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D03772

Distr.
LIMITED

ID/WG.1[illegible]/10
26 June 1972

ORIGINAL: ENGLISH

United Nations Industrial Development Organization

International Seminar on Manufacture
and Utilization of Portland Cement

7 - 30 May 1972
Holte, Denmark

PLANNING OF NEW CEMENT PLANTS AND EXPANSIONS, TECHNICAL AND COMMERCIAL ASPECTS [1]

by

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id.72-4822

Introduction

The production of Portland cement today is only economically possible, when the cement is manufactured in plants above a certain minimum size, which requires an initial capital investment of several million US dollars. The establishment of a new cement plant is therefore a major project, which calls for thorough investigations of the market, the resources, and the economical conditions before the decision to start the construction of the plant can be made.

The necessity of manufacturing cement in large-scale plants is due to competition from other cement manufacturers and the fact that the costs of production per ton of cement decreases considerably with increasing plant capacities. This is a well-known pattern within several other industries, and the principles of establishing the minimum economical size of plant are the same as those used in other industries.

Another characteristic of the cement industry is that the capital investment is high compared with the actual costs of production. However, the type of equipment used in a cement plant normally has a long life, say 25 years, and the depreciation of the plant may therefore be distributed over several years.

This means that a new cement plant should preferably run for a period of at least 25 years in order to render the full return on the capital invested. If the production is discontinued after a few years of operation, the remaining life of the equipment is in most cases completely lost because the resale value of cement plant equipment is very low due to the high costs of dismantling and transportation of this heavy type of equipment.

In other words, continuous operation during several years is essential for the economic success of a new cement plant, and the planning party must therefore take every precaution to ascertain that the surveys on market and resources contain sufficient evidence that the demand of cement and the supplies of raw materials will match the life of the plant.

In addition to the surveys on market and resources the planning team will have to find answers to a number of other questions, comprising:

1) Plant location
2) Size of plant
3) Manufacturing process
4) Plant equipment and layout
5) Financing and cash flow profiles

All these questions are important and should be evaluated in detail before the decision on the possible implementation of the project is made.

A comprehensive study as outlined above is in itself rather costly. It is therefore suggested to devide the work into a preliminary feasibility study, which is based mainly on existing information and which may thus be made at a fairly low cost. If the outcome of the preliminary study is encouraging a more comprehensive study should be carried out.

Market Survey

Portland cement is one of the most widely used commodities in the world. Due to the rather low price per weight unit (about 20-30 US dollars per metric ton) it is manufactured locally in all countries, in which suitable raw materials (limestone and shale or clay) are available.

The consumption per capita varies from about 50 kilos in many developing countries to about 500 kilos/year in industrialized countries. The average growth rate of the cement consumption is about 5-6% per year, but the growth rate varies considerably from place to place. In the industrialized countries the growth rate is normally below the world average, which indicates that the market is approaching its saturation point. In the developing countries the growth rate is usually higher than 6%, in some countries considerably higher.

In all countries the demand for cement fluctuates with the activities within the building sector, which also reflect the present economic situation in the country.

Large construction schemes such as dams for hydroelectric plants, airports or highways, may change the demand markedly.

In some areas the demand for cement may be very low because of abnormally high prices of imported cement or cement from existing uneconomical cement plants. The potential markets of such areas may be evaluated by studying the procedures within the building industry and the costs of alternative construction materials.

The competitors' activities should be studied as closely as possible. A potential market may easily attract several groups of cement manufacturers and it often happens that new plants or expansions are constructed simultaneously within the same area with the result that both works will be running at reduced outputs during several years.

Raw Materials

The raw materials for manufacture of Portland cement are normally limestone and shale or clay. Deposits of these materials are found in most countries, but the qualities and quantities are not always quite satisfactory to meet the requirements of a cement plant. In fact, only relatively few cement plants are so fortunate as to have ample supplies of high-quality raw materials available within the vicinity of the plant.

In areas with smaller - or inferior - quality limestone the prospecting for usable reserves becomes the most important part of the feasibility study, but even when raw materials seem to be available, a survey should always be carried out to ascertain that the quantities and qualities are adequate.

For a new plant the reserves of raw materials proved should cover at least 25 years of operation and preferably somewhat more to allow for possible expansions.

The limestone should contain a minimum of about 78% calcium carbonate and only small amounts of magnesia, phosphate, alkalies, chloride, and sulphur. The shale or clay should preferably have low contents of alkalies and chloride and suitable ratios between the oxides of silica, aluminium and iron. Apart from the chemical composition the raw materials should preferably have physical properties which make them easy to quarry and handle.

Geological investigations, including bore hole sampling, are normally required forthe assessement of the deposits. For these studies expert assistance may often be needed in order to ensure that the necessary evidence is obtained at a minimum cost of bore hole drilling.

In special cases low carbonate lime stone may be upgraded by different types of processes, of which selective grinding and flotation are good examples.

Preliminary Feasibility Study

As soon as it has been established that the market for cement is large enough to justify a new cement plant and that raw materials are available, a preliminary feasibility study should be made in order to examine if the project deserves further consideration. In the affirmative more detailed investigations are required to be carried out to render the basic data for a final feasibility study.

The main objective of the preliminary feasibility study is - as mentioned above to examine if the project is promising enough to justify a detailed study and planning work which will usually involve the expenditure of a rather substantial sum of money.

Other objectives are to produce a plan of actions and a time schedule for the execution of the comprehensive study and to provide preliminary information on the project, which may be required in order to calculate the initial capital requirements and to obtain financing for the detailed study.

Assuming that the preliminary survey indicates that the market for a new cement plant exists and that sufficient quantities of suitable raw materials seem to be available, the preliminary feasibility study should contain an overall estimate of the initial capital requirement, the estimated costs of production, estimates of gross and net earnings, a preliminary financing programme and the estimated profitability.

All estimates are based on the information which is readily available or which may be obtained at small cost and without delay. For example the estimate of the capital requirement may be based on typical cost figures for standard cement plants such as shown on the table, fig. 1.

The profitability is expressed as the pay-back time or the rate of return on invested capital. The pay-back time is the number of years that it takes to earn the initial capital by means of the earnings from the plant disregarding interest, amortisation, and taxes.

The gross rate of return is the yearly earnings expressed as the percentage of the initial capital, again disregarding interest, amortisation, and taxes.

Both methods of evaluating the profitability are rather crude, but are often used because they are simple to work out and readily understandable. If a more accurate picture is required, the profitability may be evaluated by the internal rate of return method, which takes into account all expenditure and income during the estimated life of the plant and with due regard to interest, amortisation, and taxes. We shall revert to the latter method of evaluating the profitability a little later when we deal with the final feasibility study.

Plant Location

The choice of the plant location is important because the costs of transportation of raw materials and cement are rather high in relation to the costs of production and also because the location has to suit the condition over the total life of the plant as the equipment can only be moved at a cost which is normally prohibitively high.

The plant site should be located near the raw materials, near the market, and near the means of transportation such as port, railway, and good roads. The availability of electric power, fuel, water and man power should also be taken into consideration.

Some of the factors influencing the choice of the plant location may be conflicting. For example, it will often be desirable to have the plant placed in the vicinity of a big city, with a dense market, but, on the other hand, the plant should not be too close to the residential areas, where complaints about dust or noise nuisance are likely to create difficulties, for example later, when the company asks for permission to expand their plant.

In general, the vicinity of the raw materials is more important than the vicinity of the market, mainly because the raw materials are by weight about 60% heavier than the cement.

The ideal location of a contemplated plant may be calculated from details on the distribution of the market and the locations of raw materials and other resources by use of linear programming. In many cases, however, the choice is simplified, because one or a few sites have obvious advantages, and sophisticated calculations are therefore not always required.

Some rules of thumb may be quite useful, such as the rule that the plant should be located near the centre of the market, but rules of this type should be used with caution, because they are not always true. If, for example, the market is mainly devided between two centres with very little sale in between, the ideal location is not necessarily the point of gravity between the two centres but rather the bigger of the two centres.

The position of possible competitors may also influence the choice of the plant site. In general, the location of a new plant should be closer to the expected markets than any competitors but the distances should then be measured in unit costs of transportation rather than in miles or kilometres.

As the costs of transportation by waterways using barges or ocean-going bulk carriers are considerably lower than the costs of rail or road transport it is obvious that a location at the waterfront places the plant in a strong position in relation to all competitors within the areas near the waterways.

The relation between the costs of road and ship transport is illustrated by the fact that the radius of the distribution of cement by road in a competitive market is usually limited to about 100-150 miles' distance from the plant, whereas cement is often shipped several thousands miles by sea carrier. Due to the low costs of shipment by sea it is in many cases economical to operate one large-capacity plant with a waterway distribution system rather than a number of smaller plants. The trend towards concentration of the production into few, big plants and distribution of the cement by ships or barges to a number of distribution silos has become more and more pronounced during recent years. All existing and new cement plants are therefore facing the threat of new competition from far away bigger producers, who may decide to extend their sphere of operation by the building of a new distribution silo.

Optimum Size of Plant

The consumption of cement is in most countries steadily increasing. A new cement plant should therefore have some excess capacity to cover the demand not only the year after the commissioning, but also a few years ahead. On the other hand, the plant must not be too big because the operation is only profitable when the plant is working at almost full capacity. The breakeven point often corresponds to about 70% utilization. In a market with competition the optimum size of a new plant will very much depend on the relative merits of the new plant and the existing competitors. If the new plant is designed to produce cement at lower costs than the existing plants it may be able to take over a considerable portion of the market, and it may be justified to build a rather big plant on this basis. However, this means hard competition with the existing producers, who may decide to lower their prices and take other actions to keep their share of the market.

The optimum plant size can be calculated from the market survey data and the basic unit prices of cement and transport as well as the calculated cost figures for the construction and operation of plants of different sizes. Such calculations are based on assumed market volumes and prices and it is recommended to carry out sensitivity tests in order to evaluate the effect of possible deviations from the estimated basic figures.

The final decision regarding the size of a new plant is often influenced by the optimism or pessimism of the planning group. Some executives wish to be on the safe side by not building the plant any bigger than necessary and other decision makers feel that the plant must first of all be big enough to meet the challenge of the future.

It is a paradox that both types of planners may claim that they were right when later facing the actual developments. The plant which was built on the small side, will be less competitive because of the higher production costs of small plants, and will not be able to conquer its share of the markets. The owners may therefore conclude that they were lucky that they agreed to be prudent about the size of the project. For the optimistic party, the bigger plant proved to be very competitive and it took over a larger share of the market making the owners happy that they decided to "think big".

The influence of the decreasing production costs with increasing plant capacity may, of course, be included in the calculations, but if the profitability curve develops a "flat" maximum with almost the same value for a rather wide range of plant sizes it is of little help for the planning group.

Although the calculation of the optimum plant size is often rather complicated the principle is in fact quite simple. As shown on Fig. 2 the unit cost of production decreases with increasing size of the plant, but at the same time the unit cost of transportation of cement increases because normally the marginal market can only be gained by increasing the radius of the market area. The theoretical optimum plant size is then determined by minimizing the combined cost of production and transportation.

This simple model may, of course, be modified to suit special characteristics of the market, the means of transportation, and the type of plant.

Choice of Process

The manufacture of Portland cement comprises the following three processes:

1. Preparation of a raw mix
2. Burning of the raw mix to cement clinker
3. Grinding of clinker and gypsum to cement

Before the year 1900, Portland cement was burnt in small shaft kilns, but today about 95% of all cement is manufactured in rotary kiln plants. Shaft kilns are today only used in special cases and are normally not competitive with rotary kiln installations because of higher costs of labour and because it is difficult to manufacture cement of satisfactory, consistent quality by means of shaft kilns.

The manufacture of cement in rotary kiln plants may be carried out by different types of processes, the most common processes being the dry and the wet methods.

A more comprehensive list of the different processes used today is shown on Fig. 3. In the dry process the raw materials are dried in a separate dryer or in a dryer crusher or dryer mill and ground to the fineness required for the clinkering process. The dry raw meal from the raw mill is homogenized in special silos before it is fed to the dry process kiln.

The wet process is characterized by the wet grinding of the raw materials into a thick slurry, which is homogenized in slurry silos or basins and pumped to the wet process kiln. One important advantage of the wet process is the simplicity of operation, which should be taken into consideration when selecting the type of process for a new plant in an area where highly qualified labour may be difficult to obtain.

Apart from the different types of equipment in the raw grinding department the kilns used for the two types of processes are also different. The initial costs of the dry and wet process plants may differ somewhat from each other and the costs of operation also differs mainly due to the higher fuel consumption of the wet process plant. The relative merits of the two methods, however, depends on the local conditions, which may be favourable for one or the other of the methods. The main factor to be considered when deciding about the type of process is the moisture content of the raw materials. In general, the dry process is preferred for all raw materials with less than 10% moisture in situ (as quarried) whereas the wet process is preferred for very wet raw materials with 15-20% moisture content in situ.

For raw materials with 10-15% moisture it is often difficult to tell off hand which of the two methods is the more advantageous and it is usually necessary to carry out rather detailed calculations in order to ensure that the right decision is arrived at.

The merits of the dry and the wet processes are summarized in the table Fig. 4. The initial costs of the plants depend on the properties of the raw materials. For example a deposit of inhomogeneous limestone may require the installation of a rather expensive prehomogenizing store for a dry process plant, whereas the same limestone may be fed direct to the raw mill in a wet process plant in which homogenization can easily be achieved after the mill in a less expensive slurry basin.

Inhomogenous raw materials are therefore a factor which may speak in favour of the wet process.

The fuel consumption is in general higher for the wet process than for the dry process plant, but the actual fuel consumption figures vary considerably from plant to plant, depending on the moisture content of the raw materials.

A dry process plant may use, say, 800 kcal/kg clinker when the raw materials are all dry or contain only a few percent of moisture, but if the raw materials contain, say, 15% moisture the fuel consumption will be about 1100 kcal/kg clinker.

For a wet process plant the fuel consumption depends on the moisture content of the kiln slurry. Some unplastic raw materials may be ground wet into a pumpable slurry with only 28-30% of moisture and the fuel consumption of the wet kiln is then only 1100-1200 kcal/kg clinker. Other types of raw materials - usually recognized as plastic materials will require about 40-42% of moisture to produce a slurry which can be handled in centrifugal pumps, and for such slurries the fuel consumption is about 1400-1500 kcal/kg clinker.

Due to these differences in conditions the fuel saving of the dry process in relation to the wet process may be anything from nil to 700 kcal/kg clinker.

This illustrates how difficult it is to arrive at the right decision regarding the type of process and it is strongly recommended to base the final choice on careful examinations of the raw materials and all other factors involved, and to carry out detailed calculations of the initial costs and the operational costs for each alternative solution that is considered. These calculations will normally be made as part of the final feasibility study.

If the dry process is chosen the next step is to select the best suitable dry kiln system among the various possible alternatives. The 4-stage cyclone preheater kiln is often preferred because it usually is the cheapest installation, but for raw materials with high contents of alkalis (more than about 1% as sodium oxide) or chloride (more than 0.05% Cl^-) it is advisable to consider other solutions such as for example a 1-stage preheater kiln, in which the internal circulation of the volatile matters does not hamper the operation as much as in a 4-stage preheater installation.

The grate preheater kiln is fed with nodules of the raw meal prepared on a disc pelletizer and the dust emission from the kiln system is therefore rather low. However, the performance of the grate preheater depends very much on the physical properties of the raw materials because it is essential that the nodules should have high strength and porosity characteristics enabling them to pass through the preheater with a minimum of breakages.

Slurry filtration has been used in a few cases to combine the advantages of wet raw mix preparation and the burning of a kiln feed with a low moisture content. This method offers a substantial fuel saving as compared with the wet process, but the cost of operating the slurry filters will usually be of the same order as the fuel saving, and the overall efficiency of a plant with slurry filters is therefore not necessarily superior to that of a conventional plant. The cost of installation and operation of slurry filtres depends on the filtering properties of the slurry.

Spray drying of cement raw slurry is a relatively new method, which may be advantageous in special cases, e.g. when the raw materials have a high moisture content in situ, but produce a slurry which is not very suitable for burning in a wet kiln.

Other types of less commonly used processes are the fluid bed, the sintering grate, and the shaft kiln methods. Normally, these processes are not competitive in relation to the conventional rotary kiln installations. The shaft kiln is still used at some small plants, but when these plants are expanded, the shaft kilns are usually replaced by rotary kiln installations, partly because shaft kilns become less competitive with increasing plant capacities, and partly because the rotary kiln produces a more consistent quality of cement clinker. In some developing countries in which suitable raw materials ("natural cement" limestone) are available and the market is rather small, it may be justified to start a new plant with a shaft kiln installation.

Plant Equipment and Layout

The selection of equipment and the type of layout involve a more detailed planning of the plant contemplated. The equipment should be selected to suit the raw materials, the process, and the site. Furthermore, the different items of equipment should be properly matched.

Quarry equipment, crushers, and raw grinding mills are selected on the basis of field and laboratory examinations of the raw materials. Most types of limestone require blasting in the quarry, but some types may be quarried by ripping with a heavy-duty tractor, and soft chalks may be dug direct from the quarry face. These different methods of exploitation call for entirely different equipment.

The loading equipment in the quarry should preferably match the primary crusher in the way that the quarry excavator does not pick up any pieces of rock that are bigger than what the primary crusher will be able to handle.

Some raw materials may require preblending (or prehomogenising) of the precrushed rock before it is ground in the raw mill. Such raw material stores take up fairly large areas and can therefore not always be fitted into a site of limited dimensions. Alternative solutions may be to place the raw material stores in the quarry or to store the crushed raw materials in silos.

The plant layout should provide sufficient space and access to the equipment and at the lowest possible cost of internal handling of materials. Very often the layout is planned with a view to expansions of the plant by a second or more future unit.

Some plants are designed as "compact plants" with the emphasis on short distances between the main production equipment i.e. the kilns and the grinding mills (Fig. 5). This type of layout has the advantage of short conveyors, power cables, and walking distances within the plant, but the layout is not very suitable for future expansions of the plant beyond the second unit. When this type of plant is to be expanded, it is therefore often the best solution to build the third unit next to the existing plant as a separate, new plant.

A different type of layout has the grinding mills and the kilns arranged with sufficient space for several expansions. The provision of space for future expansions normally increases the cost of the first unit and is therefore only justified when the expansions are expected to be implemented within a few years after the commissioning of the first unit.

Plant Expansions

The expansion of a cement plant by a new kiln and mills calls for almost the same amount of planning work as that required for a new plant. The experience from the operation of the existing plant may be very useful for selecting the equipment for the expansion, provided the reserves of raw materials for the expansion are of the same type as the materials from the existing quarries.

In some cases the expansion is made by equipment identical to that of the existing installation , but very often it is decided to alter the specification, either because a unit with large capacity is required, or because new methods or equipment have become available.

The cost of the second unit is usually smaller than the cost of the first unit (when prices are corrected for the effect of inflation). The main reason is that the storage capacity for raw materials, raw mix, clinker, and cement may not necessarily need to be extended, as the operation of a two-unit plant requires a relatively smaller buffer storage capacity.

Final Feasibility Report

After selection of process, plant size, and location, the total cost of the project may be estimated from quotations for the main equipment and estimates of costs of construction, erection, etc. Furthermore, the cost of operation and the profitability of the plant may be calculated from the estimated requirements of fuel, power, manpower and other resources and from the estimated market price of cement.

The final feasibility report should contain the calculations of the profitability of the projects, which have been selected on the basis of the preliminary study. The main purpose of the report is to enable the planning group to decide which of the alternative projects offers the best solution, and if the profitability of this project is high enough to justify its implementation. Simplified examples of estimates of initial costs and costs of production are shown on Fig. 6 and Fig. 7. The profitability is here shown as the gross profit expressed as its percentage of the total capital expenditure. The return on capital of 15% corresponds to a payback time of 6.7 years.

For the project preferred the report should contain a financing plan comprising the capital requirements, conditions of credit, cash flow profile as well as the estimated gross and net earnings and the estimated dividends to the investors. It is recommended to recalculate the return on investment by means of the discounted cash flow method.

As a cement plant is a longlasting installation the return on the invested capital is distributed over several years, say 20-25 years. The equipment and the construction of the plant, however, should usually be paid within a few years after the commissioning of the plant. The initial capital requirements are therefore rather high in relation to the yearly earnings. When the financing plan is based on a substantial portion of the initial cost being balanced against credits and loans, it is important to check the cash flow carefully because usually the yearly earnings will not be large enough to pay off large short term liabilities.

In many countries, the government aids new cement plant projects by loans, cash grants or tax exemptions during the first few years of operation.

With the comprehensive feasibility report the planning phase is completed. The planning groups is now able to decide about the possible implementation of the project and, in the affirmative, to go ahead with the formation of the company or the organisation, which will be responsible for the purchases of equipment and ordering of engineering and construction work.

The planning procedure, as outlined above, involves a considerable amount of work as well as the expenditure of capital on commercial and technical investigations. However, considering the high costs of a cement plant project and the difficulties of correcting possible errors which may have been introduced during the planning stage, the efforts and the time spent on the planning work are well justified.

Capital Expenditure for Cement Plants

Estimated cash in 1000 US $ for FLS dry-process plants with 4-stage preheater Unax kiln. Price basis date, November 1, 1971.
Exclusive of: Preliminary investigations, cost of land, housing for employees, working capital, and interest on capital during building.

Capacity m ts/day m ts/year	500 165.000	630 208.000	800 264.000	1000 330.000	1250 412.500	1600 528.000	2000 660.000	2500 825.000	3000 990.000
1. Cement Making Machinery	3.180	3.470	3.980	4.510	5.480	6.400	7.340	8.970	
2. Ancillary Machinery, etc.	400	450	520	580	710	830	950	1.150	
3. Spare Parts, mechanical	290	310	360	410	500	580	660	800	
4. Electrical Equipment	730	800	920	1.040	1.260	1.470	1.690	2.070	
5. Spare Parts, electrical	70	80	90	100	120	150	170	200	
6. Process Control Equipment	200	200	200	200	200	200	200	200	
7. Transformer station equip.	480	520	600	680	820	960	1.100	1.350	
8. Erection and Administration	950	1.050	1.200	1.350	1.670	1.900	2.200	2.600	
9. Building Work	3.600	4.000	4.500	5.100	6.200	7.200	8.300	10.100	
10. Roads, fences, levelling of site	120	140	160	180	220	260	300	360	
11. Water Supply Plant	50	60	80	100	120	150	180	200	
12. Quarry Equipment, etc.	320	350	400	450	550	650	750	900	
13. Opening of Quarry	50	60	90	100	130	160	200	250	
14. Offices, Laboratory, repair shop	100	110	120	130	150	170	190	220	
15. Freight and insurance	320	350	400	450	550	650	750	900	
16. Consulting Engineers Fee	220	250	280	310	360	420	480	540	
17. Contingencies	320	350	400	450	550	650	750	900	
Total US $	11.400	12.550	14.300	16.140	19.580	22.800	26.210	31.710	
US $/t/year	69	60	54	49	47	43	40	38	

Lecture 2. Fig. 2

Costs of Production and Road Transportation

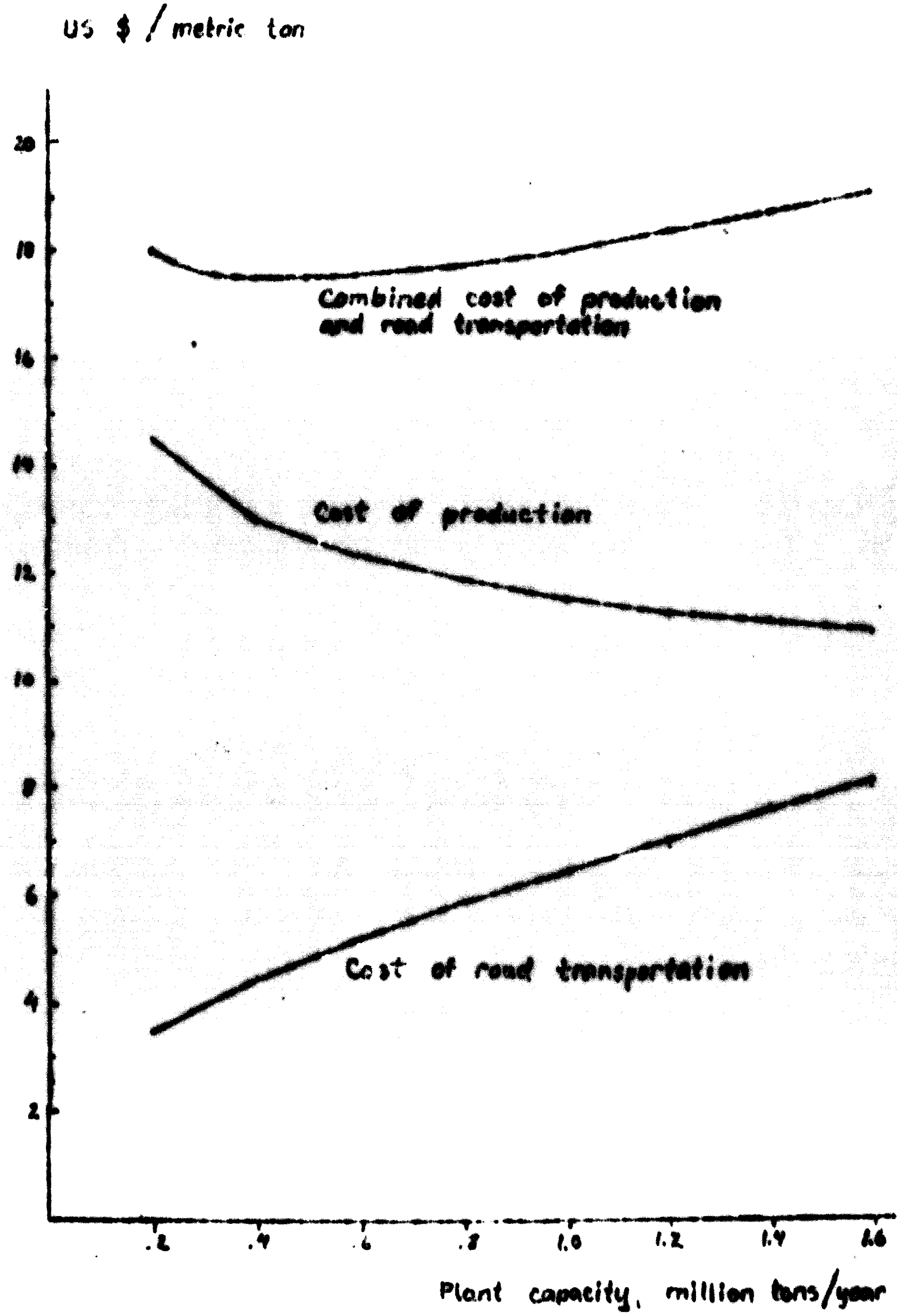


Fig. 3

Portland Cement Manufacturing Processes

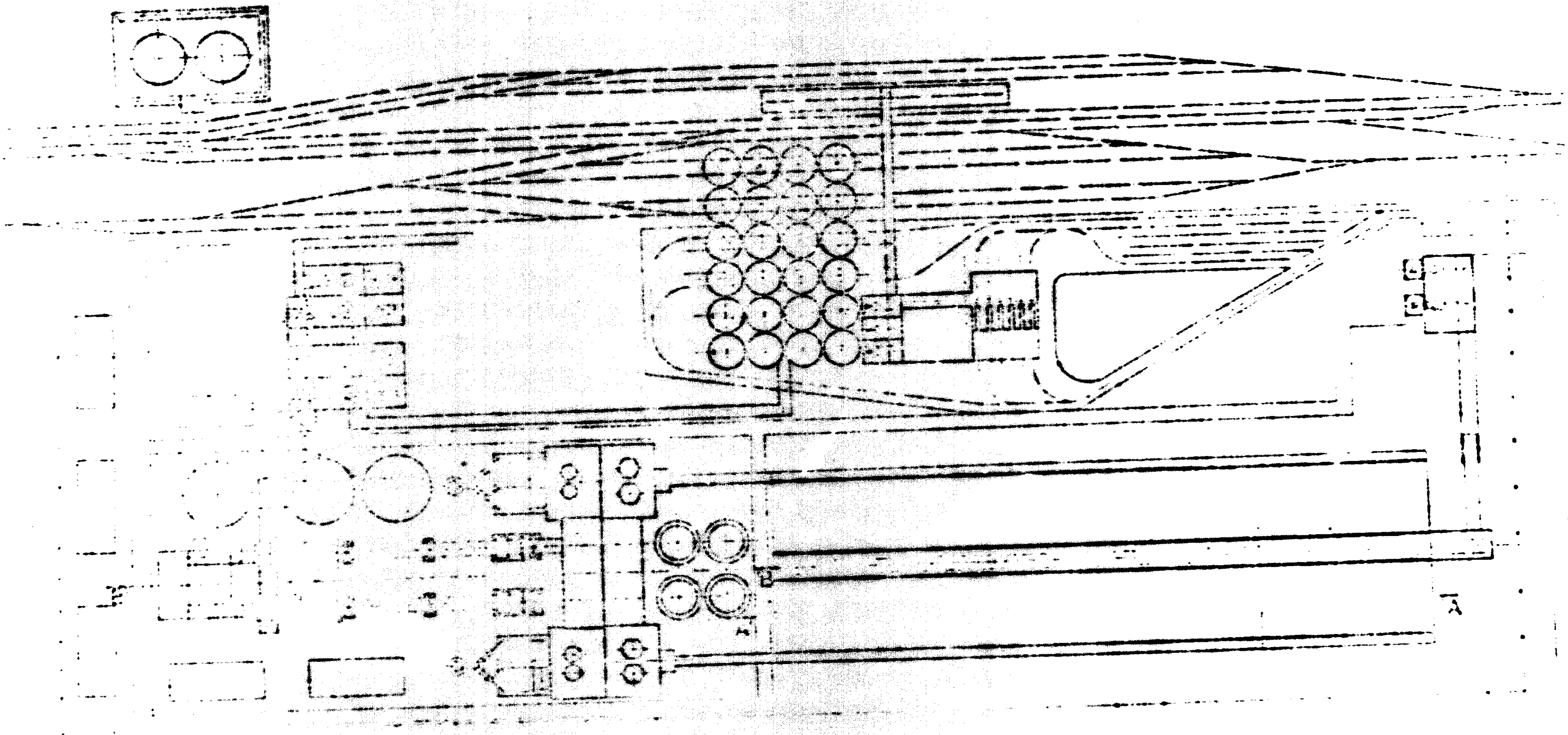
Name of process	Raw mix preparation	Clinker burning
Shaft kiln	dry grinding, pelletising	shaft kiln
Dry long kiln	dry grinding, with or without pelletising	long rotary kiln with internal fittings
Dry 1-stage preheater	dry grinding	medium long kiln with crosses and a 1-stage cyclone preheater
Dry 2-stage preheater	dry grinding	medium long kiln with or without crosses and a 2-stage cyclone preheater
Dry 4-stage preheater	dry grinding	short kiln (without internal fittings) and a 4-stage cyclone preheater
Dry shaft preheater	dry grinding	short kiln (without internal fittings) and a vertical shaft preheater
Dry grate preheater (Lepolgrate)	dry grinding, pelletising	grate preheater and short kiln
Wet kiln with waste heat boiler	wet grinding	short kiln, waste heat boiler
Long wet kiln	wet grinding	long kiln with internal fittings
Slurry filter	wet grinding, pressure filtering	long dry kiln or grate preheater kiln
Spray dryer	wet grinding, drying in spray tower	long dry kiln with or without cyclones
Fluidized bed	dry grinding	special reactors for burning raw mix in a fluidized bed
Sintering grate	dry grinding, pelletising	Travelling grate kiln
Cement/Sulphuric acid	dry grinding	Special process using natural or artificial gypsum for production of clinker and sulphuric acid

Merits of Dry and Wet Processes

Condition	Dry	Wet
Initial costs of equipment	Depend on raw materials	Depend on raw materials
Fuel consumption	800-900 kcal/kg clinker	1100-1500 kcal/kg clinker
Power consumption	Average	Average
Manpower requirements	Average	Low
Alkalies, chloride, sulphur	May cause problems of operation	Does normally not hamper operation
	Difficult to manufacture low-alkali cement of many raw materials	Possible to manufacture low-alkali cement of most raw materials
Costs of maintenance	Average to high	Low to average
Quality of cement	Satisfactory	Satisfactory

Fig. 5

Dry Process Cement Plant. Compact Layout.



Preliminary Estimate of Initial Costs

Example: 1000 ts/24 h dry process plant

	A Construction Cost of Works	**1000 US Dollars**
1.	Cement Making Machinery	4,510
2.	Ancillary Machinery, etc.	580
3.	Spare Parts, Mechanical	410
4.	Electrical Equipment	1,040
5.	Spare Parts, Electrical	100
6.	Process Control Equipment	200
7.	Transformer Station Equipment	680
8.	Erection and Administration	1,350
9.	Building Work	5,100
10.	Roads, Fences, Levelling of Site	180
11.	Water Supply Plant	100
12.	Quarry Equipment	450
13.	Opening of Quarry	100
14.	Offices, Laboratory, Repair Shop	130
15.	Freight and Insurance, Customs Duty	450
16.	Consulting Engineers' Fee	310
17.	Contingencies	450
	Total Construction Costs of Works	16,140
	B Other Expenses	
18.	Costs of Preliminary Investigations	50
19.	Costs of Land	100
20.	Interest on Capital during Construction	125
21.	Houses for Employees	1,000
22.	Working Capital	1,000
	Total of Other Expenses	2,275
	Total Capital Requirement (A + B)	18,415

Fig. 7

A Preliminary Estimate of Costs of Production

		US $/metric ton (of cement)
1.	Fuel	1,50
2.	Power	1,60
3.	Gypsum	0,60
4.	Paper Bags	1,70
5.	Consumable Stores	1,90
6.	Labour	2,00
7.	Administration	0,75
8.	Insurances, etc.	0,40
9.	Direct Production Costs	10,45
10.	Depreciations, 5% p.a. on US $ 18,4 Mill. divided by 330,000 t/year	2,80
11.	Selling Expenses	0,40
12.	Total Costs of Production	13,65

B Approximate Return on Capital

1.	Selling Price of Cement	22,00
2.	Total Costs of Production	13,65
3.	Gross Earnings per Ton of Cement	8,35

		US $
4.	Yearly Gross Earnings on 330,000 ts/year	2,750,000
5.	Total Capital Expenditure	18,400,000
6.	Return on Capital	15 %
7.	Payback Time	6,7 years

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