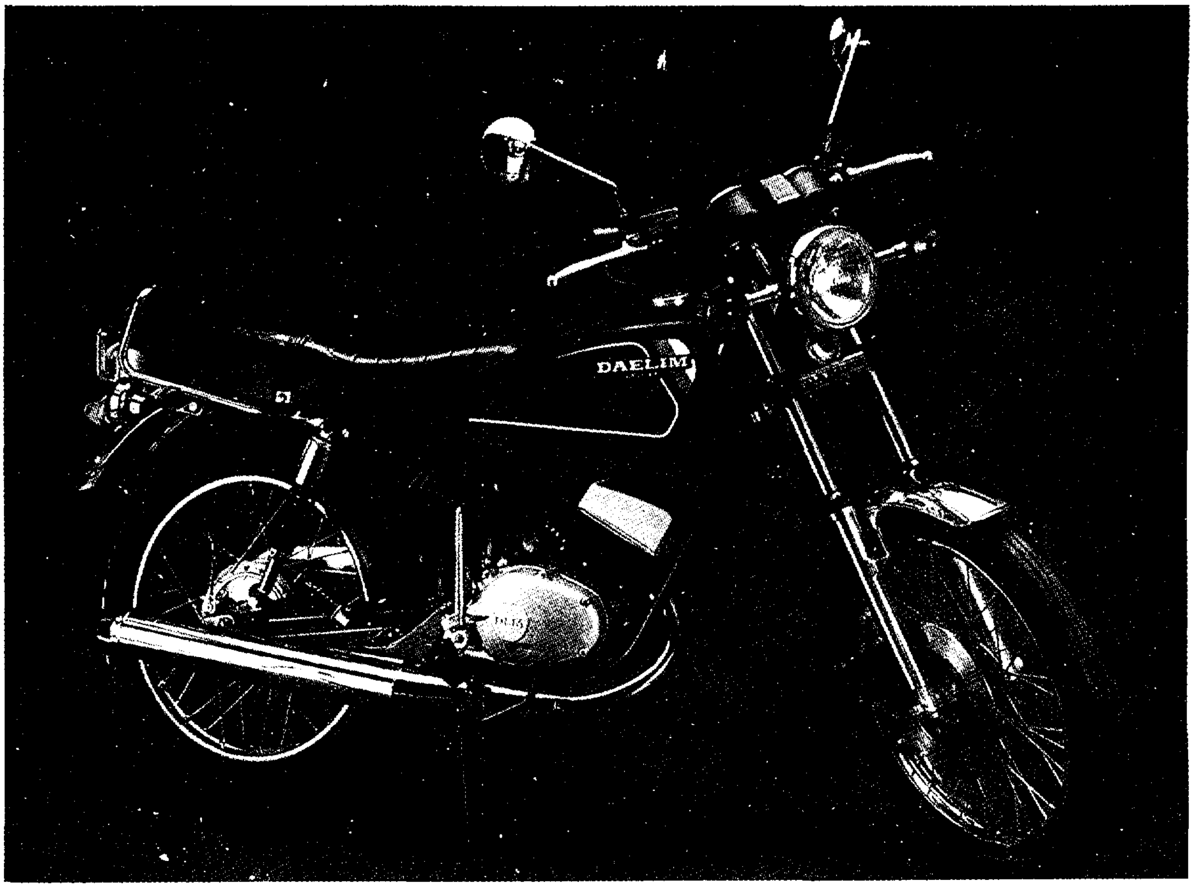
o Plant manager	:	20 persons
o Engineer	:	30 persons
o Operator	:	150 persons
o Others	:	20 persons
Total	:	220 persons

Any inquiry about the information contained should be sent to:

IO/COOP, Registry file No. ID/562/12, UNIDO, P.O. Box 300, A-1400 Vienna, Austria

FILE: Q30
ISIC 3844

Two-Wheeler Assembling Plant



View of Product

The two-wheeler is a car running on two wheels like a motorcycle and scooter. Using a small-size gasoline engine as a power generator, it usually has an output capacity of 2-15 horse powers.

Since its total weight is supported by two wheels, it is statically unstable but dynamically stabilized when running, having excellent mobile and nimble wheels unlike four-wheelers.

In comparison with four-wheelers, it is much inexpensive and convenient with outstanding mobility for industrial uses. It also provides a good feeling of speed for leisure and sports uses.

The motorcycle is largely divided into the chassis and body in terms of its structure. The chassis is composed of the power-generating device, running device, adjusting device and accessories, while the body is the outer part mounted on the chassis for a rider and freight.

A two-cycle gasoline engine is mostly used for the power generation. Its fuel consumption per cycle is rather high but can generate power twice the four-cycle engine. With 50-125cc in engine exhaust, it can run almost 10 times of the four-wheeler in distance when the same volume of gasoline is used.

The two-wheeler is globally popularized at present for its characteristics of small size and weight, kick starting and instantaneous acceleration. The construction of such a two-wheeler assembling plant in developing or less developed countries will have tremendous spillover effects of related peripheral technologies.

This plant can be introduced with much more practical benefits than from highly advanced nations in terms of its initial investment, plant capacity and manufacturing process.

Products and Specifications

Types and specifications of the two wheelers produced in this plant are as shown in table 1.

Table 1. Types and Specifications of the two wheelers

Spec. \ Types	DH 125 X	DH 100	KM 90	M 56
Engine type	2 stroke, reed valve type, 25 degrees inclined	O.H.C. 4 stroke	O.H.C. 4 stroke	2 stroke, reed valve type
Bore x Stroke [mm]	56 x 50		50 x 45.6	40 x 38
Total exhaust [cc]	123	97	89.6	47.73
Compression ratio	6.35 : 1	8.8 : 1	8.2 : 1	9 : 1
Max. horsepower [PS]	18/8,300rpm	9/9,000 rpm	8/9,500 rpm	2.4/7,250 rpm
Brake system	123cc hydraulic disc	Internal expanding shoe	Internal expanding shoe	Internal expanding shoe
Climbing ability	32 degrees	20 degrees	20 degrees	16 degrees
Dimension LxWxH [mm]	1,935 x 750 x 1,290	1,900 x 745 x 1,010	1,830x810x1,050	1,695 x 600 x 960
Fuel tank capacity [ℓ]	12	9	8.5	4.5
Dry weight [kg]	97	95	92	45
Clutch	5 plate, wet type	Multiplate, wet type	Multiplate, wet type	Centrifugal
Transmission	5 speed, const. mesh	Front 4 stage	4 speed, 1-N-2-3-4	Auto
Tires (F/R) [inch]	2.75-18/3.00-18 (4PR)	2.50-18/3.00-18 (4PR)	2.50-18/2.75-18 (4 PR)	2.25-16 (4PR)
Cooling system	Natural air cooling	Natural air cooling	Natural air cooling	Natural air cooling
Start mode	Kick	Kick	Kick	Kick
Uses	Business and street car	Bussiness, leisure, sports	Business, leisure	Family car

Contents of Technology

1) Process Description

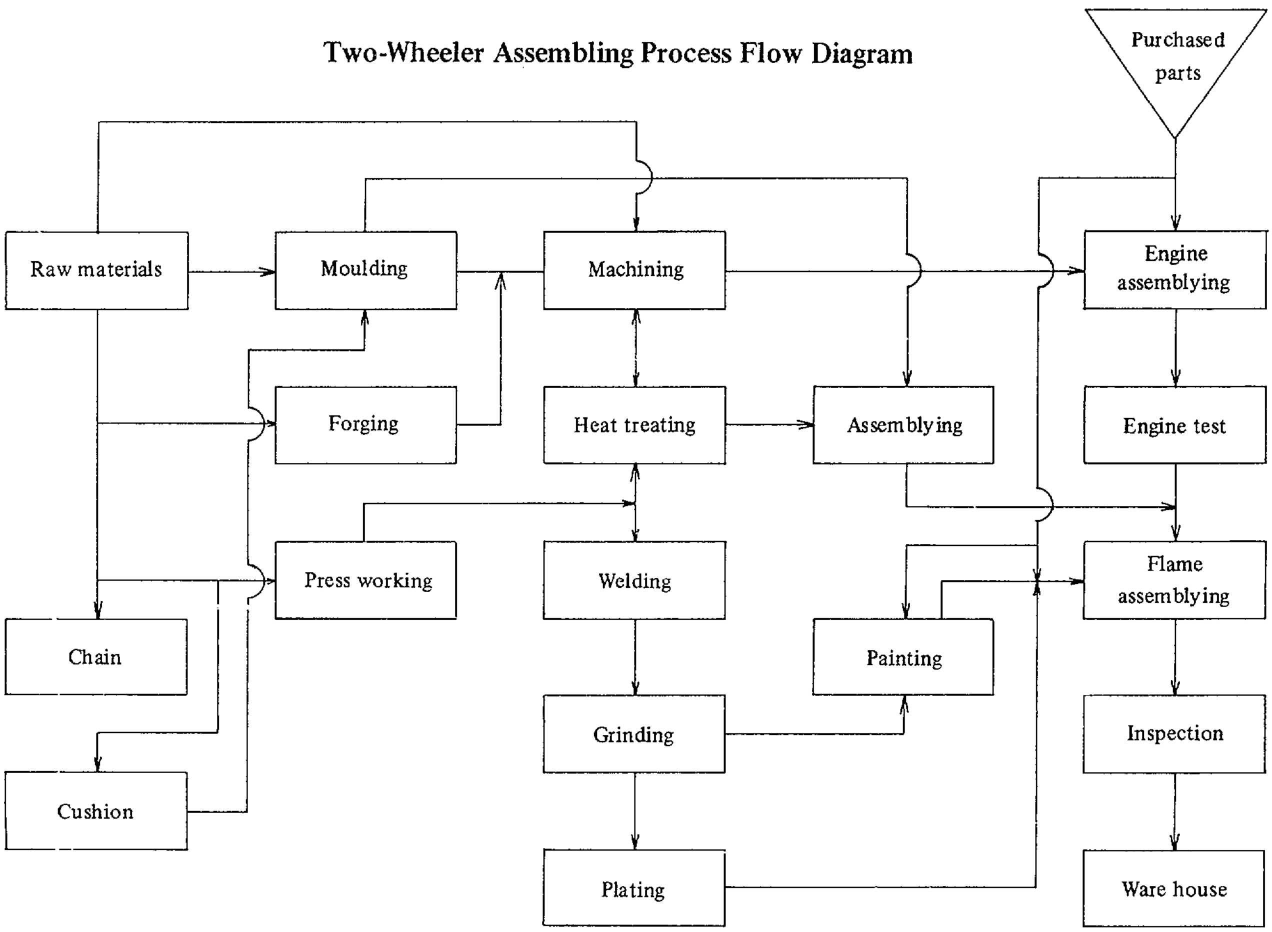
Molds of cylinder blocks and cylinder heads are cast by automatic casters making use of metal molds. The molten metal from the high-frequency induction furnace on the pouring line is poured into a mold for high grade casting and subsequent treatment by shot blast and swing grinder to be moved on to separate machining line.

The cam shaft, a power transmission element, is of high carbon alloy steel and forged to precise dimensions by forging machine.

Fuel tanks and wheel covers are manufactured by pressing hot-rolled coil steel plate, followed by plating or painting. Front cushions are cast by die casting, while air collers are manufactured by casting or molding from an alumunum ingot.

When respective parts are ready, engine parts are assembled and mounted on the frame. After sampling test, the motorcycles are packed for delivery.

Two-Wheeler Assembling Process Flow Diagram



2) Equipment and Machinery

Centering machine
Copy lathe
Simple (single) purpose thread rolling machine
Thread rolling m/c
Hobbing machine
NC lathe
Broaching machine
Horizontal milling machine
Gear shaving machine
Gear deburring machine
Cylindrical grinding machine
Mini balance
Internal grinding machine
Surface grinding machine
Angular grinding machine
Internal grinding machine
Drilling machine
Vertical boring machine
Auto therad machine
Centering grinder
Horizontal boring machine
Self feeder
Lapping machine
Multi-spindle drilling machine
Auto threading machine
Horizontal boring machine
Deep hole boring machine
Roller production machine
Auto lathe
Riveting machine
Multi slide forming machine
Transfer action crank
Spot welder
Sean welder
Tig welder
Roll cutter
CO_2 welder
Auto feeder (shearing line)
Press
Hydraulic press
Shearing machine
Tapping machine
Turret drilling machine
Multi spindle drilling machine
Coolant system
Double head milling machine
Simple (single) purpose thread rolling machine
Thread rolling m/c
Tool grinder
Surface grinder
Broach grinder
Hob grinder
Pinion cutter
Cutting grinder
Bench grinding machine
Auto gear grinder
Gear shaper
Milling machine
Rotary milling machine
Die spoting press
Sawing machine
Radial drilling machine
Chader
Spotting machine
Universal grinding machine
Jig boring machine
Jig grinding machine
Profile grinding machine
Cut-off machine
Tandem press cone
Double action crank pr.
Burnishing machine
Over head crane
Multi-action crane pr.
Crank press
Multi-action arpanging machine
High speed crank press
Chain pre-loader
Chain measuring machine
Tappet grinder
Turret drilling machine
Vertical machining

3) Raw Materials

Unit: EA

Raw materials	Requirement (per each product)
Side bar distance roller	2
Rr. shaft collar	1
Anchor	2
Hub shaft collar	1
Swing arm pivot pipe	2
Collar(R)	1
Pivot bushing	1
Steering tube	1
Steering upper B.K.T	1
Handle holder	1
Steering under B.K.T	1
Center tube	1
Steering head bearing (Top)	1
Steering head bearing (Bottom)	1
Muffler	1
Fuel tank	1
Frame	1
Handle bar	1
Swing arm	1
Rr. backing plate stay	1
Center stand	1
Battery box	1

Raw materials	Requirement (per each product)
Foot rest stay	1
Side stand	1
Muffler B.K.T.	1
Tool box cover	1
Chain guide	1
Horm B.K.T.	1
Speed meter B.K.T.	1
Head light B.K.T. (L)	2
Chain case	1
Front fender	1
Rear fender	1
Side cover (L)	1
Side cover (R)	1
Head light body	1
Cap	2
Exhaust nut	1
Shifter guide	1
Kick shaft	1
Kick idle gear (20T)	1
Cylinder	1
Magneto cover	1
Bush roller metal	1
Breather	1
Tension bolt	1
Shifter sliking holder pin	1
Spring stopper	1
Plinger case	1
Dowel clutch	2
Crank case dowel	2
Pump drive shaft	1
Rubber mount collar	2
Sprocket collar	1
Insert	1
Kick stopper pin	1
Back plate	1
Pressure plate	1
Foot chaing shaft	1
Oil guide ring	1
Inter lock plate	1
Foot change lever	1
Special nut	1
Cylinder stud bolt	1
Nut hexagon	1
Thrust washer	1
Spacer	1
Thrust washer	1
Adjust bolt	1
Foot drum	1
Hear drum	1
Front backing plate	1
Rear backing plate	1
Brake shoe	1
Steering head race	2
Steering bearing race	1

Raw materials	Requirement (per each product)
Crank case (L)	1
Crank case (R)	1
Cylinder head	1
Magneto cover	1
Clutch hub	1
Clutch case	1
Shifter cover	1
Clutch lever	1
Shifter arm pin	1
Shifter sliking pin	1
Shifter arm	1
Crank shaft (R)	1
Crank shaft (L)	1
Crank pin	1
Connection rod	1
Pump drive gear (15T)	1
R.P.M. driven gear	1
Primary driven gear (Pinion)	1
Gear (Pinion)	1
Primary gear (72T)	1
Clutch release disc	1
Push rod	8
Main shaft gear (9, 1st)	1
Main shaft gear (13, 1st)	1
Main shaft gear (20T)	1
Counter shaft	1
Counter low (1st) gear	1
Counter 2nd gear	1
Counter 3rd gear	1
Counter 4th gear	1
Control shaft	1
Ball receiver	1
Spring stopper	1
Sprocket (15T)	1
Kick gear (32T)	1
Oil pump drive gear (Lat)	1
Gear (Lat)	1
Kick idle gear (19)	1
Foot change shaft	1
Counter top gear	1
Patchit pump up	1
Steering inside nut	1
Tank drum collar	3
Pedal washer	1
Fork washer	1
Inner race	1
Chain 106 link (428H)	1
Battery box	1
Front fork B.K.T.	1
Fly wheel nut	1
Main shaft nut	1
Steering under B.K.T. ass'y	1
Kick spring stopper	1
E/G comp	1

Raw materials	Requirement (per each product)
Break pedal	1
Rr. backing ass'y	1
Muffler ass'y	1
Rear fender	1
Number plate B.K.T.	1
Muffler ass'y	1
Rear fender	1
Arm rear break	1
Stopper	1
Rear muffler cover	1
Front muffler cover	1
Cover RH/LH Fr. fork upper	1
Bar comp step	1
Front fender	1
M/C comp.	1

Example of Plant Capacity and Construction Cost

1) Plant capacity : 300,000 units/year

2) Estimated construction cost (as of 1983)

- Equipment and machinery : US$50,000,000
- Utility : US$ 2,500,000
- Installation cost : US$20,000,000

Total US$72,500,000

3) Required space

- Site area : 400,000 m^2
- Building area : 35,000 m^2

4) Personnel requirement

- Manager : 150 persons
- Engineer : 250 persons
- Speciallist : 900 persons
- Others : 100 persons

Total 1,400 persons

R

Thermometer / Pressure Gauge Plant

With the development of industries, various measuring instruments have been produced to minimize errors and strains originating from an instinctive judgement of all phenomena based on human sight, tactile sense, auditory sense, olfactory sense and the like. The manufacture of such measuring instruments, requiring a high degree of precision, is an industry which needs relatively extensive human labor and precision technologies. Among them, comparatively easy and of long tradition are thermometers in addition to pressure gauges, electric measuring instruments and other speed measuring instruments.

First of all, the principle of temperature measureemtn is based on the expansion and contraction of materials depending upon temperature changes, the thermometer being an application of this principle. Glass thermometers and Bourdon tube type thermometers are based on the application of thermal expansion of alcohol or mercury, while the bimetal is based on that of thermal expansion of metals.

In the pressure gauge, mercury or water is filled in a bended U-type tube and the liquid levels change depending upon the pressure applied to the both ends of the tube. The measurement of a difference in liquid levels leads to the pressure difference. This is the simplest liquid column gauge. Besides, there are mercury pressure gauge and also Bourdon tube type pressure gauges.

In addition, there are electronic control instruments, electronic recorder, current to pneumatic positioner as well as thermocouples and resistance bulb, optical pyrometers, ammeter, voltmeter, wattmeter and the like for the purpose of process control. All such instruments should have characteristics of high precision and efficiency, high reliability making operators feel relieved in addition to ease of maintenance and repair.

This type of plant is a small and medium industry suitable for developing countries. It is labor-intensive and requires specific technologies.

View of Assembling Plant

Products and Specifications

Explanations here relate only to the most fundamental instruments of pressure gauge and thermometer manufactured in this plant among the various precision instruments described above. Viewing pressure gauges including general pressure gauge, liquid filled pressure gauge and industrial pressure gauge, the dial size ranges 60-120mm and the case type breaks down into the stem mounting, surface mounting and flush mounting with respective ranges of 0-76 cmHg 0-1/20kg/cm^2. Detail specifications are shown in the table 1.

Thermometers are divided into two types of the bimetal type and liquid filled type with the dial size ranging between 69 and 150mm in the range of -50 to 600°C. Detail specifications are shown in the table 2.

Contents of Technology

1) Process Description

Among many precision instruments, as explained above, explanations are given on pressure gauge with industrially diverse uses and bimetal type thermometer.

(a) Pressure gauge

The pressure gauge assemblying process largely breaks down into movement assembly, dial plate attachment, calibration and finished product assembly.

i) This shank and movement are first assembled together with rod pins. The work includes the hair spring spotting and insertion.

ii) A hole is hored at the dial plate zero point and a stopper is accurately inserted to begin assemblying the movement part.

iii) The pointer head is picked up by pincers and connected to the pointer.

iv) The parts finished in the above are connected to the shank, and then the hair spring coiling and rod action are checked. Fixing at the zero point, it is hammered.

v) The next is finished product assembly process where case, glass and cover are cleaned and assembled.

Table 1. Specifications of Pressure Gauge

General pressure gauge

Dial size (mm)	Range (kg/cm^2)	Case	Connection	Materials
60		A	1/4" U type	• Case: Black coated steel • Ring: Black coated steel • Window: Glass
75	76cmHg ~0	B		
100	76cmHg ~0 ~1/20	D	3/8" U type	• Bourdon tube: Brass
150	0 ~1/1000	BD	1/2" U type	• Movement: Brass • Connection: Brass • Accuracy: 1.5% FS

Liquid filled pressure gauge

Dial Size (mm)	Model	Range	Connection	Case	Materials	Remarks
60	SS60-FA	76cmHg~0	U type 1/4"	A	• Case and ring: AISI 304, polished • Tube and socket; AISI 316 • Movement: AISI 304 • Dial: Al white coated • Window: Safety glass • Blowout disk: Plastic & rubber	• Accuracy: 1.0% FS • Filled liquid: Glycerine • Pointer: Adjustable
	SS60-FB	76cmHg~0		B		
	SS60-FD	~1/20kg/cm²				
	SS60-FBD	0~1/300kg/cm²				
100	SS100-FA	76cmHg~0	U type 1/2"	D		
	SS100-FB	76cmHg~0				
	SS100-FD	~1/20kg/cm²				
	SS100-FBD	0~1/2000kg/cm²		BD		

Industrial pressure gauge

Dial size (mm)	Model	Range	Connection	Case	Materials	Remarks
125	W1001	• 76cmHg~0 • 76cmHg~0 1/20kg/cm² • 0~1/1000kg/cm²	U type 1/2"	B D	• Case & ring: Al diecastings • Tube & plug: AISI 304 or 316 • Movement: AISI 304	• Accuracy: + 1.0% FS • Pointer: Adjustable
100	W1011			A B D		• Accuracy: ±1.0% FS • Weather-proof • Completely sealed

* Basis

Type of case

A	:	Lower connection. Stem mounting
B	:	Lower connection. Surface mounting
D	:	Back connection. Stem mounting
BD	:	Back connection. Flush mounting

Type of connection

T	:	Square
U	:	Parallel faced
S	:	Hexagonal

(b)Bimetal thermometer

i) As can be seen in the flow sheet, the original bimetal plate is measured with a rule to suit various temperatures and tailor-cut by a drill. It is then cut by a cutter for coiling and heat treatment.

ii) In the meantime, a spindle is cut and jointed with heat-treated bimetal.

iii) The shank, well and case are assembled with spot-readied bimetals and welded with argon gas.

vi) The assembled bimetal, with the use of a temporary pointer, is checked for water, ice, oil and the like, while being maintained constant each time for pencil checks.

v) The graded dial plates are affixed on correct positions by means of bonding agent.

iv) On completion, the pointer is riveted to the pointer spindle and assembled with the bimetal.

iiv) The dial plate is manually cleaned and dried for 1-2 hours by means of a heater.

iiiv) The cover is cleaned and then assembled.

xi) The finished product is tested in accordance with standards, and then inspected for water-proofness and outer appearances.

Table 2. Specifications of Thermometer

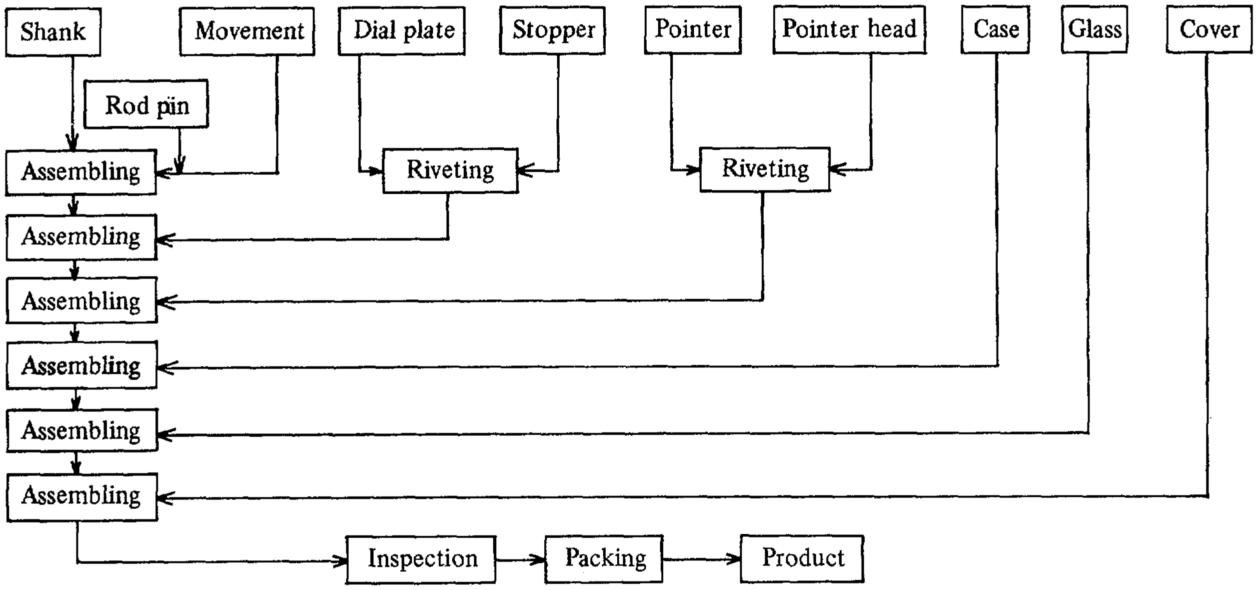
1) Bimetal thermometer (Lower connection)

Dial size (mm)	Model	Out diameter (mm)	Range (°C)	Stem(mm)		Connection	Materials	Remarks
				Dia.	Length			
75	BLL-75	85	-50–400 * Can be limited by the stem diameter and length	6.4 8 10	100 150 250 Max 500	1/2″	∘ Case & ring: Al diecasting (But ring of 75mm: AISI 304) ∘ Stem: AISI 304 ∘ Connection: AISI 304	∘ Accuracy: 1.5% FS
125	BLL-125	158						
60	BLL-60	63					∘ Case & ring: AISI 304 ∘ Stem: AISI 304 ∘ Connection: AISI 304	
100	BLL-100	104						

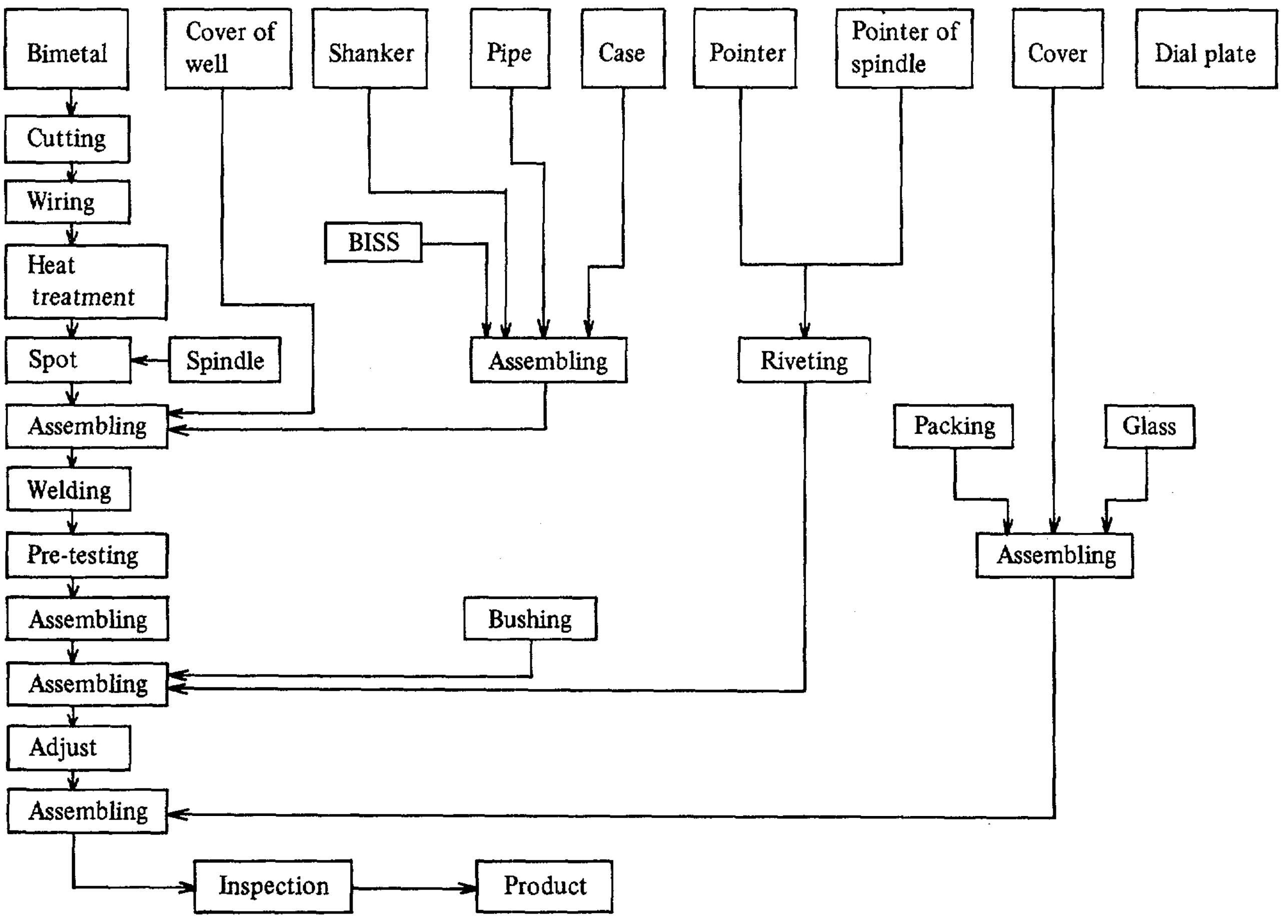
2) Liquid filled type thermometer

Dial size (mm)	Model	Out diameter (mm)	Range (°C)	Stem(mm)		Capillary tube	Connection	Materials	Remarks
				Dia.	Length				
MTG 75	75	85	-30-600	12	130	Std: 2m Available to max. 10m	1/2″	∘ Case & ring: Al die casting ∘ Capillary tube: AISI 316 • Stem: AISI 304 • Connection: AISI 304 • Flexible tube: AISI 430	• Accuracy: ±3% FS
MTG 100	100	110							
MTG 150	150	165							

Pressure Gauge Assembling Process Block Diagram



Bimetal Thermometer Assembling Process Block Diagram



2) Equipment and Machinery

High speed precision lathe
High speed automatic lathe
Gear hobbing machine
Gear cutting machine curved tooth
Vertical milling machine
Drilling machine, Deep hole vertical
Tapping machine
Multi spindle drilling machine
Welding machine
Hydraulic automatic throad cutting machine
High speed universal index drilling machine
Argon welding machine
Tool brazing machine
Power press
Super welding machine
Air drive gas booster compressor
Electric detail press
Press sensor piston dead weight tester for gas measure
Hardness tester indentation rockwell
Sound level meter
Standard glass thermometer
Dead weight tester
Mano meter
Reliability tester for press gauge
Reliability tester for bourdon tube
Pressure sensor differential U-tube mercury
Proof against vibration tester
Fluid vibration tester
Temperature control panel
Oven for drying controlled atmosphere

3) Raw Materials

Raw materials	Requirement (per unit of product)
Steel plate	160mm x 160mm
Copper pipe	200mm
Copper rod	50mm

Example of Plant Capacity and Construction Cost

1) Plant capacity: Pressure gauge 500,000 units/year
Thermometer 30,000 units/year
* Basis: 20 hours/day, 25 days/month

2) Estimated manufacturing equipment cost (as of July, 1982): US$1,330,000

3) Required space
- Site area : 9,000 m^2
- Building area : 7,000 m^2

4) Personnel requirement: 300 persons

Any inquiry about the information contained should be sent to:
IO/COOP, Registry file No. ID/562/12, UNIDO, P.O. Box 300, A-1400 Vienna, Austria

Watt Hour Meter Assembling Plant

The watt hour meter is an instrument used in a house or plant to measure electric power. The driving force caused by the magnetic field and turning force, which are generated by electric current, is represented by revolutions of a disc. The number of revolutions is transmitted by connecting its revolving axis to a gear. Such a measuring instrument should be reliable and stable with a minimum loss of electricity as well as possibility of mass production at reasonable prices.

This measuring instrument should also have excellent characteristics against possible errors due to variations in current, voltage, temperature and frequency. Its specifications include single-phase 2-wire, single-phase 3-wire, three-phase 3-wire, three-phase 4-wire, etc. for use both in houses and industries.

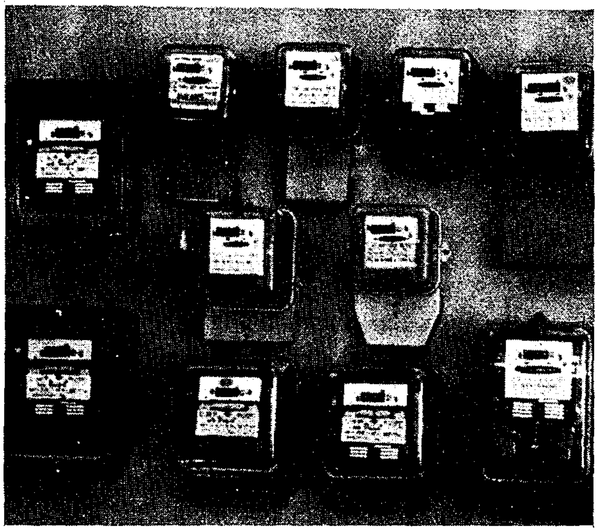
Products and Specifications

This plant produces two different types of single-phase and three-phase meters. Its mounting type also breaks down to the front connecting type and flush mounting type while having glass covers in most cases. Metal covers are available in the case of panel board. Characteristics of its products are as follows :

Table 1. Specification of Watt Hour Meter

Item \ Circuit system	Single–phase, 2 wire	Three-phase, 3-wire (single-phase, 3–wire)	Three-phase 4–wire
Rated torque	Approx. 7.5gr-cm at 200% rated current	Approx. 14.5gr-cm at rated current	Approx. 25.0gr-cm at rated current
	Approx. 12.0gr-cm at 300% rated current		
Rated speed	200% : 44rpm 300% : 66 rpm	3ϕ 3W : 38.1rpm 1ϕ 3W : 44rpm	3ϕ 4W : 44rpm
Weight of rotor ass'y	18.8gr	25.0gr	51.0gr
Weight of meter	Up to 60A : approx. 1.42Kg Over 60A : approx. 2.19Kg	Up to 60A : approx. 2.9Kg Over 60A : approx. 4Kg	Up to 60A : approx. 4.1Kg Over 60A : approx. 6.1Kg
Starting	Under 0.4% of rated current		
Load range	200% or 300% by request		
Watt losses	Voltage circuit	100V : 1.0W 220V : 1.0W	
	Current circuit	Up to 60A : approx. 0.4W–1.0W Over 60A : approx. 1.0W–2.0W	
Creeping	No creeping between rated voltage and 10% in excess of rated voltage, with current coil disconnected.		

Watt Hour Meter Assembly Shop



Watt Hour Meter

- Lower bearing

Ball and jewel bearing with a free polished steel ball between two sapphires. Lubricant oil is special watch oil which is guaranteed to be not decayed for a long use and the durability is confirmed by various inspection.

- Top bearing

Top bearing is composed of needle and collar journal. Bearing is very strong against weather condition since the material is brass. Needle is hardened steel pin with copper and silver plate, also being strong against weather condition.

- Elements

The current and voltage core is made of laminated silicon steel of superior magnetic characteristics. The laminated core is given a rustproofing treatment, and the current core is provided with an electromagnetic shunt core for load characteristic compensations. The voltage core is also provided with an electromagnetic shunt core for voltage characteristic compensation and thermo alloy for temperature compensation. Coil is insulating metal having high heat resistance.

- Magnetic floating type

Licensor's magnetic thrust bearing is of the repulsion type and two annular barium ferrite magnets are mounted, one on the frame and the other on the rotor assembly. The magnets repel one another so that the rotor shaft is pressed against the upper bearing cap, with an air gap of about 1mm between the magnet faces. The lower part of the rotor shaft is centered by a needle bearing. The magnets are fitted with temperature compensation caps and a thermo-alloy compensator to allow for temperature changes.

- External connection

Meters designed for projecting mounting have terminal screws at the front connection. Meters for flush mounting directly on a switchboard panel have terminal screws at the rear connection. Details of flush mounting style are shown in the other technical specifications. Short terminal cover is standard, but for projecting mounting extended terminal cover is provided.

- Register

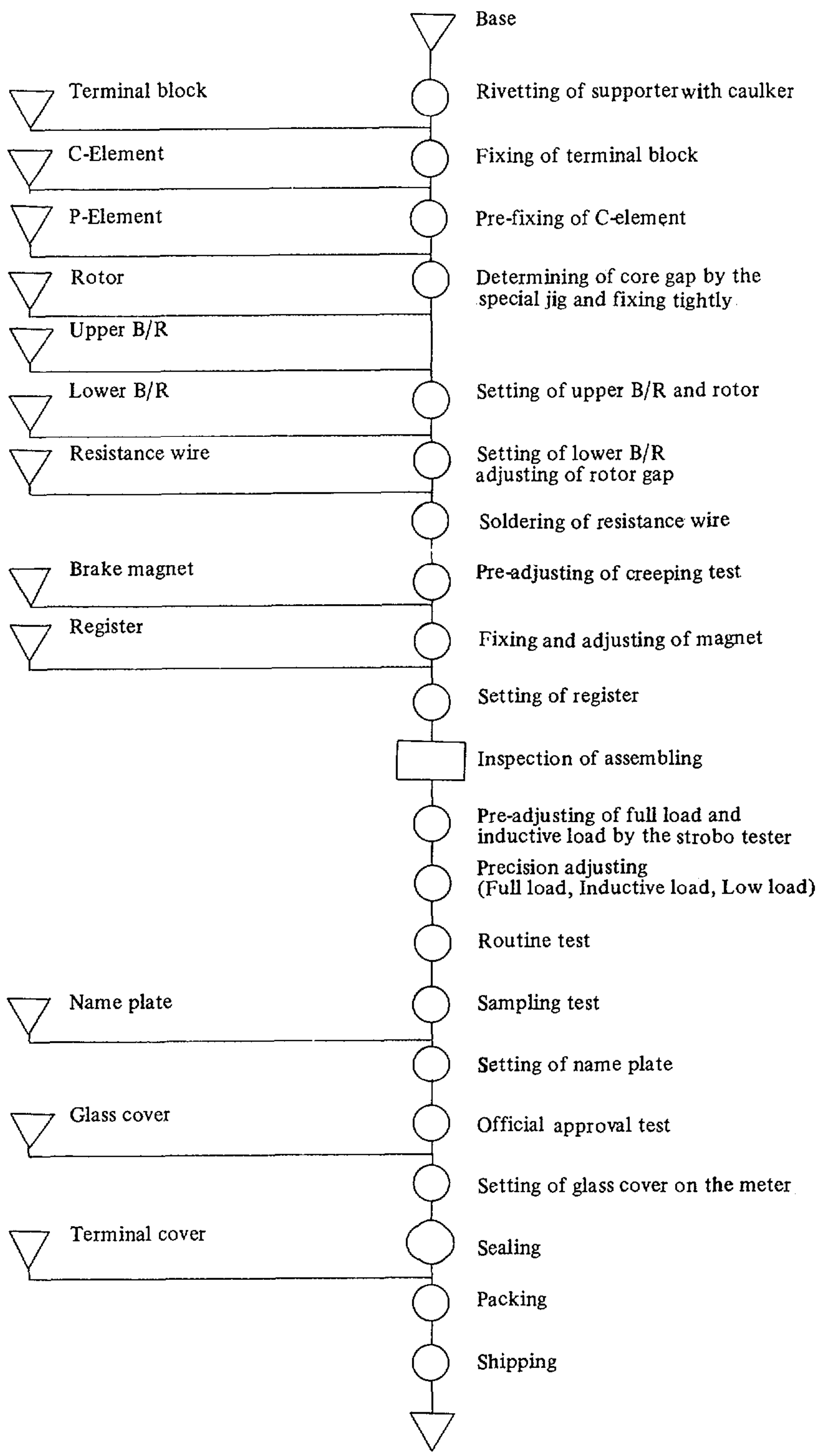
Cyclometer register with 5-6 rollers is standard. Cyclometer register with 5 rollers drawn from aluminum sheet, register frame of brass sheet nickel plating gear of brass sheet, and shaft of stainless steel. The aluminium roller is of very light weight, therefore, small friction torque due to moving up, small error and variation at the time of light load. The register has a guide plate, so that any register fits to any meter and correct engagement of the worm wheel is ensured.

Contents of Technology

1) Process Description

As can be seen in the process diagram, with the base assembly readied, the terminal block assembly, C-element assembly, P-element assembly, rotor, B/R assembly and resiatance wire assembly are assembled and subjected to creeping tests. Following the setting of break magnet and resistor, the products are preadjusted respectively for the full load and inductive load by means of a strobo tester. After fixing the name plate, glass cover and terminal cover, the final products are sealed and packed for delivery.

Watt Hour Meter Assembling Process Flow Diagram



2) Equipment and Machinery

- Watt hour meter testing board
- Strobo tester
- Press (30t)
- Conveyor
- Automatic voltage regulator
- Compound die
- Supporter caulking jig
- Terminal block setting jig
- C-Element setting jig
- P-C gap jig
- Resistance soldering jig
- Piercing jig
- Stamping jig
- Numbering head
- Numbering jig
- Air driver
- Dust remover
- Master meter
- Magnetizer
- Creeping tester
- Flux meter
- Rotary standard
- Puncture tester

Example of Plant Capcity and Construction Cost

1) Plant capacity : 30,000 set/month
   * Basis : 25 days

2) Estimated equipment cost (as of 1982)

   Manufacturing machinery & utility cost : US$1,000,000

3) Required space

Site area	: 1,700 m^2
Building area	: 4,900 m^2

4) Personnel requirement

Plant manager	: 5 persons
Engineer	: 10 persons
Operator	: 90 persons
Others	: 10 persons
Total	: 115 persons

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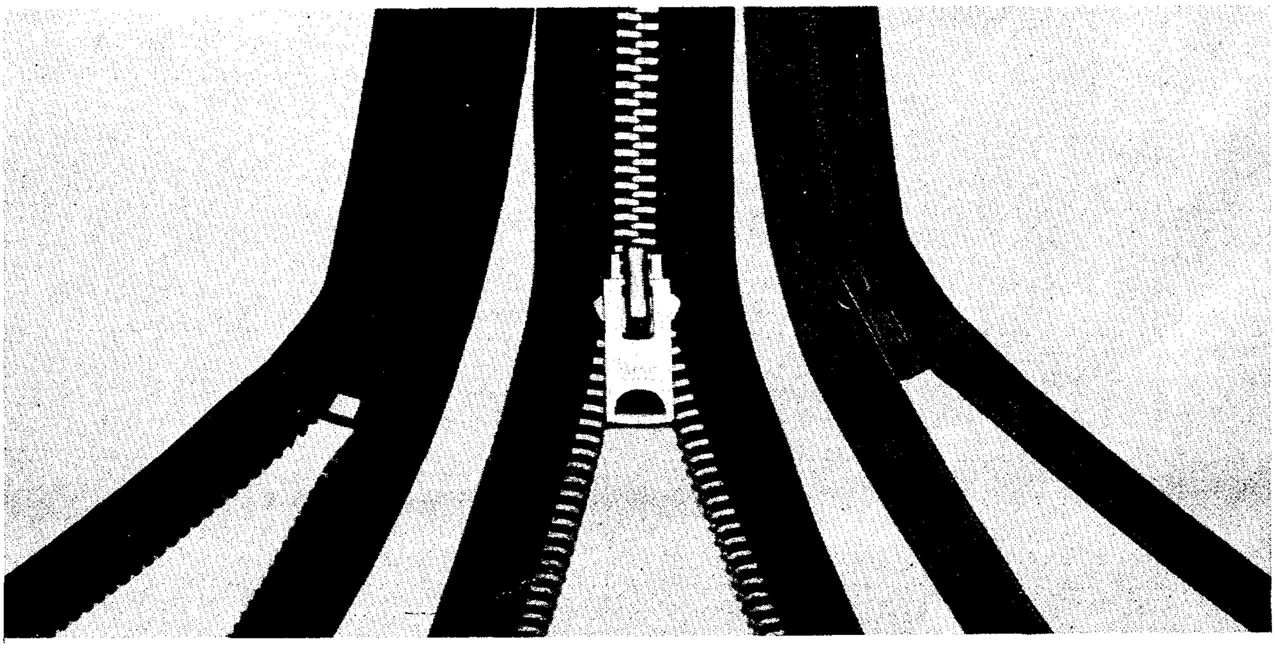
Polyester Zipper Making Plant



View of Products

Zippers are largely divided into the metallic zipper and plastic zipper for respective uses. In recent years, however, plastic zippers are in the great limelight for use in garments.

The plastic zipper breaks down to the nylon zipper and polyester zipper depending upon the material used. This plant introduced here currently produces polyester zippers suiting the uses for jumpers, trousers, bags and tents. It is characterized by distinctly lower production costs than in other countries.

Products and Specifications

The types and specifications of polyester zipper produced in this plant are as shown in tabel 1.

Table 1. Types and Specifications of Polyester Zipper

No. \ Category	Width		Thickness		Uses
	Before dyeing	After dyeing	Before dyeing	After dyeing	
#3	4.15	4.10	2.05	1.95	Jacket, bag, tent, trouser
#5	6.0	5.95	2.55	2.5	
#8	7.15	7.1	2.95	2.9	

* Allowance : ±0.05 mm

Contents of Technology

1) Process Description

Double coiling

Polyester filament yarns are coiled when forming with heating.

Sewing of double coiled yarns to tape

Coil-formed filament yarns are sewed to the tape (Semi-finished products).

Dyeing and finishing

The semi-finished products as a result of sewing are dyed in colors as ordered.

Semi-automatic gapping machine

The semi-fnished products dyed in rolls are provided with teeth in ordered length.

Automatic gap cleaning

The chains provided with teeth are thoroughly cleaned.

Semi-automatic bottom stop attaching machine

The process in which the bottom stop device is provided.

Cut-to-length machine

Cut in ordered length.

Fit slider by hand
The hand-grip is fixed to the semifinished products cut in ordered legth.

Semi-automatic top stop attaching machine
The process in which the top is provided.

Reinforcing machine
The process in which an auxiliary tape (film) is attached at the bottom part to make a jumper.

Pin attaching
The process in which pins are inserted to keep it down when making a jumper.

Box attaching
The process in which a box is inserted to keep it down when making a jumper.

Fit slider
The process in which a hand grip is fixed to the semi-finished product.

Inspection and counting
Product inspection and counting of the number of the products.

Polyester Zipper Manufacturing Process Flow Diagram

2) Equipment and Machinery

Double coil production machine
Sewing machine
Dyeing and finishing equipment
Semi-automatic gapping machine
Automatic gap cleaning machine
Semi-auto bottom stop attaching machine
Cut-to-length machine
Semi-auto top stop attaching machine
Reinforcing machine
Pin attaching machine
Box attaching machine
Die casting machine
Needle loom
Dyeing machine

3) Raw Materials

Raw materials	Requirement (per #5 standard)
Polyester filament yarn (coil)	641.8g/100m
Polyester filament stretch yarn (tape)	846.2g/100m
Polyester filament yarn (sewing yarn)	116.9g/100m
Polyester spun yarn (cord)	105.4g/100m
Zinc alloy (slider)	4.222 g/ea

Example of Plant Capacity and Construction Cost

1) Plant capacity : 300,000 m/month

2) Estimated construction cost (as of 1983)

- Equipment and machinery : US$233,000
- Utilities : US$ 2,000
- Installation cost : US$ 20,000

Total : US$255,000

3) Required space

- Site area : 4,000m²
- Building area : 2,800m²

4) Personnel requirement

- Plant manager : 1 person
- Engineer : 2 persons
- Operator : 30 persons

Total : 33 persons

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SMALL-SCALE CHARCOAL PRODUCTION

(prepared 1979)

Charcoal is a fuel which has important industrial as well as domestic uses. Being made from wood, potentially a renewable resource, the environmental implications of charcoal production require careful consideration. The process described in this profile operates with two kilns which are loaded and fired alternately. The basic sub-process involved are wood preparation, carbonization and packing of the finished product. A team of 5 workers should be able to produce 12 tonnes of charcoal per month. The fixed investment cost is under $ 5000.

1. INTRODUCTION

The art of making charcoal is at least 6,000 years old. Interest in charcoal as a fuel, both for domestic use and for industrial purposes, has recently increased because of a steep rise in the prices of all fuels and power.

Charcoal is made from wood, a renewable resource. It should be noted that charcoal industries have caused large-scale environmental damage. The ecological effects of removing trees must be understood and measures be taken to prevent such damage, prior to starting a charcoal industry.

The reason for the use of charcoal instead of wood is that the heat value of charcoal is twice as high as that of wood (1,700 kJ/kg compared to 850 kJ/kg). Therefore the shipping cost of fuel is reduced. Charcoal burns without smoke and can be used in smaller and more efficient stoves.

Charcoal is also used in industry in the process of manufacturing lime and cement, for the extraction of metals, particularly iron, from their ores. Iron and steel made with charcoal are of higher quality than that made with coal. Charcoal is used for forging and producing high quality castings. Activated charcoal is produced by treatment with zinc chloride; it is used as absorbent in chemical processes and medicine.

2. PRODUCTION PROCESSES

Charcoal is produced when wood is burned under limited supply of air. Gaseous components and water are removed, so that charcoal consists of about 90% carbon. The yield should be 50-70 kg of charcoal out of 1 cubic metre of wood.

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3. CAPITAL REQUIREMENTS

A.	FIXED INVESTMENT	$
	2 kilns at US $ 2,000	4,000
	various tools	250
		4,250
B.	WORKING CAPITAL	
	One month's wages	425
	One month's raw materials	106
		531
	Total $	4,781

4. OPERATING CHARACTERISTICS

A. MATERIAL REQUIREMENTS

Nearly any wood can be taken for charcoal production; commonly used species, which are fast growing, are Eucalyptus and Wattle trees. 6 steres are needed to load one kiln. Working 300 days a year, the annual requirement is:

1,800 cu.m. of wood at $ 0.25	450
sacks, string	816
	$ 1,266

B. WORK FORCE REQUIREMENTS

	US $/year
5 semi-skilled workers	3,300
Management, supervision and office work	1,800
	$ 5,100

C. ANNUAL OPERATING COST

Material requirements	$ 1,266
Wages	5,100
Maintenance and replacement of tools	425
	$ 6,791

Production can start two months after investment. The first month should partly be taken for training of the labourers if necessary.

5. EVALUATION (values in US $)

This is based on 5 year operating life, a one year build-up to full capacity production, and a residual value for tools, Fixed investment is 4,250. Working capital, 531, is taken in one instalment on year 0. The residual value, 1,000, and working capital 531, are returned in the 5th year of operation.

Thus, production costs build up as follows:

	Year 1 capacity (50%)	Year 2 capacity (100%)
Materials	633	1,266
Salaries	5,100	5,100
Repairs and maintenance	213	425
	5,946	6,791

The following are the results of NPV analysis:

Discount Rate	Present value of total costs	Annual revenue required	Revenue required per kg of charcoal
10%	24,575	8,621	0.059
10%	23,678	9,202	0.063
20%	20,132	9,820	0.068

V

SOLAR DESALINATION UNIT

(prepared 1979)

The solar still is used as a source of distilled water for both industrial and domestic purposes. In many parts of the world the supply of drinking water during the dry season is a problem of vital concern. The size of still described in this profile is sufficient to cater for the needs of up to 250 inhabitants. The plant requires only one attendant and has a capital cost of less than $ 18,000.

1. INTRODUCTION

By means of solar energy potable water is produced from seawater or brackish well water in the process of desalination or distillation.

The solar still consists of a shallow pool of brine covered by sloping panes of glass. The water is evaporated by absorbed solar radiation and the vapour condenses on the underside of the glass covers, which are cooled at the outside by convection. The water droplets trickle down the glass to be collected in narrow drains along the bottom.

2. LOCATION

The solar still is used as a source of distilled water for battery maintenance in garages and analytical laboratories in hospitals and schools. In many parts of the world, supply of drinking water during the dry season is one of the most crucial problems for villages.

Solar stills offer a solution for the problem of potable water supply first in places near the sea, using saline seawater; secondly in places which are rich in underground water, but when the water is unfit for human consumption; and thirdly, where only brackish or polluted surface water is available.

Furthermore on small islands distilled water may be the only source of fresh water.

Installations of solar desalination plants are widely used in the USA, Greece and Australia.

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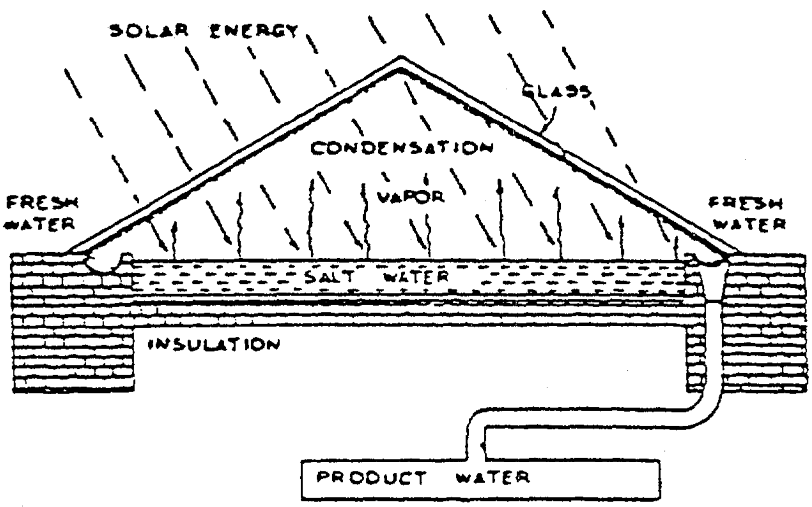
A large number of stills have been built in Niger and Mali. The great advantage of the solar still is the flexibility it offers in choice of size. The output of the still is above all a function of its area - typically 2-4 l/m^2 day or about 1 m^3/m^2 year. Durable stills have been built for a unit cost of 15-30 $\$/m^2$ dependent on design and local circumstances. Solar stills can be built in any size from a few square meters area up to some 100,000 m^2. If the output has to be greater than 1,000 m^3/day, conventional fuel fired desalination plants are more economical today.

3. DESIGNS OF SOLAR STILLS

Although small community-scale stills are competitive with other desalination systems, the process must be regarded as experimental. New plants have to be designed according to local conditions rather than being chosen from standardized units.

The variation in designs is mainly in the use of materials, so that one can distinguish between permanent and semi-permanent constructions. The basic design is shown in the figure below.

Figure 1



The most durable stills use concrete for the trough painted with asphalt. The cover is glass in aluminium frames; aluminium is also taken for the collection drains. Cheaper and less durable stills take plastic foils for the trough and the cover and frames are made of wood. Single slope roofs are used in off-equator regions whereas gable roofed stills are more common in equatorial areas.

The following section describe a solar still, which has been erected in Haiti, on a small island which during the dry season has only a saline water well as its water source.

4. WATER PRODUCTION BY A SOLAR STILL

(a) Capacity

The components of the desalination plant are:

- the saline well with a windmill driven pump and a standby handpump;
- upper feed tank for saline water;
- the fresh water reservoir.

The schematic concept is shown in figure 2, and the design of the still itself in figure 3.

The water output from the still is 1,250 l/day on an average including rain water catchment. This is sufficient for about 250 residents in the community.

The area of the still is about 400 m^2 (25m x 16m), giving an average production rate of 3 l/m^2 day, out of which 10% comes from rain water (precipitation is only 100 mm/year).

(b) Material requirements

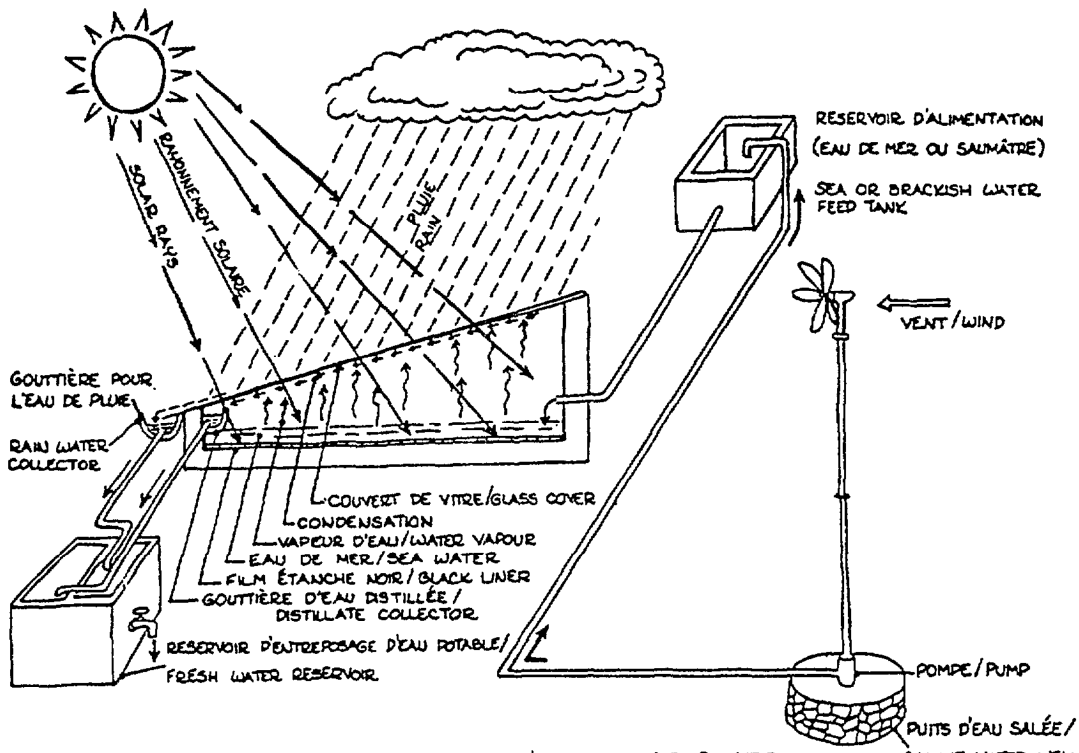
Locally available materials were used as much as possible, that is bricks, cement, sand and concrete blocks for the basic construction. The drain troughs for the distillate and the rainwater are cast in the wall structure, so that no material is used for this. As insulation material dried coffee husks were used. If no very cheap insulation material is available, insulation can be excluded, since it improves the efficiency of the still only slightly.

Imported items are the glass panes (400 m^2), the rubber basin liner (400 m^2) and the sealing compound to hold the glass in place. The pumps, PVC-pipes and fittings were also imported.

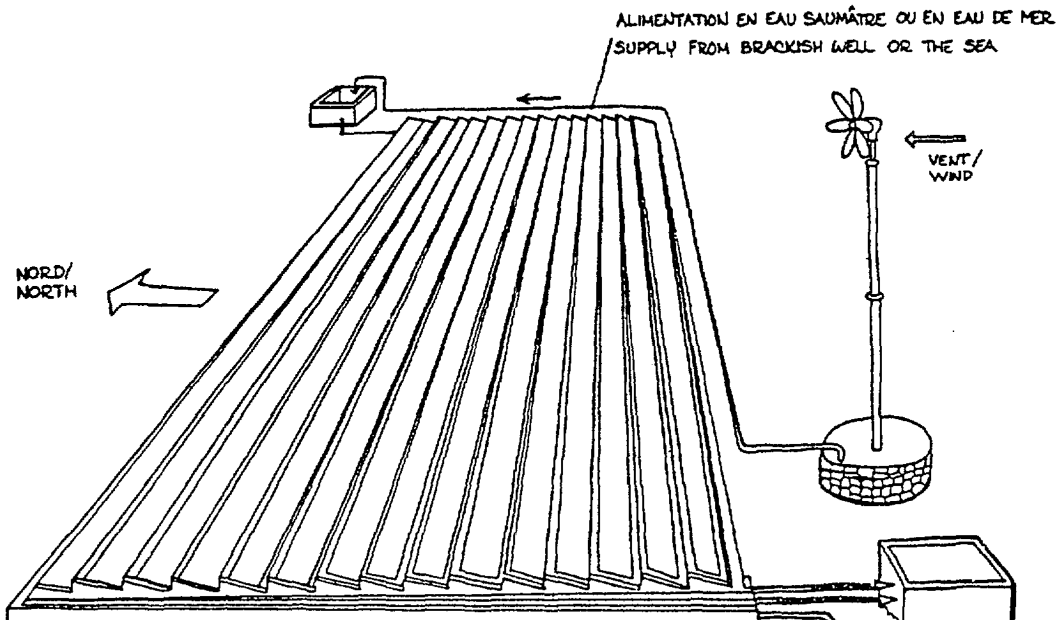
(c) Work force requirements

Various levels of skills and capabilities are necessary to install the desalination plant. Carpenters are required to build the concrete formers. Bricklayers and masons are needed for construction of the solar still basin; basic plumbing and tinsmith work is also required. All these skills were available within the community. An engineer is needed for supervision and management during installation, which can be carried out in one year.

Figure 2



VUE SCHEMATIC DU FONCTIONNEMENT D'UN DISTILLATEUR SOLAIRE
SCHEMATIC CONCEPT OF SOLAR STILL OPERATION



CIRCUIT DE BASE DU DISTILLATEUR SOLAIRE DE LA GONÂVE
BASIC FEATURES OF LA GONÂVE SOLAR STILL

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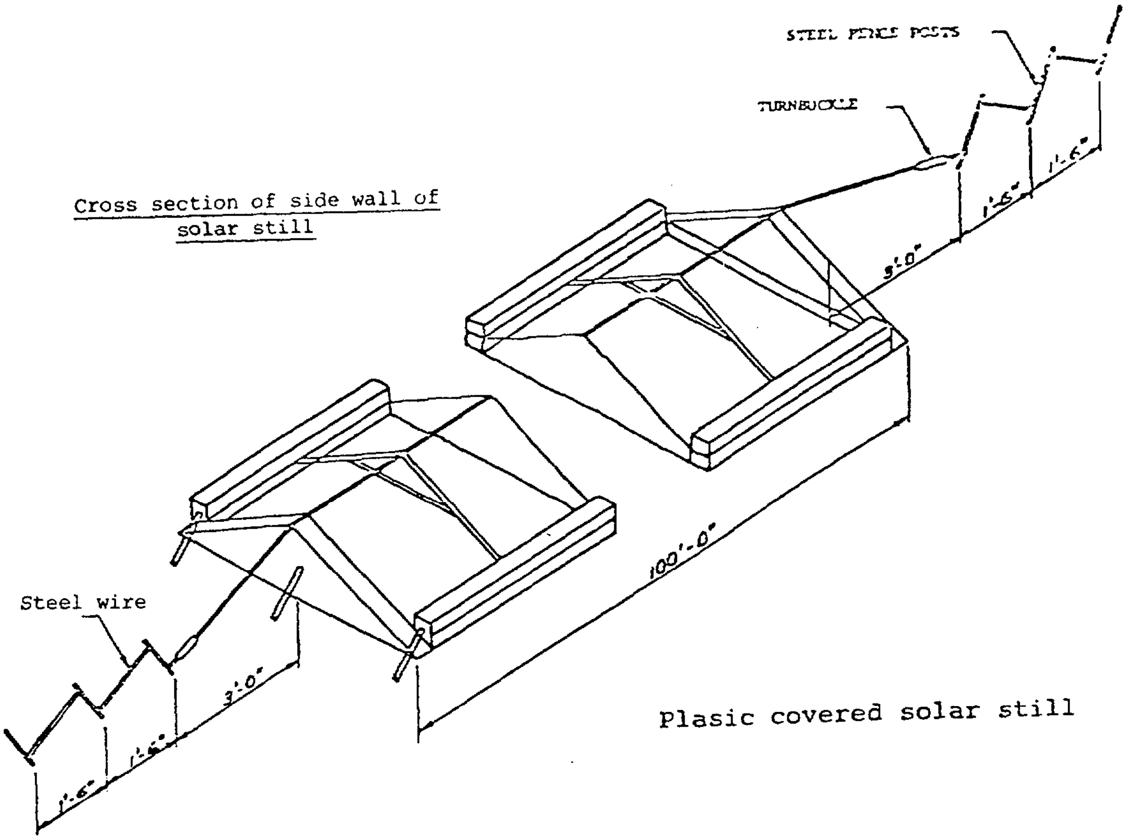
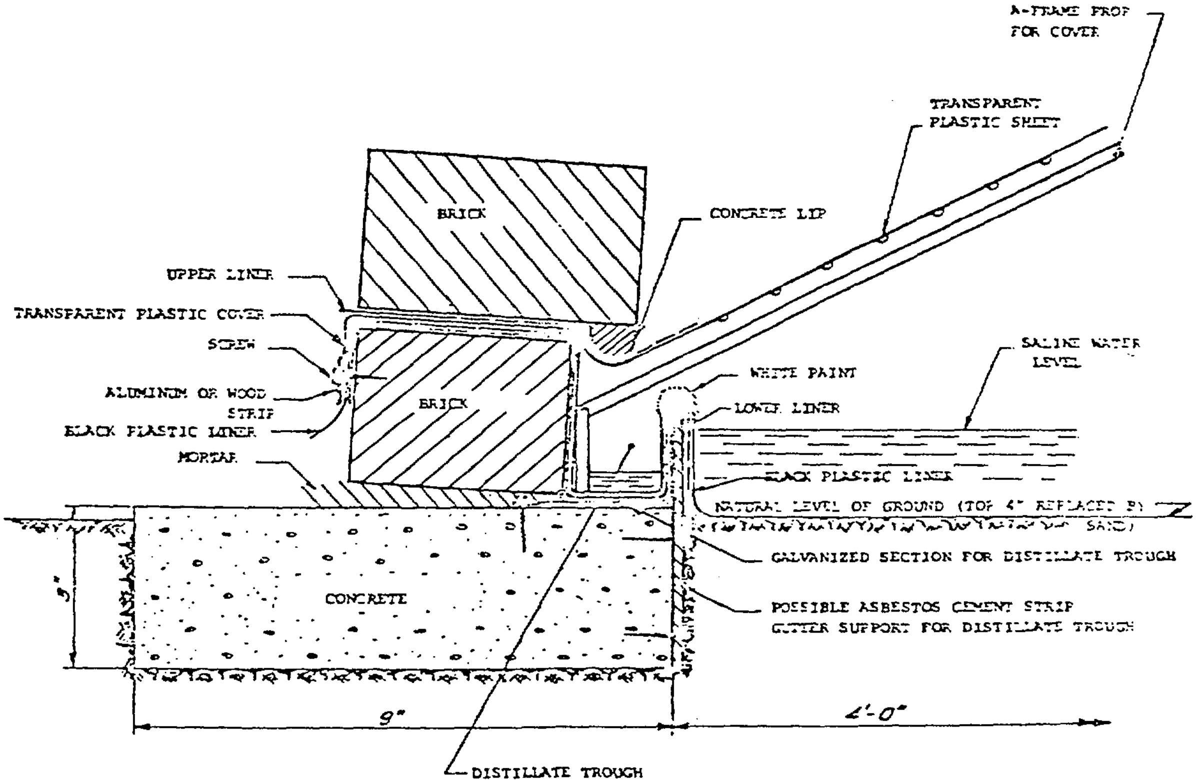
Figure 3





(d) Capital requirements

Fixed Investment:	$
land 800 m^2 at $1,00	800
materials	14,000
labour	3,000
	$ 17,800

The cost/area of $ 44,5/m^2 is above the elsewhere reported figures of $ 16-32/m^2, because all supplementary installations like the windmill etc. are included.

Working capital is not required.

(e) Operating characteristics

The plant needs little maintenance. The still has to be flushed once a day in the morning with fresh saline water, the windmill pump has to be serviced regularly and broken glass panes have to be replaced after heavy storms. So only one attendant is employed to run the whole plant.

The solar still has now been in operation for 10 years and is expected to last 20 to 30 years.

(f) Annual operating cost	$ per year
labour, one attendant	1,000
materials, replacement of glass	500
maintenance and repairs other than glass	200
	$ 1,700

(g) Evaluation (values in US $)

This is based on 25 year operating life, with neither build-up to full capacity production, nor residual value. Fixed investment is 17,800. No working capital is necessary.

Thus, production costs are as follows:

	Year 0 full capacity
Materials (to replace glass)	500
Wages and salaries	1,000
Other repairs and maintenance	200
	1,700

The following are the results of NPV analysis:

Discount Rate	Present value of total costs	Annual revenue required	Revenue required per 1000 litres
10%	33,233	3,661	8.03
20%	26,212	5,297	11.62
30%	23,459	7,047	15.45

5. ALTERNATIVE STILLS

(a) Small still for a single household

From India the design of a small still with gabled roof is reported with 10 m^2 area. It is also a concrete and glass system but without any delivery piping. The still has to be filled daily by hand and therefore installation and running costs, are much lower. The installation cost is $ 200 and the still can deliver 25 l/day on an annual average, ranging between 7 and 37 l/day according to season.

(b) Plastic covered still

From Canada the design of a 40 m^2 solar still is abailable which can be erected at a price of $ 450. Production rate is about 120 l/day or 44 m^3 per annum. The economic life of the still is 15 years, but the transport plastic cover has to be renewed every two years.

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