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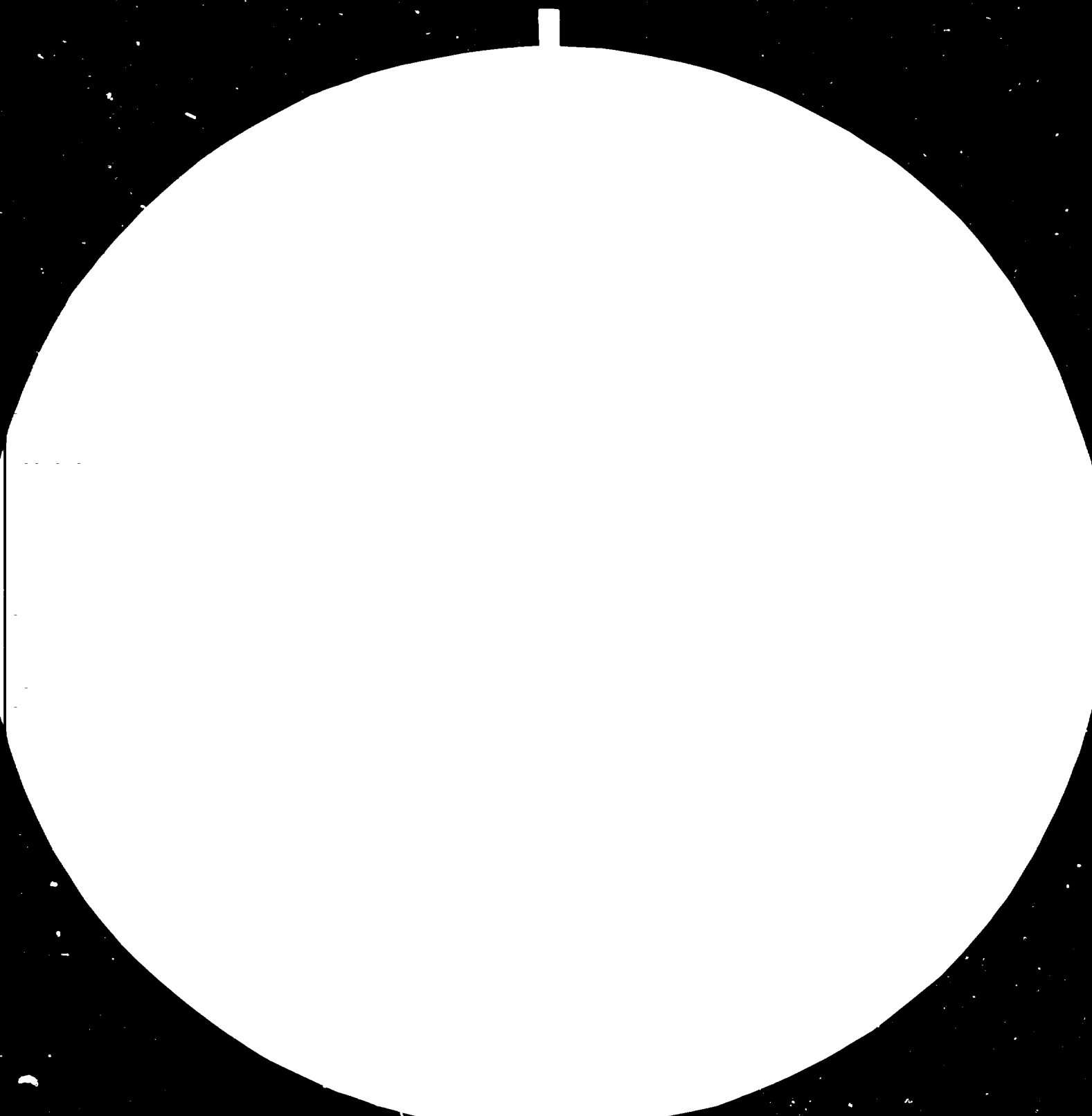

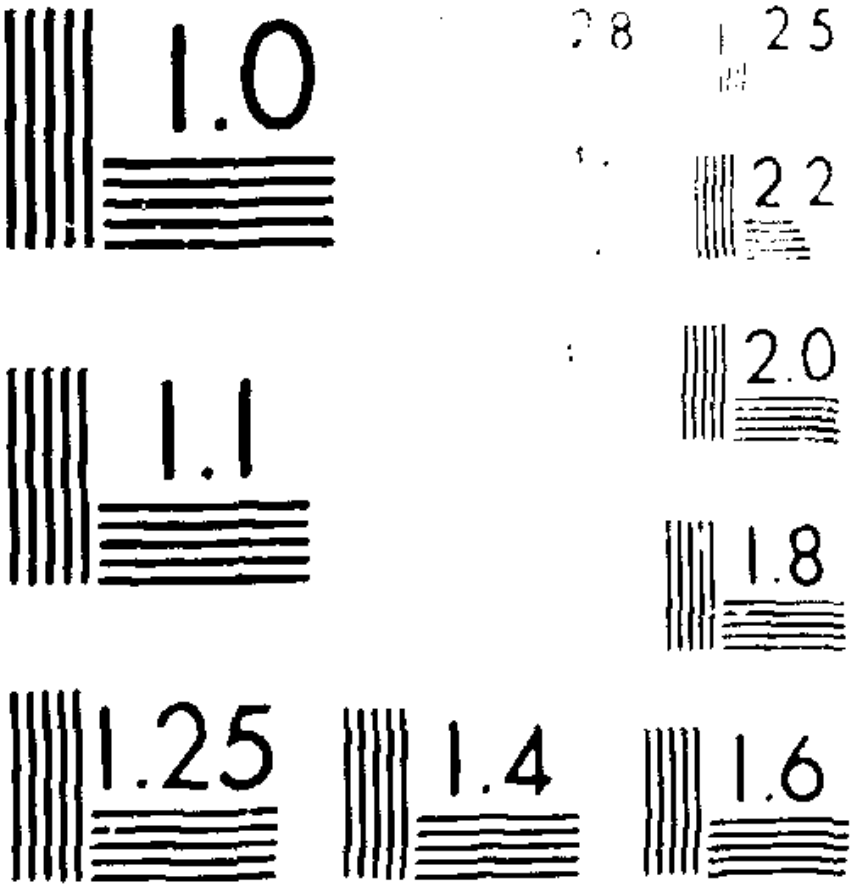
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SMALL PULP AND PAPER MILLS IN DEVELOPING COUNTRIES AND THEIR RECOVERY SYSTEM *

by

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Summary

Small scale pulp and paper mills in developing countries and mainly based on non-wood fibre raw material will still be built in the future.

Their installation can be justified not only from the point of national economics but under certain conditions also from the economics of the mill itself.

Integrated small pulp and paper mills generally show better economical viability than non-integrated mills.

Design features for small pulp and paper mills are different from the design of larger scale mills and should not be compared with jumbo-sized wood pulp mills in North America or Europe.

Small pulp and paper mills are for many non-producing countries the correct way to start their own pulp and paper industry.

With the development of a cheap, simple and reliable cooking chemical recovery system for small pulp mills based on non-wood plant fibres the economy of small mills can be improved, and at the same time problems of the black liquor effluents will be solved.

Introduction

Not enough consideration has been given to the advantages of small pulp and paper mills for developing countries. The tendency in industrialized countries to constantly increase the unit capacity of pulp and paper mills has often been transferred to new mill projects in developing countries. This has proved to be a mistake in many cases and has led to a number of new installations that turned out to be failures because they were not in accordance with the possibilities and requirements of the clients, countries or market conditions.

With this paper we want to present arguments in favour of small pulp and paper mills and try to explain why the installation of a small mill is justified, if not necessary, in specific cases. It is also discussed under which conditions such small mills can still be economically viable, especially if a chemical recovery system can be added to the mill installation.

1. What is meant by "Small" Pulp and Paper Mills

When talking about "small" mills it is necessary to first define the word. Compared to a wood pulp and paper mill with a capacity of 600 tons per day (t/d), a 200 t/d mill might be considered small and below the minimum economic size. In most developing countries, however, a 200 t/d mill is regarded as large because most of these countries start their pulp and paper industry on raw materials other than wood. For these non-wood fibre mills based on such materials as straw, bagasse, reed or grass, a 200 t/d capacity means a large plant; the capacity of "small" mills is very often only 50 t/d or even less.

This is made clear by the figures in the accompanying table 1 which lists all non-wood fibre pulp mills known to us of having been established since 1965 or being under construction. It shows:

	25 mills of	10	to 70	t/d
	10 mills of	70	to 120	t/d
	12 mills of	120	to 200	t/d
only	4 mills of	above 200		t/d

It must be mentioned that this list does not include the People's Republic of China.

TABLE 1

P U L P M I L L S

based on non-wood plant fibres
contracted worldwide after 1965

	Name of Mill*	Country	Capacity ADMT/Day	Raw Material
1	Letjes	Indonesia	22	Rice Straw
2	Klabin Ponsa	Brazil	40	Bagasse
3	North Bengal	Bangladesh	60	Bagasse
4	Central Pulp Mill	India	120	Bamboo
5	Orizaba I	Mexico	80	Bagasse
6	Pudumjee	India	25	Rice Straw
7	Illigan	Philippines	40	Abaca/Bamboo
8	Curitiba	Brazil	25	Grass/Straw
9	Basrah I	Iraq	70	Bagasse/Reed
10	Banjuwangi	Indonesia	30	Bamboo
11	Valaichchenai	Sri Lanka	30	Rice Straw
12	Tejke	India	40	Rice Straw
13	Pakistan Paper Co.	Pakistan	90	Bagasse
14	Chung Hwa Pulp	Taiwan	200	Bamboo
15	Calumpit UPPC	Philippines	50	Bagasse
16	Pars Paper I	Iran	60	Bagasse
17	Mcstaganem	Algeria	180	Espartograss
18	Saica	Spain	40	Wheat Straw
19	Sylhet	Bangladesh	30 + 20	Bamboo/Reed/Jute
20	Isarog	Philippines	10	Abaca

*) Instead of using the companies' full name and address, abbreviations have been used only.

TABLE 1 cont.

	Name of Mill*	Country	Capacity ADMT/Day	Raw Material
21	Saida	Algeria	80	Rice Straw
22	Pars Paper II	Iran	150	Bagasse
23	Menzi	Philippines	10	Abaca
24	Taiwan Sugar Co.	Taiwan	250	Bagasse
25	Embilipitiya	Sri Lanka	40	Rice Straw
26	Afyon	Turkey	170	Straw/Reed
27	Stanger	South Africa	150	Bagasse
28	Basrah II	Iraq	120	Reed
29	Nagaland I	India	50	Bamboo
30	Nagaland II	India	50	Reed
31	Mocarpel	Venezuela	150	Bagasse
32	Olmuk	Turkey	70	Straw
33	Loreto	Mexico	80	Bagasse
34	Induperu	Peru	250	Bagasse
35	Misan	Iraq	150	Bagasse/Reed
36	Deir es Zo	Syria	100	Rice Straw
37	Letjes II	Indonesia	40	Rice Straw
38	Papel Periodico	Mexico	300	Bagasse
39	Samchong	South Korea	20	Rice Straw
40	Orizaba II	Mexico	200	Bagasse
41	Rakta	Egypt	100	Rice Straw
42	Kastamonu	Turkey	15	Cotton Linters
43	Lepenka	Yugoslavia	50	Straw
44	Kerala	India	100	Reed
45	Jatibonico	Cuba	200	Bagasse
46	Papel del Tucuman	Argentina	250	Bagasse
47	Name unknown	Burma	25	Bamboo
48	Phoenix Pulp	Thailand	150	Kenaf
49	Letjes III	Indonesia	160	Bagasse
50	People's Paper Mill	Philippines	30	Rice Straw
51	Celulosa Bahia	Brazil	200	Sisal

*) Instead of using the companies' full name and address, abbreviations have been used only.

If there are some mills missing, these mills might rather be smaller units since the large scale units attract much more the attention of market insiders and their realization is always noticed.

It is thus evident that in number 50 % of all established mills have capacities of 70 t/d or less, with most of the smaller mills in the 25 to 60 t/d range. Due to various reasons discussed later it can be expected that - in the future - the developing countries will still produce more small pulp and paper mill projects based on non-wood fibres than projects of large size.

In the following we shall try to explain the reason for this statement and why such projects can be justified also from the economical point of view.

2. Reasons, why Small Pulp and Paper Mills will still be built in the Future

2.1 The market for such small mills is mainly in countries without an established pulp and paper industry. Some of these countries might have enough wood resources to build a wood-based paper mill, but in many cases it is not possible to exploit such resources economically owing to the lack of the necessary infrastructure.

2.2 Many developing countries have vast resources of readily available non-wood raw materials. It is therefore logical that they base their mills on materials such as rice straw, cereal straw, sugar-cane bagasse, reed, bamboo and grasses, and other species of the non-wood fibre family.

2.3 Nevertheless, to secure a continuous raw material supply for even a 50 t/d straw pulp mill is no easy task for a new installation. Problems of raw material collection and transport often set limits to capacity.
Even if collection problems can be solved, there is still a question of transport cost if material must be brought from a long distance.

2.4 These problems might not occur with bagasse. There is no collection problem. It is not always possible to serve a medium-sized mill of 100 t/d from one sugar mill only. Though, in the case of bagasse-based mills, the tendency clearly goes for mills in the range of 150 t/d, the 40 to 50 t/d solution may be advisable in many cases. A 50 t/d mill can in most cases be served with the bagasse of one sugar mill only, which means that due to the elimination of any transport cost, raw material cost can be kept to a minimum.

The small mill can, in exceptional cases, have the advantage of taking only excess bagasse from a well-working sugar mill. There it may happen that bagasse will be available at almost no cost since the necessity of fuel replacement does not occur.

2.5 For a country with little or almost no pulp and paper industry it is recommended to start this basic industry with a small and less sophisticated mill. After a period of successful operation an extension or a new project of larger capacity can be added.

This procedure has been very successfully practised in countries such as Indonesia, India, Egypt and the Philippines, which all have started small-scale mills and have thus achieved the experience and know-how to go on to larger units.

The advantages are quite obvious. Starting from the already discussed arguments about infrastructure and raw material supply, we can add more points which are less critical for small mills, such as management, procurement of well-trained key personnel, mill operation and efficiency.

2.6 The site selection for a small mill is easier and the possibility of placing it in the vicinity of larger cities is better. This brings advantages with regard to factors such as availability of infrastructure, recruitment of qualified personnel and availability of workshop facilities. It also offers economical advantages due to the proximity to the market, with correspondingly reduced transport cost for mill products and utilities.

2.7 Due to far-developed raw material preparation and pulping techniques the quality of pulp and paper of a non-wood fibre based mill can - with a few exceptions - meet easily standards of markets in developing countries. Also a small pulp and paper mill is able to produce very acceptable products which achieve attractive prices with reliable, simple and comparatively cheap machinery.

2.8 There are, however, some main reasons why such small mills have been built so far and will be built in future. One of these main reasons is that mills can better meet the market requirements of most developing countries. Take for example Sri Lanka (Ceylon) with a population of 14 million and a total annual paper consumption of 35,000 to 40,000 tons of all thinkable paper grades. It would have been a serious mistake for this country to start with a 100 to 150 t/d multi-purpose pulp and paper mill since this would have resulted, besides the technological problems with a multi-purpose mill, in very high investment and operation costs versus a low efficiency resulting from the frequent changes in grades in order to meet the low volumes of different products.

Sri Lanka began correctly by starting with a 20 t/d rice straw pulp and paper mill which was expanded by an additional 30 t/d line in 1968. The next step was a 60 t/d straw pulp and paper mill which recently went into production. For this mill, they could already make use of the experience gained with the two foregoing projects. Sri Lanka is now executing a study for an additional pulp and paper mill of larger capacity to cover another large product range of their total paper consumption.
This example shows that, for comparable countries and conditions, 3 mills of approx. 50 t/d for different paper grades, built one by one, will prove better for a small market than one multi-purpose mill of 150 t/d.
Though total investment cost for 3 smaller mills might be somewhat higher, these costs can soon be amortized through the higher production efficiency of the small single-purpose mills compared to the larger multi-purpose mill.

2.9 Total investment cost is another main factor which gives the small mill a considerably better chance versus the large mill. Usually, among the most difficult problems in connection with the execution of a project of this financial magnitude are capital procurement and financing.

The smaller, therefore, the investment cost the easier the problem can be solved. Many projects in developing countries are dying or at last suffering from a delay of several years just because the total costs involved for a bigger mill are too high and the problem of financing is too big. The solution in many cases is to reduce the capacity and structure of an oversized mill to an acceptable level and so to cut down the investment cost to a degree where equity capital procurement and financing are within the possibilities of the client.

2.10 The third one out of the most important arguments is the aspect of national economy which leads to the establishment of pulp and paper mills sometimes at or even below minimum economical capacities.
The saving of foreign exchange, the procurement of work, the overruling aspects of industrial development, sometimes even the earning of foreign exchange through small exports are in many cases the main parameters for smaller pulp and paper mills in the developing world.
Such arguments are mostly justified and the well-known international financing authorities accept them in some cases as more important than the economics of the new mill itself.

3. Main Features of a Small Pulp and Paper Mill

When planning a 50 t/d pulp and paper mill it would be a mistake to just scale down a larger mill. The technologically best process and the most modern equipment are not necessarily the most economic solution for a small unit. It is, however, essential to keep such mills as simple as possible and to use conventional, sturdy and well-proven equipment and to do everything to keep investment cost as low as possible.

It is sometimes difficult to convince our clients that their 50 t/d mill should by no means incorporate one of the well-known continuous digesters with high heat washing, an oxygen bleaching system, a fully computerized paper machine control system or last but not least a sophisticated chemical recovery system.

The main features of a small pulp and paper mill can be summarized as follows:

3.1 The mills should preferably be an integrated pulp and paper mill with a pulp mill capacity of up to 80 % of the rated paper production. Non-integrated pulp mills seldom prove to be viable though there are cases where such pulp mills are built.

3.2 The production program should not be too wide. In order to use the rated capacity of the mill it is necessary to run as few paper grades as possible or at least to stay within the basic grades of, let us say, fine paper with different grammages.

3.3 It is advisable to design a small pulp mill for either bleached or unbleached pulp grades since the additional investment cost for bleaching plus the necessary auxiliary departments and facilities has an effect on economy of the mill during the period when unbleached grades are produced.

3.4 Use simple and well-proven equipment with unit capacities meeting the requirements of small production. It often happens that clients ask for most modern equipment which usually is designed for unit capacities which are by far exceeding the requirements. This increases the investment cost and can lead to disadvantages due to an unacceptable difference between minimum unit capacities and actual production.

3.5 Try to reduce automation and control instrumentation to an absolute minimum. Sophisticated control instrumentation results in higher investment and subsequently increased maintenance cost.

3.6 Try to limit the scope of auxiliary and service departments to the necessary minimum. Avoid an own power plant if you can obtain power from the public grid at acceptable prices. Use simple low pressure package steam boilers. Chemicals such as caustic soda, hypochlorite etc., should be purchased rather than be produced in own facilities.
General mill departments such as workshop facilities, laboratories, and offices should only serve the minimum requirements of maintenance and production control, otherwise the mill should rely on external repair and workshop facilities for anything additional.

3.7 The applied cooking process for small non-wood fibre pulp mills is mostly the straight caustic soda cooking. Compared with the cooking chemical requirements for wood pulp, chemical consumption for non-wood fibre pulp is considerably lower. For bleachable chemical bagasse pulp the active alkali requirements are about 10 to 12 % expressed as NaOH and referred to as raw material input at a digester yield of 52 to 54 %.

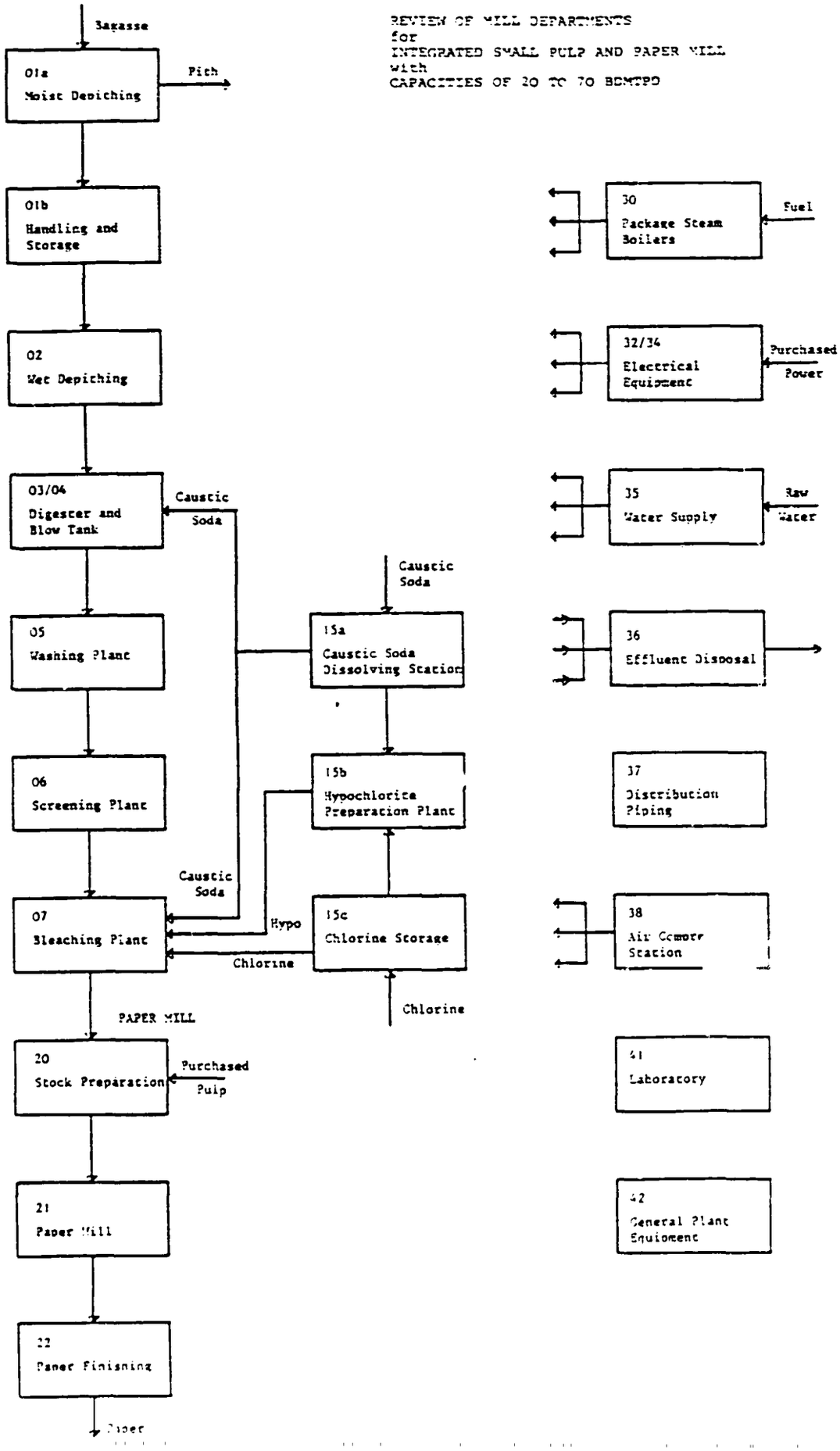
3.8 The loss of the cooking chemical is, besides the environmental aspects, still one of the arguments against a small pulp mill. Owing to reduced chemical input these losses do not affect the production cost to the same extent as they would in the case of wood pulp. There are, however, developments which in future may help small-scale pulp mills to solve the chemical recovery problems cheaply and reliably.

Under the specific aspects of small pulp mills we have developed a suitable, simple and cheap chemical recovery system. The first installation of this kind for the capacity of a 40 t/d rice straw pulp mill will start operation in a couple of months. Details will be given later.

The block diagram (table 2) shows the different plant departments of a typical integrated 20 to 70 t/d pulp and paper mill based on bagasse.

TABLE 2

REVIEW OF MILL DEPARTMENTS
for
INTEGRATED SMALL PULP AND PAPER MILL
with
CAPACITIES OF 20 TO 70 BDMTPD



4. Can Small Pulp and Paper Mills be Economically Viable?

It is generally stated that larger pulp and paper mills are more economical than small units. This must not be necessarily true. In itself, large size does not mean that pulp and paper mills are more economical.

There is, in fact, no general rule that determines minimum economic size. With over 20 years of activity in this specific field, we have met cases where even a 20 t/d pulp and paper mill, after a certain period of initial operation, has achieved or exceeded its rated production. The mill has since made excellent profits. It has earned money to the extent that the expansion to 40 t/d production was financed by the mill itself without any loans from banks or other sources. The expanded mill has already taken up production.

Economical viability must always be studied in connection with specific cases. There are, however, special conditions that prevail in many developing countries and which are more or less generally applicable.

These decisive factors are:

a) Raw material cost is, beside the investment cost, one of the most important cost factors. When talking about agricultural residues such as rice straw or cereal straw, the raw material price depends mainly on labour cost, which in developing countries is usually low. Another factor is transport cost, which can be kept low for small mills since transport is only over short distances.

We have already discussed the advantages in raw material cost for a small bagasse mill. Usually, therefore, raw material cost is lower for non-wood fibres in developing countries and can be kept even lower for small mills.

b) Labor cost is another influential factor, and offers considerable advantages to developing countries. Compared to medium or large size mills, a small and simple pulp and paper mill requires only a small number of well-trained and skilled operators, the costs for whom do not count in the overall calculation. Overall mill management is, as already mentioned, easier to handle.

c) In comparison to a large one, a small pulp and paper mill usually does not require expensive facilities for pollution control measures. On the contrary, there are many small soda-based mills, especially in Asia, which neither have nor require any mill-effluent treatment plant. The black liquor from these mills is often released to the paddy fields where it serves for irrigation and is also welcome as fertilizer. The positive effect of soda black liquor from straw mills as fertilizer for rice plantations has been confirmed in several studies
Since their volume is small, the paper mill and bleaching plant effluents can be released to the river in most cases with no special treatment.

The advantages gained from raw material cost as well as from lower investment cost for auxiliary and service departments as well as pollution control equipment can for a small pulp and paper mill very well compensate for the higher expenses for non-recovered cooking chemicals, purchased power, and possibly somewhat higher specific investment per ton of production.

Of considerable advantage for pulp and paper mills in developing countries are usually the privileges granted by Governments to facilitate the establishment of own basic industries. These privileges consist mainly of:

a) duty free import of machinery and equipment

b) tax exemption to the mill for the first few years of operation

c) special duties on imports competitive with locally produced paper products.

If governmental protection can be applied, it is generally easy to demonstrate the financial viability of integrated pulp and paper mills with capacities as low as 30 t/d.

5. Is the Installation of a Chemical Recovery System Feasible?

We have seen that small scale mills should be designed as simple as possible without a lot of service departments. However, the chemical losses are a considerable cost factor. In addition, regulations concerning water pollution can necessitate reducing the chemical content of the waste water. In this case the investment cost of a conventional recovery system for small scale mills will become so high that a feasible operation is no longer possible.

At this point developments have started with the aim to adjust the design of the chemical recovery system in a way that its installation will again become feasible. The principle of the chemical recovery system was not changed. It still consists of evaporation, liquor burning with or without waste heat boiler and recausticizing plant.

The essential difference is that these three sections have to be modified in such a way that they can be realized at minimum cost.

Nowadays, a conventional recovery system is designed in a way that a maximum efficiency is achieved. Today, the recovery efficiency is in the range of 90 % plus with a very high effort in engineering and operation. Further increases in efficiency are almost impossible.

The recovery system which we suggest for small-scale mills will have an efficiency only of 75 % plus; that is at least 75 % of the chemicals necessary in the digester house will be recovered and transferred back to the process, and 25 % of the chemicals will have to be added as make-up. The cost for cooking chemicals is thus reduced to one quarter of their original value. For a plant with an output of 40 t/d of pulp with rice straw as the basic raw material, for example, the annual consumption of NaOH will be approx. 4,400 tons. Depending on the country this amounts to more than 1.3 million US Dollar. By using a chemical recovery system approx. 350,000 US Dollar per year for chemicals must be spent. Assuming that the higher manpower requirement as well as cost for power and water will be borne by the considerably smaller load on the waste water treatment, one can expect that the chemical recovery unit will be amortized within a period of sometimes less than five years.

As already indicated a further reason for considering the installation of a chemical recovery system is to lessen the load on the waste water treatment plant. Remaining at the abovementioned example (40 t/d of of bleached pulp made from rice straw) without recovery plant approx. 52 t/d of organic matters would go to the river. This amount of organic matter will be reduced to almost zero, since the losses in the CRS will only to a minimum extent be discharged with the effluents.

From this it can be clearly seen that the installation of a chemical recovery system is feasible in almost every case. However, it demands a somewhat higher financial effort on the equipment cost for the pulp mill but this may, on the other hand, considerably improve the total efficiency respectively the cost per ton of pulp.

P.S.

The prototype of a small scale CRS operating in a 40 t/d rice straw pulp mill in Sri Lanka is introduced by a second paper presented by the author.