OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

This document has been produced without formal United Nations editing. The designations employed and the presentation of the material in this document do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations Industrial Development Organization (UNIDO) concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries, or its economic system or degree of development. Designations such as "developed", "industrialized" and "developing" are intended for statistical convenience and do not necessarily express a judgment about the stage reached by a particular country or area in the development process. Mention of firm names or commercial products does not constitute an endorsement by UNIDO.

FAIR USE POLICY

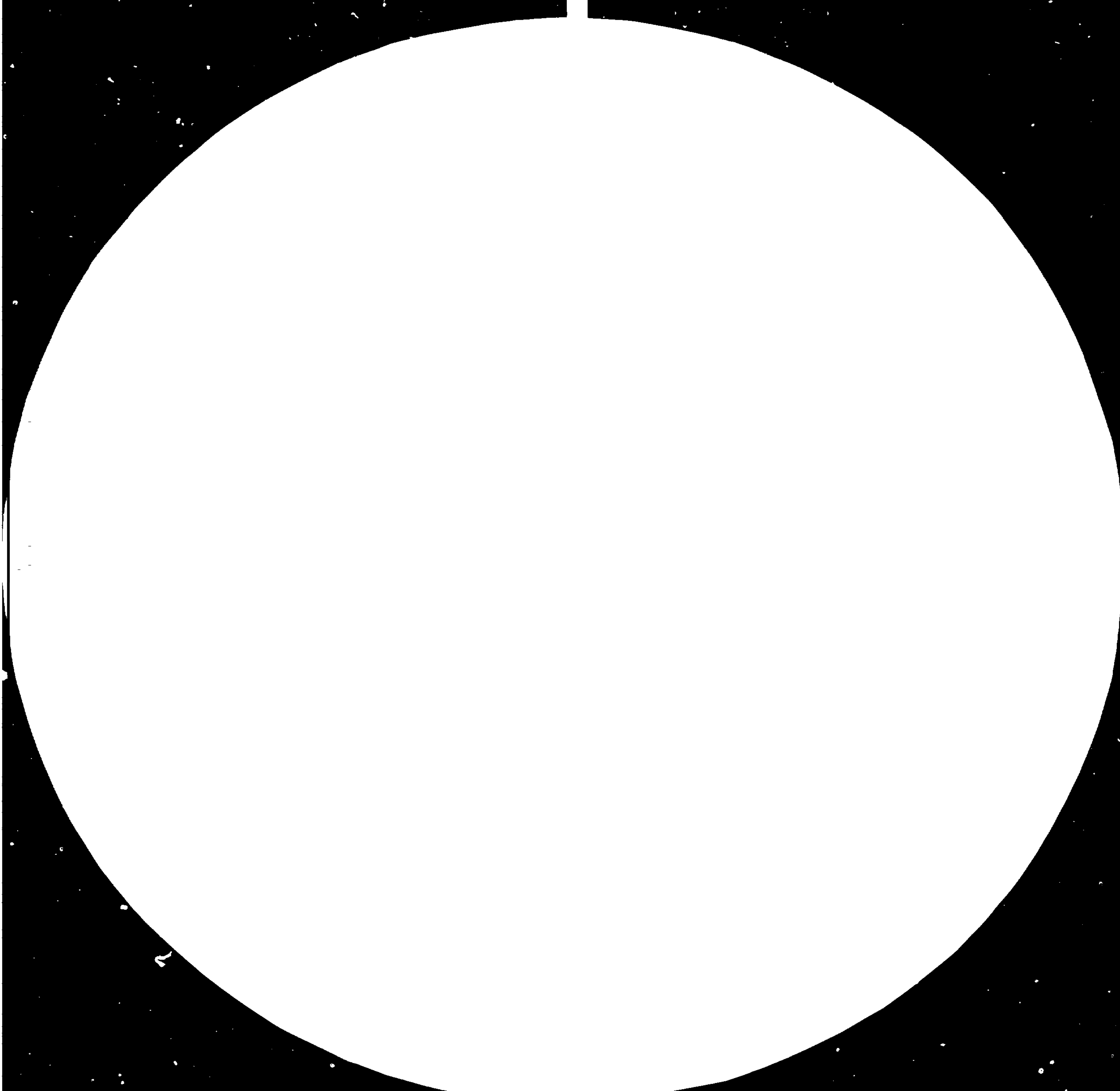
Any part of this publication may be quoted and referenced for educational and research purposes without additional permission from UNIDO. However, those who make use of quoting and referencing this publication are requested to follow the Fair Use Policy of giving due credit to UNIDO.

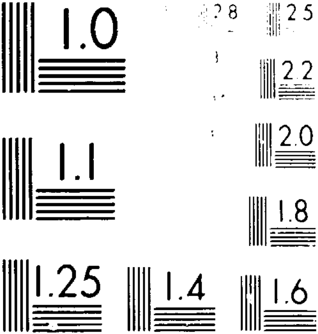
CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

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




1.0
2.5
2.2
2.0
1.1
1.8
1.25
1.4
1.6

10912

Distr.
LIMITED

ID/WG.352/27
28 October 1981

ENGLISH

United Nations Industrial Development Organization

International Experts Group Meeting on
Pulp and Paper Technology

Manila, Philippines, 3 - 8 November 1980

CRITERIA FOR CHOOSING OPTIMUM PAPER MACHINE CONCEPT*

by

A. Lehtinen **

* The views expressed in this paper are those of the author and do not necessarily reflect the views of the secretariat of UNIDO. This document has been reproduced without formal editing.

** Valmet, Rautpohja Works, Box 158, 40101 Jyvaskyla 10, Finland.

V.81-31321

INTRODUCTION

The basic idea of starting a new paper industry in a country or in a specific area has normally its origin in local governmental bodies, businessmen or some other local groups. The idea can be based on several existing conditions such as

- availability of unutilized fiber resources
- increasing demand for paper in the country in question
- attempt to enter the export markets
- attempt to decrease the amount of foreign currency used for paper imports
- labour policy
- industrializing and development plans.

Both in the industrialized and developing countries the local group or body who expresses the idea of establishing a new industry has to make sure that the chosen concept fulfills the following requirements:

- markets for chosen products exist
- raw material supply has been ensured
- selected process fits to chosen product scope and area
- mill site has been carefully selected
- time schedule is realistic
- feasibility of the project has been ensured.

Aspects of choosing a paper mill and machine concept are discussed in the following emphasizing the conditions prevailing in tropical countries and also concentrating on concepts which would fulfill the needs of the domestic markets.

LOCAL CONDITIONS

When we discuss the design criteria of a paper mill to be built in a tropical country especially the following local conditions should be taken into account:

Markets

With improving literacy standard and increasing trade the demand for cultural paper will rapidly increase. Also along with industrialization there will be an increasing demand for industrial paper, i.e. sack and bag paper as well as packaging materials.

On the domestic market, however, the demand is often divided between different paper grades and the markets cannot absorb the production of a large single-grade paper mill as is the case in the developed, industrialized countries.

To trade on international markets, mills in the nonindustrialized countries have to be competitive with large advanced mills in the developed countries. On these markets the products must also meet the quality requirements which differ from those on the home market.

Raw materials

Very few tropical countries have extensive supplies of softwood for pulp manufacturing. Therefore emphasis has to be put on existing resources such as tropical hardwoods and nonwood fibers.

Another group of fiber resources is also important to this area, namely different kinds of grasses, straws, reeds, sugarcane bagasse, bamboo, leaf fibers, etc. Many developing countries have vast resources of these nonwood materials readily available. Nevertheless, the problems of collecting and transporting raw material often set limits to the capacity.

Technology level

When reviewing the industrial experience of a country one must note that this does not mean only the pulp and paper technology but also supporting services. To those belong among others adequate servicing, maintenance and management personnel.

Capital investment and financing

As mentioned earlier the mills in industrialized countries have grown steadily larger and more sophisticated with narrow product range in order to benifit from the economics of scale.

If a mill in a nonidustrialized country is designed for export markets where competition is hard, the project obviously will be costly and difficult to finance.

Many international development agencies, consultants and machine builders have already for years worked to compete this problem by concentrating on concepts with lower initial capital investment.

Other features affecting design criteria

For all projects a lot of information must be gathered and analyzed. In case of nonindustrial countries special emphasis must be put on the following items:

- information on availability and cost of water and power
- level of existing infrastructure
- environmental requirements and costs of meeting them
- transport facilities and costs
- domestic social background and customs
- necessary level of spares.

OTHER DESIGN PRINCIPLES FOR CHOOSING THE CONCEPT

Based on the views introduced earlier the following basic criteria can be listed when choosing a paper mill and machine concept in tropical countries:

- The mill should be able to make acceptable papers mainly from locally available materials.

- The mill size should be selected to correspond with the local conditions.

- The mill should be simple and reliable.

- The mill should be staffed as far as possible by local people. A thorough training program of the personnel should be included in the implementation program. The operation of the mill should be made as simple as possible and the requirement of highly skilled operating and maintenance staff should be minimized.

- The mill should be labour intensive, not capital intensive.

- The mill should use as little purchased power as possible to avoid shut-downs due to possible limitations of public power.

- The machinery should be ea ' to maintain. The mill should be capable of handling the most repair work without outside help.

- The mill buildings should preferably be built of locally available materials and also designed where possible solely for weather protection.

BASIC ALTERNATIVES FOR PULP SUPPLY IN TROPICAL COUNTRIES

The basic alternatives for the paper manufacturing in a country, where no or only limited paper industry exists and softwood resources are scarce, are as follows (see Fig. 1-4):

Alternative A — Both long and short fiber pulp will be imported.

Purchasing of the entire pulp supply requires the smallest investment of all, but the high and continuous expenditure of foreign currency probably makes this alternative less interesting to a developing country. The availability and price development of pulp would also be a risk factor and local forest resources remain unutilized.

Alternative B — A short fiber pulp mill will be built in connection with the paper mill. No surplus market pulp.

A compromise between the high costs of purchased pulp and the high investment costs of pulp mill can be achieved by this alternative. In the following chapter some alternative pulping methods will be discussed.

Because all the production is used in the integrated paper mill the quality of pulp can be somewhat below the general standard.

Alternative C — Together with the paper mill a large short-fiber market pulp mill will be built and only part of the production will be used for the mill's own papermaking.

Construction of a large market pulp mill is economically justified when capital, large plantations and captive markets are available.

This, however, is normally not the case in a nonindustrialized country.

Alternative D — A pulp and paper mill will be built based on softwood resources.

There are special cases where long fiber pine plantations are available. In these cases an integrated unbleached sulfate pulping and wrapping/packaging paper mill concept would be the right solution.

Because this is a special case it will not be handled in the following.

Alternative B will be discussed in more detail. It is a compromise between the investment and raw material costs and it can be applied to a number of cases.

PULPING PROCESSES

In the following some of the most common pulping processes which might be considered for the pulping of tropical hardwoods will be discussed.

Mechanical pulping of hardwood

The mechanical pulping process, either stone grinding or refine pulping, is widely used for softwoods.

Hardwoods, however, are generally too dense to produce an acceptable mechanical pulp. Only a few low-density hardwood species are known which produce mechanical pulp of acceptable strength, namely aspen, poplar, willow and certain types of eucalyptus.

Thus the mechanical pulping is not the answer to be considered for the pulping of tropical hardwoods.

Sulfate or kraft process

This method is the most common pulping process used today.

When applied to tropical hardwoods this method produces pulp with strength properties equal to commercial hardwood pulps.

The main disadvantage of the bleaced kraft process is, however, the high investment cost.

This explains why very few pulp mills have been built in developing countries for the production of bleached hardwood sulfate pulp for domestic use.

Sulfate pulping process

In the case of hardwoods, the sulfite process can only be used for certain species and the strength properties of the pulp obtained and the yield are generally low. Most tropical hardwoods give poor sulfite pulps.

Neutral sulfite semichemical pulping of hardwoods (NSSC)

The process can be used for most hardwood species except for those of very high density.

It is difficult or impossible to bleach the pulp to an acceptable brightness and NSSC pulps are therefore not used for printing and writing papers. The main usage lies on the corrugating medium.

Bisulfite chemimechanical process

As we can see from this survey, none of the conventional pulping processes is well suitable for the production of bleached or light coloured hardwood pulp in a mill of small size either from processing or investment point of view. In recent years, however, new possibilities to solve this problem have been offered by the high-yield bisulfite pulping process called the bisulfite chemimechanical process.

Such pulps, both unbleached and bleached, have now been in commercial production for many years. They are used in the furnish for the production of printing papers such as newsprint, magazine paper and basepaper for coating. There seems to be no reason to limit the use of this type of pulp only to these paper grades.

The chemimechanical pulps cover the yield range 95-80 %. It should also be noted that the recovery of chemicals is not necessary in a small scale mill and that refining, washing and screening are standard operations.

Based on investigations, which include a wide range of hardwoods such as aspen, birch, beech, eucalyptus and species from Ceylon, Guyana, Nigeria and Vietnam and also bagasse, the following conclusions can be drawn regarding the use of bisulfite chemimechanical pulps for the production of different paper grades.

This kind of pulp is primarily suited for the production of printing and writing papers with moderate brightness. The amount of commercial long-fibered pulp to be added to the furnish is estimated to be up to 30 per cent. High quality chemimechanical pulps can also be used for the production of magazine papers and probably also for newsprint if the requirements are changed from present international standards to somewhat lower brightness and opacity and higher basis weight. For both these grades the furnish has to contain about 30 per cent of groundwood in order to attain the required opacity.

As far as the manufacturing of wrapping paper, corrugating medium and kraftliner is concerned, a semimechanical type of pulp could be the only component of a furnish for corrugating medium. For wrapping papers and kraftliner a mixture of about 50 per cent long-fibered kraft pulp is necessary.

MILL SIZE

The demand for paper in the developing countries falls largely into two main groups:

- cultural papers which include printing and writing papers and newsprint and usually account for 20 to 50 per cent of a country's demand

- industrial papers which include wrapping packaging papers and paperboards and account for 50 to 80 per cent of consumption.

In countries with high population the demand tends to be more evenly divided between cultural and industrial papers.

In every specific case the actual mill size has to be individually specified. As a guideline based on the existing studies it looks like the following mill capacities would be applicable to conditions in the developing countries in a number of cases:

- 20-25,000 t/a of wood-containing cultural paper with integrated mechanical or chemimechanical pulping

- 30-35,000 t/a of unbleached industrial wrapping and packaging papers with integrated unbleached kraft pulping.

///

PAPER MACHINE CONCEPT

When discussing the pulping methods the emphasis was on finding a paper machine concept which is able to produce pulp suitable for a wide range of different paper grades.

Consequently, in the paper mill the requirement is to choose a paper machine concept which while being simple, reliable and technologically suitable for the intended environment would also be flexible enough to produce the required amount of different paper grades. In recent years the TVW group has developed this kind of a paper machine concept called "The Valmet Multigrade Paper Machine".

In this development work we have had the following targets:

- low capital costs
- low automation level (labour intensive)
- easy maintenance
- minimum requirement of expert maintenance and operation personnel
- suitability for different raw materials and capability of producing a wide range of paper grades
- good runnability
- design speed round 600 m/min
- production capacity corresponding to general market studies.

Figure 5 shows the cross section of Valmet Multigrade Paper Machine.

When a 35,000 t/a mill size is chosen for a basis the production figures for different grades are the following:

- annual paper production	t/a	35,000
- operating period	d/a	350
- average daily production	t/a	100 (60-100)
- overall operating efficiency	%	77
- design capacity	t/d	130
- basis weight range	g/m^2	
- sack paper		70
- liner board		160
- printing and writing papers	g/m^2	35-120

These correspond with the following technical data of the paper machine:

-	trim	mm	3,050
-	trim more proper for sack paper	mm	2,500
-	design speed	m/min	600
-	operating speed	m/min	150-600

The paper machine itself would be described with the following basic features:

* Headbox of conventional air cushion type

* Fourdrinier wire section

* Press section (see Fig. 6)

- pick-up double press roll
- 2 press nips
- rolls:
  - pick-up suction roll
  - stone granite roll
  - grooved roll
- no pulper, broke transported to wire section pulper.

* Conventional cylinder dryer section with possibility to drive cylinders with dryer felts

* Size press if necessary

* Calender

- 4- or 6-roll for printing and writing papers
- 2-roll for wrapping and packaging papers

* Reeler pneumatically operated

* Drive and accessories

- belt variator drive
- pneumatic loadings will be used.

ECONOMICAL SURVEY

Figure 7 shows the relative approximate investment costs for three different paper mills:

Alternative 1 — Intergrated pulp mill, no surplus market pulp, capacity matching 35,000 t/a of paper, chemimechanical process without bleaching or recovery. All power purchased, heat generated in low pressure boiler by burning fuel wood.

Alternative 2 — Integrated pulp mill, no surplus market pulp, capacity matching 35,000 t/a of paper.

Semibleached (brightness 75-80°) kraft process.

Bleaching sequence C-E-H-H, bleaching agents (chlorine and caustic) are purchased. No drying department is included. Most of the heat required is generated by burning black liquor in the recovery boiler. The remaining heat is generated by burning wood fuel in a power boiler. Back pressure power is generated from process steam flow in a turbo alternator plant, the rest of the power demand is purchased, cooking chemicals are recovered.

Alternative 3 — Integrated kraft pulp mill, rated capacity 100,000 t/a meaning surplus pulp for market. Pulp to be fully bleached (brightness 90-92°).

Bleaching sequence C-E-H-D-E-D. All bleaching chemicals prepared on site in an electrolysis plant using sodium chloride as raw material, producing some caustic in the process. Pulp drying department is included. Heat and power supply as well as cooking chemicals recovery is arranged in a similar way as in Alt. 2.

In Figure 7 the low investment costs of chemimechanical pulp mills compared with kraft mills are clearly demonstrated, especially where the capacity is low. As the capacity is raised, the gap gradually decreases.

Total relative manufacturing costs of short fiber slush pulps in question are presented as a function of mill size in Figure 8.

It can be noted that

- in the low capacity range (below abt 50,000 t/a) it is less expensive to purchase hardwood kraft pulp than to make it

- the figure shows clearly that the manufacturing costs of chemimechanical pulp are the lowest of all in this capacity range.

As mentioned earlier in the studied case of chemimechanical pulp mill no chemicals recovery was needed.

Only when a chemimechanical pulp mill is big enough the pulping chemicals can be economically recovered. Figure 9 shows this clearly. The recovery of chemicals is not economical below a capacity of 100,000 t/a if the pulping yield is 85 % or higher.

At lower yields recovery is more attractive because savings increase quickly.

For example, at a pulping yield of 75 % recovery is economical from the capacity of 80,000 t/a upwards (Fig. 10).

LITERATURE

1 Chemimechanical Hardwood Pulp as Raw Material for Paper
J Pöyry, Helsinki
January 5, 1977

2 Small Scale Pulp and Paper Mills for Developing Countries
World Pulp and Paper Conference, Helsinki, 28 & 29 April, 1980
by Jack Easton

3 Expert Consultation on World Pulp and Paper Supply, Demand and Trade, Technology and Manpower
Tunis, 20-22 September 1977
by FAO

4 Small Scale Production of Cultural Papers
FAO, Rome 1976

5 Development Program Made within Valmet Company for Small Scale Multigrade Paper Machine between Years 1976-1980

ALTERNATIVE A

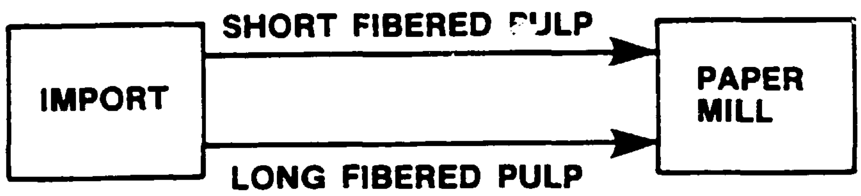


Figure 1

ALTERNATIVE B

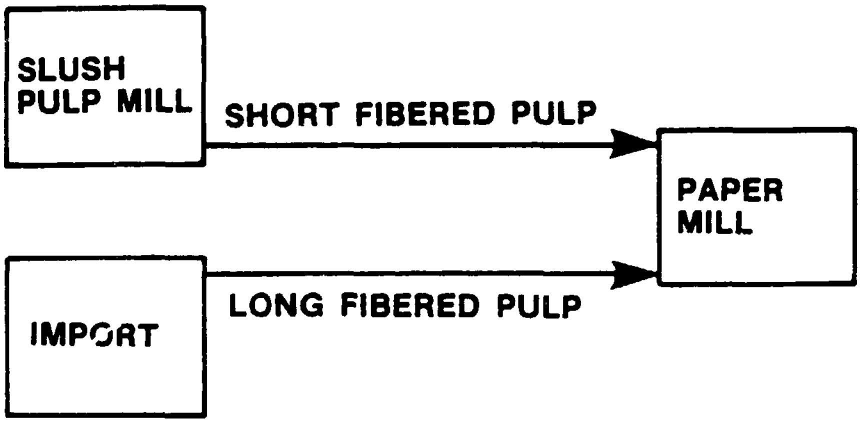


Figure 2

ALTERNATIVE C

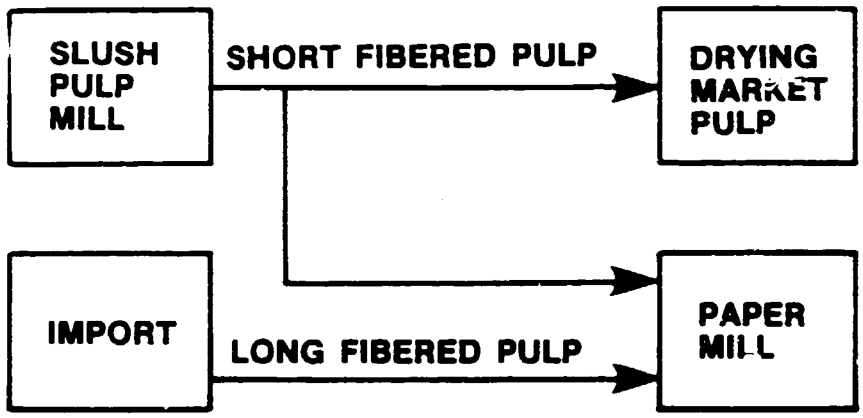


Figure 3

ALTERNATIVE D

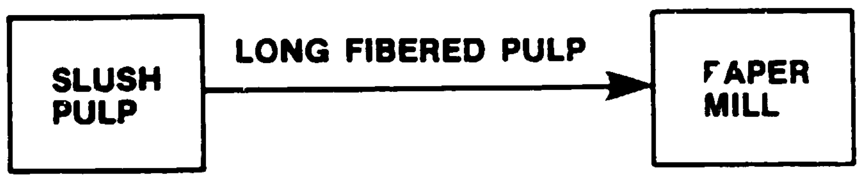


Figure 4

VALMET MULTIGRADE PAPER MACHINE CONCEPT

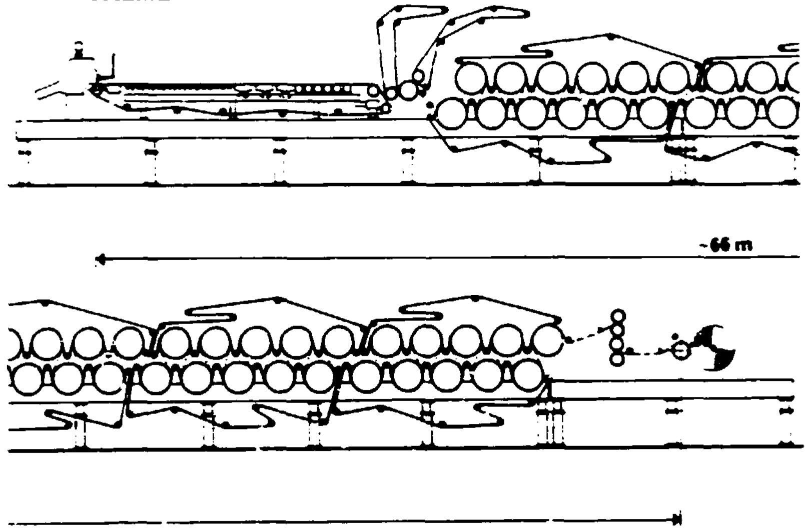


Figure 5

PRESS SECTION FOR A MULTIGRADE PAPER MACHINE

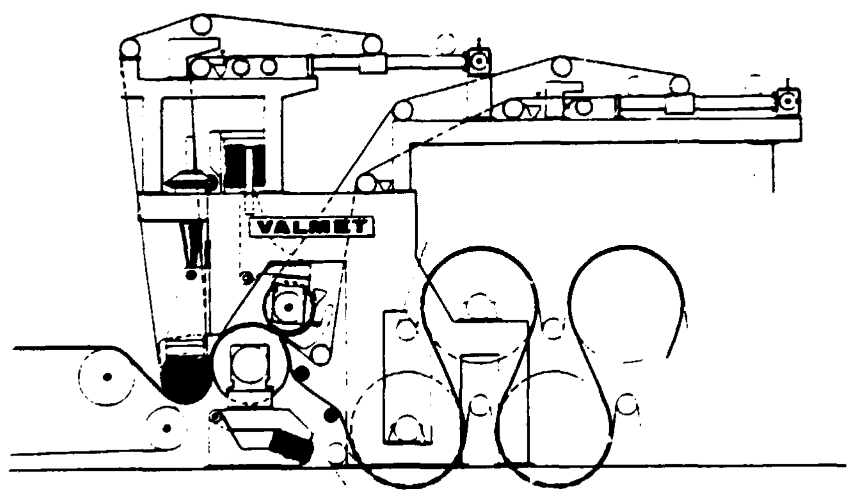


Figure 6

APPR. MILL INVESTMENT COSTS, SLUSH PULP (SINGLE LINE FACILITIES, INFRASTRUCTURE COSTS NOT INCLUDED)

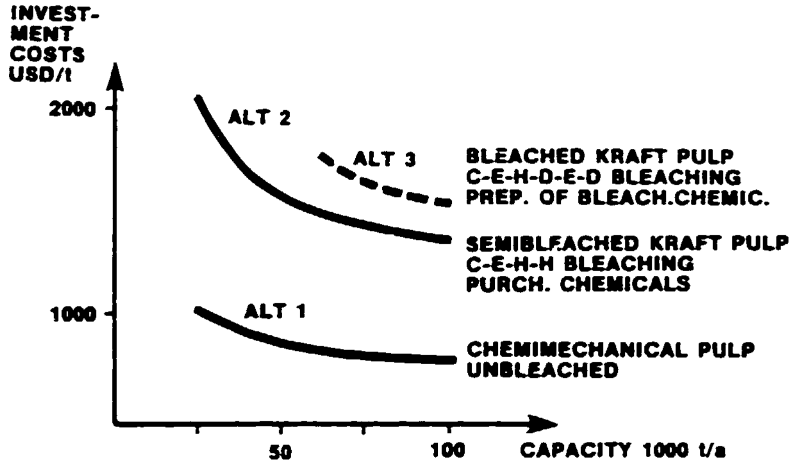


Figure 7

APPR. MANUFACTURING COSTS OF SLUSH PULP

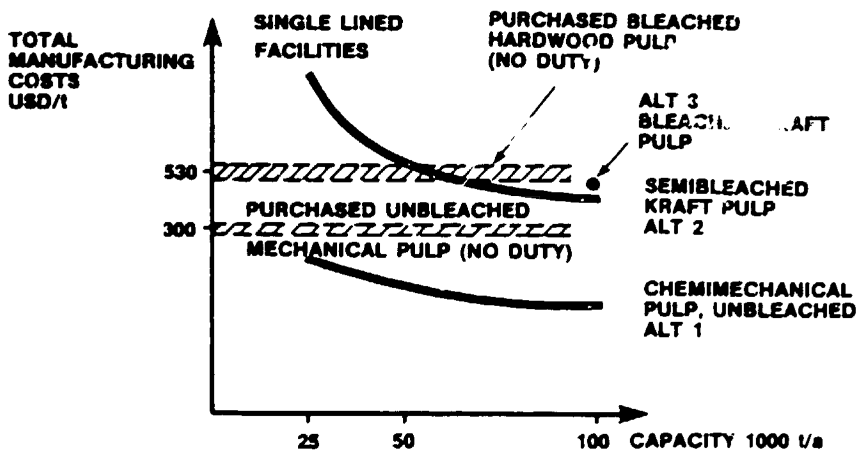


Figure 8

ESTIMATED RECOVERY COSTS OF CHEMIMECHANICAL PULPING CHEMICALS, YIELD IN PULPING PROCESS 85 %

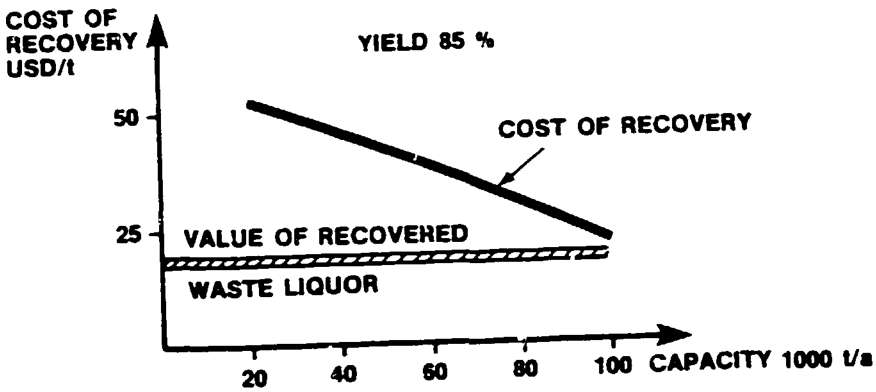


Figure 9

ESTIMATED RECOVERY COSTS OF CHEMIMECHANICAL PULPING CHEMICALS, YIELD IN PULPING PROCESS 75 %

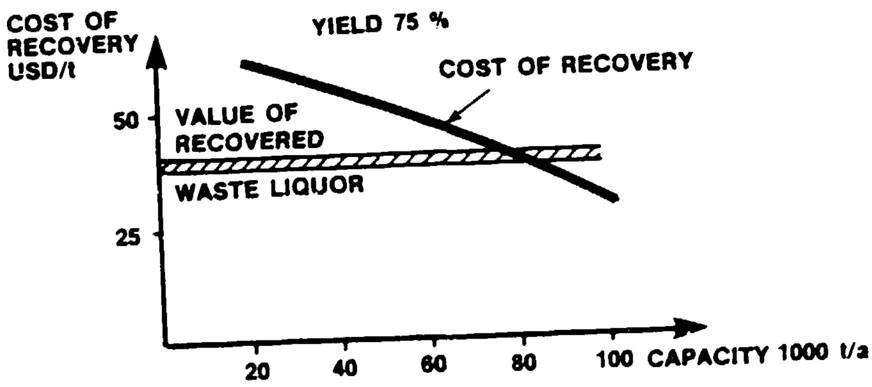


Figure 10