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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

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HOW TO BUILD A LOW-COST [1] PULP MILL IN DEVELOPING COUNTRIES

by
Erik J. van den Ent, Senior Consultant,
Ulf G. Roos, Manager of Industrial Division, and
E. Norman Westerberg, Vice President
EKONO,
Helsinki, Finland

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SUMMARY

The developing world is deficient in pulp supplies even more than in paper. It has, however, many fibrous raw materials for paper pulp, and it may become a major pulp producer in the future. The estimates of unit investment and unit manufacturing cost, for pulp manufacture, show a sharply increasing unit cost for decreasing mill size. Pulp markets in developing countries do not offer the opportunity for pulp mills to benefit from economies of scale, Certain cost reductions, the major ones discussed here, are still attainable. It is difficult to imagine a pulp mill of small investment, at the same time producing at a low unit cost of manufacture.

1. INTRODUCTION

In the course of economic development of developing countries, one invariably finds new sectors of industrial activity being established. With economic progress, industrial establishments grow increasingly complex, product- and process-wise.

Paper manufacture is among the early activities in a developing economy because paper is a basic commodity. The technology of papermaking, at the early stage of development and for the primary paper products, is not a very complex one (a parallel is found in textile manufacture). From here to the complex engineering and technology of modern paper production is a long and complicated way. As the economy progresses, market trends develop towards more and more sophisticated products. At all stages papermaking as an industry is very much part of a country's industrial development.

With a paper industry operating, the demand for pulp (raw materials for paper manufacture generally) is obviously one to be satisfied. It would be natural to assume that pulp requirements, just as paper requirements, are satisfied through local production also, but this has not been the rule. For a variety of reasons, some economical, some technical, and some arising from the nature of pulping and papermaking itself, pulp manufacture in the developing countries has always remained behind. The developing areas of the world are net importers of pulp, and have been so since the modern process technology, in papermaking and in pulping, was developed eighty years or so ago.

Presently, the world picture on pulp supply is greatly changing. It is not changing so much in the net deficiency of pulp in developing areas (1), as it is in the structure of the deficit, presently and in the future. The tropical areas are becoming increasingly selfsufficient in short fiber chemical and semichemical pulp, but remain deficient in long fiber chemical pulp. The subtropical zones, while becoming selfsufficient in short fiber pulp rapidly, also have a great potential to become mass suppliers of long fiber cellulose in the long run.

In the hope of contributing to a better understanding of the major problem areas in pulp supply through local manufacture, we will attempt to analyse some of the economical aspects of low cost, general purpose pulp for papermaking.

2. DEFINITIONS, ABBREVIATIONS

pulp	chemical and semi-chemical pulp, for paper manufacture
groundwood	mechanical and semi-mechanical pulp, for paper manufacture
paper	as a general term, includes all paper and paperboard grades
LF	long fiber pulp
SF	short fiber pulp
ADMT	air dry metric ton
ADMTPD	air dry metric ton per day
PA	per year
$	U.S. dollars

3. PULP AND PAPER INDUSTRIES IN DEVELOPING COUNTRIES

Nowadays, most countries of more than token market size have their own paper mills, which supply, part or all of some or several sectors of the paper and paperboard demand.

The degree of selfsufficiency, of course, varies much. It may be nominal in some countries, where only chipboard and other coarse grades are produced locally. In other cases, a variety of paper grades is usually available from local sources. Finally, hardly any country (a notable exception is Chile) is fully selfsufficient in all grades, newsprint and mass packaging grades usually being the problematic sectors.

It is very much a matter of local market conditions whether the paper industry is developed satisfactorily, is deficient or, conversely, whether it has developed to a size and efficiency beyond its own natural market and thus grown into an exporting factor. The natural history of paper manufacture (whether in Europe or overseas) is very much based on a sequence of gradually increasing technology, more sophistication in processes, products and market demand, and increasing economies in manufacturing size.

For paper manufacture, a dependable source of pulps is necessary, the properties of which should correspond to the grades and qualities produced. Owing to their characteristics, the several types and qualities of pulps are not easily interchanged for paper manufacture at a definite level of quality. Where larger variations of paper quality are permitted, some more freedom in pulp choice is possible. The notorious example is wrapping paper: high quality wrapping paper is made from coniferous kraft pulp, however, much wrapping paper in overseas countries (and some in Europe) is produced from wrapping waste of low quality, from bagasse pulp, from short fiber kraft pulp, etc. Another example is hygenic tissue at high and low levels of quality. Of course, paper volume, quality and price are interdependent.

There are far fewer pulp mills than paper mills in the developing world, even counting the numerous integrated pulping units in paper mills. The ratio may be found somewhere near 2 or 3 to 1, the cottage pulp and paper industry also included. Traffic in pulp to and between developing countries reflects the difference. Even with the large capacities under construction or envisaged, the developing world will remain a net importer of pulp (1). The demand continues to concentrate on bleached and unbleached chemical, coniferous pulp. Short fiber chemical and semichemical pulps are becoming available more and more and are traded in increasing quantities.

For an analysis of pulp manufacturing cost, one should distinguish between the several types of pulps. In pulp manufacture, more cost is involved in producing pulp of (a) lower yield, (b) lighter color. At the same yield and roughly at the same manufacturing cost, there is a distinction to be made between less and more sensitive pulping processes. The sensitive, sulfite-based processes will only pulp selected raw materials satisfactorily. Pulps are classified roughly as follows:

(1)	groundwood and mechanical pulp,	90 - 93 % yield
(2)	chemically pretreated groundwood,	84 - 88 "
(3)	high yield (crude) semichemical pulp,	72 - 78 "
(4)	bleachable semichemical pulp,	58 - 62 "
(5)	high yield and linerboard kraft,	51 - 55 "
(6)	unbleached (chemical) sulphate,	47 - 50 "
(7)	bleacheable (chemical) sulphate,	43 - 46 "
(8)	unbleached sulphite, cellulose,	46 - 48 "
(9)	bleached sulphite, cellulose,	41 - 43 "
(10)	soda (unbleached or bleached) pulp.	39 - 46 "

For paper manufacture, it is equally important to distinguish between long and short fiber pulps. Long fiber pulps (generally classified as chemical pulps) are produced from coniferous woods, but certain other raw materials (bamboo, etc.) can be used. World trade in pulp is confined generally to chemical coniferous pulps, but some quantities of short fiber chemical pulps are also traded. There is minor traffic in semichemical pulp and groundwood. The chemical pulps are in the most expensive group, but their transport and subsequent storage and paper mill use present no problem, as other pulps may do.

The world trade in chemical wood pulp reflects the fact that their cost of manufacture profits greatly from economies of scale. It is generally unprofitable to produce chemical wood pulps locally in small quantities, since it involves steeply rising unit cost of manufacture, and a disproportionally higher unit investment.

On the other side of the scale, it is less prohibitive to produce the higher yield pulps on a local basis. In many situations it is very profitable to produce pulp and paper in one integrated operation. With higher yield pulps, it is possible to do so in quite small quantities. (In general, considerable economies are involved in the integrated production of chemical wood pulp also, but the size of operations for optimum mill size is out of proportion to the size of the market of most developing countries, or the fibrous raw material base is not available).

Therefore, paper mills in developing countries have a certain tendency towards integration with pulp manufacture. Such mills have several pulp sources to draw on: one or more types of pulp (semichemical pulp, groundwood, etc.) from their integrated units, imported pulp of types and qualities they cannot produce or obtain locally, and a variety of waste paper grades. The balance between the sources is a question of continuing attention, with much of the manufacturing profit depending on striking the right cost balance.

In several publications, for instance (2) and (3), the effect of balancing pulp sources on the profitability of the enterprise has been examined. It is generally found that pulp from an integrated unit, so long as it is suitable to the paper grades produced, is cheaper than imported pulp and allows a better profit. In addition, waste paper of the proper grades tends to be an even less expensive fibre source. The price for waste is a function of the price for imported pulp, of the availability and applicability of pulp from integrated units at the paper mills, and of the prices for imported paper which compete with local products. Although paper waste is a useful source for paper manufacture, paper mills will try to establish independent sources of pulp as a matter of cost control, and in doing so balance the use of waste against the use of integrated and imported pulp.

As definite as the place is which integrated pulp has gained itself in paper manufacture around the world, as complicated is the calculation of its profitability, because so much depends on the papermaking operation and the market. For a general review of pulp cost, in the present type of presentation, it is impossible to discuss the various cost aspects of integrated pulp manufacture. Besides, the price of pulp is not the proper yardstick to measure the degree of cost efficiency. Only the final product, paper, is expressed as a price. For this reason the following sections will concentrate on the cost aspects of non-integrated pulp manufacture in developing countries, and this only from a broad viewpoint emphasizing where economies can be obtained through the reduction of certain items of cost. It will soon be clear, that pulp manufacture, more specifically the manufacture of chemical pulps based on wood, is in principle a large scale capital-intensive operation in those cases where economies must be obtained: Only exceptional circumstances can have the effect of reducing unit manufacturing cost.

4. FIBROUS RAW MATERIALS FOR PAPER PULPS

The several pulping processes will produce pulps with a wide range of properties: partly, this is due to the process and subsequent treatment, partly this is also due to the fibrous raw material involved. Table 1 presents a summary of fibrous raw materials for pulp manufacture.

Among the fibrous materials, several wood species find the widest application. Over 75 percent of world pulp consumption is from wood species, mostly coniferous woods, that produce long fiber pulp. Broadleaved species from the temperate and subtropical zones are gaining in importance rapidly. Pulp from broad-leaved wood, mostly bleached, finds its application in white papers where it can offer sheet properties not available from coniferous pulp. Some unbleached short fiber wood pulp is produced and consumed locally, but there is no trade in this type of pulp, as there is on a limited scale in bleached short fiber pulp.

Chemical pulp from the tropical zone is confined to limited quantities, the tropical zone has few and small pulp and paper mills as yet. Pulp from mixed tropical hardwoods is expected to become a more familiar commodity towards the end of the decade.

Coniferous pulping, by tradition originating from the northern temperate zones of Europe and North America, is gaining in importance throughout the subtropical zone where large plantations of pines have grown up in recent years. Tropica pines, of which there ar a few large areas around the world, have not yet found so much acceptance (due to political reasons, not due to their technical characteristics).

High yield kraft involves a chemical type of unbleached pulp, from conifers, of a slightly higher yield (through adjustment of cooking conditions, digesting time and with the use of disc refiners) specially apt for linerboard. The process has spread over North America.

The range of semichemical pulps, manufactured from deciduous woods, comprises bleacheable pulps of lower yield and unbleached and coarse grades of pulp of regular and very high yield. The white pulps are used for printing paper, tissue and white board, in varying degrees in their furnish, and offer a distinct advantage in sheet quality and cost for such grades. The unbleached grades are used in the furnishes of many wrapping grades (in developing countries), coarse printing and mimeo, tissue, paperboard and, of course, for corrugating medium of high quality. As a mass commodity, semichemical pulp from mixed tropical hardwoods has a considerable potential.

Chemical and semichemical pulp from agricultural waste (bagasse, straw) is used in the furnish of printing papers and tissue. It is also used (as a crude pulp) in the furnish for certain wrapping grades, board, and in corrugating medium (in countries where such raw materials are abundant). They offer an alternative (if somewhat limited) for wood pulp, and more so where a price advantage can be realized.

The mechanical types of pulp, (mostly from conifers although disc groundwood from deciduous woods is gaining acceptance fast), are used in cheap printing grades in low or high volume (the latter being newsprint), and as a filler for other lower grades of paper, and for paperboard.

The price for fibrous raw material is an important factor in the cost structure of pulp. A rough comparison of the cost for fibrous raw materials, expressed as a percentage of pulp cost, reveals how much bearing this variable has on the pulp cost pattern. In Scandinavia, the proportion of wood cost to total unit manufacturing cost of pulp is to 42 - 48 percent (sulphate). . In North America, the comparable figures are 28 - 32 percent. In developing countries, the cost of wood is less percentagewise, not only because a larger proportion of cost goes for capital items, but also because wood prices are lower. The comparable figures are about 20-24 percent. (Latin American LF cellulose), 12-14 percents (Latin American SF cellulose), and 22 percent (Mexican bagasse pulp).

5. THE NECESSARY INVESTMENT FOR PULP MANUFACTURE

For a discussion on the relative importance of cost items in the aggregate unit cost of pulp manufacture, we will examine one pulping process of general use, at one specific set of cooking and bleaching variables, with one or two fibrous raw material sources, for a series of increasing mill sizes. The relative cost positions of other processes, yielding pulp of the same nature, can be found by extrapolation.

For our cost analysis, we have chosen the kraft process, coniferous wood, and a mill size range between 25 and 500 ADMTPD.

Total investment cost for the size range is presented in Figure 1.

These costs include investment in live, respectively dead plant. The charges include investment in plant site, site improvements, road connections, office and plant buildings, structures, equipment, spares, auxiliary services, other installations, freight, engineering, design, construction and construction supervision, personnel training, crew instructions, price escalation during construction, interest during construction, initial operating losses. The mill cases are self-contained for process water, electric energy, and bleach chemicals where applicable. For transportation, the cases depend on infrastructure, not included in any capital items. Forestry (or similar) investments have not been included, because the price for fibrous raw material, delivered mill yard, allows for such cost items.

Whether at the small mill sizes (25 ADMTPD) recovery is economically feasible is questionable. The manufacturing cost estimates approximate the case with or without recovery, since in the latter case the lesser capital charges are offset by higher charges for chemicals.

The estimates are based on current average prices for plant and equipment and services, for conservatively designed plant capable of reaching nominal capacity with properly trained personnel. The emphasis is not on the level of investment or capital charges, but on the relative positions of these in respect to mill size.

The slope of the curves flattens out with increasing mill size. For developing countries, where markets for each class of pulp are likely to be in the size up to 100 ADMTPD, the influence of scale economies on investment is extremely unfavorable. Capital charges in this range of mill sizes are the most pronounced factors in the aggregate unit manufacturing cost of pulp.

6. COST OF PULP MANUFACTURE

The unit manufacturing cost of pulp from the hypothetical mills are shown in Figure 2. A cost break-down is given in Table 2. Again, the restriction is made that the cost analysis refers to a generalized set of productive conditions (as it were average conditions throughout the world) which, by their nature, are not applicable to any specific site without modifications of their entry values. It should be stressed that not the absolute value of the costs, but their relative values are significant in this analysis. Again we conclude that there is steeply rising cost with dimishing plant size.

On this provisional, comparative basis, the limited markets of most developing countries do not offer the conditions necessary to reduce local production costs for chemical pulp so as to compete on world markets. Only through export, by lack of an appropriate market size of its own, is it possible to overcome a country's unfavorable position. But export introduces a new series of independent variables, which have a tendency to make a national project a riskier one. The alternative is to wait the several years until the national market has caught up in size, something equally unattractive.

As to export, it is advisable to count on it only where a captive market for the remainder of the output is assured over a span of years. This leads, naturally, to cooperation between markets or governments, to a project of bi- or multi-national nature. The alternative, again (viz. to set up a very large project which by its cost structure would have a market assured, something like 1000 to 1200 ADMTPD), is unattractive to developing countries because they do not have the resources (capital, manpower, know-how) required. Even the large companies in North America are hesitant to set up mammouth projects outside their own area.

Therefore, the viable alternatives, where a certain market size is given, are to see whether for small and medium-sized mills any possibilities remain to decrease investment cost, capital charges and to reduce items of direct manufacturing cost.

7. COST ECONOMIES

The information so far leaves no doubt that pulp mills are capital-intensive projects, require much market room to be able to operate at acceptable cost and that, most important, developing countries (with few exceptions) are in a disadvantageous position in respect to their own supply of chemical pulp.

For chemical pulp this is the principal picture. (Soluble base sulphite wood pulp gives manufacturing costs of the same magnitude and size dependence as that shown here for kraft pulp). Som what more favorable cost comparisons are found when considering the semichemical processes, which, however, by their nature refer to short fibre pulps that have a limited market. The fact that short fibre pulp finds its way increasingly in applications for paper (technical innovations some day might make it applicable also for high strength packaging grades) cannot foreclose their present limited application, mostly in white papers. The cost situation, in short, is discouraging.

Nevertheless, from a recognition of the principal positions as pictured, there are a series of economies obtainable which, properly applied, have a significant influence on unit cost of pulp manufacture. We must limit ourselves to a discussion of the principles of possible reductions in pulp cost, because specific cost reductions depend so much on specific productive conditions.

The discussion on cost reduction is centered on four aspects: (A) the analysis of cost factors in the sulphate process for wood pulp, (B) comparisons of other fibrous raw materials relative to wood, (C) comparisons of process variables, (D) integration of pulping units with paper mills.

(A) The Sulphate Process

Running through the cost items of pulp manufacture (Table 2), we find several occasions for comment in the principal cost items, as follows:

(aa) the cost item of fibrous material is low for coniferous wood, and even lower for hardwood pulpwood. This presupposes an efficient system for growing coniferous or deciduous wood, or for extracting pulpwood from existing reserves. Plantation-grown pulpwood can be grown in an efficient, low cost way, especially if suitable exotic species are chosen. In the subtropical zone, growth rate for young wood is high, and the same can be the case with proper species in the tropics. Besides, the higher density of most hardwood species (wood is bought on volume, pulp sold on weight basis) favorably influences raw material cost. The cost for pulpwood, extracted from tropical hardwood forests (on flat, accesible sites), need not be much out of line with the assumed cost, even if allowance is made for reforestation with species for future recycling.

(bb) pulping chemicals remain a low cost item only with the proper investment for recovery. Chemicals recovery may not yet be a necessity in many developing areas, as a tool in pollution control, but the day will soon come when this will be required. For very small chemical pulp mills, recovery is probably not attractive, yet, it would be wise to allow room in the layout of mills for this purpose.

(cc) a bleach plant, and the electrolysis and electric power plant for it, adds considerably to the investment needs and to operating cost. On the other hand, the price for the product is considerably higher. The balance between higher operating and indirect cost and the return price, depends very much on local conditions. In many cases, a simple bleach plant of a straight-forward design, with fewer stages to start with (sacrificing some brightness), is attractive to new projects. Higher brightness can be obtained in the gradual course of operating and optimizing a mill, and it would be wise to allow space for it in the bleach plant layout. Brightness requirements in developing countries, although increasing, have not yet reached such levels as e.g. in North America.

For a bleached pulp mill, there is usually no alternative to generating its own bleach chemicals. In many cases excess caustic soda can be sold at attractive prices, yielding economies.

(dd) In many areas, where power supply from the public grid is deficient or less than fully dependable, it will be necessary for the mill to generate its own electricity. Considerable economies are obtainable, not only because generally the price of public power is excessive, but also because the extraction and back-pressure steam from the turbine can be used to a full extent as process heat. It is not unusual for a newly designed mill to generate its own electric power at less than half the cost of public electricity.

(ee) A well known feature of pulp and paper mills in developing countries is the large number of personnel (in particular labor) they employ. Although labor cost is considerably lower than in North America, the cost of labor per ton of pulp is frequently higher.

In certain departments (wood yard, barking, transportation, baling, liquor preparation, quality control) there are limited ways to reduce investment costs by increasing the number of personnel. There are governments which, as a matter of policy, look favorably on projects where larger numbers of people can be employed. There is not a big latitude in this respect, in a pulp mill project, compared to the considerably greater flexibility in the wood felling, extraction and reforestation sector, where there usually are a large number of personnel involved.

(ff) the largest single items in small size mills are for capital outlays. Our calculations have been based on quite modest conditions for the capital invested: 6 percent straight line amortization per year, and an average annual interest on total investment plus working capital of 9 percent. Perhaps, both conditions are not sufficiently attractive to investors (either local or international). It is much a matter of the political and economic climate whether investors would be prepared to discuss a project on such or similar terms as have been assumed here.

Unless one could obtain long term financing at soft loan conditions for the major part if the investment, the above rates appear to be the prevailing minimum rates for any project at the present time. With higher interest rates or faster amortization, capital charges increase rapidly and tend to render even moderately attractive sizes (around 200 to 300 ADMTPD) unprofitable.

Particular importance is placed on obtaining the best rates possible for capital, financing conditions and amortization. The most important opportunities to reduce investment and manufacturing cost charges are in this area.

(gg) As an important step towards lower capital costs, one would buy second hand machinery, in combination with locally made equipment, of good design and craftmanship. Allowing for freight on imported items, and otherwise ordering from local manufacturers, it is quite possible to decrease equipment cost to a level 2/3 (installed basis) of our estimates. In exceptional circumstances, it would be possible to get the equipment at 50 or 60 percent of the latter, and still satisfy the requirement of conventional design and high class machinery. The example of a tissue mill in Central America, operating Japanese machinery which it bought eight or so years ago, is well known. Economies of this sort are often attained with second hand paper machines, but they are available just as much for pulping plants.

Naturally, a project wanting to benefit from such economies, would be in the smaller size class. It would be a sound way of solving the problem of high capital charges with the proper precautions for equipment and design.

(hh) Personnel training carries a separate cost but offers a considerable return if properly done. It is unwise to economize on training of labor and personnel for medium-size and major projects. The optimum balance between prior local training, training abroad and on-the-job training by foreign personnel can contribute to cutting initial operating losses.

(ii) Initial operation of a new mill, gradually increasing output to reach nominal capacity, entails losses which are normally capitalized.

Figure 3 shows a hypothetical curve of the situation. A well designed and operated mill may reach rated capacity within a number of months. Considerable economies are so obtained. Severe losses are suffered when a new mill fails to produce at capacity for a number of years. This, unfortunately, is too often the case with projects in the developing world. Several reasons for the delayed performance are:

- inadequate design e.g. insufficient buffer storage throughout the process, including liquor storage capacity
- inadequate purchasing or delivery schedule for equipment, missing parts
- equipment breakdowns
- inadequate personnel training
- disturbed flow in the supply of raw materials

Unexpected events, or shortfalls in production are a costly item, reflecting on mill performance in a very unfavorable way. Emergency situations during construction or initial operation (lack of equipment, piping, spares, materials) should be avoided by careful planning to any extent. Not only failure to reach nominal capacity, but also the production of off-quality product, affect the economical performance of a new project. While both conditions are part of the routine of initial operation, they should be limited in time as much as possible.

The provisional (feasibility) and final cost estimates should allow for start-up expenses, both in investment cost and in the operating budget.

(jj) Tax relief for the initial life span of a mill project, is a usual condition for new mill projects of this nature, at the same time having a low return on capital and featuring intrinsic advantages for the industrial and social development of a developing country. For new industries such as these, it is usually possible to obtain partly or fully tax exemptions on imported machinery, estate, and initial income. Where a project, due to size, has a marginally positive or negative return on capital, it is advisable to carefully examine, with the authorities involved, the immediate and medium-term tax situation to see whether relief might be justified (it usually is justified) to get the project off the ground.

In tax-protected economies, a smaller mill size is usually acceptable: the unit manufacturing cost can be allowed to rise to a level higher than permittable in the free, international market.

As a transitional measure, tax protection (duties, import restrictions, etc.) is one of the tools that may help to get new industries started. On the other hand, more than nominal tax protection has often led to the establishment of non-competitive industries that require increasing concessions with time. On a long term basis, a more than nominal protective policy is disastrous for a nation's growth. Tax policy is not the appropriate way to keep weak industry alive. A low cost industry (with low manufacturing cost), and one which could successfully compete in export markets if required, should be the aim of government policy.

(kk) A special situation is found in "pocket" markets, a rather autonomous part of large national markets, where for certain reasons (infrastructure, transport distance, raw material, specific demand structure) production proves to be attractive, even if unit cost of manufacture is higher as compared to the overall national market. This renders production at a quite smaller scale an interesting proposition.

(B) Other Fibrous Raw Materials

The cost effect of other fibrous raw materials (bagasse, straw) reveals a 6 - 9 $ higher unit cost for bleached pulp on that basis, depending on mill size, although it is possible to find areas where bagasse cost, and the consequent pulp price differential, is less.

In areas with sugar production, the cost of wood (if at all available) is usually higher than we have assumed for our estimates (Table 3). The economics of bagasse pulping, therefore, depend very much on local circumstances. The same applies to straw pulping. Since straw is used for many alternative purposes, this may make it unavailable or too expensive for pulping. Straw pulping is disappearing from the developed countries, but in developing economies can have a proper and rewarding place. As with other fibrous materials (kenaf, bamboo, reeds, etc.) its proper use depends on local conditions. There may, e.g. be no other materials for papermaking available.

C. Alternative Chemical Processes

Within the sulphate process, separately for bleached and unbleachable grades, economies are obtainable through proper design and equipment selection, aiming at a balanced operation of the total process. Such economies, although small compared to other considerations discussed here, should, of course, be utilized.

Between the chemical pulping processes, there are some economies obtainable if one is prepared to only consider for papermaking the quality differences of pulp between the soda, sulphate, high yield kraft, sulphite and neutral sulphite processes. Each pulp has its market price. There are differences in manufacturing costs, of course, and Table 3 lists typical relative manufacturing cost figures:

Table 3: Relative total manufacturing cost figures (Sulphate pulp = 100)

	bleached LF	bleached SF	unbleached LF	unbleached SF
sulphate pulp	100	100	100	100
high yield kraft	-	-	96	-
acid sulphite	98	-	98	-
neutral sulphite	-	88	-	80
soda	-	94	-	86

(D) Integrated Mills

Integration of a pulping facility with an existing paper mill is a common example of achieving economies, and at the same time assuring a reliable supply of pulp. Integration is usually first accomplished under some form of tax protection, so that quite small pulping units achieve the purpose. It depends naturally on the local circumstances which effect is achieved, but some general observations can be made:

(aa) for 50 and 500 ADMTPD mill sizes, the omission of a pulp drying and baling plant and storage has the effect of unit savings of 18 and 6 $, respectively.

(bb) the supply of imported pulp is frequently interrupted (exchange control, import duties, import restrictions, delivery time).

(cc) lower or no charges for pulp inventories.

(dd) with integrated pulps, there are savings on papermaking unit cost by replacing expensive imported pulp by locally made pulp, from cheaper fibrous resources, at a higher yield.

(ee) with mechanical pulp (usually 50 percent moisture) the savings are proportional.

(ff) an integrated pulping unit of small or medium size uses the services, facilities and overheads of the paper mill at little extra expense.

Therefore, for paper mills of small and intermediate size, the first economies obtainable are derived from integrated pulping units, likely to be operated by a semi-chemical process. With further expansion, demand for pulp will grow to a point where a medium size integrated unit for chemical pulp may be justified. The savings obtainable from integration are likely to offset higher pulping manufacturing costs. At the next phase of expansion, the mill may finally be in a position to consider a pulping operation of economical size on its own merits.

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Table 1: Survey Of Fibrous Raw Material Resources For Pulp Manufacture x)

type	species	unbleached	semibleached	bleached	temperate zone	subtropics	tropics	long fiber	short fiber
wood	coniferous	x	x	x	x	x	x	x	
	deciduous (one species)	x	x	x	x	x	x		x
	deciduous (mixed species)	x		x	x	x	x		x
agricultural residues	wheat, rye straw	x		x	x				x
	rice straw	x		x			x		x
	bagasse	x	x	x			x		x
other	flax			x	x	x		x	
	kenaf			x		x		x	
	agave, sisal	x	x			x	x	x	
	bamboo	x	x	x			x	x	
	esparto			x		x			x
	reed		x	x	x	x	x		x
	hemp	x		x		x		x	

x) not including groundwood types of pulp

Table 2: Typical Approximate Unit Manufacturing Costs For Sulphate Wood Pulp, $/ADMT

Mill size ADMTPD		50				200			
Pulp grade		unbleached		bleached		unbleached		bleached	
Wood type		LF	SF	LF	SF	LF	SF	LF	SH
Unit cost	$/ADMT								
Wood		40	18	44	20	40	18	44	20
Pulping chemicals		3	3	3.3	3.3	3	3	3.3	3.3
Bleaching chemicals 1)		-	-	-0.3	-0.3	-	-	-0.3	-0.3
Power, steam, water		3	3	7	5	3	3	7	5
Supplies, maintenance		3	3	4	4	3	3	4	4
Salaried personnel		25	25	26	26	7	7	7	7
Labor, foremen		29	29	35	35	10	10	12	12
Contingencies		7	7	7	7	7	7	7	7
Capital charges									
- amortization	(6 % PA)	39	39	55	55	23	23	28	28
- interest 2)	(9 % PA)	65	65	89	89	42	42	50	50
Total	$/ADMT	214	192	270	240	138	116	162	136

1) Credit for excess caustic soda offsets bleaching chemicals cost

2) Interest on working capital included, three months' supply

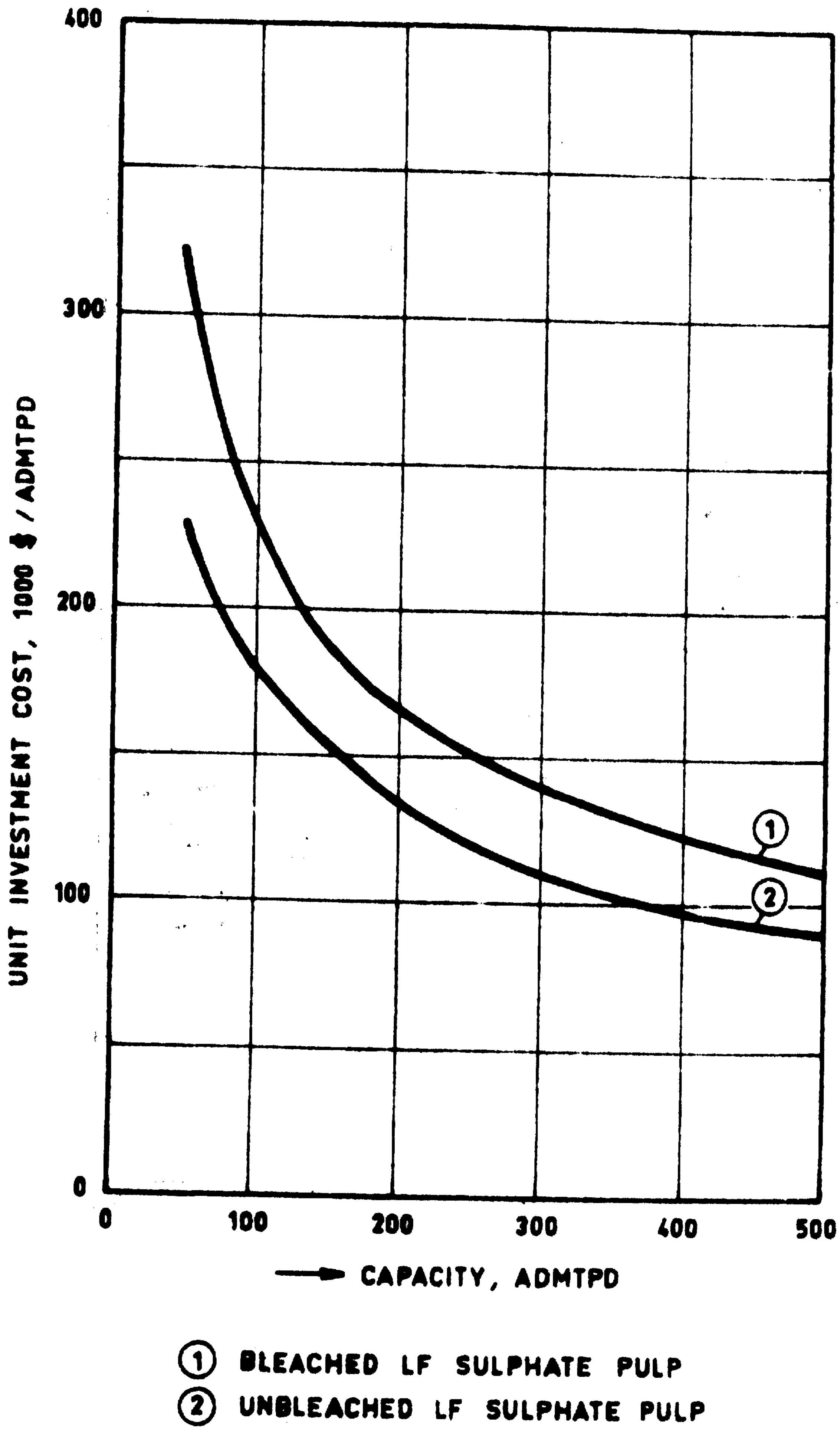
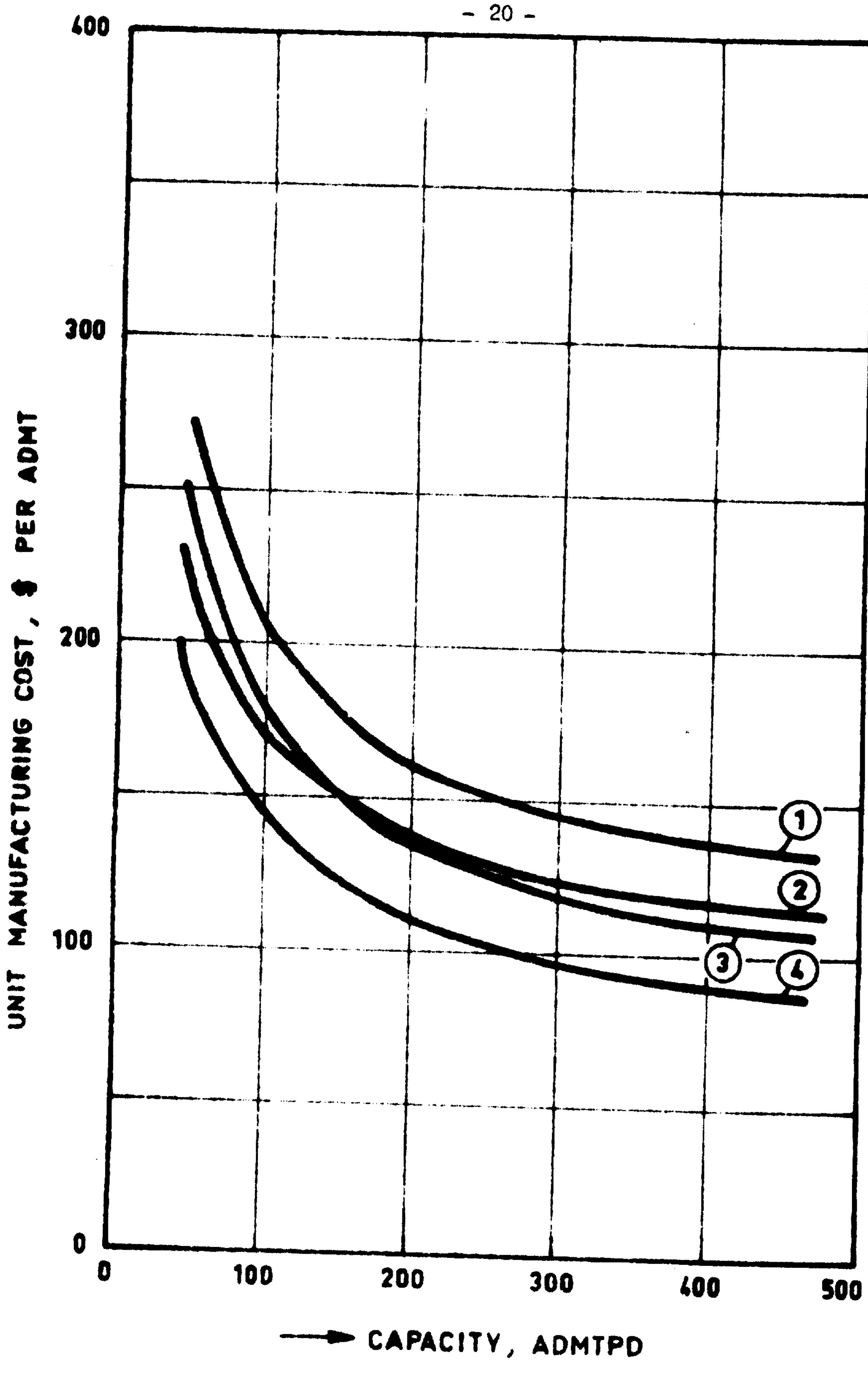


Figure 1. - Unit Investment Cost As A Function of Mill Size



(1) BLEACHED LF SULPHATE PULP
(2) UNBLEACHED LF SULPHATE PULP
(3) BLEACHED SF SULPHATE PULP
(4) UNBLEACHED SF SULPHATE PULP

Figure 2. - Unit Manufacturing Cost As A Function of Mill Size

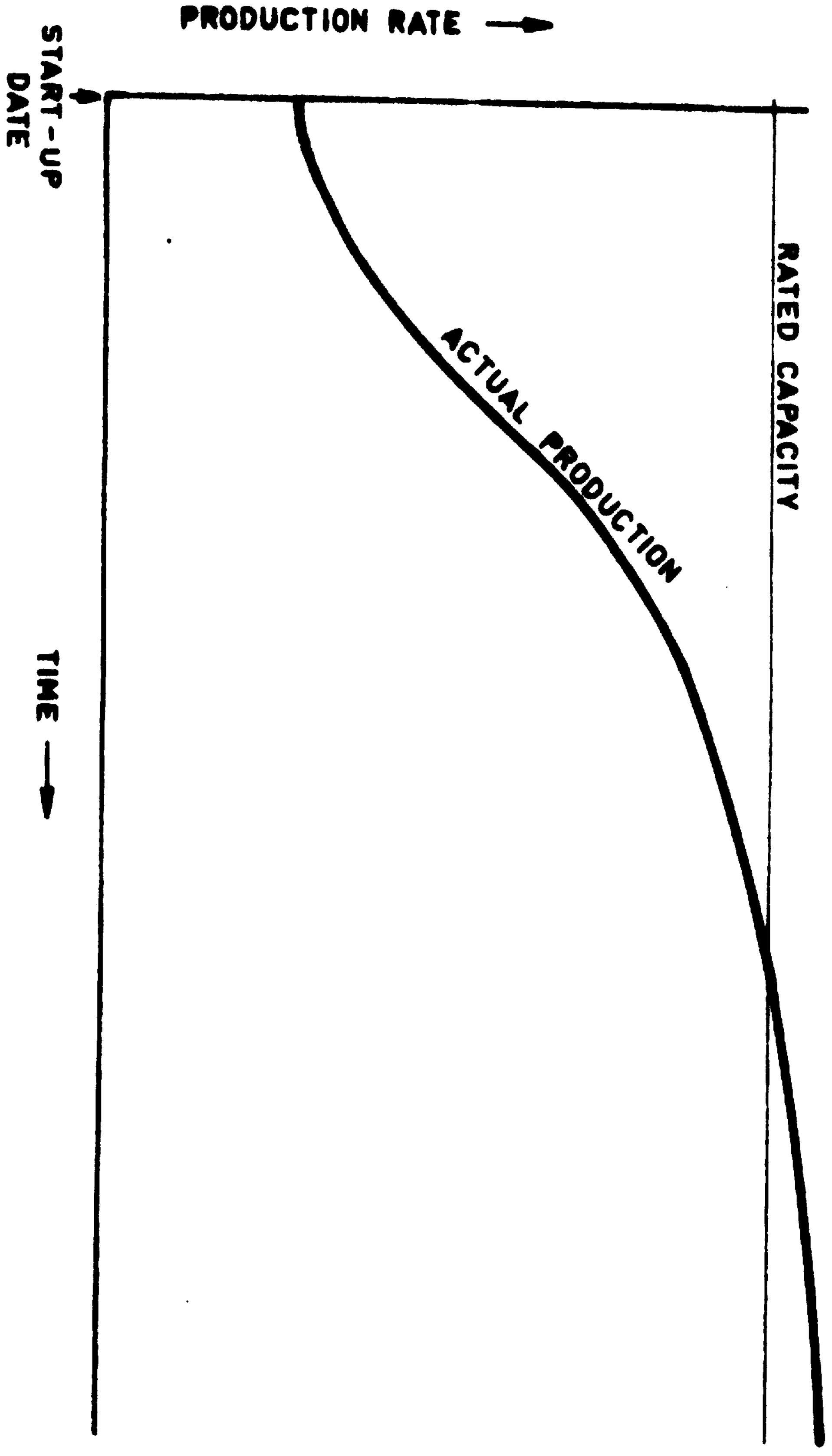


Figure 3. - Production Performance

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