Small Scale Papermaking

by A.W. Western

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PREFACE TO THE THIRD EDITION

To those interested in applying the Indian experience to their own needs and circumstances, ITIS can offer guidance to suitable consultants able to advise on the technical and economic factors surrounding the introduction of the technology into each country. If required, certain consultants can also assist in the purchase and commissioning of plant.

Since the publication of the first edition of this book in 1979, a number of technical developments having potential in the small-scale field have emerged. In the second edition a number of new processes were outlined in a Technical Postscript which is repeated here. Also included in this edition are detailed case studies of operational mills ranging in size from 1 to 30 tonnes/day. These were previously published separately and are referred to in the text.

The attention of the reader is drawn to the fact that the costs given throughout this book are based on data collected in 1979. The Indian High Commission in London gives the official inflation rate in India as less than 5% for each year since that time and prices quoted should be adjusted accordingly.

SUMMARY

HISTORICAL

1. GENERAL

The predilection of mankind to express itself by drawing or scratching on any suitable surface led to the development of paper. The invention of paper is described but it is necessary to define what paper is before any precision can be attached to the date of its first manufacture. Quasi-papers, such as papyrus, tapa or amatyl are known to have been in use use long before the accredited date for the discovery of paper as defined by accepted standards. This specifies that it should be a mat of cellulose-based, vegetable fibre separated by mechanical or chemical treatment, hydrated and refined by further mechanical treatment whilst suspended in water, deposited as a mat on a screen and finally removed from the screen by a felt, or blanket. By this definition the invention of paper is accredited to a Chinese eunuch T'sai Lun, in 104 AD.

The development, growth and spread of papermaking throughout the world is described. It was not until the 12th Century that it reached Europe and it remained a hand-made product, expensive and selectively used until the early 19th Century when the Industrial Revolution inflenced it by introducing mechanisation. The increased demand created pressure to find cheaper and more plentiful fibres, and processes for using wood were developed in the middle of the 19th Century. Since then the machine and pulping processes have been improved and paper has become the "throw-away" material now required in such quantity that it ranks fifth amongst the world's manufactured materials. Its uses have increased to include packaging, as well as writing, printing and specific industrial purposes.

Machines have increased in width, speed and capacity, and pulp mills correspondingly to the point that units capable of producing up to 1000 Tonnes per day (T.P.D.) are now in operation. Sophistication has followed scale and quality of production to the extent that plant costs have multiplied at a rate greater than product cost.

The cost per mill installation has reached the level where only governments and multi-national companies can afford modern, large-scale "economic" mills. The sophistication has brought the industry to the position where highly skilled technicians are required for machine or pulp mill control, operation and maintenance.

Consumption of paper is unevenly spread amongst the population of the world, varying from 250 Kg/capita/annum in affluent, developed societies to as low as 1.5 Kg/capita/annum in Third World under-developed areas.

INDIA

Paper-making reached India in the 7th Century and remained a hand-made art until the early 19th Century when factories were established by British interests. In the 1930's Indian entrepreneurs set up mills. The second World War stimulated production which had reached 100,000 Tonnes per annum (Y.P.A.) when it ended. Local materials, in particular, bamboo, were used and Indian paper manufacture is still heavily dependent on bamboo but it is considered that this resource has about reached its limit and the use of other materials is being actively encouraged by the Government. Straw and bagasse are available and promising but not suited to large-scale production, so the government incentives criteria include mill size, and, in combination, these measures have stimulated the promotion of small mills under private enterprise. The per capita/annum consumption of paper in India is, at 1.8 Kg., amongst the world's lowest although currently over 1,500,000 T.P.A. is being produced. Plans to double the per capita comsumption rate over the next ten years will still leave it very low by world standards but will require a more than corresponding increase in production to provide for population increase. The small mill is expected to make a significant contribution, raising its proportion of overall production from 15% to nearly 40%.

2. PAPER QUALITIES

Paper grades and qualities in general use are described by classification and categories. Newsprint and mechanical printings are unlikely to be products for the small mill over the next two 5-Year Plan periods but writings, printings, tissues and wrappings can be produced together with some specialty grades. Boards of multi-ply manufacture can also be produced throughout the range of qualities required.

3. THE ECONOMICS OF SCALE

The question of large scale mills is discussed and their diasdvantages for the Western developed world are stressed. Countries are divided into exporters and importers, dependent on the forest resources available. Soaring capital costs and the impact of large tonnages on a market where selling prices are set by the inertia of older, small machines has made the paper industry a depressed one in countries lacking timber resources, and not profitable-even in countries where wood is available - unless linked to timber production. Private industry, with few exceptions, can no longer afford to renew its plant.

For Third World developing countries, large scale where adopted has proved generally unsuitable. The absence of raw materials in sufficient quantity; the exorbitant capital costs; the initial and continuing dependence on imports for spares, technology and design; the poor contribution to employment, training and other socio-economic needs are all factors making the large mill a poor investment. The relatively small but diversified market and the distance involved in transporting finished goods in a climate of rapidly escalating fuel costs are also factors making dependence on the large mill more likely to restrict than encourage growth. Finally, the entrepreneur has no part to play and initiative is stifled.

Detailed comparisons between the large mill and the equivalent capacity in small mills overwhelmingly favour the smaller unit. The analysis concludes that it would be folly for India, or other developing countries, to imagine that "modern" large scale installations are appropriate to their conditions. Today the larger mill, unsupported by timber or conversion activities, is seldom profitable and growth has been halted. Developing countries should not blindly accept "economic" scale arguments which have not always been successful where they originated. India has officially recognised this in policy which is paying dividends.

4. THE PAPER INDUSTRY IN INDIA

4a Production

The growth of paper production in India stagnated over the period 1970-1976 at less than 4%/annum, compared with a target of 7%. From 1977 to the present time, due almost entirely to official encouragement, growth increased by as much as 21%/annum. In 1977, 51 small mills were in operation producing 130,000 T.P.A.

In terms of capacity, not production, nearly 600,000 T.P.A. will be represent by the additional small mills already scheduled for commissioning but, for a number of reasons discussed later, production seldom reaches 65% of installed capacity. Even at such low efficiency, however, the greater majority are profitable.

Official forecasts, embodied in the next two 5-year plans culminating in 1989, indicate growth averaging 7% per annum over all grades, and total consumption, including 800,000 tonnes of newsprint, around 3,150,000 tonnes. At current rates of installation, controlled by government licencing, the small mills are likely to contribute up to 40% of the non-newsprint requirements and probably more if 7% proves to be a pessimistic growth forecast.

4b <u>Selling prices</u>

Selling prices are currently difficult to estimate because a seller's market exists and all paper is in great demand. The large-mill companies publish ex-mill list prices but sell through agents on commission. Excise duty of up to 40% according to grade is included in the ex-mill price but must be paid to the Government before despatch. State sales tax, around 10%, may also be applicable. The ultimate customer pays all charges plus freight.

The small mill aims at selling to customers slightly below the large mill all-in price but can obtain up to 75% exemption from the excise duty provided that agricultural residues are a major part of the furnish. The sales tax may also be considered initially as an interest-free loan and the small mill seldom delivers; the customer collects. In spite of the levies, paper prices are, by international standards, reasonable for printing and writing grades, but slightly higher for "Kraft" wrappings due to the scarcity of long-fibre resources. Taking account of freight, however, home-produced paper would be competitive against imports, proving that the small mill in India is viable without protection. It could be viable in other developing countries.

5. <u>GOVERNMENT INCENTIVES</u>

With the exception of a cash subsidy of up to R.1,500,000 according to cost for mills in specified backward areas, the incentives given by the government are really reduced disincentives, although there is a ban on imports other than newsprint.

The small mill pays less excise duty, is not obliged, as are the large mills, to sell 30% of total production as writing or printing papers at a price below cost, can import second-hand machines duty free, subject to a price limitation, can regard sales tax as a duty free loan and investors obtain wealth and dividend tax reliefs. In India these are substantial incentives but, with the exception of mills in backward areas, there are no subsidies as such. Paper is sold to customers above ex-mill selling price, the difference going to the state or government as a levy, besides a tax on profits.

6. MANUFACTURE OF PULP AND PAPER MAKING MACHINERY

A leading British manufacturer set up a works in India in the 1930's. Paper machine manufacture was to the design standards of that era - small, slow (by modern standards) but robust and unsophisticated. Pulping equipment was also produced and was again small, batch-type, suitable for grasses and straw, and based on pulping esparto-grass, at that time a well-established industry in Britain. Crude, roaster-type chemical recovery was also available. Machines conforming with this technology were subsequently built and operated successfully in India.

World War II stimulated production but after Independence in 1947 the British interest waned. The demand for paper increased, import of machinery was forbidden and several of the established mills, seeking to expand operations, began to manufacture machines themselves, copying the existing models. The chief engineers of such mills became experienced in manufacture and seeing a market opportunity went into the machine manufacturing business.

The industry has since expanded until many small businesses of this nature exist. Ancillary equipment throughout the range was added, sometimes by licence, and to-day complete small scale mills can be manufactured in India and there is a large choice of suppliers. Much of the larger component work is sublet to substantially equipped general engineering companies. These machines at unit cost per tonne of paper produced are about one-third of the corresponding price for large machines. There are limitations in respect of some items such as suction rolls and drying cylinders because special and expensive equipment is required for their manufacture. They can be made in India, but only by one or two companies, set up with foreign partnership to produce larger machines, and they represent a bottleneck. The larger machine builders follow more "modern" techniques but cannot compete in price with the small manufacturers and cannot produce the small scale pulp-mill equipment at all - it is not in their repertoire.

The small Indian made machine probably represents the best value for money anywhere in the world today. It is capable of improvement because the design is substantially still that of the 1930's, but such improvements need not be expensive and would be economic, contributing also to quality. A schedule of suppliers and products is appended.

7. FIBRES - CHARACTERISTICS AND AVAILABILITY

The most desirable qualities are suitable fibre length, availability and low cost delivered to the mill, the latter to include infrastructure, harvesting, preparation and transport. Cost is of prime importance and waste materials with no better end use are emerging as most favoured for paper, at least in the mass produced common grades.

Wood, particularly long-fibred soft wood, is very much in demand and, in combination with saw-milling operations can be cheap as waste wood. India has some soft wood resources in the high Himalayas but they represent only 4% of total forest resources, are inaccessible without heavy infrastructural costs and remote from the areas of greater paper comsumption. Hardwood forests are more plentiful but not all species of wood are suitable and the forests are remote from populated areas. Some of the large mills now use up to 30% of hardwood pulp. Wood generally is more suitable for a large mill but some small mills use waste wood from local converters.

Agricultural resides, such as rice or wheat straw, are available in quantity all over India and suit the small mill. These can present a disposal problem, so their use for paper benefits local farmers. Chemical recovery can be incorporated with straw-based pulp mills but the high silica content presents problems with conventional processes. The pulp is weak and needs long-fibre reinforcement but has some advantages for writing or printing qualities.

Bamboo is the most commonly used paper fibre in India. It has reasonable strength qualities and India has developed pulping techniques giving it versatility. Resources are limited, however, and there is competition for it as a material. It grows naturally, is not planted and cannot be expected to contribute much beyond the present quantity to future needs.

Bagasse is very promising, is versatile, amenable to recovery by conventional methods and is suitable for small or medium sized mills. However, some practical kind of fuel substitution is required because bagasse is wastefully burned as fuel for sugar processing. Integration between sugar mill and paper mill is desirable, and the government are now applying special incentives.

A great problem in India is the shortage of long-fibre resources. Sabai grass, jute, hemp, cotton waste in several grades all contribute, particularly to the small mill but supplies are limited. Processes and machines should be designed to minimise this problem and the chemical recovery short-comings of straw. Sufficient fibrous materials for India's needs are available and most economical if exploited by small mills. Success is being achieved but technology should be directed towards optimising the situation.

Waste paper recycling suits small mills near population centres and is increasing as overall consumption and the proportion of of waste increases. Duty-free import is expected and this should have a significant impact on development because long-fibred materials will be preferred as better able to support freight costs and could greatly assist the small mill.

8. OTHER MATERIALS

Caustic soda, for cooking and bleaching, chlorine for bleaching, resin for sizing, talc or clay as fillers, alum for pH control and lime are the chemicals most in demand. All are available from Indian sources as also are less commonly used materials such as dyes, starch, titanium oxide, cleaning acids, etc.,. Coal is available at relatively low cost but distribution and delivery is unreliable. For small mills, grid power is universally used but there is a national shortage and interruptions are a major cause of under-utilisation. Large mills are normally self-supporting in power generation, a great advantage.

9. SMALL MILL PROCESSES

a. Pulping

For straw, bagasse, rag, gunny sacks, jute, hemp, etc the soda process is universally used by small mills. Chopping and dusting precede digestion and the rotating, spherical digester is vertually standard. Pulp washing varies according to scale and raw material. Potcher-washers are commonly used for rags, gunny sacks, hemp, sabai grass, etc. and occasionally, at the low end of scale, for straw. Straw and bagasse, more frequently use vacuum washers or deckers for 15 tonnes per day or more.

Bleaching can be single-stage calcium hypochlorite in the beater or washer, and for mills 20 T.P.D. upwards, conventional 3-stage chlorine, caustic extraction and calcium hypochlorite with vacuum washers after the first two stages and a decker-washer after the final stage. Screens and centrifugal cleaners are incorprated with most systems.

The chemi-mechanical process of cooking at atmospheric pressure in open Hydrapulper type units followed by more intensive mechanical treatment has advantages in capital costs and has been adopted by mills as low as 10 T.P.D. capacity which can seldom afford a full digestion plant. It has the advantages of simplicity, low chemical cost and yield but is more difficult to bleach, no disadvantage when making packaging papers. The advantages have begun to attract larger mills making packaging grades.

Mills between 5 T.P.D. and 10 T.P.D. usually cannot afford pulping and are more likely to be based on the use of waste. The pulping and cleaning systems could be improved.

Hand made paper mills exist as cottage industries, making a coarse, sun-dried board from waste paper, or making high quality products from cotton waste, using the soda process.

b. Machines

Stock preparation may be by using beaters, common for rags or gunny sack waste, or refiners of many types, all of India manufacture. Screens and centrifugal cleaners are incorporated, but they are no' consistency regulators, absence of which is a major defect.

The paper machines vary in width from 1.7 metres to 2.5 metres and in speed (normally determined by the number of dryers) from 75 metres/ minute to 150 metres/minute. Second-hand machines may run faster. up to 250 metres/minute, and have suction couch and presses. These are seldom incorporated in the Indian-made small machine, which is usually a simple Fourdrinier of 1930 design, which use stonite top press rolls instead of granite, a cause of many breaks and low efficiency.

Simple converting equipment, cutters, winders, guillotines, etc., are all available inexpensively from Indian sources.

c. Chemical Recovery

For mills up to 20 T.P.D. capacity, chemical recovery is seldom installed because the capital cost is relatively high (though cheaper than could be obtained anywhere else in the world) and the economies in chemical consumption are offset to some extent by additional fuel costs. A principal consideration is the ecology and the effluent burden which cannot be tolerated in an agricultural environment. The standard Indian plant comprises 3-stage evaporation of brown-wash-liquor, followed by calcination of the concentrated liquor in a rotary or stationery furnace. The resultant smelt is dissolved in water, treated with lime, clarified and returned as caustic. Efficiency of recovery averages 75%.

d. Services

Water is usually obtained from one or more boreholes and seldom needs treatment. In rare cases sedimentation may be necessary.

Steam is generated from coal-fired boilers of Indian manufacture; fire or water tube types can be obtained. Operating pressures seldom exceed 12 atmospheres.

Effluent Treatment is rare, and limited where it is installed to clarification in lagoons and, even more rarely, aeration. Effluent from the smaller mills usually runs in open drains over considerable distance, clarifying and aerating en route and is acceptable, even welcomed, in some areas as irrigation water.

Electrical Power is always imported from State Grid and subject to interruptions.

10. CASE STUDIES

Book 2 provides detailed case studies for a number of operating mills as well as information in respect of some mills under consideration. These studies cover the full range of capacity within the specified definition and a wide range of products. From these studies of actual mills, which will vary even when capacity and products are similar because of local factors, it is possible to simulate model small mills typical of what could be built and operating, and five such models are presented in Book 1. Descriptions of plant, capital cost estimates, production costs and financing methods are all set out with profitability forecasts. The models selected cover 1 T.P.D., 5 T.P.D., 15 T.P.D. and 25 T.P.D. mills with new plant of Indian manufacture. An actual and most recent 30 T.P.D. mill with an imported second-hand machine is also described.

All mills are shown to be viable under prevailing indices of capital and operating costs without positive subsidy, except for a cash contribution not exceeding R. 1,500,000 and reduced excise duties payable. They would be viable elsewhere in the world under similar conditions which exist in most developing countries.

11. POTENTIAL IMPROVEMENTS

a. Government Incentive Policy

The incentives for the small mill given by the Government of India can fairly be said to have achieved their main objectives: the number of mills going into operation will triple within the next two years and the contribution to overall output will increase proportionately. In some ways, however, the incentives inhibit development which ought to be accelerated. A tonnage definition is crude: the real criteria of capacity are speed and width and it has been demonstrated by several authorities what these factors should be for minimum capital and operating costs. Adopting these criteria would have one effect of incalculable value: the standardisation which would follow, to the benefit of all parties in India and the developing world, and for which an export market would be created. It is also suggested that confining the incentive criteria to size and speed of the machines and not to overall tonnage would encourage mills to expand practically and more effectively. At the present time new companies are formed for each new machine, a subterfuge which helps no-one and hinders some genuine scale benefits such as better laboratory and research facilities, more adequately equipped workshops, the possibilities of power generation, lower building costs, etc.,.

b. Instrumentation and Control

Low cost instrumentation and control is now available, but is almost totally absent from the small mill. A new attitude towards an effective minimum is desirable, particularly in the field of consistency regulation. Irregular consistency is a significant contributor to excessive breaks and poor quality paper. The Indian small mill industry must accept a learning period and progress towards economic measurement and control.

c. Machine Design

Efficiency must be improved - the small machine, under equal conditions, should be more and not less efficient than the large machine. The inherent weakness of the fibre source contributes to low efficiency and steps to improve the ability of the machine to cope with this situation are suggested. Granite top press rolls, simple pick-ups, and, most promising, the adoption of vacuum-less dry formers are amongst suggestions made. Systems and cleaning are also capable of improvement at low cost.

12. MANUFACTURING LIMITATIONS

a. Machines

Suction rolls and drying cylinders are the major items beyond the manufacturing capabilities of the small workshop. Other large components may also be beyond their capacity but can be sublet to larger engineering manufacturers economically. Several suggestions are made:-

(i) Drying Cylinders could also be made by the larger engineering companies of mild-steel, rolled and welded with heat treatment. The standard machine concept would greatly facilitate this move. There are overseas precedents and costs are lower.

(ii) The single, or multi-former does not need a suction couch; the presses are incorporated with the forming felt.

(iii) The fabric felt would eliminate suction presses without detriment. (At present in small mills, suction presses are seen only on second-hand machines and the plain presses limit speed and promote breaks.) If the fabrics cannot be supplied from Indian sources, imported ones should be allowed, although the time has come for fabric wires, dryer felts and press fabrics to be made in India.

b. Pulp Mills

New processes already being developed should be studied and given official backing where considered sufficiently promising. The main objectives are to reduce chemical consumption to arrive at effective low-cost chemical recovery, or to eliminate the necessity for it altogether. Long-term pulping processes suit seasonal crops held for long periods in storage.

New processes, particularly the ammonia process, are discussed, as are the limitations of small scale chemical recovery under conditions of excess silica, when straw is used.

c. General

Having established, beyond reasonable doubt, the viability, practicality and desirability of the small mill for India, two further objectives emerge:-

(i) To further improve overall efficiency and quality.

(ii) On this basis, to establish an export market to other developing countries because they need the same small-scale approach and have neither the inherent industrial capacity to build for themselves nor time to reach the standards which India has achieved.

13. IMPLICATIONS FOR DEVELOPING COUNTRIES

What has been accomplished in India is needed by many other developing countries which cannot afford the so-called "economic" installations and do not have the skilled technicians available to operate and maintain them. The small mill offers the possibilities of utilising agricultural residues, of raising finance through private enterprise, of producing paper instead of importing it, of spreading industrialisation in rural areas at a rate which can be absorbed and of avoiding the pollution risks attendent on large mills tied to large-mill technology. If the weaknesses of the small mill are eliminated by application and effort, it may indeed be possible for developing countries to be more "modern" in paper production than the developed countries whose mills are anachronistic but locked to their present standards by the vast inertia of the combined manufacturers of paper and paper-making machinery.

CHAPTER 1

HISTORY OF PAPER

The man who ....
Showed how on the tissue made from reeds
Growing beside the Nile one may inscribe
Symbols of sound and so present the voice
For sight to grasp, did lighten human lot.

Edmund Shelley's "Ode to Newton". Preface to "Principia".

1.1. GENERALLY - WORLD WIDE

The discovery and initial appearance of paper in history cannot be dated with any precision without first defining what paper is. The definition most acceptable without a lengthy dissertation is that paper is a deposit of vegetable fibres obtained by processing the vegetable source to break it down into individual or near-individual fibre clumps, suspending the fibres in an aqueous solution, depositing the solution on a mesh screen which retains the fibres in a wet, more concentrated form, by allowing surplus water to drain away, lifting the fibrous mat off the screen usually by applying a cloth to it under pressure so that the mat adheres to the cloth (a process known as "couching"), applying pressure to the combined cloth and fibrous mat thus removing more water to the extent that the mat becomes strong enough to be detached from the cloth without breaking, and finally drying the resulting sheet which has now become "paper".

If this definition is accepted the history of paper-making may be said to have begun in China, about 105 A.D. and the first manufacture is accredited to a court eunuch, T'sai Lun, who was head of the Imperial Supply Department of Emperor Ho. It is doubtful that he actually invented the process; silk floss and cocoons had been used in a similar manner years before this date to make a sheet which could be written or painted on and it was much in demand, but expensive and weak - T'sai Lun, spurred on by the Empress, experimented with the existing process, using a variety of raw materials and finally produced an acceptable paper from all-vegetable fibres, old hemp, cotton rags, old fish-nets and bark from the mulberry tree. It was cheaper, presented a better surface and was durable. Significantly it was made from waste materials with little other commercial value and this can also be used as a base for a more philosophical definition of paper. It should always be the cheapest material possessing the characteristics required for the purpose to which it will be applied.

If another possible definition for paper is taken, that it is a relatively thin sheet of materials presenting a suitable surface for writing or painting upon, we cannot be at all certain about the starting date. Papyrus, from which the name paper was derived, was certainly in use three thousand years before Christ. It was made from strips cut out of the papyrus plant stem, soaked and laid first longways then crossways to form a mat, pounded and pressed until it became a sheet. Tapa and amtyl are also hammered bark sheets, fortified in some cases with gums and both existed long before T'sai Lun was born. Primitive forms of such quasi-paper are known to have been used much earlier than paper by our classic definition, in areas all over the world, including remote regions of Africa. Man has always loved the flat, clear surface as a means for self-expression and has used great ingenuity to produce it from the crudest of raw materials.

Manufacture of paper improved with experience in China. Other materials were subsequently used including grasses, bamboo, flax, laurel and rattan. Properties were manipulated by blends or variations in treatment. Paper initially was a prized commodity greatly in demand by those who could appreciate its potential - and afford it! The process could not be confined to China, by the third century A.D. it reached Japan and by the seventh century it turned up in India. In 751 A.D. during the Turkestan-China border war a number of Chinese paper-makers were captured and Samarkand became a noted centre for paper production. It spread westward to Egypt and Morocco and finally reached Europe around the twelfth century A.D.

The early European papers used linen or cotton rags as raw material. Initially the sheets were thick and rough and the surface had to be "sized" with animal gelatine to be acceptable to ink. The process improved and a renowned paper-maker, Ulman Stromer, set up a paper-mill in Nuremberg in 1390, using water-powered hammers for beating the material thus emulating technology used much earlier by the Chinese. The craft spread slowly around Europe, not reaching England until the 15th Century A.D. but it was established universally in the then-developed world by the end of the 16th Century and reached the New World by the 17th Century.

In the Western world its use was confined to writing, painting and ultimately printing, which enormously increased the demand. In the Eastern world, by modifying the process or adopting secondary processes, other uses were developed such as personal clothing, bags or satchels, bedding sheets and even building materials.

The development of paper from a relatively high-priced, hand-made product in limited supply to the machine-made "throw away" article which is in such common use today came entirely from the Western developed world, Europe and North America, as part of the 19th century surge towards industrialisation.

The early improvements were directed towards designing machines to replace manpower and minimise human skills, to take the "art" out of the industry. The first machine appeared in 1799, in France when Nicholas Louis Robert built one with an endless wire mesh and an incorporated press.

The unsettled conditions of that period in France were not conducive to development so the device was taken to England and sponsored by the brothers Fourdrinier, who owned a stationery business. The cost of development bankrupted these pioneers but their name remains as descriptive of paper machines using an endless moving wire for formation.

In 1804 Brian Donkin, a millwright-engineer from Dartford, England, built the first successful paper machine in Two Waters Mill, Hertfordshire, England, and followed this with the first machine in America, 1827. From a fairly crude start the design improved steadily. By the late 19th century the machine had assumed the characteristic Fourdrinier form, was about 2.25 metres wide, built primarily for the growing newsprint market and producing around 25 T.P.D. Some of these machines are still in production today though no longer producing newsprint. Major improvements arising after the first World War influenced performance; for example, the suction couch and presses. After the second World War the vacuum pick-up, pressurised flow boxes, foils, plastic wires, twin-wire formation, etc. still further enhanced capacity. Operating speeds increased from around 100 metres/minute in the early 20th century to 900 metres/minute at the present time and even faster for tissue grades of paper. Widths also increased to around nine metres. The modern newsprint machine can produce 150,000 T.P.A. and a linerboard machine nearly twice as much. The basic Fourdrinier remained as standard until recent years when formers began to appear in the field, offering versatility in production and the possibilities of multi-layer formation for paper or board at relatively high speeds. The standard multi-vat board machine was developed much earlier back in the first part of this century and it still operates in many board mills but is likely to be replaced, for new machines, by formers.

The continuous paper machine created a demand which could not be met by traditional raw material and a search for cheaper and more plentiful substitutes ensued. The supply of rags, which had to be cotton, linen or hemp based, was scarce and expensive to collect and limited production. The process was also expensive in labour and chemicals. It was recognised that paper is fundamentally the cellulose component of vegetable matter and that the treatment given to rags, etc. was basically one to remove non-cellulose material, normally by cooking with lye, or crude caustic and subsequently isolating and hydrating the residual fibres so that a self-adhering mat could be made by natural "felting". It was also recognised that trees are primarily cellulose-based, far more plentiful in supply and much cheaper to collect because of the convenient bulk and the compact numbers in forest areas. As early as 1719 a French scientist, Reamur, drew attention to the fact that wasps make very good paper from wood and suggested that man could do the same but no serious attention was paid to this advice. In 1800 an English papermaker, Matthias Kroops, actually produced wood-based paper but went bankrupt trying to promote the business, a fate shared by many of his pioneering successors.

Around 1840, a Canadian, Charles Fenerty, and a German, Friedrich Keller, both produced paper from wood. It is interesting that each adopted a wet, chemical-free, grinding process to produce individual fibres which could be felted and become paper with maximum yield. Groundwood pulp dates from this period but the first commercial mill to produce it was not commissioned until 1866, in Quebec. The use of groundwood developed rapidly and today is responsible for approximately 80% of the world's huge newspaper production. It is also interesting to note that poplar, a hardwood, was first used for groundwood because it had then no other commercial use, except as firewood but the weakness of the resultant paper due to the short hardwood fibres soon led to a more general use of coniferous, longer-fibred wood.

Groundwood is inherently weak, even when produced from strong-fibred wood because only 50% is cellulose; the non-cellulose components are not removed. Rags contain a higher proportion of cellulose initially and the cooking process still further increases the content of the finished paper. In 1851 chemical wood-pulp was first produced by two Englishmen, Hugh Burgess and Charles Watt. They cooked willow shavings with lye in an open vessel. No commercial recognition could be obtained in England as the process was taken to America in 1854 where it soon achieved favour because by evaporating the cooking liquor, burning the thickened black liquor and treating it with lime, the caustic could be recovered and the cost of chemicals reduced. The first chemical wood pulp was therefore soda-pulp, with recovery, on small scale!

In 1867, the acid, sulphite process was patented and in 1874 the first commercial mill started production in Bergen, Sweden. The chemicals, sulphur, calcium or magnesium, were cheaper than soda although recovery was not possible and after a series of improvements, from indirect to direct cooking, the sulphite process became standard for producing chemical wood pulp. The pulp was considerably stronger than soda pulp and bleached to a higher degree of brightness. It remained the predominant pulping process until the late 1930's and the damage caused by the enormous pollution burden which was permitted to flow untreated into the rivers and lakes of the world is inestimable. Many years will pass before the effects have disappeared. The process is still being used but on a greatly reduced scale, only for special grades of paper and under pollution control.

In 1889, a German chemist, Dahl, experimented with the soda process to make it less expensive. Up to that time the alkaline cooking liquor was generally produced from a solution of saltcake, or sodium sulphate, a chemical found in natural state. Dahl used saltcake direct with some lime and the pulp produced was found to be greatly superior in strength to soda or sulphite pulp and for this reason was called "kraft", the German word for strength. It was, however, more difficult to bleach and the familiar "brown" paper used for wrappings is usually unbleachable kraft. The great boom in packaging increased the demand for unbleached kraft and the five-stage bleaching process came along to give it the degree of whiteness required for other grades of paper. The process was also found to be applicable to species of resinous pine less amenable to the sulphite process. These advantages, coupled with effective chemical recovery, which included steam generation for mill use, have caused kraft pulping to supersede the sulphite treatment for wood pulp and most modern mills have adopted the process. The continuous digester accelerated the development of kraft cooking and pulp mills of capacity up to 1000 MTPD have become standard. Air pollution was an environmental problem, ignored for many years, but stricter legislation has now resulted in measures considerably reducing the nuisance.

1.2. INDIA

Paper was hand-made in India in the 7th century but not extensively until the Mohammedan era in the 12th century. It is still produced crudely, from waste paper, making rough boards, and as an art to produce expensive rag-based papers which still have a market. The first attempt to mechanise the business was made by William Carey who set up a factory at Sorampur, West Bengal, in 1812. The Royal Paper Mills at Bally, near Calcutta, followed and it subsequently was taken over by the Titaghur Paper Mill. The Upper India Couper Paper Mill was set up at Lucknow in 1882 and the Bengal Paper Mill followed at Raniganj.

At the beginning of this century the total production of paper in India was estimated at 15,000 T.P.A. By 1925, seven mills were operating and the production had increased to 25,000 T.P.A. The paper industry up to the early thirties was open to competition from import and not without hazards. Financial failures of new ventures were common and production remained fairly static for a period. A brief boom occurred in the late 20's and by 1930/31 home production reached 40,000 T.P.A., about 70% of total consumption. British interests controlled most of the operating mills but in the late thirties Indian entrepreneurs appeared on the scene. Rohtas Industries at Dalmin Nagur, Orient Paper Mill at Brij Raj Nagur, Shree Gopal Paper Mill at Yamuna Nagur, Star Paper Mill at Saharanpur and Mysore Paper Mill at Bhadrawati were all built by Indian private enterprise. Kenn competition existed between the Indian and British-owned mills; all employed foreign technicians, mostly from the UK but some from Germany and Sweden, because the number of technically skilled Indians was small, in the early learning stage.

Production reached 60,000 T.P.A. by 1938 and the second World War gave the industry a boost so that by 1945 the level of 100,000 T.P.A. was reached. Before the war, only standard grades of writing, printing and wrapping papers were produced and imported pulps were commonly used. By 1947, other specialised grades such as blotting paper, bank note paper and imitation kraft were also being made but no longer from imported pulp to any significant extent. Imports were restricted and local materials were substituted. Bamboo, sabai grass, jute waste, rags, cuttings and old hemp rope were all used with moderate success.

After the war ended the industry stagnated for a period as did most other industries. Plant and equipment had to be imported and funds were low. The years following Independence in 1947 were difficult in terms of foreign exchange and the balance of payments. Price control, imposed during the second World War, was not removed until 1950 and imports were restricted. Prices were then revised in accordance with the recommendations of the Tariff Commission and subsequent revisions were periodically made to compensate for increasing costs.

During the first three 5-year plans, over the period 1955 to 1970, the production of paper increased from 137,000 T.P.A. out of 17 mills to 730,000 T.P.A. from 57 mills. Bamboo became the major raw material and remains so today, although its proportion of the total is reducing in the circumstances of depleting bamboo resources and an increase in the use of hardwoods and agricultural residues. The evolution of a successful technology for pulping bamboo can fairly be claimed as an Indian contribution to the industry. In the middle 60's paper technologists drew attention to the potential of tropical hardwoods, naturally adjacent to the mills using bamboo from the same forests and a technology suitable for Indian mills was evolved.

As of April 1st, 1977, there were 75 mills operating in India, with total production around 900,000 T.P.A. from nearly 1,500,000 T.P.A. installed capacity. Newsprint is excluded from these estimates. 51 of the 75 mills were of capacity lower than 30 T.P.D. but their total output was less than 15% of the overall production. However, more than 100 new small mills were planned to come into operation and the small mills' contribution can be expected to increase substantially in total and as a proportion of the overall consumption.

To some extent the large increase in the number of small mills going into operation is due to market forces because virtually all are arising from the private sector but the Government of India have been wise in recognising the potential contribution of the small units, not only to the growing demand for paper but to the socio-economic development of the country, and have provided incentives to encourage investors.

However, in spite of the growth record, per capita consumption in India, at present1.8 Kg/annum, is one of the lowest in the world. It compares with 30 Kg/capita for the UK in 1900 and well over 100 Kg/capita currently for most developed countries in the world. Much, therefore,remains to be done: for India the small mill is seen as the quickest and least expensive way forward. What is true for India is also likely to be true for most of the developing countries in the world.

1.3. PAPER GRADES

A complete schedule of the various grades of paper being manufactured today would fill many pages and confuse the reader. An understanding can be more quickly reached by separating the range into classifications and categories.

1.3.1. Classifications

There are two main classifications as follows:-

a. Machine-finished (M.F.) papers

These papers, as the name suggests, acquire their finished surface from the drying cylinders to which they do not adhere, but pass from one to another until the sheet is approximately 95% dry. Both sides of the sheet acquire the same degree of finish, which may subsequently be improved by calendering.

b. Machine-glazed (M.G.) papers

The finish on these papers is one-sided, imparted by one large drying cylinder with a ground polished surface. The wet sheet is pressed firmly to this cylinder and sticks to the surface. It will not freely leave the surface until it has attained a high degree of dryness, around 80% and the smoothness, or polish, of the cylinder is imparted to the sheet on one side only and is not subsequently improved. An M.G. machine can also be used to produce creped paper by "docting" or scraping the sheet off the cylinder before it has reached separation dryness.

1.3.2. Categories

There are eight main categories as follows:-

1.3.2.1. Newsprint or Mechanical Printings, Bulky News

These papers are similar. The use of newsprint is self-evident. Mechanical printings are normally used for magazines and may be regarded as superior newsprint. The furnish for each is similar, around 70% - 80% coniferous groundwood and the balance, as fibre, semi-bleached kraft or sulphite. Newsprint has substance 45-50 gsm but mechanical printings are normally 60 gsm. Newsprint does not usually contain clay as a filler, except in the UK where its cheapness permits around 5% to be included in the sheet. Mechanical printings contain more clay, up to 25% and are brighter and acquire a better finish. Both grades are M.F. but some newsprint is supercalendered to improve the finish. Most mechanical printings are supercalendered. "Bulky" news, (a cheap paper used for paperback publications) can be included in this category.

1.3.2.2. Writings and Printings

A generic name for these grades is "woodfrees", used to indicate that no groundwood has been used in the furnish, only chemically prepared pulp, fully bleached kraft or sulphite. At one time coniferous pulps were used exclusively but for some years now at least 60% and sometimes higher proportions of hardwood pulp are included. Strength is not an important characteristic for these papers; the furnish is slightly less expensive and opacity improves with hardwood. In very recent times some bleached groundwood pulp has also been added to cheapen the furnish still further. It also improves opacity.

Writings and printings are recognised in two main grades: banks and bonds. The terms were originally intended to show quality differences but today denote substance, banks usually being less than 60 gsm and bonds above 60 gsm up to 100 gsm. There may be quality variance but these are a function of the manufacturer. All grades are M.F., normally given a starch addition at a size press, may be white or tinted and contain about 10% of retained clay.

1.3.2.3. Educational or Scholastic Papers

These are really the same as writings and printings but are inferior in quality, normally lightweight, around 50 gsm and less bright, using semi-bleached pulps and often some groundwood.

1.3.2.4. Packaging Papers

There are many grades; strength is the desirable characteristic, so kraft pulp is preferred as the principal furnish consituent. The most well known grades are:-

Sack Kraft. This is chiefly used, as the name suggests, for paper sacks. Pure unbleached kraft is the best material but serviceable sacks can be made from other materials, bagasse, waste grades, etc. with a blend, at least 50%, of kraft pulp. This paper is M.F. and normally of 70 gsm substance. Special sacks may use bleached kraft for appearance and printing reasons.

Bag Papers. Pure unbleached kraft is again most popular but the paper is M.G. finished and seldom heavier than 45 gsm, because of the machine limitations if a pick-up is involved. Again, bleached kraft may be used for special orders and the material may also be tinted to serve as decorative wrapping paper.

Liner Board. The best quality is unbleached kraft, usually made two ply using a more refined quality of pulp for the outer surface. It is normally made at very high production rates on a Fourdrinier type of machine with a secondary flow box for the upper layer. Bleached varieties are also made and are known as food board, because the end use is for food packing. It is always of M.F. finish, and of substance 90 gsm to 150 gsm. It is used primarily for the outer and inner layers of corrugated board.

Test Jute Liner. The name is really a misnomer - no jute is included in the finish, although it may have originated in India with jute as a component. It is now waste paper based, with a kraft liner about 25% by weight. Test liner currently challenges kraft liner for boxes, in Europe particularly and if made by modern formers with more than two plies can achieve quality very close to the pure pulp product, at much less expense.

Corrugated Medium. Here stiffness is the criterion because this paper is used as the corrugated centre of case material. Short fibres are better than long fibres for this purpose and hardwoods, pulped by the neutral sulphite semi-chemical process were once standard and still set quality criteria. Of recent years, however, it has been challenged by waste size press. Semi-chemical medium cannot compete in price and has an effluent problem because chemical recovery is seldom practical. It is likely that waste paper will oust semi-chemical altogether in the foreseeable future and this process is being accelerated by the new formers and multi-ply formation. All corrugated medium is M.F. Waste-based corrugated medium, non-sized, is known as straw board and is of inferior quality.

1.2.3.5. Industrial Papers

These are all specialties and it is not possible to do more than mention some of the most common, as follows:-

Glassine, banknote paper, greaseproof, one-time carbon paper, carbonless papers, blotting paper, insulation papers, and more recently, continuous stationery, computer card or tapes. The processes and furnishes vary considerably, according to desired characteristics.

1.2.3.6. Tissue Grades

Toilet or facial tissues and kitchen towelling are grades produced almost exclusively on M.G. machines using sulphite, bleached kraft and an ever-increasing proportion of waste paper as furnish. Bagasse pulp has, of recent years, been found to be a good material and 75% or more can be very successfully used. Modern machines for tissue products now operate at the highest speeds - up to 1250 metres/minute.

1.2.3.7. Boards

The definition of boards is that they should be of multi-ply formation. They are used primarily for carton manufacture and should have good folding qualities. Until recently, virtually all carton board was made on multi-vat machines and the preponderance of production is still made this way but the new formers are challenging the vats on quality grounds. Boards may be all pulp, all waste, pulp and waste, chemical pulp and groundwood according to quality and finish required. It may also be of M.F. or M.G. classification. The substance range is wide; from 100 gsm to 450 gsm is most common.

1.2.3.8. Art Grades

High quality papers or board, such as Bristol board containing rag or esparto with chemical woodpulp, plain or watermarked, still have a market. Hand-made papers represent the peak in this field, in terms of desirability and cost. Water-colour and draughtsmen's papers are also in this category.

1.2.3.9. General

The foregoing is a greatly condensed schedule of the multitudinous varieties of paper and board being manufactured. It should be added that many varieties can be coated, for better appearance or printing purposes or for special qualities; silicone release papers and magnetic coated boards are examples of the latter.

CHAPTER 2

INFLUENCE OF SCALE AND THE CASE FOR SMALL MILLS

2.1. GROWTH OF SCALE

Until the advent of wood-based pulp the size of paper machines and integrated mills was, by modern standards, very small, for several reasons. First, it was difficult and expensive to collect sufficient raw materials to satisfy large units. Secondly, the paper being produced was principally used for books, writing paper and records. Newspapers existed but were expensive and of limited publication. The degree of literacy was low and the reading and writing market correspondingly small. Thirdly, the facilities for manufacturing big machines were also limited and large machine tools very scarce indeed. General industrial growth, the increase in literacy and the accompanying improvements in the standard of living all combined to present for the paper industry a booming market in the Western world. The development of wood pulp, particularly groundwood pulp, was inspired by the increasing demand for cheap paper. It was most noticeable in the newsprint market. When cheap paper became available the newspaper industry soared into big business, often owning the paper mills which satisfied their requirements. It is interesting that a large proportion of the new mills built around the 1900's were designed to produce newsprint. It is also of interest to note that they were almost standard, around 2.25 to 2.5 metres wide, running as speeds from 100 metres/minute to 150 metres/minute. They were also relatively inexpensive and profitable with an assured and growing market. Paper companies began to grow in size by multiplication of units; machines also increased in width and speed. Machine manufacturing became a very profitable business and the proprietors took steps to increase their machine tool and foundry facilities in terms of size and precision to build machines of greater width and higher speeds. The impetus given to engineering by World War I accelerated progress, In 1929, the largest machine in the world was built, in England, for a national newspaper which also controlled the Canadian groundwood and sulphite mills supplying the pulp. This machine was 5.3 metres wide and could run at nearly 250 metres/minute. It had the first all-electric sectional motor drive which had become a necessity for such a machine because the steam engines and flat belt pulley drives previously used had reached their limit with the materials then available. By 1937, the world's largest machine, again in England and owned by another newspaper company with North American pulp interests, had reached a width of 7.7 metres and could run at 420 metres/minute. No logical reasons can be traced for increasing size to this extent. Labour costs have often been quoted, but machine labour was then, and still is, a relatively small proportion of overall costs. More likely reasons, in the author's opinion, were pride and prestige, characteristics typical of the newspaper giants of the period. A similar situation was developing in the ship-building industry which proved it could make the now obsolete 80,000 ton ocean liners such as the Queen Mary, the Bremen, etc. Willing paper machine manufacturers responded to the requests of mill-owners - in fact they anticipated them; certainly they did not question them. The result was that machines ceased to be standard; each new one incorporated fresh parameters of design and was a one-off. Unit costs began to increase accordingly.

The rapid growth of the Kraft sack and wrapping paper industry from 1930 onwards accentuated the trend towards size and machines of corresponding width to those for newsprint were developed. The machine manufacturers could now produce such machines so they were ordered!

After a lull in the paper machine manufacturing industry during World War II, engineering progress was accelerated and shortly afterwards the race for even more width and speed was resumed. The inventions previously mentioned in Chapter 1 assisted and by the early 1960's widths of 9 metres and speeds of 700 metres/minute were achieved. Then the consequences of such development began to manifest themselves. Capacity exceeded consumption and paper prices slumped. The widths and speeds began to require sophisticated and expensive controls for efficient operation, still further adding to already disproportionate machine costs, which were no longer compensated by increased paper prices because these were set by the mass of earlier, written-down machines still in operation. From 1930 to 1975, the cost/annual tonne of a newspaper machine increased at least forty fold while the price of newsprint increased less than twenty fold! A strange progress this. The installation of new machines became a luxury which could be afforded only by multi-national giants or the government of developing countries, advised by consultants that only scale to this degree could be economic! For the consultants it <u>was</u> economic; they were now essential for large mill design and coordination.

Alternatives could not easily be considered. The enormous investment in large machine tools locked the major machine suppliers to the unprofitable giants. The sheer cost of the money involved for a new mill now exceeds in many cases the margin between production costs and revenue. The situation has became uncontrollable and paradoxical in that, despite steadily growing demand, paper manufacturers, with few exceptions, cannot afford to renew their equipment! In many cases, they have chosen to upgrade it by modifications producing paper grades with greater margins of profitability, leading to the closures of many smaller mills not necessarily for price reasons but by market control. No new machines, except for tissue or specialty papers has been built in England since 1960 and the decline in production overall has been met by imports. The same applies to other developed countries and this outcome should be a lesson to the developing world.

2.2. DISADVANTAGES OF SCALE

The comments which follow are presented against the background in India but are applicable to most developing countries in the world, and for some of the factors mentioned, universally.

2.2.1. Appropriateness

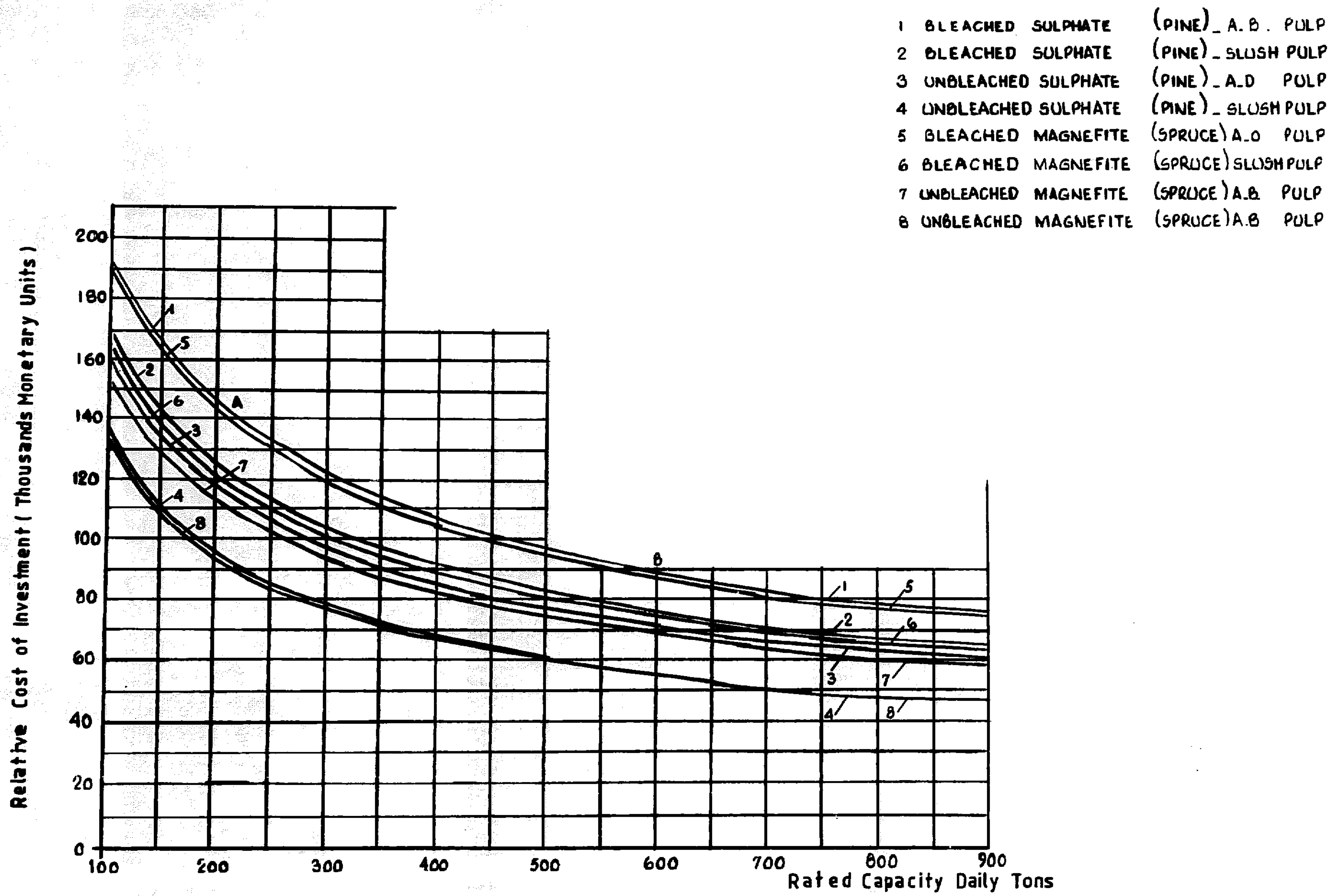
The total paper and board consumption in India is estimated for 1978/9 to be around 1,600,000 tonnes, including 350,000 tonnes of newsprint (largely imported) and 70,000 tonnes of low-quality straw and mill board. The officially estimated annual growth in demand over the next 5 years is 7% p.a. with the bulk of increase in general papers and board. Consumption is expected to increase at a higher rate, around 10% for the ensuing 5 years up to 1988/9. Elementary calculations therefore indicate an average annual growth in each grade of around 40,000 T.P.A. for the next 5 years and 80,000 T.P.A. thereafter. A single, modern "economic" newsprint machine can have 150,000 T.P.A. capacity, and "modern" Kraft or writing and printing paper machines can produce around 100,000 T.P.A. or more. How can such capacities be absorbed? The impact of giants such as these on the Western world market has done much to undermine the viability of the paper industry world-wide.

2.2.2. Availability of Raw Materials

There are no coniferous forests naturally occurring in India or in many countries outside North America and Scandinavia but vast wood supplies within close range are required to satisfy large mills. There are forests of assorted tropical hardwoods in India but they are regarded as sources for bamboo rather than for pulp wood, although some of the wood species are now being used. There are also areas where confiers can be grown and some plantations exist but they are remote from populated regions and require inordinate expenditure for infra-structure. India is primarily an agricultural economy and there is greater value in exploiting agricultural residues available in all areas of the country.

2.2.3. Sophistication and Technology

The modern large paper mill is not easy to operate at the high levels of quality and efficiency necessary for viability. Even for the developed countries of the world, with their resources of



Investment Requirements for Pulp Mills as Function of Mill Size. Source:
FAO Forestry & Forest Products Studies N°18 1973

FIG 1

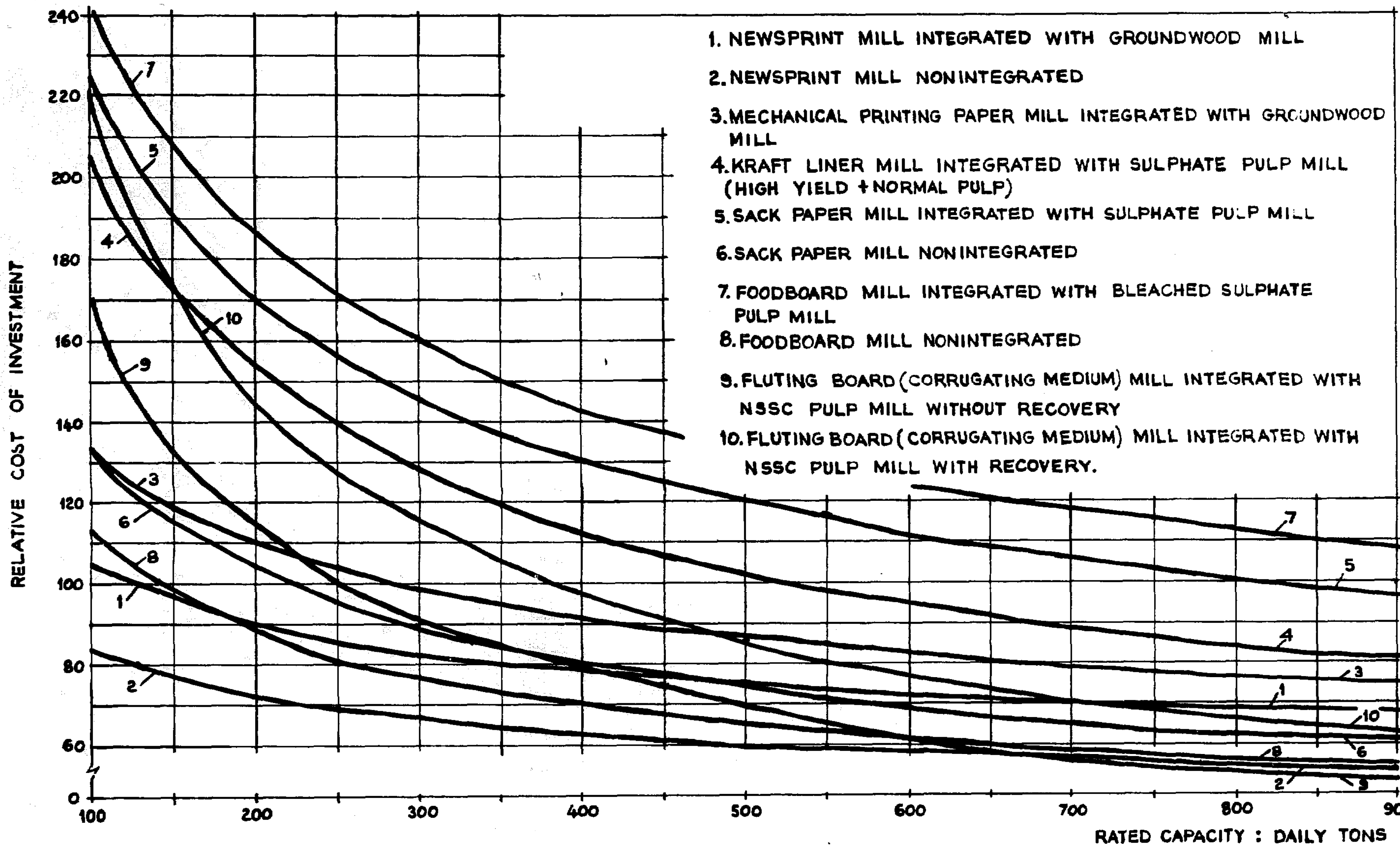


FIG 2. Investment Requirements For Paper And Paperboard Mill As Function Of Mill Size

Source:- F.A.O. Forestry & Forest Products Studies No-18-1973 experienced operators and technologists, it has been estimated that the learning curve for a modern large mill is three years, i.e. it is unlikely to reach designed standards of production earlier. In developing countries the skilled manpower resources are less and very expensive expatriate support is necessary, often for long periods after start-up. Heavy losses over the initial years of operation are all too common - but are seldom added to the investment cost to assess true viability. The degree of sophistication necessary may be judged by the fact that in Western countries, large machines now invariably use expensive controls to eliminate the human factor.

2.2.4. Capital Costs

The two curves, Figs. 1 and 2, prepared by F.A.O. Forestry Studies, 1973, show the influence of scale on investment costs for mills of varying types and capacity. At first glance the case for large scale appears overwhelming but closer investigation reveals some factors not included and conclusions which are suspect:

(i) The curves do not include writing and printing papers but only the mass production, cheaper grades of paper.

(ii) The curves show no costs for mills of capacity less than 100 T.P.D., which by Indian standards would be termed large.

(iii) The mills are all wood-based, as if no other raw materials are worthy of consideration, whereas it is known that for instance bagasse-based mills of around 100 T.P.D. for writings and printings are less capital intensive than wood-based mills, particularly where infrastructure costs are involved. The curves do not, incidentally, include infrastructure costs for the forest areas and these can be very significant in overall costs.

(iv) The case for scale in respect of newsprint, particularly non-integrated, is far from convincing and is likely to disappear altogether if the losses sustained by the larger mills over the initial years are added.

(v) Some of the best cases presented, for corrugating medium, now represent an obsolescent material being replaced, world-wide, by waste paper substitutes, usually being made on ex-newsprint machines. No one today can afford a new "modern" machine for waste-based corrugating medium and the world is not likely to see many more new wood-based fluting mills. The curves may indicate cost but do not show viability.

(vi) The case for scale most difficult to challenge is the liner-board mill where the output of one unbleached Kraft pulp mill, around 900 T.P.D. capacity can be fully absorbed by a single board machine, but enormous wood resources close to site are required because the product is sold almost at pulp price and the margins are small. There have, indeed, been occasions when the product, in a flagging market, has been sold as pulp to contribute to costs because mills of this capacity are so capital intensive that idle time is fatal. In any event, potential locations for such mills are unlikely to be found in India or many other developing countries and even if practical would require unremunerative export because the home market could not absorb the output.

(vii) The prices are based on Western manufacture, linked as it is to high tooling and labour costs. They are not representative of costs applicable to machines purchased from small, Indian manufacturers, with lower overheads and labour expenses. The cost per annual tonne of a large scale pulp and paper mill, which of necessity will involve considerable imports of machinery, today exceeds £1,000. The cost of the money required in interest and repayments, because heavy loans will be necessary for such a burden, is now greater than the profit margins in many paper grades and for developing countries this means protective tariffs and high prices which retard literacy and development, because paper should be cheap! The sheer magnitude of the capital required precludes private enterprise and this inhibits growth. For India, it is a fact which will be demonstrated beyond doubt in this volume, that the same amount of investment in small mills nationwide, will result in twice as much production in a considerably shorter period of time.

2.2.5. Transport Costs

With paper consumption per capita/annum as low as it is in India and many other developing countries, a large mill must of necessity distribute over an extensive area. Transport costs have risen nearly six-fold since the OPEC fuel price increases began and can be expected to go on rising. The customer bears the cost of transport directly or indirectly and beyond a relatively short haul around 500 kilometres,the costs are becoming prohibitive. India has thousands of kilometres to cover, many over indifferent roads.

2.2.6. Energy

It is only fair to point out one decided advantage of scale. Large mills, with the exception of groundwood-based mills can be self-sufficient in power generation and usually are. The capital costs quoted above for the large mill include generation, a factor which should also be taken into account. This has significance for India because the small mills in the country almost without exception rely on purchased power, which under present circumstances is unreliable and a major cause of inefficiency arising from under-utilisation. It is to be hoped that this is a temporary phase. There is also need to study the steam heating power potential for small mills because they are undoubtedly capable of improvement. In spite of this present handicap, however, small mills in India are still viable and represent by far the best value for investment.

2.3. ADVANTAGES OF SMALL SCALE

To some extent the comments under this heading are corollaries of those discussed under the previous section, but there are side-issues within the various sub-sections which are worthy of discussion: and additional, positive factors applicable to the small mill only can be added. Beginning then, with the sub-sections from the previous section in order, the following can be stated:-

2.3.1. Appropriateness

The small mill is more appropriate to the needs and aspirations of India. This is not a dogmatic, biased statement; its validity has been recognised by the Indian Government who, after due consideration have adopted the policy of encouraging small mills as the quickest least expensive and most effective means of resolving the shortage of paper problem. It uses indigenous materials to the maximum extent and satisfies local demand at source successfully because private enterprise, and their supporting bankers, require evidence of viability before investing. It meets market demand at the rate arising and minimises costly failures with ensuing hardship to investors, employees and the public in general.

2.3.2. Availability of Raw Materials

Agricultural residues are available all over India. Wheat or rice straw and bagasse are the most prolific and can be obtained in such quantities as to make a very significant contribution to the increasing paper demand. The surplus of straws have virtually no other economic use; after use for cattle food and domestic purposes the residue has to be ploughed back or burned for disposal. Bagasse, the cane residue from the sugar industry, is burned to generate steam for the sugar process, but wastefully; there is always a surplus even from fully-refining sugar mills and from non-refining mills there can be a genuine disposal problem. Bagasse is a very versatile fibre, capable of producing many grades of paper to high quality because it can be bleached by a cheaper process than is required for wood and requires less long-fibre support than most hardwoods or straw. If substitute fuels can be arranged it is probably the most valuable raw material available in India or the developing world. Even without fuel substitution the surplus bagasse can be used for small mills to supplement other fibres and new processes with this objective are emerging and showing considerable promise. There is great need for total energy studies on sugar mill complexes to optimise overall use of the cane.

Industrial residues such as hemp, jute and cotton waste are also available in India and are particularly valuable in providing long-fibred material to reinforce the weaker, short-fibred straws or, to a lesser degree, bagasse. Certain grasses, such as sabai, also have this characteristic. Kenaf is another very promising source of long-fibred material already being processed in India but the treatment is specialised and would probably benefit from further development work to optimise utilisation of the whole plant. All the materials mentioned above suit small mills; none, with the possible exception of bagasse, where pulp mills up to 150 T.P.D. have already been built, can have any possible application to large mills due to collection costs for the quantities required. In addition, waste paper is available from the larger cities, but not to the degree justifying large scale because the total quantity available in the whole country is unlikely to be more than 200,000 tonnes/annum spread amongst many towns or cities widely separated by distance.

2.3.3. Sophistication and Technology

The paper industry in the developed Western world reached its present status from small mills of relatively simple design with few automatic controls. Papermaking skills were acquired and gave the industry a sound base for development. The introduction of large machines, of necessity highly instrumented and controlled, bye-passes this essential learning stage. At best, opportunities for learning are confined to a small number of people in a few mills. Technology for the large mill must be imported at great expense but this is not the worst aspect. More seriously, the opportunity to acquire and use technology is restricted to a select few.

The small mills bring industry to under-developed areas to a degree which unskilled labour resources can absorb and thus creates an industrial climate of benefit to the whole country. Supporting industries, such as repair shops, converting factories, etc. emerge to acquire new skills and disseminate them in many areas. The small mills now operating do need the benefits of low-cost instrumentation and control to improve quality and efficiency but they are becoming more and more aware of this need and are beginning to take corrective measures. The learning process may be gradual but it is widespread and will rub off on other industries. It is sound, because it can be expected to bring about development directly applicable to circumstances which have no counterpart in the developed world.

2.3.4. Capital Costs

This subject should be considered from two aspects, first the unit cost per tonne of paper produced and second the magnitude of the total investment required. From both of these aspects the small mill has irrefutable advantages. The many case studies examined demonstrate by concrete evidence that the unit cost per tonne of paper is never more than one-half and often as low as one-quarter of the corresponding costs for the large mills. Viability is greatly influenced by this factor. In terms of overall total cost per installation it is obvious that a mill one tenth the capacity of a large mill, requiring less than one-half the investment per unit output will need less than 5% of the large mill's financial burden, putting it within the scope of private business to sponsor. The government is consequently relieved from the pressures which would otherwise arise because paper is an essential commodity and the supply must be assured.

2.3.5. Transport

Many small mills do not concern themselves with transport. The customer, who may be the direct consumer or the bazaar, collects because the distances involved are small and the costs less. Double-handling is eliminated and existing local transport facilities are more fully utilised. Where transport is organised by the mill, it is normally confined to a limited distance, for a proportion only of total capacity and often handled by mill-owned vehicles. All parties benefit under these arrangements which cannot be duplicated by the large mills.

2.3.6. Socio-Economic Considerations

The foregoing paragraphs outline the direct and clearly evident benefits arising from the small mill. There are other, indirect and less obvious benefits which, in final effect, can show advantages of equal, or even greater, value in developing countries such as India.

The process of superimposing an industrial economy upon one primarily based on agriculture can be painful and result in side-effects creating formidable problems, for the present time and long into the future. All developed countries passed through this phase, suffered and are still suffering the effects. They were less painful than might have been the case because early industrialisation created an export market to less developed countries and benefited by being able to import raw materials at low-cost. Wealth was created to provide capital for further industrialisation and to relieve the worst features of poverty accompanying the transition phase. Underdeveloped countries today cannot hope for such ameliorating factors. The most important contributions the small mill can offer in these circumstances are as follows:-

2.3.6.1. Employment

Large mills in developed countries are designed to minimise manpower requirements because they work to very narrow margins of profitability, competing for export business or against imports. Labour rates are high and although, for the mill as a unit, labour is a relatively small proportion of total cost it is very significant in relation to profit. For small mills in developing countries the reverse is more often the case; it is certainly so for India. Labour rates are low, linked to agricultural standards and unemployment is high. The impact of industrialisation causes a drift to the cities from rural areas which creates problems very difficult to solve.

The small mill, rurally sited to use agricultural residues, is a very real benefit in these circumstances. More people are employed per tonne of paper produced.The gain is not so much in the mill itself, although ten small mills of 30 T.P.D. capacity will employ up to three times as many operators as a single large mill of 300 T.P.D. capacity (see page 44). A further, larger gain arises from collecting and handling the raw material and it is satisfied by unskilled workers desperately seeking employment.

The mill operators and maintenance staff acquire marketable skills; engineers and tradesmen are trained for progress towards industrialisation and the higher standard of living which follows is achieved at a rate which can be absorbed with much less pain and hardship. The drain on governmental relief resources is eased and tax revenues are substituted to augment the requirements of less fortunate areas.

2.3.6.2. Side Benefits

Apart from direct employment provided by the mill indirect employment follows from servicing such as transport, repair or machine shops and village trade generally. In some areas converting factories for case making, carton manufacture, production of envelopes or stationery, exercise books, etc. can be established.

The local farmers benefit by receiving remuneration for material formerly of little value and other supplies, such as limestone, resin, alum or burnt lime will be required from local resources, where possible.

2.3.7. General

All the above mentioned direct and indirect benefits, arising from the policy of building numerous small mills rather than a few large mills, have a very important bearing on the economic justification, taking the widest, long-term view and this is fully recognised by the Indian government which, perhaps to a greater extent than any other democratic government has had to meet the problems of industrialisation and is now more experienced in tackling them.

2.4. SUMMARY - SCALE COMPARISONS

2.4.1. Direct Comparisons on a Single-Mill Basis

A comparison between two mills, one a 300 T.P.D. mill for Writing and Printing Papers and the other a 30 T.P.D. mill for similar grades of paper, both with chemical recovery, is set out hereunder on the basis that the prevailing socio-economic conditions in India apply to both cases. The cost data is relevant to 1978/79 and 330 working days/annum are assumed.

ITEM	LARGE CAPACITY 300/T.P.D. MILL	SMALL CAPACITY 30/T.P.D. MILL	
		2nd hand import machine	New Indian made machine
Capital Cost	Rupees 1,200,000,000 = US $ 150,000,000 = £ 70,000,000 Sterling not including forest infrastructure	Rupees 60,000,000 = US $ 7,500,000 = £ 3,537,000	Rupees 80,000,000 = US $ 10,000,000 = £ 4,700,000
Capital Cost per Annual Tonne of Product	Rupees 12,000 = US $ 1,500 £ 700	Rupees 6,000 = US $ 750 = £ 350	Rupees 8,000 = US $ 1,000 = £ 470
Fibrous Raw Material	Forest based, resulting in depletion of forest resources. Creates shortage of timber unless combined with saw-mill operations, difficult in mixed tropical forest conditions.	Uses agricultural and/or industrial wastes with negligible economic value, or waste paper. A small percentage of purchased long-fibre pulp may be required, 10% to 25% of fibre content, according to circumstances and paper substance. Timber in forests remains available for more economic exploitation.	
Direct Employment Potential	1,500 employees	350/500 employees, according to materials used.	

ITEM	LARGE CAPACITY 300 T.P.D. MILL	SMALL CAPACITY 30 T.P.D. MILL
Capital Investment per Job Created	Rupees 800,000 = US $ 100,000 = £ 47,000	Rupees 120,000/171,500 = US $ 15,000/ 21,420 = £ 7,000/ 10,100
Agricultural Advantage	None	Farmers obtain additional income and are encouraged to produce. They also acquire funds for mechanisation investment. A cost become a profit.
Time Required Overall to Commission Mill	5 years, from first concept to completion.	2/2½ years.
Period Required to Reach Designed Capacity After Start-Up	3 years.	1 year.
Infrastructure Requirements and Transport Facilities	Large capital investment necessary.	Virtually no requirements; backward areas benefit from such as may be involved.

ITEM	LARGE CAPACITY 300 T.P.D. MILL	SMALL CAPACITY 30 T.P.D. MILL
Demand on Public Funds from Exchquer	Total investment costs very high with inadequate return.	Very little; virtually all small mills are in private sector. Borrowings are rapaid with interest.
Profitability	Seldom reached in less than 3 years from start-up and losses incurred can require 2/3 more years of operation to recover. Ultimate profitability not assured, low at best.	Profitable within one year of start-up. Return sufficient to attract private enterprise; best guarantee of viability.
Technical Support Required	Considerable, involving expensive expatriate support from consultancy, through construction and into production period.	None, from outside India. Experience in small mill operation is widespread in India. The mills are simple and unsophisticated.
Productive Efficiency	Ultimately high, to world standards but the profit gain in this aspect is more than offset by the higher financial costs.	At present, low, but mills are still profitable. Efficiencies are capable of considerable improvement if more attention is paid to low-cost instrumentation and controls, now virtually nonexistent. The short fibre weakness is also a factor and some development is necessary in machines and techniques. Efficiency can equal best, with effort and some mills have progressed well in this direction.

ITEM	LARGE CAPACITY 300 T.P.D. MILL	SMALL CAPACITY 30 T.P.D. MILL
Quality	Normally better, having instrumentation and controls, more uniform stock supply and superior grade of raw materials with modern, applicable technology.	Not so good but serves the purpose. Can be as good and in some circumstances is actually better, but more attention must be paid to quality control, stock preparation, screening and cleaning. Appropriate technology must be developed.
Product Distribution Costs	Much greater, due to large area to be served. Wasteful of fuel resources and, because costs must ultimately be borne by the customer, a cause of unnecessarily high prices.	Are almost always covered by existing local resources. Customer usually collects and pays less for the paper on this account.
Environmental and Pollution Hazards	Much greater, and more damaging, not per tonne of product because chemical recovery is assumed for both cases, but because ten times as much pollution burden is concentrated in one area. Air pollution becomes a serious factor, and bleach liquors are irrecoverable.	The same per unit of production but much less in total quantity per unit area of district and it can normally be absorbed without problem. Some areas actually benefit because treated effluent can be used as irrigation water in the relatively small quantities involved.

ITEM	LARGE CAPACITY 300 T.P.D. MILL	SMALL CAPACITY 30 T.P.D. MILL
Chemical Requirements for Cooking and Bleaching	Greater, for wood or bamboo. Cooking chemicals are reduced by recovery but are still greater because 15% of a large quantity required for make up is greater than 15% of a smaller quantity. Bleaching chemicals cannot be recovered.	Less, because agricultural fibres require less cooking or bleaching chemicals and waste paper none.

2.4.2. Comparisons Based on the Models Previously Used by Assuming that the Total Quantity of Paper, 100,000 T.P.A. (within the Capacity of One Large Mill) is Required.

ITEM	LARGE CAPACITY 300 T.P.D. MILL	10 SMALL MILLS OF 30 T.P.D. CAPACITY
Potential Locations	Very limited, need proximity to forest areas and availability of large water resources, such as rivers, for supply and effluent disposal. Must avoid urban areas for pollution reasons and the resultant of these factors usually requires large haulage distances for final product and substantial infrastructure costs.	Considerable choice is available. Backward areas can be designated for socio-economic reasons, without prejudicing viability. Virtually no infrastructure costs involved. Boreholes are usually sufficient for water requirements.
Total Capital Costs (less Infrastructure Costs)	Rupees 1,200,000,000 = US $ 150,000,000 = £ 70,000,000	Rupees 800,000,000/600,000,000 = US $ 100,000,000/ 75,000,000 = £ 47,000,000/ 35,000,000 Expressed in another way for the same investment, capacity could be increased by 50% to 100%
Direct Employment Potential	1,500 Employees	3,500/5,000 Employees plus casual workers, approximately 20% more.

ITEM	LARGE CAPACITY 300 T.P.D. MILL	10 SMALL MILLS OF 30 T.P.D. CAPACITY
Indigenous Machinery Manufacture	Limited. Very few Indian suppliers can produce large size paper machines; none can supply large scale pulp mill equipment.	Extensive. Small pulp mill and recovery equipment can be supplied by all-Indian manufacturers who are, in fact, about the only economic sources in the world for this plant, the paper machines can also be made by relatively small engineering companies, importing a small, specialised element.
Balance of Trade and Foreign Currency Considerations	Adversely affected by need to import equipment and technology and not offset by the finished paper production to the same degree as the small mill.	Greatly assisted by the small mill policy, directly, in terms of equipment and technology and indirectly in that Government funds are less involved because private industry provides finance.

2.4.3. General Conclusions

The evidence is overwhelmingly in favour of the small mill policy which has now been so strongly adopted by the Indian Government. It should be emphasised that the case for the small mill does rest on evidence and not opinion. The case has not been overstated in the foregoing analysis; examples fully justifying the views stated will be given in Book 2 and they have all been taken from actual small mills in operation or building. Literally, more than 100 such mills exist and the case presented has been deliberately framed to show average rather than extreme values. Conversely, examples can be quoted where the parameters for the large mill are far less favourable than those adopted above as the case for comparison. Reference will be made to such later in the book.

Some important but less quantifiable areas for comparison have not been mentioned, as, for example, training opportunities - India must one day have a paper industry with at least ten times the present output level. People must be trained for this period in large numbers, over the intervening years. There is no practical substitute for in-house, operational training in terms of cost or effectiveness. The small mill widely disseminated over the country, has enormous value for the future in this context alone. Another very important area not discussed is creation of wealth or contribution to living standards and here again the small mill is overwhelmingly superior to the big brother. More paper is produced per cash input; the money spent is distributed amongst a greater number of indigenous participants in the overall exercise; essential skills are acquired by a greater number of people; agriculture benefits from the increased demand; the rural outflow is checked and fringe benefits of incalculable value to the country are distributed widely amongst a large number of employees. Accommodation, medical care, canteen food subsidies, occupational clothing, supplementary education, even bicycles for transport are all facilities which can be quoted from factual examples.

In developed countries lacking the huge resources of wood required to sustain the high per capita paper and board consumption of its inhabitants, what was once a flourishing industry has become a depressed one due to the impact of the overseas-based forest-based giants and imports have largely replaced home production. In true economic terms the advantages of such a policy are very suspect but the return course is difficult if not impossible; the point of no-return has been passed.

For India and other similar developing countries, it would be sheer folly to permit these conditions to be repeated under the facade of "modern improved technology". Appropriate technology must be the keyword for the foreseeable future, if not indefinitely. Fortunately the Indian Government, under the pressure of what Bacon once termed "the virtues of adversity", has recognised the real from the unreal and now sets an example to the developing world.

CHAPTER 3

THE CURRENT STATE OF THE PAPER INDUSTRY IN INDIA

3.1. MARKET

3.1.1. General

The current and estimated market for paper in India is outlined in this section. It is analysed in terms of present demand, present capacity, future demand and the additional capacity necessary to satisfy it. The proportionate part of the market supplied from small mills by Indian definition i.e. not exceeding 30 TPD, is given together with an estimate of their potential to satisfy future demand. Current selling price and the sales distribution systems adopted are also included.

3.1.2. Background

At April 1977, there was a total of 75 mills producing paper in India and the gross, installed capacity was estimated at 1,127,000 metric tonnes per annum. The total referred to includes all established paper mills of capacity greater than 5 TPD. The records do not provide information on the very small units, but their contribution to total production is relatively small, limited to low quality hand-made air-dried boards, or hand-made paper of high quality. The actual production from the 75 mills listed amounted to 880,000 M.T., indicating that utilisation overall was just under 74%, a low achievement for which there are several reasons: insufficient demand is not amongst them. The utilisation factor is, however, one to appreciate in estimating future requirements. The growth in production and its distribution amongst the principal grades is given overleaf in Table 1.

TABLE 1

PRODUCTION OF PAPER PRODUCTS (in Metric Tonnes)

Year	Writing & Printing Paper	Wrapping & Packaging Paper	Paper Board	Specialty Papers	Total
1968-69	393,670	127,400	106,060	19,450	646,580
1969-70	415,440	146,020	124,540	20,520	706,520
1970-71	444,710	161,890	128,350	23,600	758,550
1971-72	463,650	163,640	125,750	27,990	781,030
1972-73	444,300	198,400	132,800	28,000	803,500
1973-74	440,200	195,900	130,800	29,700	796,600
1974-75	480,000	180,000	140,000	30,000	830,000
1975-76	503,900	158,200	120,900	46,200	829,200
1976-77	526,500	198,900	137,300	17,600	880,300

It is noteworthy that no newsprint production is included is these statistics. Some newsprint is produced in India's only groundwood mill, at Nepanagar, from Salai, a hardwood, but the quantity is not sufficient for the demand. Generally it is cheaper to import it and utilise production for the more expensive, higher added-value grades of paper. Around 325,000 tonnes of newsprint were consumed, however. The bulk of non-newsprint production, 60% of the total, was in writings and printings and this is typical of a developing country, progressing towards full literacy. The years 1970-75 show a stagnant market, more probably resulting from lack of investment than absence of demand. The Regulation of Production Order for Paper encouraging the smill mill was not passed until 1978. The average growth per annum over the period covered by the data given above was around 4%, compared with official projections of 7%. Excluding newsprint, the anticipated production for 1978/9 is estimated at 1,255,000 M.T. which indicates an increase of 21% per annum since 1976/7, raising the average over the period from 1968/69 to nearly 9%, thus exceeding the official projections. This indicates the impact of the small machine and the response of private industry to Government encouragement. It should be noted here that Government plans in India are known long before they are officially promulgated and private industry evidently moved before the order was finally made official.

The contribution of the small mills, in terms of capacity, to the 1976/7 production given above and the response to the Government encouragement promised can be gauged from Table 2. (Overleaf)

The data relevant to mills in operation shown in Table 2 are difficult to compare with that shown for mills planned because the definitions of capacity are given in different terms but a comparison can be made because it is known that the installed capacity of the 61 operating mills was 236,700 T.P.A. which indicates that planning is in hand to increase the small mills' overall capacity by 280% within 2 years following the Government's initiative. The data suggests that the 61 operating mills achieved only 55% of potential capacity and 15% of total production. Comments on this will be given in a later chapter.

The foregoing data are based on records of necessity backdated at least one year. Current and future production can only be estimated. The records on the contribution from small mills has been taken from the report for 1977, published by the All India Small Paper Mills Association,

TABLE 2

SMALL-SCALE MILLS IN OPERATION AND PLANNED - 1977

EXISTING				PLANNED		
Capacity in TPA	No. of Mills Operating	Total Capacity in TPA	Production in TPA (1977)	Capacity in TPA	No. of Mills Planned	Total Production Capacity in TPA
Up to 2,000	21	28,800	15,100	1,800-3,600	18	45,000
2-5,000	25	88,800	55,000	3,600-5,500	17	79,000
5-10,000	15	119,100	60,000	5,500-7,300	42	282,000
				7,300-11,000	26	247,000
	61	236,700	130,100		103	657,000

(Source: All India Small Paper Mills Association, 1977) whose headquarters are in Bombay. The information given is derived from returns submitted by the members and there is no reason to doubt its authenticity, but not all small mills in India belong to the Association so the data are not comprehensive. In addition, very small mills, up to 5 TPD do not qualify for membership and at least 35 units existed at that time producing only crude straw and mill boards by rudimentary low capacity plant or hand moulds from waste paper. Again this is typical of a developing country. Cottage or family industries eke a precarious living by collecting waste paper from any possible source, rubbish tips, etc., and convert it to pulp and paper, drying it in the sun. It is used for book or file covers and crude, handmade boxes. The contribution of recognised and registered small mills is, therefore, conservatively expressed in the preceeding paragraph and that of cottage industry omitted altogether but the discrepancy is not considered to be of any serious magniture and the totals given are reasonably representative.

A schedule listing more than 130 small mills in operation or under construction and nearly 50 straw-board and mill-board mills is given in Appendix 1.

3.1.3. Current Demand and Production

The per capita consumption for all grades of paper and board in India is today estimated at 1.8kg/annum, and the population is said to be 670 millions. For the eight years 1969-76 inclusive consumption remained virtually static at around 1.45kg/annum. Comparing it also with the corresponding levels for other countries considered to be developing e.g. China, 10kg/annum and Malaysia, 20kg/annum, it is also low, only Indonesia and some African countries have equally low standards. Reflecting on the status of India as an emerging developing country, with the degree of self-sufficiency it has achieved in other industrial fields and the progress being made in literacy and technology generally it seems clear that the present low levels of paper consumption are indicative more of import restrictions and lack of investment than absence of demand and this view is supported by evidence. In the two years, since the Government adopted the present incentive policy for small mills consumption per capita has increased by nearly 25%. All this suggests that, not only must there ultimately be a large increase in paper production but that a considerable step forward is now urgent requiring immediate action. In other words, today is a seller's market. Recent press excerpts confirm this view, indeed, emphasise it. One typical of many such reports is reproduced below.

"New Delhi" May 25th

"Scores of publishing houses are likely to close down due to an 80% rise in the price of paper during the last few months as well as its virtual non-availability in the open market.

This gloomy forecast was made by Mr.O.P. Ghai, Chairman of the paper committee of the Federation of Indian Publishers at a press conference here today".

The interesting aspect of the above is not as much the paper famine complained about but the inference that "scores of publishing houses are likely to close down". In a year when paper production and consumption over all grades had reached an all-time high level this can only indicate that in recent times scores of publishing houses must also have come into production! Demand is surging, greatly beyond productive capacity, and increased prices follow, themselves an indication of demand and scarcity. Selling at present is more a question of distribution than positive action.

The estimated levels of consumption and corresponding capacity requirements for the year ended 30th June, 1979, are given in Table 3. (Overleaf)

3.1.4. Future Estimates

Official estimates to satisfy future demand have been made by the Planning Commission and are reproduced in Table 4 for the next two 5-year Planning periods.

TABLE 3

ESTIMATED CONSUMPTION OF PAPER PRODUCTS AND PRODUCTION CAPACITY REQUIRED FOR 1978/79

	Consumption	Capacity Required
Paper and Board	1,185,000 Tonnes	1,350,000 Tonnes
Newsprint	350,000 Tonnes	400,000 Tonnes
Straw and Mill Board	70,000 Tonnes	120,000 Tonnes
TOTALS	1,605,000 Tonnes	1,870,000 Tonnes

TABLE 4

PROJECTED CONSUMPTION OF PAPER PRODUCTS FOR 1983/84 AND 1988/89

Grade	1983-4	1988-89
Printings	532,900 T	706,900 T
Writings	245,200 T	325,300 T
Subtotal	778,100 T	1,032,200 T
Wrapping & Packaging ("Kraft" brown)	386,600 T	583,900 T
Other grades	129,000 T	189,800 T
Paper Boards	367,600 T	540.100 T
Subtotal	883,200 T	1,313,800 T
Overall Totals (less newsprint)	1,661,300 T	2,346,000 T
Newsprint	500,000 T	700,000 T

(Source: Planning Commission, India)

These projections are interesting and significant. The indications are as follows:

	Forecast Average Growth/Annum
Writings and Printings	5% - 6%
Packaging Grades (Paper)	10%
Boards	9%
Newsprint	8%
All Grades	7%/Annum

As was indicated earlier, the previous projections were also for 7% per annum growth overall but the attainment, after several years of stagnation, was 9%, boosted by a 21% increase over the last two years. The official projections must be considered pessimistic, in view of recent performance and the considerable number of small mills known to be under construction. For a developing country so low in the scale of consumption levels, the projections fall far short of requirements. Assuming only a very moderate, and unlikely, growth in population over the planning period, at the end the per capita consumption annum if these targets are met will still be less than 4kg, below that currently being achieved in China!

The programme cannot be regarded as ambitious. It may be conservative, but realistic in that it should easily be attained. It may reflect a realistic outlook on shortage of raw material availability but this is doubtful; for more than a year now the Government has been promising to remove the current restrictions on the import of waste paper and it is known that many potential small mill investors are impatiently waiting for this promise to be honoured before putting plans for further mills into operation. Agricultural resources are also still available and restrictions on imports of pulp have been lifted.

Whatever the basis for these estimates, with booming demand and improvement in selling prices plus incentives, the private sector can be expected to improve on the forecast and will find a way of overcoming obstacles if profit can be expected to follow. The small mill gives private enterprise the opportunity and is likely to surprise the forecasters and the world by its response.

3.2. ADDITIONAL CAPACITY REQUIREMENTS

From the foregoing estimates of present and future consumption a forecast of the additional capacity required to meet the declared objectives can be deduced and is set out overleaf in Table 5.

TABLE 5

Paper Grades	Additional Annual Capacity Requirements, Metric Tonnes By 1983/84	By 1988/89
Printings & Writings	390,000	672,000
Packaging paper grades	210,000	425,000
Boards	200,000	387,000
Other Grades	65,000	131.000
Total (Excluding Newsprint) (Grades in Production)	865,000	1,615,000
Newsprint	570,000	800,000
Overall Totals	1,435,000	2,415,000

The reader will have difficulty in reconciling these figures with those quoted in the preceeding paragraph and the earlier statements of production and capacity given. The reason for the ambiguity is that the official statements use the terms "demand" and "capacity" rather loosely. "Demand" is understood to be an estimate of the quantity of paper to be produced whilst "capacity" is an estimate of the nominal capacity of the plant involved, necessary to produce it. As can be seen from the previous paragraphs, utilisation of plant can vary from 55% upwards according to grade of paper, power availability, scale and other factors. Utilisation is taken into account when forecasting nominal capacity to be installed but the factors used to derive the capacity definition are not given. A rudimentary calculation indicates that utilisation has been assumed at 85% to produce the capacity estimates given in Table 5. On past performance this seems optimistic and the extra capacity requirements shown above may need increasing to fulfil desired objectives.

3.3. SELLING PRICES

It is very difficult to give firm prices for the various grades of paper being produced at the present time because, as has been previously stated, there is now a sellers' market and the situation is fluid and likely to remain so whilst demand exceeds supply. These conditions encourage black-market dealings and, to the credit of the manufacturers, many have published list prices in the press, advising customers not to pay more. These lists quote prices on an ex-mill basis, exclusive of freight, excise duty, sales tax, or any other levies which may be imposed and must be borne by the customer. The ex-mill prices vary even for the apparently same product on the basis of quality and since freight also varies according to distance and excise duty according to the size of mill and its raw materials it is difficult to quote prices actually paid by the customer. Excise duty varies from 15% to 40% on the ex-mill price and must be paid to the Government before the paper leaves the mill. State and Central sales-taxes are both around 10% of ex-mill price. Table 6 gives an indication of prices prevailing in the Delhi Paper Market, Chawri Bazaar, June 1979.

Table 6 gives representative grades and prices selected to show that small mills can obtain better ex-mill prices than large mills, mainly because freight and availability are important factors. The aim is to sell competitively to the customer in terms of delivered price.

TABLE 6

EX-MILL PAPER PRICES (INCLUDING EXCISE DUTY) AT JUNE 1979

Mill	Size	Paper Quality	Ex-Mill	Price/Kg
1. Rajendra Paper Mills	Small	Writing & Printings(45gsm)	7.30	0.91
2. Hindustan Paper Corporation	Large	Writings & Printings (all grades)	6.24	0.78
3. Haryana Paper Mill	Small	Kraft Wrappings		
		34 gsm	7.60	0.95
		40 gsm	7.20	0.90
		60 gsm	6.40	0.80
4. Shree Gopal Paper Industries	Large	Kraft Wrappings		
		36-40 gsm	6.90	0.86
		46-50 gsm	7.01	0.88
		60 gsm	6.67	0.83
		80 gsm	6.05	0.76

The following comments apply.

a) For Writings and Printings the ex-mill prices, excluding excise duty, sales tax, etc., vary between R.5.2 and R.5.8/Kg averaging R.5.5/Kg. This is equivalent to £340/Tonne in U.K. terms and as such is competitive world-wide because the U.K. price is higher and the market is open to Scandinavian and North American competition with little protection. The Indian Government surcharges can add up to 50% to these prices, which would make them uncompetitive. Adding freight costs, paper is becoming an expensive commodity.

b) For "Kraft" Papers prices average R.5.0/Kg excluding excise duty of 30-37½%, equivalent to over £300/Tonne ex-mill. Considering the quality this would be a high U.K. price. It reflects the scarcity of long-fibre in India.

c) For White-lined Board, a price of R.4.3/Kg, equivalent to £260/Tonne, corresponds to U.K. prices.

d) In general, ex-mill prices are not excessive, indicating that paper in all grades can be made competitively from indigenous materials. They would stand up against imported prices plus freight showing that developing countries can be self-sufficient without heavy tariffs. The Indian Government in fact, levies income from paper sales, and for small mills provides "incentives" by reducing "disincentives".

3.4. DISTRIBUTION

3.4.1. Large Mills

Large mills sell paper through distributors appointed for different territories throughout the country. They also advertise periodically in the national press to show prices and promote sales by showing the range of products available. Freight to the distributing agents is pre-paid but included in the price charged. Distributors are allotted quotas according to sales potential or, in difficult times, as at present, in proportion. The distributor holds stocks and receives a commission on sales, normally 7½%.

3.4.2. Small Mills

Small mills do not normally use the developed agency network. They often sell directly to large consumers who arrange their own collection. They also sell to local agencies or to the bazaar. Deposits are required in advance against annual sales for regular purchasers or agents; the amount varies between Rupees 250 and 500 per tonne of the annual quota. Thus a mill with, say, 10,000 T.P.A. sales could obtain up to R.5,000,000 in forward cash, a great assistance for working capital. Approximately 60% - 80% of writing and printing sales are in sheet form but no sheeting surcharge is made. It is more common to charge the same price for reels or sheets and to offer a discount for substantial reel sales.

3.5. GOVERNMENT POLICY AND INCENTIVES FOR SMALL MILLS

3.5.1. The Paper (Regulation of Production) Order

This order was put into effect by the Ministry of Industry (Department of Industrial Development) March 8th, 1978. The following are the significant clauses:-

c) Regulation of Production of Paper

Every manufacturer shall manufacture .... White printing paper to at least 30% of the total produced, and coloured printing paper, cream-laid or wove paper, duplicating paper, offset or litho paper and typing paper up to at least 33% of the total produced. At least 20% must be cream-laid or wove paper.

g) The ex-factory sale price and retail sale price shall be stamped on every ream of paper and every gross of paper board.

k) Certain provisions not to apply to certain manufacturers

The above shall not apply to manufacturers of capacity less than 25 T.P.D.

3.5.2. Import of second-hand machines

The Government permit the import of small, second-hand machines, subject to a capital cost limit and a certificate of worthiness.

3.5.3. Subsidies for units installed in backward areas

A small plant, with capital cost between R.20,000,000 and R.30,000,000 can obtain a cash subsidy of R.1,500,000 if it is installed in a specified backward area. There is also a concessional rate of interest for loans, exemption of excise duty on electrical power for 3 years and a deduction of 20% of the assessable income for tax for 10 years.

3.5.4. Excise Duty Rebate

a) Mills up to 2000 T.P.A. capacity	Rebate 75%
b) Mills between 2000 and 5000 T.P.A.	" 60%
c) Mills between 5000 and 10,000 T.P.A.	" 50%

The above are subject to the use of at least 50% agricultural residues or waste paper as raw material.

3.5.5. Price Control

The 30% white printing paper specified in 3.5.1. c) above has to be sold at the (unremunerative) price of R.2750/Tonne. The small mill is exempt from this obligation.

3.5.6. Investors

Shareholders in small mills obtain exemption from wealth tax in respect of their investment for 5 years, and up to 150,000 Rupees/annum indefinitely. The first 3000 Rupees of dividend income is also tax-free.

3.5.7. Sales tax - Small Mills

Sales tax may also in special cases for development areas be regarded as an interest-free loan for the first 5 years of operation, repayable over the subsequent 10 years of operation.

3.5.8. General

Although some of the "incentives" for small mills are really reduced or postponed levies, they do act as positive incentives because prices are fixed by the large mills, not exempted from the levies and, moreover, obliged to sell 30% of their production below cost. The combination of growing demand and the Government attitude to small mills are the fundamental reasons for the unprecedented boom in low-capacity, rurally-sited installations, benefiting the country as a whole. It was obvious that some impetus to investment would be required to avoid a paper famine and the indications are that the policy adopted will be successful, at minimum cost and maximum return.

3.6. GOVERNMENT PLANS AND THE ROLE OF THE SMALL MILL

3.6.1. Targets

The objectives of the two next 5-year Plans, ending 1983/4 and 1988/9 respectively, have been summarised, so far as paper and board are concerned, in Section 3.2.

3.6.2. Direct Government Action

3.6.2.1. Newsprint

The target is 570,000 T.P.A. In 1974, a project for a newsprint mill, based on wood-pulp, was initiated by the Union cabinet, the mill to be set up in the southern State of Kerala. The mill, of nominal 300 T.P.D. capacity, will come under the Public sector and the original estimate for capital cost was R.390,000,000 ($48,000,000). By the end of 1975, this cost had been revised to R.1,000,000,000 ($125,000,000). It is now thought that the final cost may well exceed R.1500,000,000 ($187,500,000). Assuming interest at 12% and repayment over 10 years, the financing costs initially will amount to R.3,300 ($410) per tonne produced and over the repayment period will average R.2,100 ($265) per tonne produced. This assumes full production from Year 1 which is very unlikely. The selling price of newsprint in India is R.2,800 ($350), per tonne set by another Government mill. This project is, therefore, bound to operate at a loss for the first 10 years of operation or raise the price of newsprint substantially, probably to a level in excess of the imported price.

The project was initially deemed viable by Western consultants and probably has received financial loan support from the countries supplying the essential equipment, which must be imported but the outcome will not be viable and will be dependent on Western Technology. It will do little to promote industry in India but will undoubtedly benefit the importers. In 1979, the mill has not yet been commissioned, 5 years after its inception.

3.6.2.2. Writings and Printings

a) Assam

A mill of 300 T.P.D. capacity is being built at Jagiroad, Nowgong District in Assam, financed also by the Government Public Sector. The project will be based on bamboo and the Forestry Department of the Assam Government are selling it at concessional, give-away prices which represent a loss of potential revenue. The cost is expected to exceed R.1200,000,000 ($150,000,000) so that, using the same basis for computation as above the financing costs alone will initially be R.2,640 ($340) and will average R.2,040 ($255) per tonne produced, again on the improbable assumption that rated production is achieved from start-up. It is almost certain that this will not be the case and heavier financing costs will initially apply. By the Regulation of Production Order, 1978, referred to earlier, mills above 25 T.P.D. must sell 30% of production at R.2,750 ($345) per tonne and the balance averages, ex-mill R.5,600 ($700) per tonne. Raw material costs alone amount to more than 65% of total production costs, excluding finance and depreciation, so this mill must also operate at a loss or lead to higher prices.

b) Nagaland Pulp and Paper Mill

The Government propose (through the Hindustan Paper Corporation) to set up an integrated pulp and paper mill of capacity 100 T.P.D., of which 60 T.P.D. shall be writing and printing papers and the balance 40 T.P.D. industrial papers. The total project cost is expected to exceed R.600,000,000 ($75,000,000) and again, the financing costs on the same basis and assumptions as preceding will amount to R.4000 ($500) initially and average R.3000 ($375) over the first ten years of operations per tonne of product, assuming rated production throughout. The average selling price is R.5600 ($700) and there is the obligation to sell 30% at R.2,750 ($345). Viability cannot be expected and the mill must represent a loss on investment.

The cost breakdown of this mill has been given and is shown in Table 7.

TABLE 7

Civil Works	R. 90,000,000	($11,250,000)
Plant and Equipment	R.400,000,000	($50,000,000)
Project Implentation	R. 51,200,000	($ 6,400,000)
Working Capital	R. 8,800,000	($ 1,100,000)
Staff and Key Workers Accommondation	R. 38,000,000	($ 4,750,000)
Other Infrastructure Costs	R. 12,000,000	($ 1,500,000)
TOTAL	R.600,000,000	($75.000.000)

3.6.2.3. General Comment

The above mills of large scale (by Indian standards) could only be financed by the Government who are able to guarantee the loan investment and are not directly responsible to investors for a reasonable return. In Government terms the above examples may provide an acceptable return on investment because sales returns are augmented by income tax revenues and the loans hedged by inflation if they are on a long-term basis as sums of such magnitude usually are. The point can be made that if finance on easy terms can be obtained externally and repaid in currency which has devalued because of inflation, the government can acquire very tangible assets relatively painlessly. The counter-argument is that such investments provide more indirect benefits to the lenders than to the borrowers. The countries exporting advanced technology sustain and further develop their industrial resources already far ahead of borrowing countries, who can only take their latest investment as a pattern. The technological gap widens. The small mill represents better value for money directly and indirectly.

3.6.3. The Role of the Small Mill

At present the contribution of the small mills to overall production is estimated at 15%. To maintain this ratio, by the end of the first 5 year Plan, 1983/4, approximately 130,000 T.P.A. additional capacity would be required, accepting the 865,000 T.P.A. target overall, excluding newsprint. As shown earlier, already 103 new small mills are planned with rated capacity 1800 T.P.D., equivalent to nearly 660,000 T.P.A. total rated capacity. Accepting that the utilisation, by present standards, cannot expect to reach the 85% level on which the targets of capacity were apparently based but will more probably be around 60% this is still equivalent to over 400,000 T.P.A. effective capacity and it should be in operation within 2 years. Even assuming no further activity in the small mill field the contribution to the 5-year plan 1983/4 target must be around 50%. The large mills quoted above, planned by the Government, will add around 150,000 T.P.A. leaving 300,000 T.P.A. effective capacity to meet first 5 year plan requirements. If 400,000 T.P.A. effective small mill capacity can be put into commission in 2 years, the 300,000 T.P.A. balance ought certainly to be achieved in the last 3 years available and would require about 40 mills. If the balance is obtained in this manner, the contribution of the small mills to non-newsprint production would be 40% by 1983/4.

One interesting comment should be added. There is no valid reason why small mills should be less efficiently utilised than large mills. In developed countries, for similar grades, the opposite is more often the case. The major cause of poor utilisation in India is electrical power shortage and it must equally effect other industries. It might be more effective for the government to invest in greater power generation or to encourage self-generation which is possible to a significant extent in the small mill. Their contribution would increase to 50% of the total with more acceptable efficiency standards.

It seems inevitable that the small mill will be a very significant contributor by the end of the first 5-year Plan. The achievement of the second 5-year Plan targets will also be influenced by the small mill, but in a changing industrial climate and the proprietors and designers of these mills must prepare for change to meet new challenges and maintain, or increase, their contribution overall.

3.7. PULP AND PAPER MACHINERY MANUFACTURE IN INDIA

3.7.1. Historical and Current Situation

Manufacture of Pulp and Paper machinery was initiated in India during the thirties by a leading British manufacturer, at that time one of the world's leading companies in the field, responsible for many important innovations in paper and pulp machine manufacture of that time. So far as pulp was concerned, very small-scale, spherical or cylindrical digesters were chiefly involved, with simple, roaster type recovery systems, based on esparto grass pulp technology which at that time was a flourishing British industry. It proved to be a happy start for India because whereas esparto pulping in Britain declined and has now virtually ended, the technology based on cooking grasses proved most suitable to the Indian context, has survived there for other materials and has been developed and improved to the extent that India is now the leading country in the world for manufacture of pulping equipment using agricultural residues on appropriate scale.

Although the British subsidiary company in India was not an overwhelming success, (the Indian market was not large then), the company still exists but under Indian control. The Second World War stimulated activity for a while but afterwards there was stagnation and it was not until 1955 that there was a boom in domestic production. Paper machines could not be imported except by the Government, but they could be - and were - copied and produced in India. This began first in established mills, to increase existing capacity because the prototypes were there and of unsophisticated pre-war design, not difficult to repeat and familiar in operation. Some plant manufacturers today are associated with operating paper mills, who developed their business by first building for themselves.

As demand grew, engineers from the larger mills, by now experienced in manufacture, saw the opportunity and founded independent workshops for manufacturing pulp and paper mill equipment and today it is a flourishing and growing industry, capable of supplying virtually all the plant and supporting equipment for integrated pulp and paper mills up to medium size, but specialising in small size, where the demand is greatest. Supply potential includes service equipment such as boilers, electrical equipment, pumps, screens, cleaners, beaters, refiners, etc. etc.,.

There are two major categories of equipment suppliers: one caters to the needs for large mills and these companies normally have licencing or technical know-how agreements with established overseas companies. These companies are few in number, but well-equipped for complete manufacture. By domestic standards, their prices are high, though lower than for the equivalent imported equipment.

The other category, the small manufacturers although they will undertake supply and commissioning of a complete, small mill, cannot normally manufacture all the equipment involved; they sub-let large fabrications or special castings etc., to large engineering companies, who manufacture to their drawings and designs and purchase "specials", such as drying cylinders and suction rolls, from the larger paper machinery manufacturers. Suction rolls are sometimes imported, since Indian manufacture is comparatively recent and capacity restricted. Drying cylinders are a bottle-neck to small manufacturers, limited to two suppliers with full order books and it is not uncommon for small machines to start up, still awaiting some of the dryers. M.G. cylinders are imported; no Indian manufacturer has yet to set up the expensive foundry equipment to produce them.

In other supporting aspects, the manufacture of felts, wires, (but not plastic), rubber covering of rolls, etc., India is now self-sufficient. Altogether, for small integrated mills in particular, India today represents the most versatile and least expensive source of supply in the world. For the very small agriculturally based pulp mill, it is almost the only economic source of supply and a large potential export exists to other developing countries once the viability of these small mills is accepted, and the latent potential of the Indian manufacturers is more fully recognised.

A schedule of Indian manufacturers covering the full range of supply is given in Appendix III and the numbers engaged and the range covered will surprise those not familiar with the comprehensive and growing capabilities of the industry.

CHAPTER 4

RAW MATERIALS

4.1. FIBRES

4.1.1. Desirable Characteristics

4.1.1.1. Yield

Pulp can be made from any material containing cellulose, and virtually all vegetable matter conforms with this condition. The process of producing pulp suitable for the manufacture of paper is fundamentally one of removing the non-cellulose components of the vegetable until the residual cellulose content is sufficient to make pulp suitable for paper. The yield after processing varies according to the vegetable source and is very important because it determines how much raw material will be required but also because, inversely, it determines the quantity of chemical necessary and the burden of combined chemical and non-cellulose material to be treated for recovery or accepted as an effluent disposal problem, under present processes.

4.1.1.2. Availability

In terms of quantity manufactured paper is fifth amongst the world's processed materials so very large amounts of the raw material source are required. A relatively small mill, producing 10,000 T.P.A. of paper will require around 60,000 T.P.A. of the basic raw material (as received) if agricultural residues are used. Availability applies not to quantity alone but to the concentration of it, to reduce the effort of collection. The forest stands supreme in this respect, it represents a compact source of raw material with high yield, about 38% overall for chemical pulp, and minimum bulk for transport. Extreme climatic conditions excepted, it is also non-seasonal and can be harvested all the year round whereas agricultural materials are normally seasonal, necessitating collection over a short period and storage for the rest of the year.

4.1.1.3. Fibre Length

Paper is formed in a wet condition and, after removing as much water as is practical by pressing, must be strong enough to sustain the tensions of separation from the wire and those (which increase with speed) of conveying it through the machine to the winder. Strength increases as it is dried; the critical area is that where the formed sheet is wet and has to support its own weight before entering the dryers. This "wet-web" strength is essential for the process of manufacture, except for some tissues and M.G. papers where the sheet is supported by felts throughout. For certain papers, particularly wrapping or packaging grades, finished product strength is also an essential characteristic. The most important factor is the fibre length. Strength characteristics can be added to paper by stock preparation treatment, or in some cases by additives, but the fundamental requirement is fibre length, which varies greatly according to the raw material.

4.1.1.4. Other Characteristics

Fibre length/width ratio also affects paper quality and, where favourable, can influence strength or other physical qualities. Colour, affecting bleachability, can also be favourable, or otherwise. Hardness, or toughness can be a factor, affecting for woods in particular, the chipping or grinding power and the life of knives. The nature of the raw material is another factor. Wood, for example, can be chipped and the chips will flow like sand or gravel, facilitating continuous pulping processes. On the other hand, stringy materials such as straw or bagasse will not flow and must be cooked batch-wise or propelled through the cooking zone by screw feeders for continuous cooking.

4.1.1.5. Cost

All other things being equal, the cost of the raw material delivered to mill is the most important factor. Paper must be cheap! It is the original, classic throw-away. Its consumption is an index of the standard of living. Where it is too expensive development is retarded. The ideal material for the manufacture of paper is a waste material, available in the quantity required but not economically suitable for any other purpose. Slowly this vital factor is being recognised and the world is turning to waste products for paper. The lowest value is the fuel value taking into account the condition as collected. All paper-making materials will burn and their value as fuel competes with their value for making paper; this factor is likely to become more important as fossil fuels become scarcer.

4.1.2. INDIAN FIBRE SOURCES

4.1.2.1. Coniferous Softwood, Long-Fibre

The most desirable fibrous raw material at the present time is undoubtedly the coniferous softwood, used until recently for over 75% of the world's paper production. There are various grades (pines, firs, spruces, etc.) but they possess all of the desirable characteristics enumerated in 4.1.1. except cheapness and, for India and other developing countries, availability. The fibre length is between 3 and 5 mm, averaging 3.5mm and the strength qualities are good, amongst the best. Cost for all wood is principally that of the infrastructure and transport. At today's costs and selling prices it is uneconomic to undertake forestry solely for pulp or paper manufacture if the whole log has to be felled, transported only for pulping, and the distance from forest to mill exceeds 80 kilometres.

In the high Himalayas there are forests of spruce, fir and pine but they represent only 4% of the total forest areas in India and the wood is most valuable for the manufacture of wooden products.

Approximately 420,000 T.P.A. of coniferous woods are considered to be potentially available in India. The royalties and extraction costs are high and it is estimated that the cost delivered to mill can be R.600 ($75) per cubic metre. Allowing for moisture and yield the wood cost alone per tonne of pulp would be R.3,000 ($375). At these rates it would be cheaper to import finished pulp. There are also problems of infrastructure, roads, etc., and distance. However, a fact of saw-milling, particularly where the forest source is a natural one, is that nearly two-thirds of a log ends as waste wood when producing timber and at least half of the waste can be used for the production of pulp. The remainder can be used as fuel for pulp and paper mill processes or power generation. Even in timber-rich countries the practice of combining timber and pulp production is becoming the norm.

In British Columbia, perhaps the world's finest source of softwood, it is now mandatory to use saw-mill wood waste for pulp; the use of whole logs is forbidden. It is also becoming mandatory to use bark, sawdust and forest trimmings as fuel. The softwood Himalayan forests could follow this practice and set up pulp mills for much required long-fibre, indigenous pulp at competitive ex-mill cost but the distance to the points of utilisation are great and overland, across difficult terrain which could be prohibitive in ultimate cost. It is possible to make use of the waste arising from timber conversion into wood products manufactured from bulk timber in urban areas and this would suit small pulp and paper mills but these are long-term future considerations, worthy of study, but unlikely to have any significant impact on the Indian pulp and paper industry for many years.

4.1.2.2. Hardwood, short-fibre

The fibre length varies according to species from o.5mm to (rarely) 2.00 mm and averages 1.00mm, so hardwoods lack strength. However, for printing and writing papers, proportions around 60% are now being used because strength is not the vital characteristic and the short fibres improve opacity and printing quality. Hardwoods amount to 94% of Indian forests, in mixed tropical grades. The forests are controlled by the State Governments but precise estimates of areas, species and yields are not available. The hardwoods are also used for timber and the comments in 4.1.2.1. are applicable, saw-milling and pulp can, and should be combined. A number of the large mills are now using up to 30% of hardwood but the opportunities for small mills, which are best suited to a local market, are less because the forests are located in land-locked areas with poorly developed transport facilities. Broad-leafed Salai wood is available in some states, especially Madhya Pradesh, and it is used to make groundwood for India's only newsprint mill at Nepanagar. The cost of hardwood delivered to mill varies according to location by R.250/350 ($31/44) per tonne is considered a reasonable estimate. At this price the wood cost/tonne of pulp produced would be between R.1,300 to 1,800 ($163 to 225) which is more reasonable though still high by world standards. Under State control, tropical hardwoods, after felling and land clearance, are being reafforestated with quick-growing hardwoods, suitable for timber or pulp. This is good policy but again, unlikely to have a great impact on the paper industry for many years.

4.1.2.3. Bamboo

The fibre length ranges from 1.0mm to 5mm and averages 2.8mm so it has strength properties midway between hardwoods and softwoods and is a good papermaking fibre which can be used 100% as fibre or with 30% of hardwood for cultural papers. It has a relatively short growing cycle and is therefore a renewable material. It grows over an area of 100,000 sq.Km. in India generally with a potential annual crop of 4,300,000 tonnes. The average yield as pulp is

38% on a Bone Dry basis, which represents a potential of around 800,000 tonnes/annum as pulp. Almost 65% of all the paper produced in India is currently bamboo-based. The average cost as delivered to mill is between R.350/400 ($44/50) per tonne which means that the fibre cost/tonne of pulp is around R.1,900 to 2,000 ($190 to $250). It has a low yield/hectare and availability is restricted. It is also subject to flowering, after which the area concerned loses its yield. It is now recognised that the resources of bamboo in India are almost completely utilised and little more can be expected for additional paper manufacture. There is also considerable competition for its use in other directions. It has given and will continue to give a great contribution to the paper industry in India but cannot be expected to supply the additional fibre required for the planned increases.

4.1.2.4. Bagasse

Bagasse has a fibre length range of 2.8mm to 0.8mm averaging 1.7mm but the fibre diameter is greater than for other agricultural fibres. The length puts it between bamboo and hardwood for strength but the length/dia. ration is 85, compared with 190 for bamboo so it is stiffer and stronger than the fibre length alone would suggest. It makes excellent quality paper over quite a versatile range and it is now the most common raw material in the world, next to wood for pulp and paper, particularly writing and printings, tissues and corrugating medium. Over the past 12 years many advanced mills based on bagasse have been built in various countries around the world and the technology has improved to the point where it is genuinely competitive in quality with wood-based products and, in some respects, superior. Technology continues to improve and papers with 75% to 100% bagasse content are practical. One of the reasons for improved technology is that developed country manufacturers of paper or pulp machinery see it as a material suitable for scale and able to conform with their technology. Mills up to 150 T.P.D. are common, almost standard for the pulp mill, and mills of capacity up to 300 T.P.D. (multiples of the 150 T.P.D. unit) have been planned for writings and printings. Recently attention has been given to its potential for newsprint, adopting higher yield chemi-mechanical pulping processes, and a satisfactory product has been obtained. A newsprint mill of large capacity, equal to that of modern wood-based mills, has been planned and is expected to materialise.

Bagasse is the residual fibre from sugar cane after it has been crushed to extract the sugar juices. Between 27% and 29% of the cane is available as bagasse and traditionally it has been burned to provide fuel for the sugar process, using boilers designed for the purpose. In calorific terms 6 tonnes of bagasse as produced are equal to one tonne of oil fuel. The ratio for coal averages 3.5:1. It is burned wastefully, with little regard to efficiency because the rate of production may not coincide with the rate required for process steam and there is always a surplus, especially from non-refining sugar mills where bagasse is burned for disposal as much as for fuel. Ironically, at today's prices, the end value of bagasse as paper is three times the value of the cane as sugar. Bagasse has to be depithed before making pulp and developments in depithing have contributed most to its recent advance. About 30% pith is removed and it can be burned with the same fuel value as raw bagasse but the boilers usually need modification. It has 45% yield as bleached pulp from the depithed bagasse, so 100 tonnes of sugar cane can produce 10 tonnes of sugar, 9 tonnes of bleached pulp and 9 tonnes of pith for burning. The pulp will produce, with the normal fillers, about 12 tonnes of good quality writing and printing paper worth more than 3 times the sugar produced. Provided that the scale of the pulp mill is equated to the output of the sugar mill, no handling is required or transport, other than conveying, and bagasse is the cheapest raw material in the world. If it has to be transported any distance it loses some of this advantage and there is great merit in limiting the size of the paper mill to that of the sugar mill bagasse supply. There would be even greater merit in unifying sugar mill and paper mill management because both parties would benefit. The greater problem with bagasse pulping is that of providing fuel replacement. It is no problem at all in oil or coal-rich countries except in boiler conversion, a relatively minor cost. Where substitute fuels do not exist or are difficult to provide there is still scope for utilising surplus bagasse for small mills.

India produces nearly 10,000,000 tonnes of bagasse/annum and it should be the most suitable and economic raw material to meet future needs. However the sugar mills are normally remote from the coal fields, and rail transport is unreliable so sugar mill owners are reluctant to change. Recognising this, the Government of India is now offering incentives, as follows, for bagasse-based mills:-

1. Complete exemption from excise duty for 3 years from commencement of production.

2. Favourable financial gearing i.e. equity: loans ratio and priority for loans provided the bagasse content in writing and printing papers is at least 75%.

3. Priority from the Indian railways to transport coal as the substitute fuel.

The cooking process for quality pulp can be soda or kraft dependent on the availability of chemicals. Requirements are high, around 30% on pulp produced but recovery is practical at 75% or more. It is easily bleachable; a 3-stage process produces results almost equivalent to 5-stage for wood.

Other processes are now being developed which should considerably enhance the utilisation of bagasse. Without doubt it is the best material in terms of cost, availability, quality of product and versatility to meet India's future needs, (including newsprint) and worthy of deeper consideration at all levels, especially from the Governmental department concerned.

4.1.2.5. <u>Sabai Grass</u>

Sabai Grass is collected from sub-Himalayan tracts and has been used for paper-making since the early 1930's. The average fibre length is 2.08m/m so it has reasonable strength and can be used up to 100% as furnish for quality papers. It is also used in smaller proportion to add strength to straw-based papers. Cooking chemical requirements are less than for wood, bamboo or bagasse but collection and transport costs are high and its use is declining. The average delivered cost is around R.500 ($63) per tonne but the yield is small, up to 35%, and this brings the fibre cost/tonne of pulp to around R.1,700 ($210) which is expensive and this makes its use selective. Grasses as a whole, principally Sabai, are used for paper-making in India to the extent of approximately 600,000 T.P.A. and cannot be considered as a substantial fibre source but can assist small mills in favourable areas, to produce saleable grades.

4.1.2.6. <u>Wheat and Rice Straw</u>

Wheat straw has a fibre length range of 3.1m/m to 0.7m/m averaging 1.5m/m with length/diameter ratio of 110. Rice straw has a range of 3.5m/m to 0.6m/m, also averaging 1.5m/m but the length/diameter ratio is 170. In use, there is little difference and they may be considered interchangeable. India has been making good progress in the formidable task of becoming self-sufficient in feeding its immense 670,000,000 population and it is estimated that the current annual grain production and the consequent straw availability are as follows:-

	Grain (T.P.A.)	Straw (T.P.A.)
Rice	44,000,000	77,000,000
Wheat	28,000,000	51,000,000
	Total:	128,000,000

Not all of this great quantity is available as waste for pulp. 75% is used for cattle-feed and other non-industrial purposes. Of the remaining 32,000,000 T.P.A. a large quantity is used by the population for numerous domestic purposes but it is conservatively estimated that at least 6,400,000 T.P.A. is freely available for the production of paper. Assuming 33% yield, around 2,000,000 tonnes of pulp could be produced, sufficient to supply at least 200 small mills, by Indian definition, enough to meet the first 5-year plan targets. Straw pulp is weak and must be reinforced by a proportion of stronger pulp to make paper. It is also "slow" i.e. it drains slowly on washers or the paper machine but it can make good writing or printing papers and good corrugating medium. Without doubt it will be a major raw material source for the large numers of small mills emerging, and to the country's requirements. Other straws, maize and linseed, are also available but to a lesser degree and not so widespread. Their properties are similar to the grain straws. The price of straw delivered to mill averages R.200 ($25) per tonne. At 30% overall yield, the fibre cost/tonne of pulp is R.670 ($84) which is relatively inexpensive. Higher yields can be obtained by modifying the process.

4.1.2.7. Other Agricultural Fibres

In the search for long-fibre substitutes a number of sources are used but the quantities available are limited or the technique laborious. However, in favourable areas they are an aid to the industry. The following are the most significant:-

Cotton Pure Cotton has fibre length 10mm to 40mm, averaging 20mm and is almost all cellulose. It is therefore very strong and easily bleached by a simple, single-stage process. It is too expensive to use new but cotton waste from mills is in great demand for the hand-made papers and as long fibre support for others. It costs from R.3,000 to

R.5,000 ($375 - 625) per tonne according to quality; this price is too great for all but speciality papers and the small long-fibre use.

Cotton Linters are available in 2 grades, first cut and second cut. First cut has an average fibre length of 6m/m which makes it very valuable and it is used to make high value pulp for special papers, such as filter paper, or as long fibre strengthening blended with weaker fibres. Second cut linters are much poorer in quality, dusty, with fibre length averaging 2.0m/m. It is, however, used to the extent available for blending with other fibres.

Jute Waste Old gunny sacks are used, where available, for packaging papers. The fibre length is between 5m/m and 1.0m/m averaging 2.5m/m so it has strength but the natural dark colour makes it too expensive to bleach for cultural papers.

Hemp Waste Hemp Waste from old rope, or similar refuse, netting, etc., is used. The fibre range is 2.0m/m to 6m/m averaging 4m/m so it has very good strength qualities and is used for specialties such as cigarette paper or, again, for reinforcing weaker fibres.

Kenaf The fibre length is 2.6m/m on average so it can be used 100% for quality papers and at least one mill has a good business entirely kenaf based. The preparation is laborious and the cost high in consequence.

4.1.2.8. Waste Paper

Reliable statistics are difficult to obtain but it can be stated with assurance that very little paper is wasted in India. Much has a secondary wrapping use which often renders it useless or of limited value for repulping. However, it is estimated that 25% of all paper consumed in India is now recycled. There is no organised market or grading and none is needed at present because all available waste has a market and the purchaser himself estimates what the raw material is worth, varying from R.2,800 ($350) per tonne for printers' white cuttings to R.400 ($50) per tonne for road sweepings. It is customary to hand-sort mixed waste, piece by piece, to optimise the value. Waste is used, according to grade and quality, for printings and writings, board and wrappings, 100% as furnish in some mills or, in smaller proportion, as a blend in others. As paper consumption and production grows, recycling of waste paper will follow and if imports are allowed, production in port areas such as Bombay or Calcutta could grow very fast indeed and cover many grades of paper because the high freight cost will be less in proportion to good selected waste grades, virtually pure pulp substitutes, and used as such.

4.1.2.9. Summary

Hardwoods are rarely available to the small mill. Bagasse and straw are the natural fibres which will contribute most to the small mill industry in rural areas. Waste paper will play an increasingly large role in urban areas, particularly when the restrictions on import are lifted, as promised. Agricultural residues are already being utilised to a significant extent and would doubtless be used even more extensively but for certain disadvantages which hitherto have seriously concerned potential investors. These are:-

(a) Pollution Hazards

Although many small mills are operating with little, if any, effluent treatment, it is inevitable that the high Government standards nominally existing will eventually be enforced. The cost could be prohibitive, as has been the case in developed countries following the imposition of high standards which have closed many small mills, unable to meet the heavy extra capital and operating costs, which produce no financial return.

(b) Chemical Recovery

Chemical recovery greatly reduces the effluent burden and gives a substantial financial return but it is more difficult for agricultural fibres because of their relatively high silica content which dissolves in the cooking process, precipitates on evaporator tubes, and is almost impossible to remove. This applies particularly to straws where the silica content is very high; recovery is difficult and often omitted on this account. It is less of a problem with bagasse because the silica content is much smaller, but it still exists and reduces lime recovery to a low level, creating problems for disposal of lime mud. Bagasse chemical recovery is now established and economic above a given scale, about 50 T.P.D., because heat can be recovered as steam to supply the evaporators. Recovery down to 25/30 T.P.D. is practical for bagasse and straw by the "roasting" process but it requires steam for evaporation and recovery is often spoiled by the presence of soot or carbon in the smelt, very difficult to eliminate and undesirable in the pulp. New and promising processes for pulping and recovery are being developed to eliminate the need for recovery or to make small-scale recovery of agricultural residues simple, self supporting and economic. When these processes pass the development stage, which is imminently expected, agricultural residues can be expected to become very practical and economic sources for small mill operations. They represent a renewable source of fibre, with a yield per unit area of twice that of reafforested wood. The pulp from the new process is also claimed to be superior in quality to that from conventional processes. Twenty years ago, hardwood as fibre for paper was almost unknown. The insistence of governments on clear forest felling, to preserve the forests and facilitate reafforestation, forced pulp companies to find a use for the hitherto despised hardwoods. The pulp was sold at a substantial discount to encourage purchasers. Today, hardwood pulp is an accepted material, with recognised, desirable qualities and the discount is negligible. The same will almost certainly happen with agricultural residues. Neccessity is the mother of invention and many minds are now concentrating on new processes and techniques. Success will certainly be achieved, making small scale pulping attractive in terms of quality, environmental acceptability, low capital investment, and rapid viability.

4.2. CHEMICALS OR ADDITIVES

4.2.1. Cooking Chemicals

4.2.1.1. Caustic Soda

The most common cooking chemical is caustic soda, available as solid, flake, or liquid at 50% concentration (which is most common and least expensive). Liquid caustic is delivered by road tanker and stored at site in a steel tank. Solid caustic is supplied in 1-ton drums and must be dissolved in a tank before being used. India is self-sufficient in caustic soda. Around 35 factories, spread over the country, existing to produce it and over 500,000 tonnes was consumed in 1977. Current prices are in the region of R.3,000 ($375) per tonne delivered. This is expensive by world standards, and prices are rising as demand increases.

4.2.1.2. Lime

Some small mills also use lime as a cooking medium and as a component of calcium hypochlorite for bleaching. It is normally produced at site by open kiln or purchased. The cost averages R.370 ($44) per tonne but the quality is not always good, averaging 65% to 75% as CaO.

4.2.2. Bleaching Chemicals

4.2.2.1. Calcium Hypochlorite

Small mills, up to 10 T.P.D. normally purchase bleaching powder, calcium hypochlorite, in dry form, for single-stage bleaching. Larger mills make calcium hypochlorite at site by adding chlorine to milk of lime.

4.2.2.2. Chlorine

Where higher standards of bleaching are required the traditional 3-stage system is used. The first stage is to add chlorine in gaseous form to the pulp in a bleach tower. From 5% to 7% chlorine by weight of pulp is average. The second stage, after washing, is caustic extraction, adding around 2% of caustic. The final stage is calcium hypochlorite. Chlorine costs around R.1,000 ($125) per tonne delivered and is supplied in 1-tonne cylinders which must be returned promptly.

4.2.3. Rosin

Rosin is used for "sizing" paper to improve writing and printing properties. Raw rosin is available in India and small mills normally produce their own size by cooking it with soda ash or dilute caustic soda. Rosin prices fluctuate wildly with demand and the currently quoted price is R.12,000 ($1,500) per tonne delivered. From 1.5% to 3.0% may be used in the paper furnish, according to quality of paper being made.

4.2.4. Alum

Papermakers' alum is used for pH correction in the paper stock, to assist the sizing process and also to help the wet paper release itself from the press rolls. It may also be used for primary water treatment, to promote coagulation in clarification. It is normally delivered in slab form and dissolved at site for use in liquid form. Around 5% to 6% of alum per tonne of paper is the average consumption. The current cost is R.750 ($94) per tonne.

4.2.5. Fillers

Clay or talcum powder is used for cultural papers to improve brightness and opacity. Both materials are available in good quality from Indian sources. The clay is found in the southern part of India and the best talcum is mined in the central regions. Proximity to source governs selection to a large degree and talcum is more generally used; it is also cheaper at first cost. The price of talcum delivered varies from R.250 ($31) to R.400 ($50)/tonne. The price of clay averages R.600 ($75) per tonne delivered. Up to 10% retained filler is used but about 15% has to be added to obtain this retention because losses occur by drainage from the wire and final effluent, except where very close systems exist, which, at present, is seldom the case for small mills. For very special paper grades titanium oxide may be used because of its high brightness and opacity, but the high cost, R.20,000 ($2,500) per tonne limits the quantity to a very small percentage used only for high quality papers.

4.2.6. Other Chemicals

The above are the main chemicals in use but others are used for special circumstances. Dyes for colouring, starch or Gowar gum for strength improvement, Hydrochloric acid for cleaning are examples.

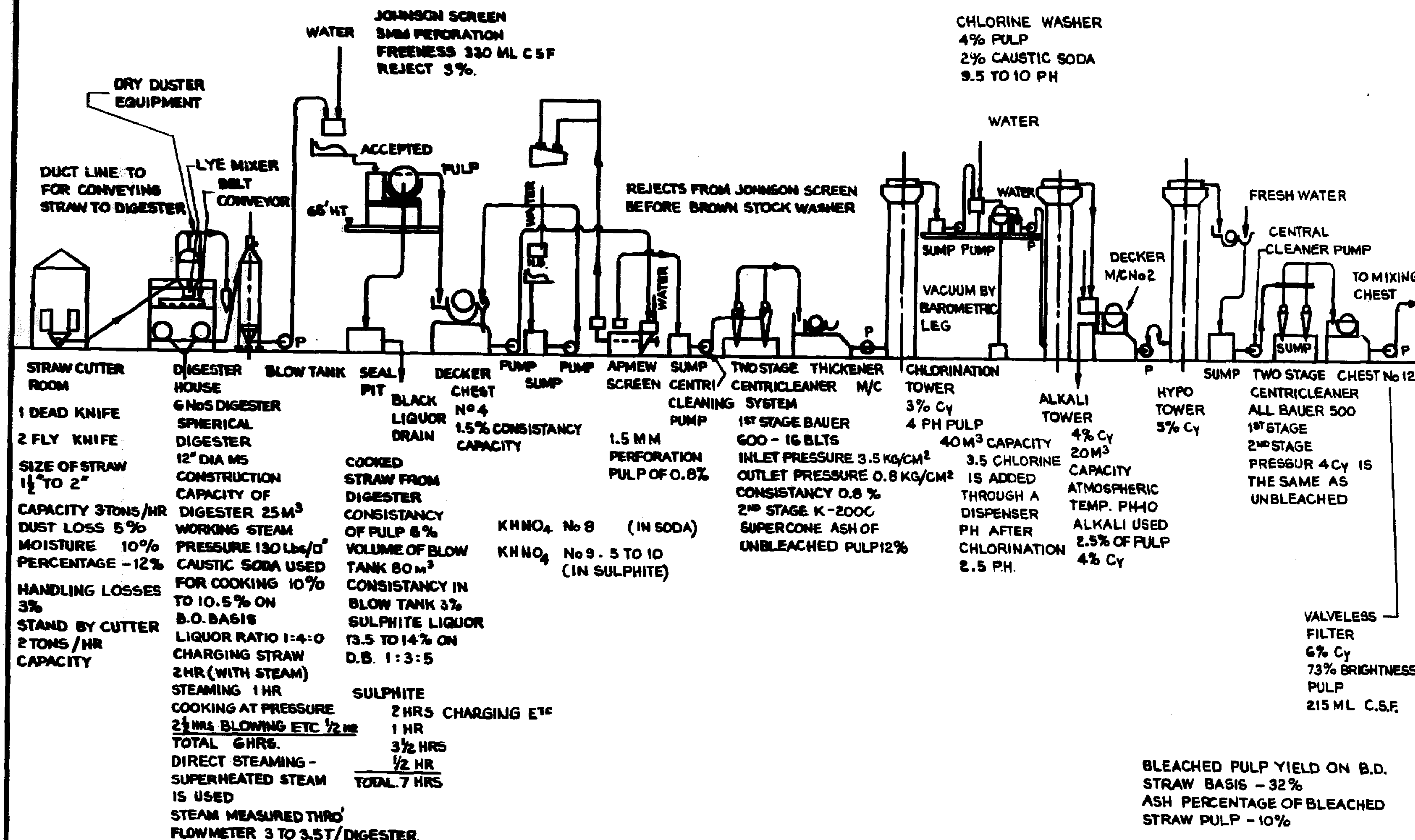


Fig 3 FLOW SHEET FOR STRAW PULP

CHAPTER 5

PROCESSES ADOPTED IN SMALL MILLS

5.1. PULPING

5.1.1. Straw Pulp (Writings and Printings, bleached grade)

The straw is first chopped into small pieces, 35mm to 50mm long, by a mechanical chopper. Dusting is included with chopping or should follow it. The chopped and dusted straw is then taken by conveyer to the digester section for cooking. The digesters are normally of rotary spherical type, 12.5 ft. in diameter, with a capacity of 25 cubic metres and the numers of digesters employed varies according to the output required. Caustic liquor in the ratio 4:1, liquor : straw is added with the caustic concentration such as to represent 8% to 12% on bone-dry straw. Occasionally cylindrical rotating digesters are used but the spherical type is more common, practically standard, in India. The steam pressure is between 6 to 8 atmospheres and the cycle as follows:-

Charging, straw and liquor		2 hours
Steaming (1 hr) and pressure cooking		3½ hours
Discharging		½ hour
	Total Cycle	6 hours

The cooked pulp discharges to a blow tank where the pressure is released and it is then diluted and screened, usually over a vibrating, Johnson type screen with perforations around 3mm dia. Rejects amount to about 3%. The stock is then washed and at this stage is known as brown stock. The washer is normally a single, vacuum, drum type unit and the wash liquor is sent to drain or, if a recovery plant is included, to evaporators. The washed pulp is then diluted and screened again through a rotary outward-flow or Cowan type screen, and cleaned through centrifugal cleaners before passing over a decker, or thickener, to storage at 3% to 5% in the chlorination tower.

Bleaching is the standard, 3 stage C.E.H. system (chlorine-caustic extraction and calcium hypochlorite). Chlorine around 3.5% of pulp is added in gaseous form upwards through the chlorination tower. A vacuum washer follows and the pulp then passes at 4% - 5% consistency to the extraction tower where caustic soda to the extent of 2% of pulp is added. The pulp is diluted and washed again in a vacuum washer before passing to the hypochlorite tower where 3-5% by weight of chlorine is added as calcium hypochlorite.

The pulp is now bleached and has brightness around 73°GE. It is then diluted and cleaned again through 2 or 3 stage centricleaners before passing over a thickener to storage for paper-mill use. The inherent ash, chiefly silica, can be as high as 10% and the freeness around 215 Canadian. Overall yield is 30% to 35%. Corresponding characteristics from bagasse would be, from the same process brightness, 80 - 85° GE, freeness, 450 to 500 Canadian, ash 1.0 - 1.7% and yield 40% - 45%, indicating its superiority as a raw material. The cooking time would be shorter but cooking chemical greater. The latter is not important if recovery is included. Bagasse, when available only in small quantity is sometimes added to the straw to improve the pulp quality.

The foregoing is illustrated in Figure 3 diagramatically. There can be variations according to scale and quality. The blow tank is sometimes omitted and pulp emptied on to a drainage floor or directly to washer troughs. Vacuum washers may be replaced by simple breaker type drum washers. Single stage hypo-bleaching may be used where standards are lower, and only one stage of centricleaners. The flowsheet and description above, however, are typical of what would be installed for straw pulp manufacture in the new mills under construction. The variations mentioned above are representative more of the older operating mills of lower capacity, below 15 T.P.D.

5.1.2. Bagasse Pulp (Writings and Printings)

Up to 30 T.P.D., the bagasse pulping system is virtually the same as described above for straw, except that de-pithing replaces the chopping and dusting preparation because pith in the sugar cane is undersirable. It does not contribute to the paper-making fibre but absorbs chemicals and reduces the pulp freeness so that the paper-making process is slower and drying more difficult. Bagasse requires more caustic for cooking, up to 27% on pulp produced but, the cooking time is shorter.

Above 30 T.P.D. bagasse pulping (and straw) is usually continuous because one continuous, screw-type digester is less expensive in capital cost and space requirements than a miltiplicity of spherical digesters; it still further reduces cooking time, down to 12-15 minutes, and ensures more uniform pulp quality. The elementary system outlined above normally becomes more sophisticated, with increasing scale for operating cost reduction or qualitative reasons. Three stage, counterflow brown stock washing gives cleaner pulp, washes out more chemical for recovery and concentrates the extracted black liquor, reducing the evaporator burden for recovery. Heat exchangers are incorporated to provide hot washing water, more effective than cold water.

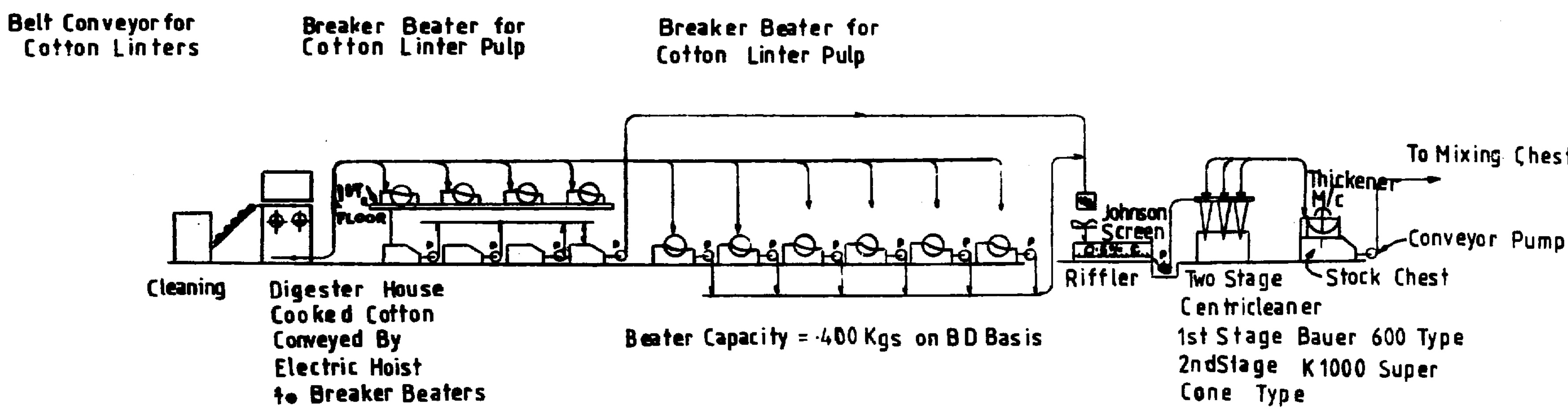
5.1.3. Rag or Cotton Waste Pulp

The scale is usually smaller than for straw or bagasse because rag pulp is normally used as a long-fibre blend to impart strength and quality, seldom exceeding 20% of the total furnish, or, in higher proportion for hand made papers where total output is very small.

The cotton waste or rags are first cut to small pieces, using a rag-chopper, are dusted and then charged into a single spherical digester. It is customary today to sort mixed rags to eliminate synthetic material which will not pulp and this necessary function is presenting an ever-increasing problem. The chopped and dusted rags are cooked for around 3 hours in the digester with 4% of caustic soda using steam at 4 to 6 atmospheres pressure. The resultant pulp is then dumpted into a drainage chest where the cooking liquor drains off naturally and a preliminary hot water wash is given. The pulp is then removed by hand to a series of wooden draining compartments and left to stand for about 12 hours to allow the fibres to swell and mature. (Sometimes this part of the process is omitted but results are better with it.) The pulp is then charged into breaker washers. After breaking and washing, calcium hypochlorite is added, from 1% upwards according to rag quality, as a bleach to obtain desired brightness. It then receives a final wash and is ready for the paper mill. The overall yield of pulp is around 80% from purchased rags, higher if selected cuttings are used. A typical flow-diagram is shown in Figure 4.

5.1.4. General Comments on Batch Digester Pulping

Hemp waste or old gunny sacks are cooked and treated in the same manner as rags, but gunny material is not economically bleachable and is used only for brown, wrapping grades. Caustic is less, about 5% for gunny and yields around 60%. For non-bleaching grades, hemp is treated similarly but for speciality papers with a majority of hemp furnish, such as cigarette papers, longer cooking with more chemical is adopted. Wood waste can also be cooked by spherical digesters and some mills adjacent to woodworking factories use soft-wood waste for the long fibre components. 22% caustic is used for this material as an average. Cooks may be "hard" or "soft", depending on the end use of the pulp. A "soft" cook uses more cooking chemical and can take longer, to remove more of the non-cellulose elements and improve bleaching. Each mill will arrive by experience at the degree of cooking and bleaching required for its particular products. The degree of cooking can be quantified by tests and is rated by the permanganate number which by definition is the number of millilitres of 0.1 N potassium solution absorbed by 1 grm of moisture-free pulp under specified test conditions.



FLOW SHEET FOR COTTON PULP

FIG 4

5.1.5. Other Processes Used in Small Mills

5.1.5.1. Neutral Sulphite Semi-Chemical

This process uses sodium sulphite ($Na_2 SO_3$) and sodium carbonate ($Na_2 CO_3$) as the cooking chemicals but the same digester and washing plant are utilised. The cook is harder, the yield higher, bleaching more difficult and chemical-consuming so its use is confined mainly to pulp for packaging papers, particularly corrugating medium. Chemical recovery is not practical.

5.1.5.2. Chemi-Mechanical (Mechano-Chemical) Process

This process has the merits of lower capital costs, higher yields and lower chemical consumption, at the expense of some quality but for many of the smaller mills around 10-15 T.P.D. the economies outweigh the quality considerations. For wrapping grades of paper the quality is not impaired to any significant degree, and may in fact be improved.

The chopped fibre is fed with water into open vessels, normally the Indian version of the Hydrapulper, and steam is injected to raise the temperature to 100°C, atmospheric boiling point. The pulp consistency is about 10% and the cooking time 30-60 minutes. From 5% to 10% of caustic is added. Bleaching can follow, single stage or 3-stage, as required and the overall yield is around 45% to 50%. The fibre is less well cooked and harder, but washes better on this account. More mechanical treatment subsequenly is required than for fully-cooked pulps of similar materials, hence the name, but this is not serious for the small mill. Chemical recovery is not normally incorporated because the relatively small quantity of chemical used would not justify the plant required and the effluent burden can be tolerated. The system is shown diagramatically in Figure 4A. In recent times more attention is being paid to this process by the larger mills because of the yield and other attractions. It can be adapted using batch or continuous digesters,and hot-stock refiners,of large capacity, fulfil the mechanical requirements.

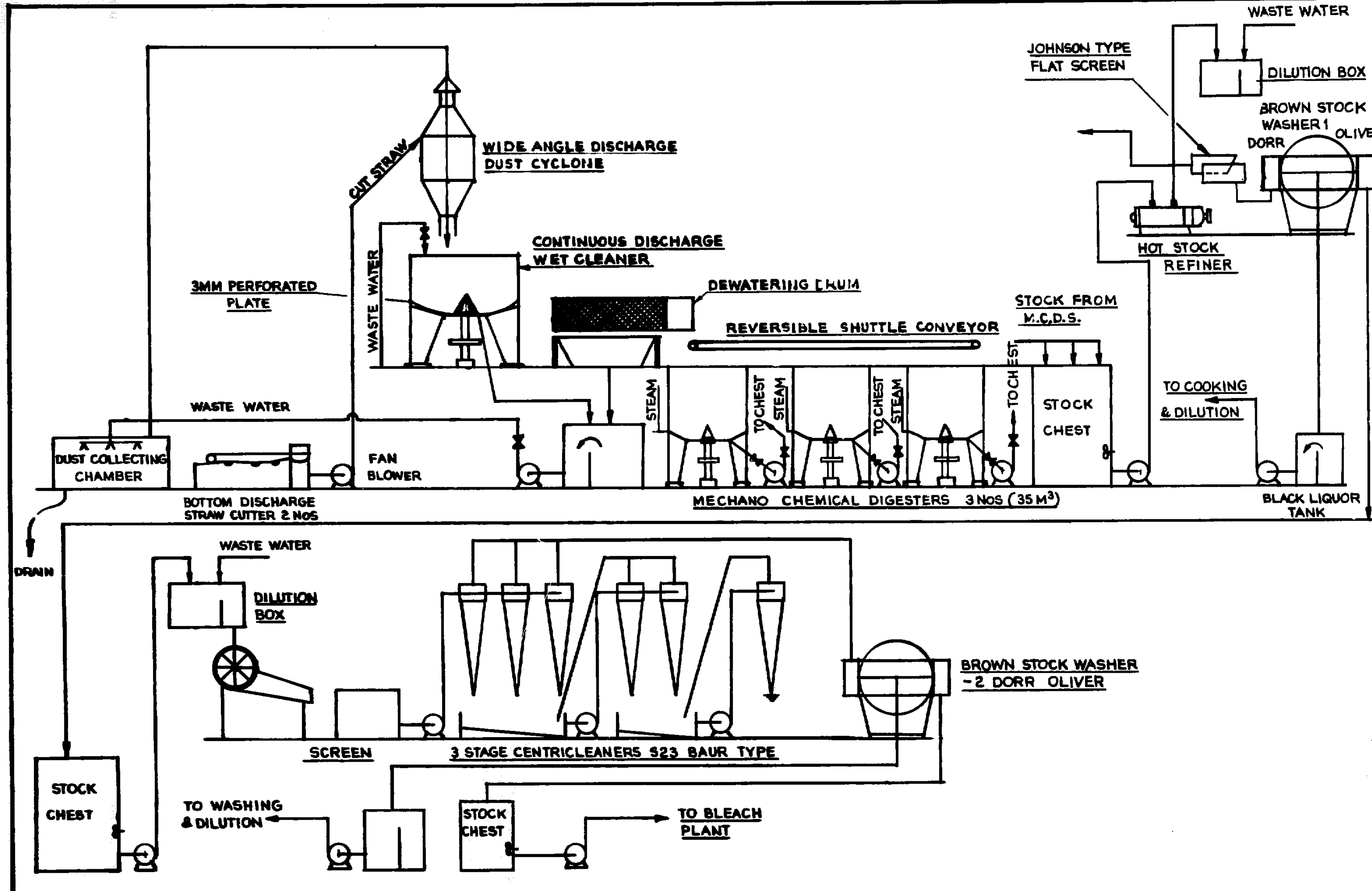


FIG 4a. Process Flow Sheet No 1 Cooking Washing & Screening

5.1.6. Waste Paper

The fundamental process is defibering and cleaning because of the "contraries" which are present in degree according to quality, for the lowest grades up to 20% but averaging for most unsorted grades 10% to 13%. The Indian type of Hydrapulper is invariably used but it is very simple and seldom has the ragger rope (to remove strings, wires, wet-strength papers or plastic) or the junk-remover now universal in developed countries for waste paper treatment. Occasionally junk traps are fitted but it is normal to adopt a batch process and physically remove the contraries at intervals. High density centrifugal cleaners, pressurised screens and vibrating screens are also used, followed in some instances by low-density cleaners up to 3-stage, but the systems are not good in arrangement or sequence and are seldom operated satisfactorily because of the absence of control and some of the modern, but not expensive, equipment now being used in Western developed countries. Waste paper utilisation will increase in India with availability and the owners of small waste-based mills would benefit considerably by studying operations overseas.

5.1.7. Raw Material Storage

For seasonal agricultural residues, storage presents problems of space, fire hazard, decomposition or rotting, and handling. The crop may be gathered over a relatively short time, around 2 months for straws, 5 months or longer for bagasse but has to be used daily over the whole year. For straw the great danger is wetness which is said to induce spontaneous combustion and certainly does lead to decomposition. It is accordingly stored in thatched piles, well separated to minimise fire damage, this requires considerable ground space. Bagasse, after depithing can be stored in large open piles up to 20 metres high and provided that the top is kept wet during the dry season will not burn and suffers no serious decomposition. Alternatively it can be stored wet by pumping it to the storage areas and allowing surplus water to drain away. The top must still be kept wet in the dry season to avoid fire risk and in the author's opinion the capital and maintenance costs of wet storage are not justified but this is a contentious subject.

Some wet storage systems add chemicals or use pulp-mill effluents and yield or quality advantages are claimed. The recent surge in bagasse-based mills of relatively large scale has inspired designers and consultants to develop proprietary systems and the storage aspects are a progressing field. Apart from the physical aspects of storage, the problem of producing uniform pulp from a pile whose contents change in character with storage time has been studied and pile management is becoming an operational science.

Bagasse and straw can be baled for storage and this was originally the standard but the fire risk is greater and the capital costs higher. The operating costs are also greater and the space requirements. For these reasons bagasse baling for storage is now obsolescent and even when adopted for transport the bales are likely to be broken up and stored in bulk. Straw bales can be stacked and thatched for protection against the weather but packed and thatched ricks are most common.

5.1.8. Chemical Recovery

One advantage of the soda process is that chemical recovery can be incorporated. The efficency of recovery varies from 60% to 85% dependent on scale and capital cost. As currently practiced, the process is fundamentally simple. Weak black liquor from the brown stock washer is first evaporated, from as low as 6% concentration to as high as 60% concentration. The liquor contains the inorganic chemical compounds resulting from the cooking process and the organic lignins, etc., removed from the raw material. The latter are combustible and the evaporation stage is designed to reduce the water content to the point where the viscous strong black liquor will sustain combustion, leaving the organic chemical contents as smelt which is dissolved in water and becomes "green liquor". Lime is added and "causticising" takes place where the dissolved smelt, which is basically soda-ash ($Na_2 Co_3$) reverts to caustic soda for re-use. The lime becomes chalk, calcium carbonate and can be recovered also by reburning.

The plant can be simple, 3-stage evaporation and a rotary, or stantionary burning oven plus tanks, or highly complex with 5-stage evaporation, a very sophisticated 40-atmosphere pressure water-tube boiler for combustion, a substantial lime-kiln and slaker for lime recovery, and electrostatic precipitators for recovery from flue gases. Scale undoubtedly benefits recovery; above 100 T.P.D. as pulp the steam produces from the recovery boiler is sufficient for the evaporation and causticising requirements; at 500 T.P.D. or above it can satisfy the whole pulp mill demand for process steam; below 50 T.P.D. heat recovery is uneconomic and recovery has a fuel cost. The presence of silica is a handicap; it affects the evaporator tubes and makes lime recovery impossible for straw, with very high silica, and fractional, up to 60% for bagasse. Other factors are signigicant; the viscosity of the strong black liquor, for example, limits the evaporation levels for bagasse. It can be said that whilst recovery from the soda process has been known from very early days, the major developments have all followed the wood based kraft-pulping process and have contributed greatly to its viability, at the same time minimising pollution. For the small-scale mill, chemical recovery is still economic above 20 T.P.D. and essential to avoid pollution, but requires considerable capital outlay. Closer attention is now being paid to alternative processes more appropriate to the small mill and the results already indicate several promising lines. These are being pursued and can be expected to be operationally available within a few years, given sufficient encouragement. The problems are not insoluble but, for obvious reasons, the expense of research and development cannot easily be borne by the small-scale industry. It is a matter for government support, particularly in India where the potential rewards are so great.

In India, recovery falls into one of two categories, of which the most popular is the rotary "roaster" type illustrated in Figure 6. The flow diagrams for evaporators, roaster and recausticising are shown on Figures 5, 6, and 7 respectively.

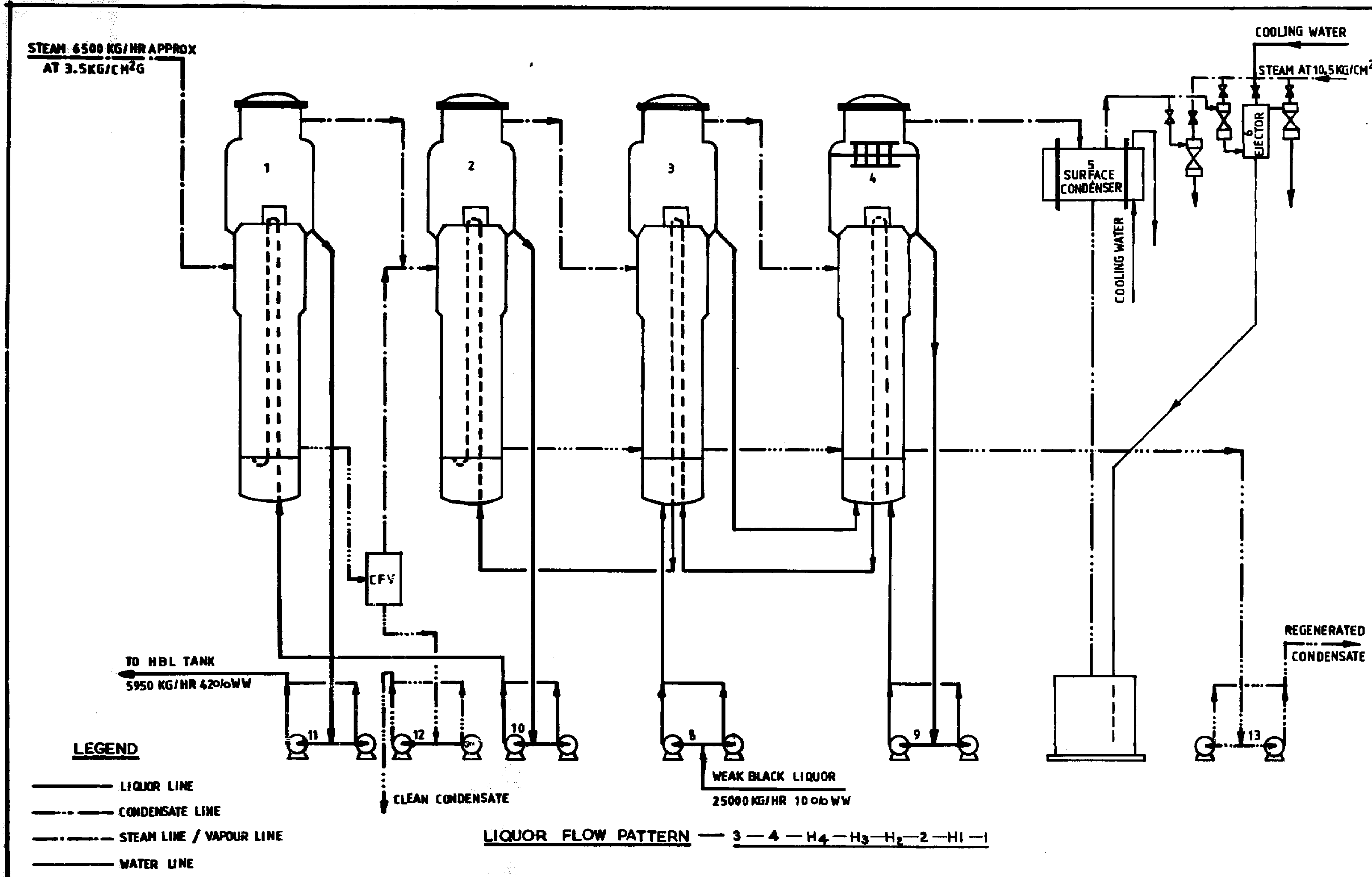
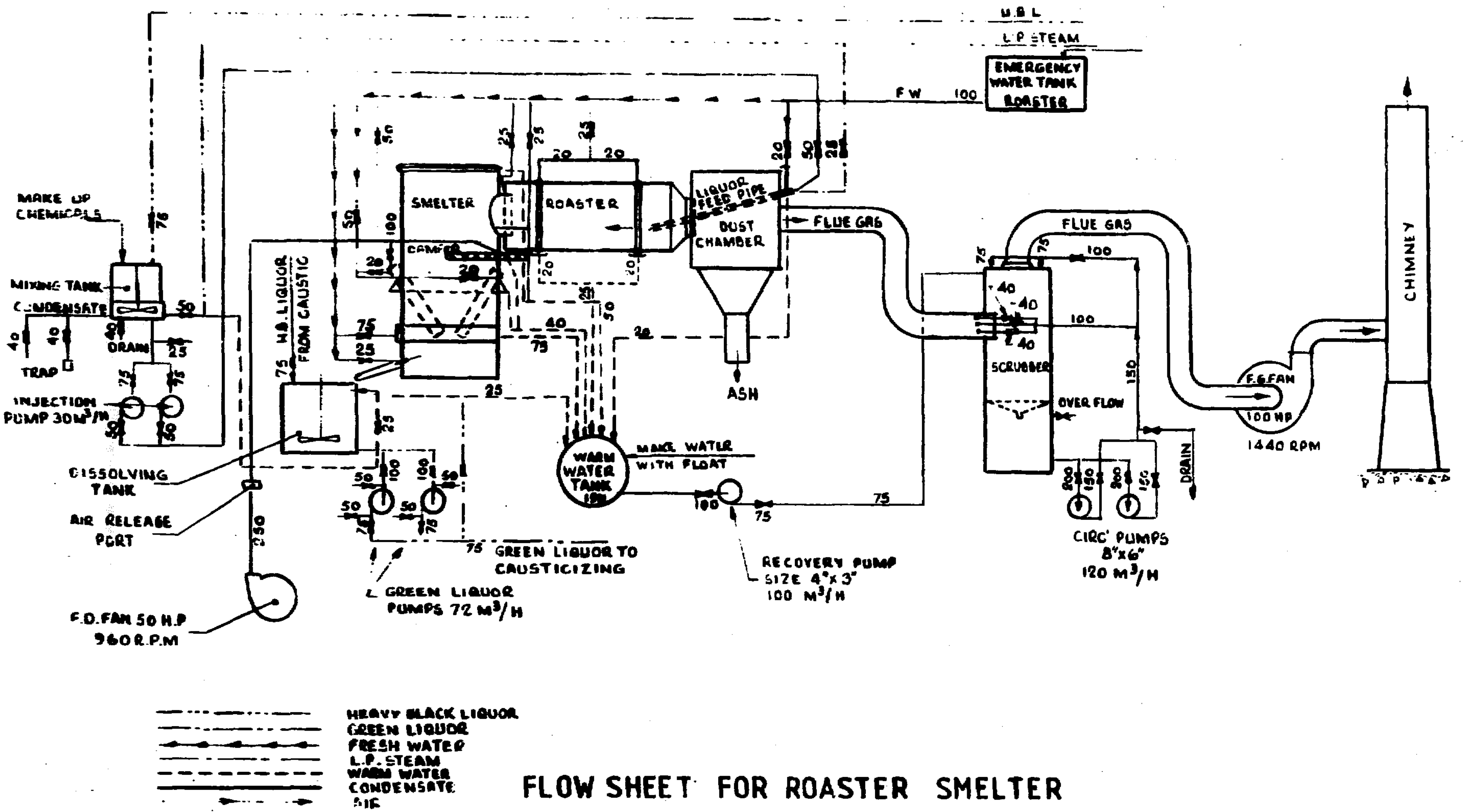
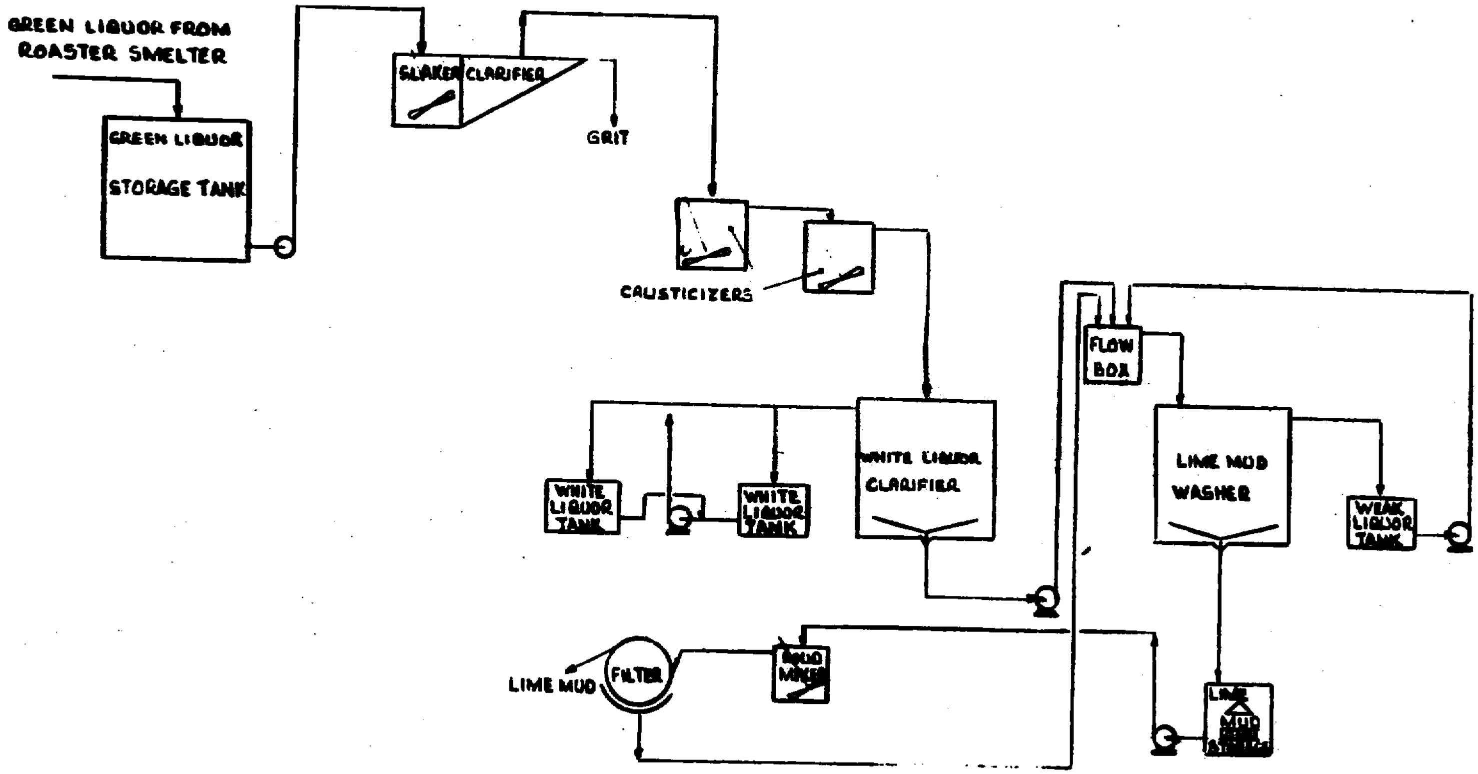


FIG 5 FLOW SHEET QUADRUPLE EFFECT L.T.V. EVAPORATOR



FLOW SHEET FOR ROASTER SMELTER

FIG 6



FLOW SHEET CAUSTICIZING PLANT
FIG 7

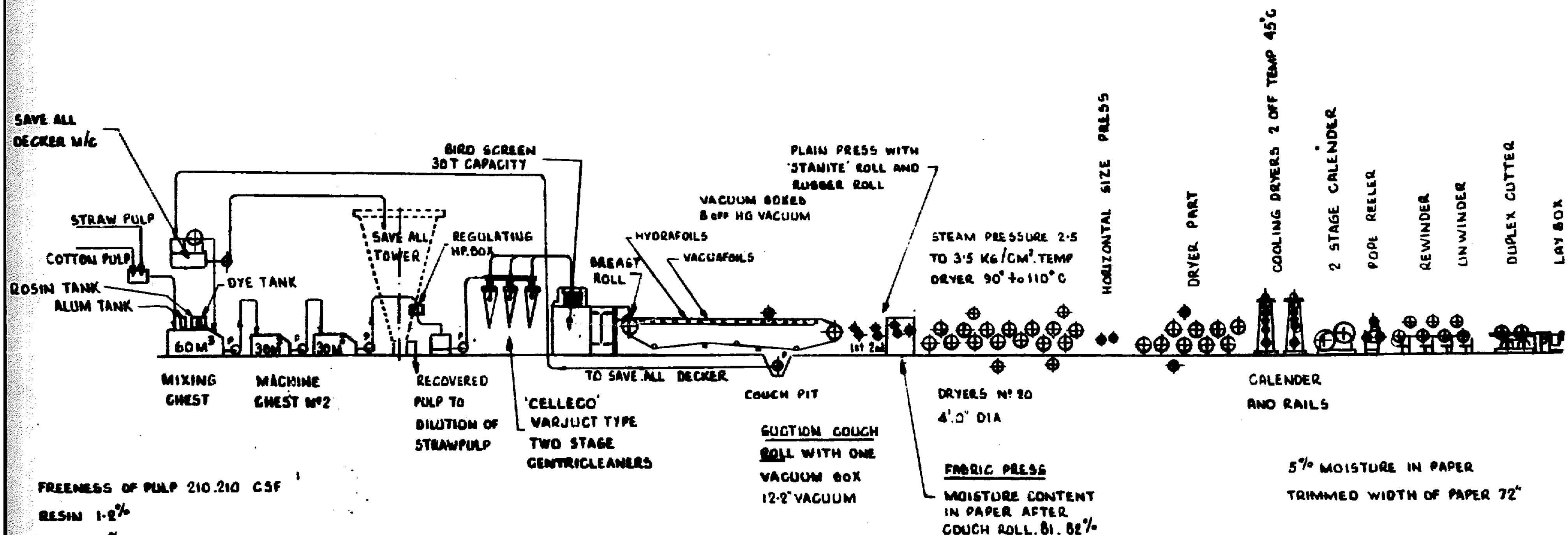
5.2. STOCK PREPARATION

The pulp produced by the pulp mill requires further treatment before it is suitable for the manufacture of paper. The treatment fundamentally is one of subjecting the fibres to mechanical action by passing the raw pulp between a multiplicity of opposing steel, bronze, stainless steel or cast-iron surfaces with a very small gap between them. This is known as beating or refining and it can be accomplished by selection from a wide range of equipment. Originally beaters, or Hollanders as they were known, were concrete or tile-lined cast iron troughs divided by a mid-feather with a heavy roll, furnished with a large number of bars on the periphery, poised above one or more bedplates around its lower circumference. The bedplates are also barred and the roll is pivoted and arranged so that pressure can be applied between its bars and those of the bedplates. The roll, whilst doing work on the fibres, also pumps the pulp around the trough and the desired result is obtained batchwise by a combination of time and pressure applied. The bars are kept apart by the hydraulic qualities of the pump solution which vary according to the nature of the fibres. Such beaters are obsolescent in the Western world but are still made and used in India.

Refiners undertake the beating, or refining function continuously and many types exist. Conical refiners have a conically shaped barred inner plug rotating in a correspondingly barred shell and it is possible to move shell or plug relatively to apply pressure. Disc refiners have opposing discs with barred segmental plates. Deflakers have plates or cones which do not quite touch and are often used as a preliminary treatment before refining and sometimes as the only treatment for waste paper because they do not cut or shorten the fibre which have already been treated in the original manufacture.

Beating, or refining, has two functions. It develops strength, up to the degree required within the potential of the fibre and it imparts uniformity of length and hydration to the pulp to enable the paper machine to run consistently. As mentioned earlier, fibres vary in their capacity to endure beating or refining pressures. Cotton, for example can take, and needs, up to 100 HP/tonne/day and sometimes even more. Beaters are universally used for cotton, batchwise. Groundwood cannot take more than around 5/7 HP/T.P.D. without suffering damage and bagasse is limited to around 3 HP/T.P.D. as refining. Kraft pulp can take up to 50 or 60 HP/T.P.D. but such levels are seldom required; 20 HP/T.P.D. is about the limit for common grades of paper, e.g. wrappings or writings and printings. Higher levels are required for speciality papers such as carbonising grades or greaseproof. Straw cannot sustain high beating levels without damage. It is good practice, when using blends of pulp, e.g. straw and rag to refine separately so as to optimise the potential of each fibre.

Stock preparation includes cleaning, screening, the addition of chemicals or dyes and should include essential controls, of which undoubtedly the most important is consistency control in at least two stages because it is essential for optimum refining and substance control on the machine. Regrettably, very few small mills in India are so equipped and efficiency suffers in consequence. A typical 2-stock preparation plant flowsheet is given in Figure 8. The points of desirable application for the consistency regulators are indicated.



FREENESS OF PULP 210.210 CSF

RESIN 1·2%

ALUM 5%

DYES TO MATCHSTORE

WIRE PART

WIRE LENGTH 23·5 M

36 OFF TABLE ROLLS AT 5" DIA

WIRE WIDTH 8'.6"

3 VACUAFOILS OF 5 BLADES EACH

2 HYDRAFOILS OF 3 BLADES EACH

PRE. DRYER PART

MOISTURE CONTENT IN PAPER BEFORE ENTERING DRYER SECTION 61%

MOISTURE CONTENT AFTER 1ST PRESS 72%

" " " " 2ND PRESS 66%

" " " " FABRIC PRESS 61%

STOCK PREPARATION PAPER MACHINE

FIG 8

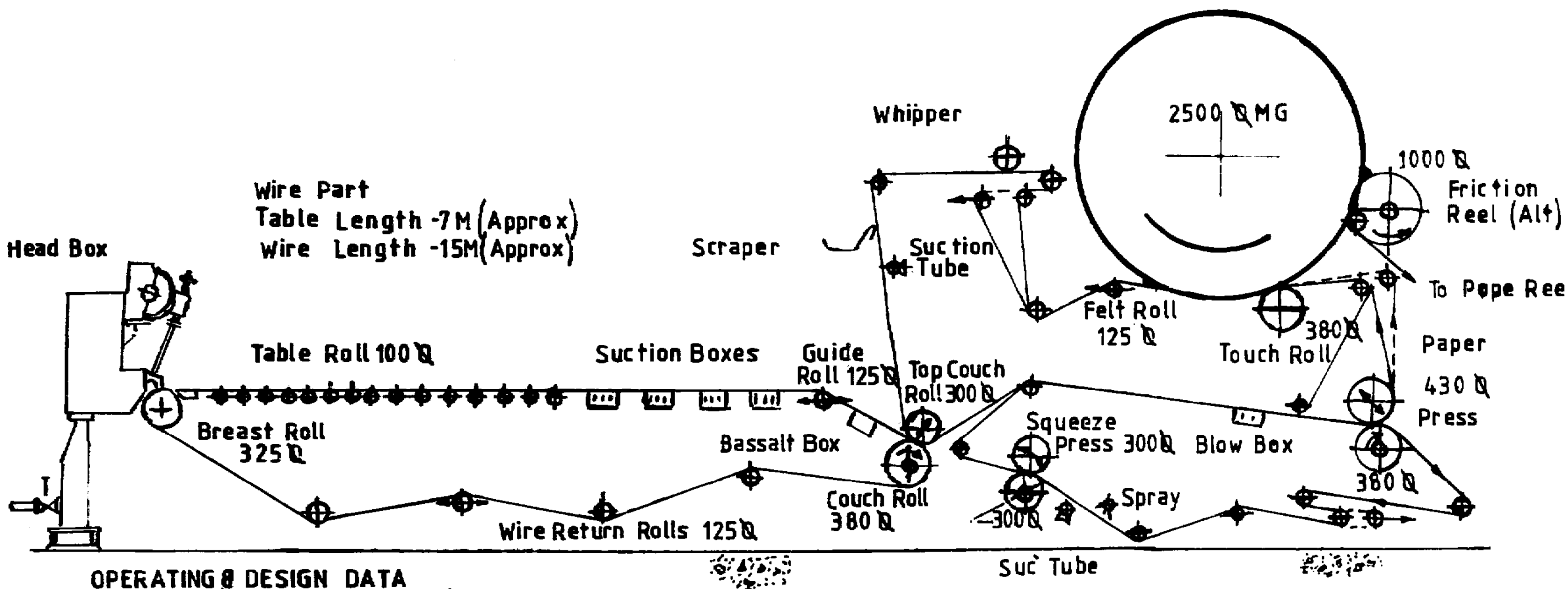
5.3. PAPER MACHINES IN SMALL MILLS

5.3.1. Indian Manufacture

The Fourdrinier type of machine can be obtained very cheaply from many suppliers. A typical machine is illustrated in Figure 12, which shows in profile a 10 T.P.D. machine but, in fact, with more dryers and perhaps (but not essentially) a third press the same machine would produce 30 T.P.D., by running faster, on suitable substances. The width of these machines is almost standard at 1.75 to 2.5 metres. The machine illustrated has no suction rolls, because the small manufacturer cannot make them. If specified, they would have to be ordered from the large suppliers. The flow-box is, for such small output usually wooden, and of open, scissors slice type. For high production, an open type with projection slice and perforated rolls would be required but this would not greatly add to the overall cost. The wire part has table rolls and vacuum boxes, easy to make. The presses are plain, with rubber covered bottom rolls and Indian "Stonite" equivalent for top rolls, a cause of many breaks and low efficiency. Many of the small mills visited run only one of the presses installed to avoid sticking problems. The dryers are usually purchased from one of the few manufacturers in India able to cast and machine them and are a bottleneck at present. The machine has a simple mechanical drive, lineshaft, cone pulleys, gearboxes and clutches and a variable speed D.C. motor supplied from an AC motor generator.

For its cost, the Indian machine is exceptionally good value and certainly capable of producing to rated capacity but it is also capable of substantial improvement with some extra cost, small in relation to the advantage gained. It will produce papers from 50 gsm to 150 gsm in most grades. To obtain 10 T.P.D. at 60 gsm it should run theoretically at 115m/min. Practically, it would need to run around 150m/min. allowing for low efficiency, but it is capable of running at 200m/min. For heavier papers the speed required is proportionately less.

5TPD CAPACITY PAPERS MACHINE FOR TISSUE AND M G KRAFT



OPERATING & DESIGN DATA
Type of m/c Fourdrinier (M G)
Capacity Gross 4.5 to 5 Tonnes/Day
Substance Range - 30 to 120 GSM
Operating Speed 12 to 90 m/min
Trimmed Width 1500 at Reel
Wire Width 1750 (Effective)
Wire Length 15m (Approx)
Range of Prod Kraft Tissue Poster
Wrapping and other variety of paper

TYPICAL FLOW SCHEME FOR 5TPD MACHINE
FIG 9

Figure 9 illustrates an MG machine for tissues and lightweight wrappings. As described on the drawing the machine is for 5 T.P.D. capacity but the width is 1.75 metres and the speed 90 metres/min. maximum. The M.G. cylinder would be imported and its drying capacity limits the speed. An effective hood would permit at least 30% increase and can be added later. Without doubt this simple machine was installed to serve a restricted market in a small district and as such is viable.

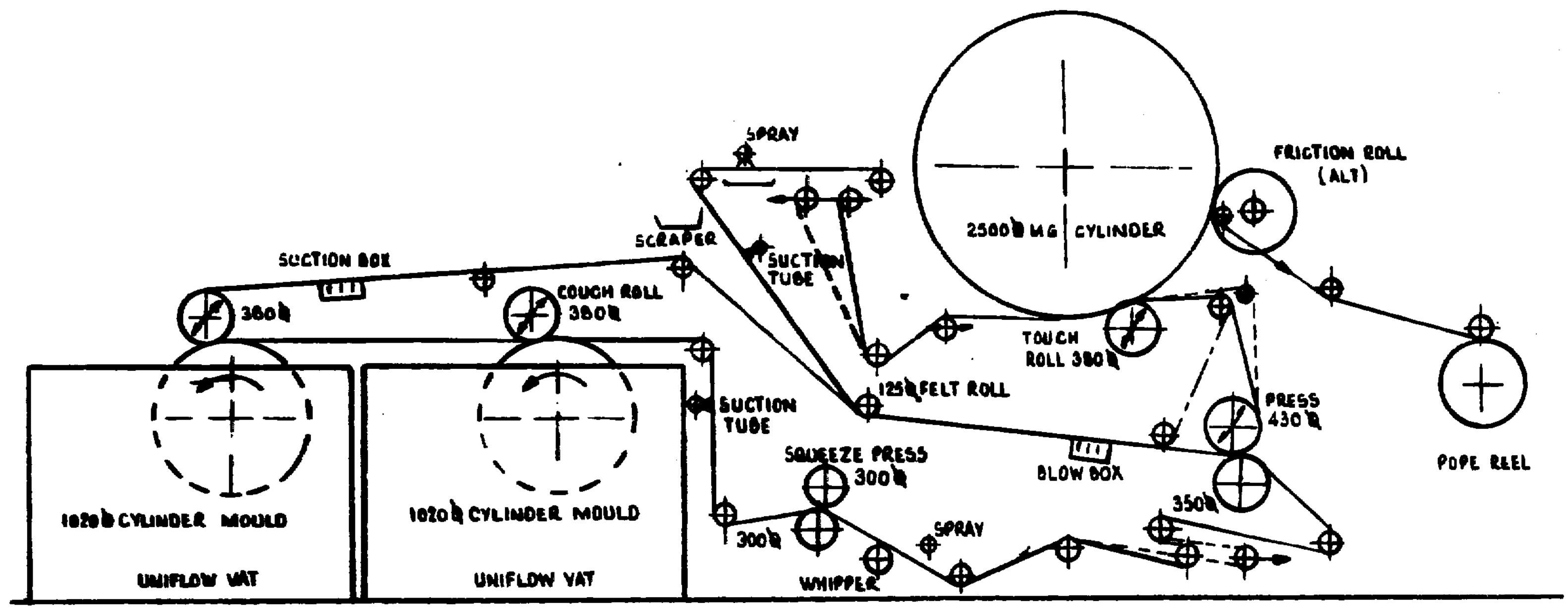
Figure 10 illustrates a 2 vat machine for MG papers or boards over the substance range 40 gsm to 120 gsm. Figure 11 illustrates a similar machine for M F grades. Multi-ply boards of greater substance can be produced on machines of this type by adding to the number of vats and more speed can be obtained by adding to drying. As illustrated these machines are very versatile and more efficient that the Fourdrinier because the sheet is supported, full width, through the presses and breaks are considerably reduced.

The foregoing illustrates only a part of the range of small machines which can be built in India at prices lower by far than anywhere else in the world. In some respects they lack finesse and they can undoubtedly be improved but nowhere can they be equalled in terms of value for money.

5.3.2. Imported, Second-hand

Since the Indian Government relaxed the restrictions on importing second-hand machinery and permitted import of small capacity machines within a price limit and subject to certified worthiness, many such machines have been imported from developed countries. There is irony in the situation; small machines in developed countries have been closed due to the impact of large machines usually operating in other countries . However, the availability has benefited India. Incorporating second-hand machines is said to reduce the overall cost of a small mill by 10% but there are other advantages. The imported machines have modern features, such as suction roll, and presses and often still later improvements such as foils, size presses, crown-compensating rolls etc. Such machines often come with the instrumentation and control systems included. It has been noted that the present small machine manufacturing industry in India is really based on copying the installed machine of the 1930's or earlier. The second-hand machines now present opportunities to copy later technology and to acquire experience in more advanced operating methods. Used machines cannot be expected to satisfy the total, growing needs of India; already the indications are that the supply is running out but they can provide a boost to indigenous small-scale machine manufacturing, as well as an advance in operating techniques.

5 TPD CAPACITY PAPER MACHINE WITH TWO CYLINDER MOULDS & MG CYLINDER



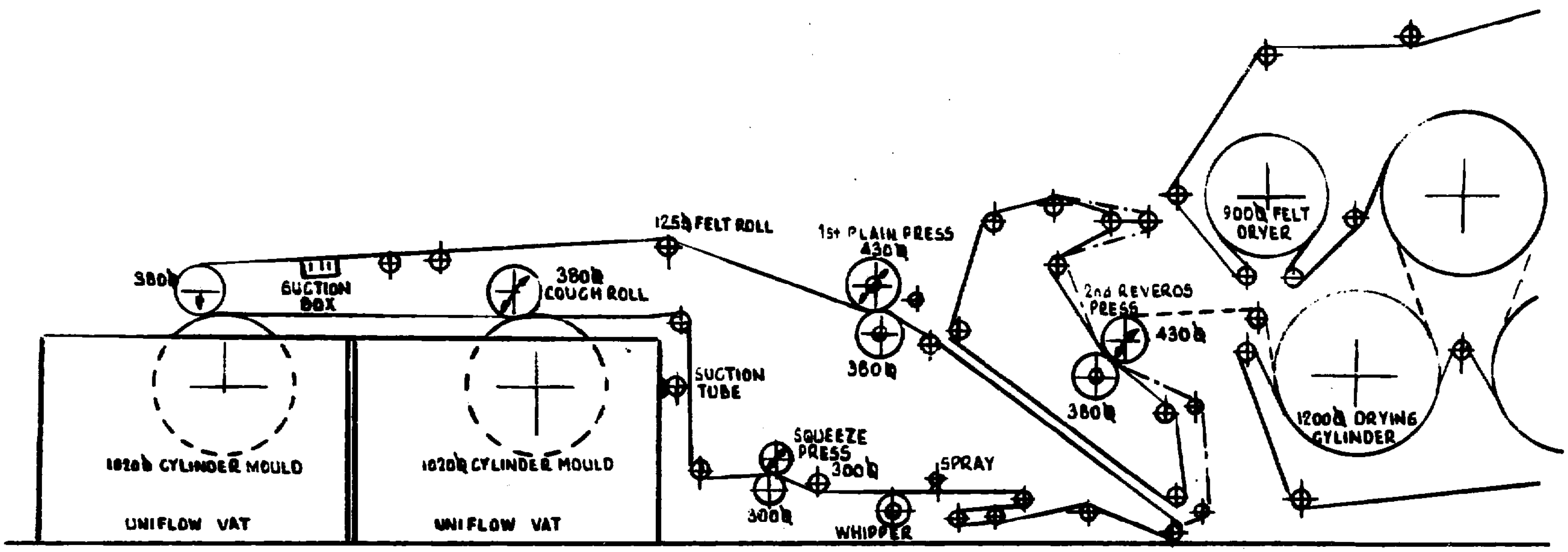
DESIGN AND OPERATING DATA

TYPE OF MACHINE	-	CYLINDER MOULD (M G)
CAPACITY (GROSS)	-	4.5 TO 5 TONNES/DAY
SUBSTANCE RANGE	-	40 TO 120 G.S.M
OPERATING SPEED	-	12 TO 70 M/MIN
TRIMMED WIDTH	-	1500 AT REEL
MOULD WIDTH	-	1750 (EFFECTIVE)

ALL SIZES ARE IN MM

TYPICAL CYLINDER MOULD MACHINE

FIG 10



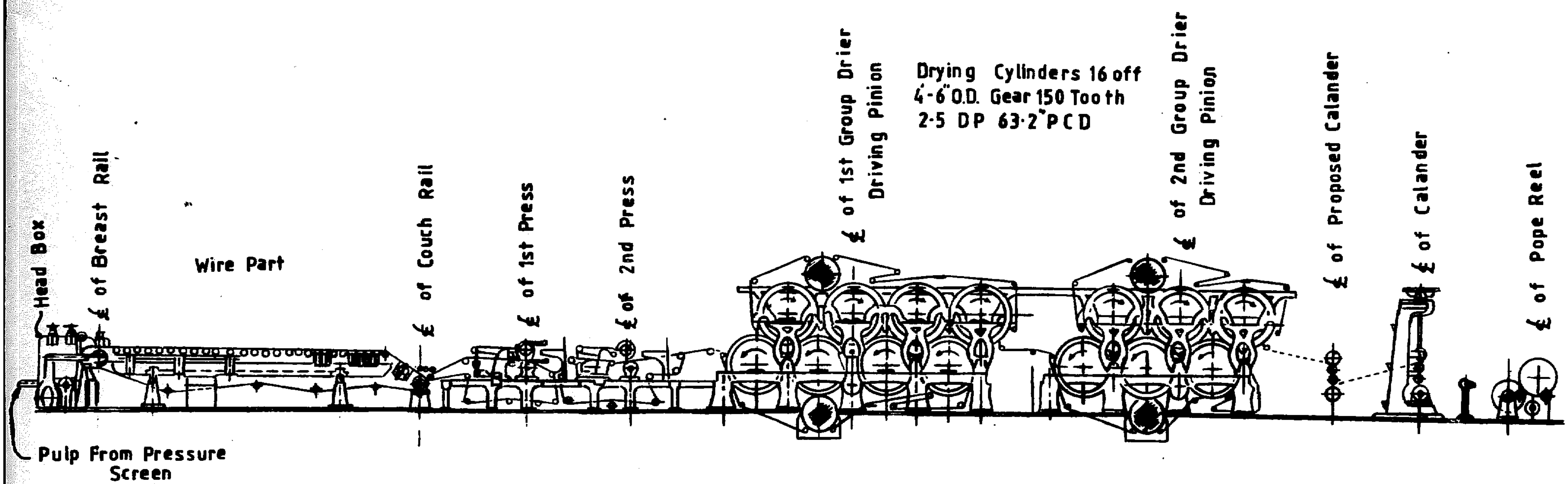
DESIGN OF OPERATING DATA

TYPE OF MACHINE	-	CYLINDER MOULD (ME)
CAPACITY (GROSS)	-	4.5 TO 5 TONNES/DAY
SUBSTANCE RANGE	-	40 TO 120 G.S.M
OPERATING SPEED	-	12 TO 70 M/MIN
TRIMMED WIDTH	-	1500 AT REEL
MOULD WIDTH	-	1750 (EFFECTIVE)
RANGE OF PRODUCTION	-	VARIOUS TYPES OF PAPERS

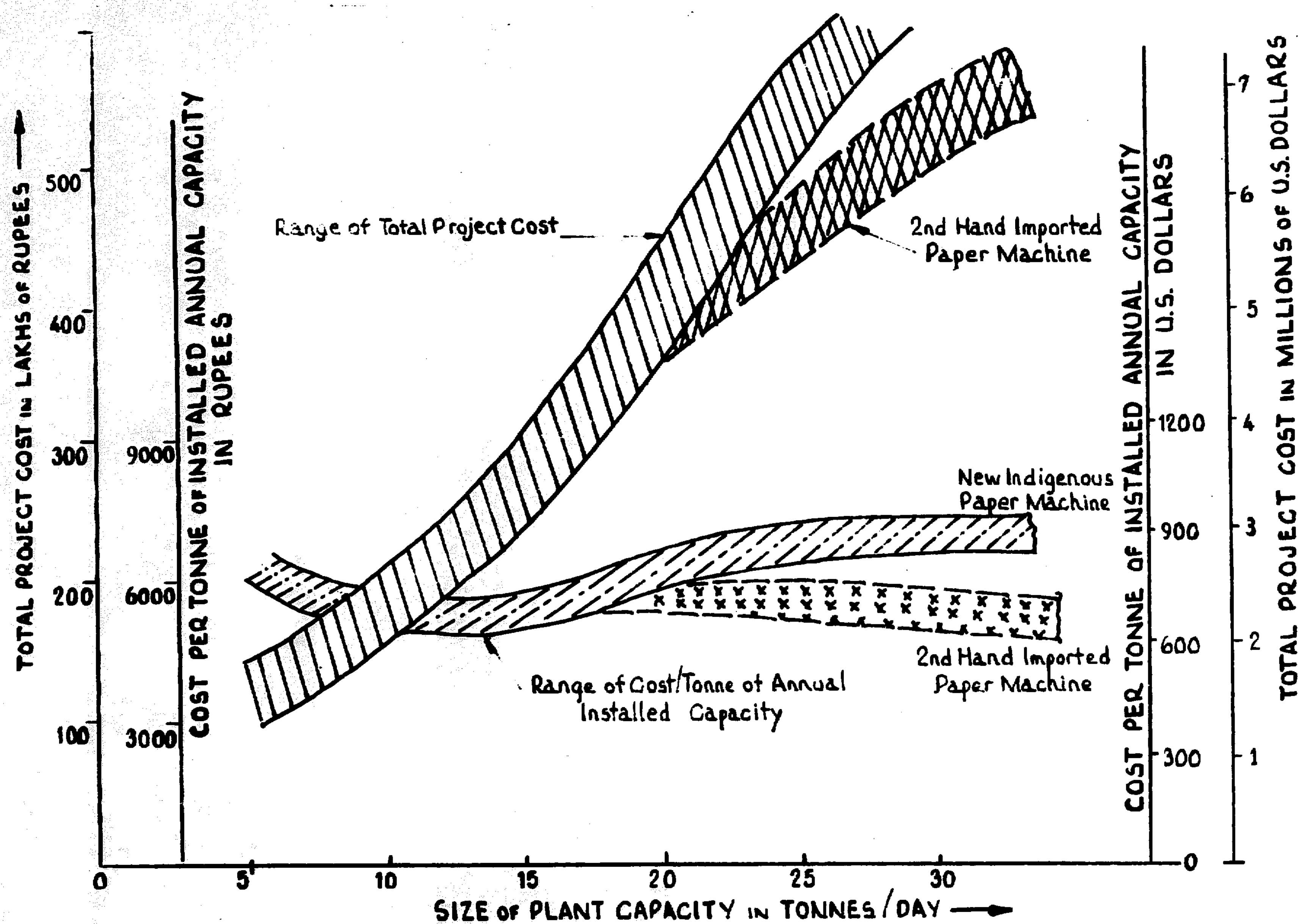
ALL SIZES IN M.M

TYPICAL CYLINDER MOULD MACHINE

FIG 11



10 TON/DAY
PAPER MACHINE
FIG 12



TOTAL PROJECT COST IN LAKHS OF RUPEES
100
200
300
400
500
COST PER TONNE OF INSTALLED ANNUAL CAPACITY IN RUPEES
3000
6000
9000
Range of Total Project Cost
2nd Hand Imported Paper Machine
New Indigenous Paper Machine
Range of Cost/Tonne of Annual Installed Capacity
2nd Hand Imported Paper Machine
COST PER TONNE OF INSTALLED ANNUAL CAPACITY IN U.S. DOLLARS
0
300
600
900
1200
TOTAL PROJECT COST IN MILLIONS OF U.S. DOLLARS
1
2
3
4
5
6
7
0
5
10
15
20
25
30
SIZE OF PLANT CAPACITY IN TONNES/DAY

FIG 13.

CHAPTER 6

REPRESENTATIVE, SUMMARISED CASE-STUDIES

INTRODUCTION

From the large numbers of small mills visited, more than twenty in all, covering the range of capacities within the "small" category it is possible to present model examples, typical of these mills in terms of capacity, product, raw material source and process. Capital and operating costs can be estimated together with selling prices, financing terms and the company structure can be postulated and viability calculated as an exercise. The following section presents summary details of typical mills of standard capacities. Fully detailed case studies of actual mills are given in Book 2.

Since no actual mill is described in these model cases it is necessary to make certain assumptions as follows :

1). Utilisation of Installed Capacity

70% is assumed for all cases. Whilst many mills operate at lower efficiencies, 65% being typical of the mills examined, the installed capacity rating is usually very conservative and is often exceeded in practice over good periods. The figure assumed is considered reasonable in these circumstances.

2). Capital Costs

These have been derived from the curves on Figure 13 which has been compiled from the actual case studies and supplementary information obtained from the Small Mills Association and elsewhere.

3). Cost of Land

Rs. 10,000 ($1250)/acre plus development costs at Rs. 1000 ($125)/acre.

4). Incentives

Each model except where otherwise stated is presented on the basis that it is located in a specified backward area and entitled to the full benefit of the cash grant. However, the models are shown on the basis of normal incentives only. Finally, the effect of levies is shown to indicate expected financial results.

5). Working Capital

Estimated at Rs. 480 ($60) per tonne of paper produced which is considered adequate for 4 months' supply of straw, 1 months' supply of waste paper, gunny sacks and chemicals, 2 months' coal stocks, 2 weeks' stock of finished product and one months' period for sales payments, plus wages and other requirements.

6). Profits

All profits and returns are shown before tax and financial charges.

7). Discounted Rate of Return

The rate of return shown against each case study is a discounted one which equates the net present value of project cash flow over a project life of 12½ years with the initial investment outlay. Project cash flow is the gross margin. No allowance is made for the residual value of capital assets at year 13, which makes the rate of return calculations conservative, as the equipment has a working - and, hence, income-generating - life well beyond this period.

6.1 HANDMADE PAPER MILL, 1 TPD CAPACITY

6.1.1 Description of Mill

The handmade paper mill used for this case study cannot be regarded as typical of operating handmills as generally existing but more as a model of what a handmade paper mill can be. Cottage-type waste based handmade paper mills are domestic businesses which generally keep no records, and similar industry can be found in many developing countries using self-collected waste paper to make cheap, sun-dried boards.

The mill adopted for this section represents the top end of hand made paper, the quality, selective, art paper market. It is based on pure cotton pulp, tailor and hosiery cuttings, and is a mill employing 90 workers, using a central pulping plant to supply 15 paper making vats. For hand made paper it is sophisticated including drying and finishing. At 70% utilisation and 330 operating days, the annual output is 231 tonnes.

The pulp mill is standard in system but special in equipment for reasons of scale and cleanliness. It comprises rag chopper, duster, stationary cylindrical digester, externally fired, stainless steel lined, manually fed and emptied, operating with steam at atmospheric pressure, fibre-glass lined washer and beater, followed by a 25HP Claflin wide-angle refiner with 5.5 bars, a vibratory screen followed by a riffler and stainless steel centri-cleaners.

The paper mill has 15 hand operated vats, a hydraulic press, a tunnel dryer, a smoothing calender and a sheet cutter.

Incoming water is filtered through a micro-mesh filter. Process steam is supplied by one 500 Kg/hour packaged boiler operating at 6.7 atmospheres pressure.

6.1.2 Capital Cost Summary

Item	Rupees	$
Land & Building		
(600 sq,metres in an industrial area)	300,000	37,500
Plant & Equipment	950,000	119,000
Miscellaneous Fixed Assets		
Furniture	10,000	1,250
Vehicles	50,000	6,250
Fire Protection	10,000	1,250
Laboratory Equipment	10,000	1,250
Pre-operational Costs	100,000	12,500
Spares	20,000	2,500
Preliminary Expenses	30,000	3,750
Sundry Expenses	100,000	12,500
Contingency	100,000	12,500
Working Capital	300,000	37,500
	1980,000	247,750

6.1.3 Labour Costs

It is estimated that 90 employees will be required, at an average Rs. 260 each per month plus 25% fringe benefits, equivalent to Rs. 351,000 per annum total, or Rs. 1520 ($ 190) per tonne of saleable paper. Administrative costs are estimated at Rs. 100,000 ($ 12,500) or Rs. 434 ($54.25) per tonne.

6.1.4 Production Costs/Tonne of Saleable Paper

Item	Quantity Req'd Tonnes	Unit Cost Rupees	Unit Cost $	Cost/Tonne Rs.	Cost/Tonne $
Cotton Furnish (85% yield)	1.2	3400	425	4080	510
Chemicals					
Caustic (10% on pulp)	0.10	3000	375	300	37.5
Alum	0.06	1100	137.5	66	8.25
Talcum	0.08	600	75	48	6.0
Animal Glue (Sizing)	0.02	13,000	1625	260	32.5
Starch	0.01	2,000	250	20	2.5
Sodium Silicate	0.01	1,000	125	10	1.25
Resin	0.15	12,000	1500	180	22.5
Services					
Coal	0.8	220	27.5	176	22.0
Power	500 Kwh	0.25	0.03	125	15.6
Other Costs					
Repairs and Maintenance				11	1.375
Consumable Materials				20	2.5
Packaging				200	25.0
Despatch				100	12.5
Labour				1520	190.0
Administration				434	54.6
			Total:	Rs.7550	$944

6.1.5 Sales Revenue

Average wholesale selling price/tonne	Rs. 11,000 ($ 1375)
Less Sales Commissions (10%)	1,100 ($ 137)
Net Sales realisation	Rs. 9,900 ($ 1237)

Annual Sales Revenue

Based on 231 TPA sales	Rs.2,286,900 ($286,000)

N.B. The price is almost irrelevant. For such paper, with 100% cotton furnish, it is about one tenth of that which can be obtained in developed countries for equivalent grades. The whole output can be exported without difficulty. The manufacturer aims at around 25% profit on sales.

6.1.6 Profitability

	Per Annum		Per Tonne of Paper	
	Rupees	$	Rupees	$
Net Sales Revenue	2,286,900	286,000	9,900	1237
Cost of Production	1,744,050	218,000	7,550	944
Gross Margin	542,850	68,000	2,350	293
Depreciation				
(Taken as 8% on plant & equipment Rs.1,000,000)	80,000	10,000	346	44
Net Profit Margin	462,850	58,000	2,004	249

% Return on Total Investment 26%

Fixed Costs/Ton of Paper (at 70% utilisation) Rs. 2,300 ($288)
(depreciation, plus labour and admin.)

Surplus of sales over variable costs Rs. 4,304 ($538)
(gross margin, plus labour and admin.)

Break-even Point

$$\frac{2,300 \times 0.7}{4304} \times 100 = 37\% \text{ of Installed Capacity}$$

6.1.7 Comments

a) The mill would be very profitable and repay total cost within 4 years. It is of course unique in having access to low cost raw materials and labour, but is a real, and enduring benefit to the country and the local community.

b) The above analysis is before tax. No incentives other than the Central Cash subsidy are involved.

c) The most common financing programme involves a debt-equity ratio of 2:1, with long term capital repayable over 10 years at 9½%, and short term working capital repayable at 16%. The total equity stake of Rs. 560,000 would comprise promoters' equity of Rs. 418,000 supplemented by a central cash subsidy of Rs. 142,000.

6.2 SMALL MILL - 5 TPD CAPACITY

6.2.1 Description of Mill

Mills of this capacity are almost exclusively based on the use of waste paper and for this reason are most frequently sited near the larger towns or cities. The capacity will not support integrated pulping equipment but the total cost of the mill is small and attractive to the private invester with limited means. The mill represented in this case study is designed to produce writings and printings from selected, white waste paper, printers waste. A yield of 85% from this material is assumed and reasonable. With a closed water system it could be improved. At 70% utilisation and 330 operatings days an annual production of 1155 tonnes is assumed.

Pulping and stock preparation comprise the standard Hydro-pulper type unit with a 60 Hp drive, a riffler, a Johnson type vibratory screen, a decker thickener, a conical refiner with 30 Hp drive, 2-stage centrifugal cleaning and a simple plate screen, plus chests etc, as required.

The paper machine is of simple Fourdrinier type capable of producing paper of 1.25 metres width at speeds up to 75 metres/minute. For writing and printing paper, width is not important, being multiples of 210‰ or thereabouts. Paper over the substance range 45 gsm to 100 gsm would normally be produced. The flow box is of simple, scissors type because the maximum fluid head will only be around 80 ‰, insufficient for a projection slice without a vacuum chamber but a perforated distributor roll is included in the approach system. The wire part has a forming board, tube rolls with deflectors, 5 suction boxes, shaking mechanism, jacketed couch and steel fabricated framing, with stainless covered top rails.

There are two plain presses, each with rubber bottom and stonite top rolls and a wringer, felt press. The drying section comprises 12 - 4'-0" diameter cylinders and 2 felt dryers. It is designed for cotton drying felts and has a simple hood. A 5-roll calender stack is included and a standard Pope reel. There is no winder but one duplex cutter, so that all paper is sold in sheets.

The paper machine drive is of mechanical line-shaft type with cone pulleys, gearboxes and clutches standardised, 3-15 Hp, 2-10 Hp and one 5 Hp (reel drum). A variable speed D.C. motor supplied from a standard motor-generating set is the prime mover.

Services comprise water from a borehole, steam from a 3 TPH 100 p.s.i. packaged boiler and state grid power, average load 250 Kw at 440 V, 3-phase. Effluent goes to drain without treatment.

6.2.2 Capital Cost Summary

	Rupees	Dollars	Rupees	Dollars
LAND				
Land @ Rs. 10,000/acre for 15 acres	150,000	18,750		
Land Development @ Rs. 1,000/acre	15,000	1,875		
Road at Rs.50/metre for 1,500 metres	75,000	9,375		
			240,000	30,000

	Area m²	Cost	
CIVIL COSTS @ Rs. 500/sq.metre		Rupees	Dollars
Raw Material Preparation	120	60,000	7,500
Stock Preparation	200	100,000	12,500
Paper M/C House	350	175,000	21,875
Paper Stores	150	75,000	9,375
Utilities (Boiler House, workshop, pump house, power house)	160	80,000	10,000
Administration Office	80	40,000	5,000
Chester & Silos (150m @ Rs. 800)		120,000	15,000
Sewer and drains		70,000	8,750
Fencing		50,000	6,250
		1,010,000	126.250

PLANT AND EQUIPMENT	Rupees	Dollars
Waste Paper Pulping	150,000	18,750
Chemical Preparation	70,000	8,750
Stock Preparation	150,000	18,750
Paper Machine	4,500,000	562,500
Finishing	150,000	18,750
Utilities	1,500,000	187,500
Freight, Taxes	900,000	112,500
	7,420,000	927,500

Miscellaneous Fixed Assets	Rupees	Dollars	Rupees	Dollars
Furniture	20,000	2,500		
Vehicles	50,000	6,250		
Workshop Equip.	30,000	2,750		
Fire Fighting	15,000	1.875		
Laboratory Equipment	10,000	1,250		
			125,000	15,625

GENERAL				
Pre-operative costs	300,000	37,500		
Spares	150,000	18,750		
Preliminary	200,000	25,000		
Sundries	500,000	62,500		
Contingency	550,000	68,750		
Technical Fees	300,000	37,500		
			2,000,000	

WORKING CAPITAL	1,500,000	187,500
Total Project Cost :	12,055,000	1,506,875

6.2.3 LABOUR AND SALARIES

6.2.3.1 Wage Rates are based on the following :-

Unskilled labour	Rs. 250/month
Semi-skilled "	Rs. 325/month
Skilled "	Rs. 400/month
Highly skilled	Rs. 550/month

6.2.3.2 Salaries are based on the following :-

Works Manager	Rs. 2,500/month
Chief Engineer	Rs. 2,500/month
Paper Mill Supt.	Rs. 1,700/month
Shift Foremen	Rs. 700/month

6.2.3.3 Fringe Benefits

These have been estimated at 25% on wages and salaries.

6.2.3.4 Mill Labour and Salaries

It is estimated that the mill will employ 180 workers, in all grades, averaging Rs. 380/month. With fringe benefits the total wage bill is estimated to be Rs. 1,025,000 ($128,125) equivalent to Rs. 885 ($111) per tonne. Salaries and administration are Rs. 200,000 ($25,000), equivalent to Rs. 173 ($21.6) per tonne.

6.2.4 PRODUCTION COSTS/TONNE OF SALEABLE PAPER

ITEM	Quantity Req'd / tonne	Unit Cost Rs.	Unit Cost $	Cost/Tonne Paper Rs.	Cost/Tonne Paper $
Raw Materials					
Waste Paper	1.17	2,400	300	2,808	351
Chemicals					
Alum	0.06	1,100	137.5	66	8.25
Resin	0.015	12,000	1,500	180	22.5
China Clay	0.08	600	75	48	6.0
Dyes & Misc	--	--	--	60	7.5
Utilities					
Coal	0.8	220	27.5	176	22.0
Power	800 Kwh.	0.25	0.03	200	25.0
Other Costs					
Maintenance				135	17
Consumable Stores				120	15
Packing & Despatch				120	15
Labour				885	111
Administration				172	21.5
			Total :	4,970	621

6.2.5 SALES REVENUE (1155 TPA)

		Rupees	Dollars
a)	Basic selling price ex mill	6,000	750
b)	Excise duty payable (25%)	1,500	187.5
c)	Ex-mill price including excise	7,500	93.75
d)	Excise duty rebate (75%)	1,125	141
e)	Gross sales realisation (a + d)	7,125	891
f)	Sales Cost (7.5% of basic price)	450	56
g)	Net Sales realisation	6,675	834

6.2.6 PROFITABILITY

	Per Annum		Per Tonne of Paper	
ITEM	Rupees	Dollars	Rupees	Dollars
Sales Revenue	7,709,625	963,703	6,675	834
Cost of Prod.	5,740,350	717,544	4,970	621
Gross Margin	1,969,275	246,159	1,705	213
Depreciation (8% of Plant & Equipment Rs. 7,500,000)	600,000	75,000	519	65
Net Profit Margin	1,369,275	171,159	1,186	148

Net Return on Total Capital 13%

Fixed Costs/Tonne of Paper Rs. 1,576 ($197)

(Depreciation + labour & admin. @ 70% utilisation)

Surplus of Sales over variable costs Rs. 2,762 ($345)

Break-even point

$$\frac{1,576 \times 0.7 \times 100}{2,762} = 40\%$$

6.2.7 Comments

a) Rs. 375/tonne are paid as excise duty to the Government. Whilst comparatively, this is an incentive because 75% rebate is given, in absolute terms it is a penalty. The customer will evidently pay the total price. If this were revenue, as it would be in most developing countries seeking to encourage positively, the profit/tonne would virtually double.

b) The mill is fundamentally profitable but the first two years could be difficult particularly if long term loans of Rs. 7,036,000 were raised at 9.5% interest for repayment over ten years, and working capital needs were met through a short term Rs. 1.5 million loan repayable at 16%. However, the labour force, for such a small mill, 180 labourers and around 30/35 staff, is high, and unlikely to reach this level until justified by income and profit.

c) The mill is capable of increasing output by adding dryers at relatively low cost.

6.3 15 TPD MILL - FULLY INTEGRATED

6.3.1 Description of Mill

The mill described is designed to produce M.G. grades of papers from a furnish of straw pulp, gunny sack waste and waste paper. Unbleached, wrapping and packaging grades are manufactured. All machinery is new and of Indian manufacture, except the M.G. cylinder which had to be imported.

6.3.1.1 Pulping Plant

Straw is chopped by two straw choppers and dusted by one duster blowing to a cyclone separator. There are three spherical digesters of 12'-6" diameter, each discharging into a washing potcher, with drum. The washed pulp is screened over a vibrating screen, diluted and cleaned by two-stage centricleaners, thickened over a decker washer and refined by a disc refiner. Caustic consumption is 8% on straw supplied.

Gunny Rag is chopped, dusted and fed to a similar 12'-6" diameter spherical digester where it is cooked with 5% caustic and dropped to a draining blow pit from which it is fed into two breaker beaters with washing drums. It is screened over a vibratory screen and thickened over a washer decker.

Waste Paper and broke are pulped in a Hydrapulper type unit and cleaned by a high density cleaner.

6.3.1.2 Stock Preparation

The three stocks plus couch pit broke, are mixed in a blending chest, refined by two conical refiners, cleaned by two-stage centricleaners and screened through a pressure screen with a horizontal vibrating auxiliary screen. A decker is used to thicken couch broke before feeding it to the blend chest.

6.3.1.3 Chemical preparation

A resin cooker, plus storage tank and an alum dissolving tank are included, plus a caustic soda storage tank for liquid supplies and a dissolving tank for solid caustic alternative.

6.3.1.4. Paper Machine

The machine is capable of producing papers to 1.870 metres trimmed width at speeds up to 125 metres/minute over the substance range 40 gsm to 160 gsm. The drying capacity is equivalent to 15 TPD of 60 gsm paper, assuming 85% efficiency. At 70% efficiency and 330 operating days/annum the annual output should be 4,075 TPA. The machine has an open flow box with projection slice, standard wire part with formation board and tube rolls, suction couch, 2 plain presses with rubber bottom and stonite top rolls, 7 - 5'-0" diameter pre-dryers, 1 - MG dryer (3.00 metres diameter), Pope reel and variable speed line shaft, mechanical cone pulley, gearbox drive with DC motor prime mover and AC motor generator. A fibre recovery decker is included.

6.3.1.5. Finishing Equipment

A slitter winder, a simplex cutter and a guillotine comprise the finishing equipment.

6.3.1.6. Services

3 steam boilers of water tube type, each of capacity 3-5 TPH at 10 atmospheres pressure are included with feedwater treatment. The boilers are coal fired and coal handling equipment is provided.

Power is from the state grid, supplied at 11 Kv. Two 1,000 KVA transformers reduce the voltage to 440 V.

Water is obtained from a bore hole, capable of pumping 4,000 litres/minute.

Effluent Treatment is limited to settlement, the clarified effluent going to drain.

6.3.2 CAPITAL COST SUMMARY

LAND COSTS

	Rupees	Rupees	Dollars
30 acres @ Rs. 10,000 ($ 1,250) per acre inclusive of conveyance & registration charges	300,000		
Development Costs, levelling etc.	30,000		
Roads, 3,000 metres @ Rs. 50 ($ 6.25) per metre	150,000		
Total Land Cost		480,000	60,000

BUILDINGS AND CIVIL

	Covered Area	Rate	Rupees	Rupees	Dollars
Raw material storage	1,500	300	450,000		
Raw material preparation	200	500	100,000		
Pulp Mill	700	500	350,000		
Stock Preparation	350	500	175,000		
Paper Machine House	400	500	200,000		
SERVICES					
Boiler House, workshop, pump house, power house and weighbridge	200	500	100,000		
Finishing Room	200	500	100,000		
Finished Paper Stores	150	500	75,000		
Administration Office	100	500	50,000		
Time Office - Canteen, Toilets	60	500	30,000		

MISCELLANEOUS	Rate	Rupees	Rupees	Dollars
Chests Silos 500m^3	800m^3	400,000		
Sewers & drainage		130,000		
Overhead Storage Tanks		100,000		
Fencing		100,000		
Architects Fees		100,000		
	Total Civil Cost		2,460,000	307,500
PLANT AND EQUIPMENT				
Straw pulping		1300,000		
Gunny Sack Pulping		700,000		
Waste Paper Pulping		150,000		
Chemical Preparation		120,000		
Stock Preparation		350,000		
Paper Machine (New)		8,200,000		
Finishing Equipment		750,000		
Utilities		3,900,000		
Taxes, Freight		2,300,000		
			17,770,000	2,221,125
MISCELLANEOUS FIXED ASSETS				
Furniture and Office Equipment		100,000		
Vehicles		100,000		
Workshop Equipment		100,000		
Fire Fighting		25,000		
Laboratory Equipment		25,000		
			350,000	43,750

GENERAL	Rupees	Rupees	Dollars
Pre-operational Costs	600,000		
Spares (2% of Plant)	340,000		
Preliminary and Capital Issue Costs	400,000		
Sundry Costs	1,300,000		
Contingencies (5% of Total)	1,250,000		
Technical Fees (2% of Total)	500,000		
		4,390,000	548,750
WORKING CAPITAL		3,900,000	487,500
Overall Total Project Cost		29,350,000	3,668,750

6.3.3 LABOUR AND SALARIES

Wage Earners 265 Average Pay Rs. 380/month

Fringe Benefits 25%

Total Wage Bill Rs. 1,516,000 ($ 489,500)

Cost/Annual Tonne Rs. 372 ($48) based on 4,075 TPA.

Salaries and Administration Rs. 370,000 ($46,250)

Cost/Annual Tonne Rs. 91 ($12)

Around 50 staff in all grades would be employed.

6.3.4 PRODUCTION COSTS

ITEM	Quantity per tonne	Unit Cost Rupees	Cost/T.Paper Rupees	Cost/T.Paper Dollars
Raw Materials				
Straw	1.56	2.30	359	45
Waste Paper	0.12	1800	216	27
Gunny Waste	0.33	740	244	30.5

g) Net Sales realisation Rs. 5,520 ($ 690)

h) Annual Sales Revenue (4,075 TPA) Rs.22,494,000 ($ 2,811,750)

6.3.6 PROFITABILITY

	Rupees/Annum	Per Tonne Rupees	Per Tonne Dollars
Sales Revenue	22,494,000	5,520	690
Production Costs	12,225,000	3,000	375
Gross Profit Margin	10,269,000	2,520	315
Depreciation			
(@ 8% on Plant & Equipment, Rs. 18,000,000)	1,440,000	416	52
Net Profit Margin	8,829,000	2,104	263
Return on Total Capital 34%			
Fixed Costs/Tonne (Depreciation, Labour and admin)		879	107
Surplus of Sales over Variable Costs (gross margin, plus labour and admin)		2,983	373

Break-even point

$$\frac{879 \times 0.7 \times 100}{2{,}983} = \underline{21\%\ \text{Utilisation}}$$

6.3.7 COMMENTS

a) The mill is very profitable but the capacity is really 17.65 TPD at 100% although the capital costs relate to nominal 15 TPD.

b) Profitability is largely due to the selling price, which is high by international standards but it would still be competitive against imports, taking freight and inland transport into account.

c) There is no chemical recovery, uneconomical at the level of pulping installed. In due time, some additional, unremunerative capital expenditure may be involved but the mill is strong enough to absorb it.

6.4 25 TPD MILL-PULP & PAPER, INTEGRATED

6.4.1 Description of Mill

The mill is designed to produce writing and printing papers from a blend of straw pulp, rag pulp and waste paper, from which it can produce good quality paper. It is based on two imported, second-hand machines, one MF and the other M.G., both 15 TPD capacity, equivalent to 5,775 TPA at 70% utilisation based on 25 TPD jointly for 330 days.

6.4.1.1 Pulping

Rice Straw is chopped, dusted and blown via a cyclone separator to 5 standard 12'-6" diameter spherical, rotary digesters. It then goes to a blow tank, from which it is pumped to a vibrating screen, over a riffler and on to a rotary vacuum washer. It is then diluted and cleaned through a 2-stage centricleaner system after which it is thickened by a washer-decker and passed to a 3-stage bleaching plant, chlorine, caustic extraction and hypochlorite with rotary vacuum washers after the first two stages and a washer decker after the final stage. It is beaten batch-wise in a Hollander beater.

Rag is chopped, dusted and taken to one 12'-6" spherical washer which is emptied on to a drainer and the pulp is then broken up and washed in 2-washer breakers, where bleach as hypo is added as required. From the washers it passes to a Hollander beater and then is diluted and screened over a vibrating screen from which it is fed by a riffler to a decker thickener.

Waste Paper. The system follows the Indian standard, Hydrapulper, vibrating screen, 2-stage centricleaners and decker-thickener, followed by disc refiner.

6.4.1.2 Stock Preparation

a) M.F. Machine

2-conical refiners treating blended stock, 2-stage centricleaners and a pressurised screen.

b) M.G. Machine

As for M.F. machine but operating from its own blending chest.

6.4.1.3 Chemical Preparation

Calcium hypochlorite preparation section, resin size preparation plant, alum dissolving unit; clay talcum loading preparation plant, mixers, filters etc., dye preparation plant.

6.4.1.4 Paper Machines

a) M.F. Machine

1,900mm trimmed width, standard open flow box, drainer wire part, 2 plain presses, dryers, calender, reel with mechanical drive and D.C. motor prime mover following an A.C. motor-generator. Capacity 15 TPD.

b) M.G. Machine

1,580mm trimmed width, wire part and presses as for M.F. machine, imported M.G. dryer with hood, reel etc. Mechanical drive as for M.F. machine. Capacity 15 TPD.

6.4.1.5 Finishing

Slitter Winder, simplex sheet cutter, guillotine.

6.4.1.6 Utilities

a) Water 2 boreholes each of 60,000 gph capacity

b) Steam 2 coal fired boilers, each of 5 TPH capacity

c) Power Grid supply, 2-1,500 KVA transformers to 440 V.

d) Effluent No special treatment, pumped away to settling pond, thence to drain.

6.4.2 CAPITAL COST SUMMARY

LAND COSTS	Rupees	Rupees	Dollars
70 acres @ Rs. 10,000/acre including conveyance and registration	700,000		
Development @ Rs. 1,000/acre Levelling etc.	70,000		
Roads 4,000 metres @ Rs. 70/metre	280,000		
		1,050,000	131,250

CIVIL COSTS	Covered Area sq. metres	Rate/m^2 Rupees	Cost Rupees	Dollars
Raw Material Storage	2,500	300	750,000	93,750
Raw Materials Preparation	300	500	150,000	18,750
Pulp Mill	1,800	600	1,080,000	135,000
Stock Preparation	450	500	225,000	28,125
Paper M/C Building (with basement)	2,000	800	1,600,000	200,000
Finished Paper Stores	500	500	250,000	31,250
Finishing Room	450	500	225,000	28,125
Services				
Boiler Room, Workshop, Pumphouse, Weighbridge etc.	400	500	200,000	25,000
Administration Office, Canteen, Toilets etc.	60	500	30,000	3,750
Chests and Silos	1,200	800	960,000	120,000
Overhead storage tanks			100,000	12,500
Sewer & Drains			120,000	15,000
Fencing & Compound Wall			150,000	18,750
Architects' Fees			125,000	18,125
		Total Civil Costs:	6,025,000	753,125

PLANT & EQUIPMENT	Rupees	Rupees	Dollars
Straw Pulping	6,000,000		
Rag Pulping	900,000		
Waste Paper Pulping	400,000		
Chemical Preparation	200,000		
Stock Preparation	850,000		
Paper M/C's	9,000,000		
Finishing Equipment	750,000		
Services	5,000,000		
Freight & Taxes	4,600,000		
Erection	2,000,000		
		29,765,000	3,720,625
MISCELLANEOUS FIXED ASSETS			
Furniture & Office Equipment	100,000		
Vehicles	200,000		
Workshop Equipment	200,000		
Fire Fighting	100,000		
Laboratory Equipment	60,000		
		660,000	82,500
GENERAL			
Pre-operation costs	1,200,000		
Spares (2% on equipment)	600,000		
Preliminary & capital issue costs	700,000		
Sundries	2,500,000		
Contingency (5% on total)	2,100,000		
Technical Fees (2% on total)	800,000		
		7,900,000	962,500
WORKING CAPITAL		7,500,000	937,500
Overall Project Total Cost Rs.		52,900,000	6,612,500

6.4.3 LABOUR & SALARIES

Workers all grades 325 @ Rs.380/month average, plus 25% fringe benefits.

Total Wages/Annum	Rs. 1,852,500 ($231,600)
Labour/tonne paper	Rs. 320 ($40)

Staff and Administration

Total salaries/annum	Rs. 500,000 ($62,500)
Cost/tonne paper	Rs. 88 ($11)

Around 70 staff, all grades, would be employed.

6.4.4 PRODUCTION COSTS

	Quantity /tonne paper	Unit Cost Rupees	Cost/tonne Rs.	Cost/tonne $
RAW MATERIALS				
Straw	2.1	230	483	60
Rag	0.15	3,000	450	55
Waste Paper	0.25	2,400	600	75
CHEMICALS				
Caustic	0.30	3,000	900	113
Bleaching	0.16	1,500	240	30
Alum	0.08	1,100	88	11
Rosin	0.15	12,000	180	22.5
China Clay	0.10	600	60	7.5
Misc. Dyes etc.			60	7.5
UTILITIES				
Coal	1.5	220	330	41
Power	1500 Kwh	0.25	375	47

	Cost/tonne of paper Rs.	$
OTHERS		
Maintenance	104	13
Consumable Stores	120	15
Packaging & Despatch	120	15
Wages and Administration	408	51

6.4.5 SALES REVENUE

	Per tonne of paper Rupees	Dollars
a) Basic selling price	6,000	750
b) Excise Duty (25%)	1,500	187.5
c) Ex mill price, including duty	7,500	937.5
d) Excise Duty Rebate (50%)	750	94
e) Gross Sales Realisation	6,750	844
f) Selling Expenses (7.5%)	450	56
g) Net Sales Realisation	6,300	788
h) Annual Net Sales Revenue (based on 5,775 TPA)	Rs.36,382,000	$ (4,547,750)

6.4.6 PROFITABILITY

	Rupees/Annum	Per Tonne Rs.	$
Sales Revenue	36,382,000	6,300	788
Cost of production	26,091,450	4,518	565
Gross Margin	10,291,550	1,782	223

	Rupees/Annum	Per Tonne Rs.	$
Depreciation (8% on Plant Rs. 29,765,000)	2,381,200	412	52
Nett Profit Margin	7,910,350	1,370	171

Return on Total Capital 17%

Fixed Costs/Tonne of Paper
(Depreciation, labour and admin) Rs. 820

Surplus of Sales over Variable Costs Rs. 2,190

Break-even Point

$$\frac{820 \times 0.7 \times 100}{2,190} = 26.2\% \text{ utilisation}$$

6.4.7 COMMENTS

a) The project is viable, although long-term loans of Rs. 30 million and short-term working capital financing of Rs. 7.5 million would place a strain on the cash flow in the first two years, and the fixed loan repayments would raise the break-even point to nearer 50%. The real capacity is also 30 TPD which will ultimately be achieved.

b) No chemical recovery has been installed initially but it would be viable on the scale of the mill and the extent of caustic consumption. It will be installed when funds permit and will be necessary for pollution prevention because the burden over a period of years could be damaging.

6.5 30 TPD MILL: SPECIAL CASE

6.5.1 General

The foregoing case studies are intended to be representative of the many mills visited in respect of size and process. Book 2 presents more detailed case studies of actual mills in greater number and with full accompanying schedules. Since visiting India on several occasions, for the investigations involved, discussions have been held with Indian mill executives visiting England and the following, summarised account of one mill is presented because it came into operation in June, 1978 and is up to date, in respect of cost and results.

6.5.2 Description of Mill

The Company is Pondicherry Papers Ltd., and the Manager, Mr. P. Krisnen, provided the information summarised below. Mr. Krisnen is an example of the changing nature of management in small mills operation in India. He has years of background in the industry (was founder secretary of the Small Mills Association in 1967), is not owner or shareholder of the mill, but fully experienced and has assembled a team of young, qualified executives.

The mill produces writings and printings over the substance range 30 gsm to 60 gsm and waste-based wrapper, 150 gsm. The furnish is rice straw, plus surplus bagasse, waste paper and some imported pulp (from 10% to 25% according to substance). The imported pulp is unbleached sulphite, very cheap at $ 360 F.A.S. and it is beater bleached at the mill with 0.5% hypochlorite as bleaching powder. 10% of clay is also used as filler.

Straw Pulping is standard, as described earlier. There are 6-spherical digesters, one was intended for rag pulping but the imported pulp is more economical. Bagasse and straw are considered interchangeable. The dusting plant effectively depiths the bagasse used. Caustic addition is 8% on incoming materials and is obtained in liquid form 37.5% concentration. An Impeo vacuum washer is used followed by a Cowan screen and 3-stage centrifugal cleaners. Three stage bleaching, chlorine, caustic extraction and calcium hypochlorite follows, with vacuum washers.

The Rag System is conventional, a potcher-washer follows the digester and 6 beaters, with 90 HP drives were installed. Each beater could produce 1 TPD as beaten stock. Using imported pulp only 2 beaters are required.

The Waste Paper System is also conventional, for India, comprising 2 Hydrapulpers, 1 high density centrifugal cleaner and a Johnson screen.

Stock Preparation comprises 2-wide angle refiners and 2 - standard conical refiners, for blended stock. A selectifier screen and 3-stage centrifugal cleaners are incorporated.

The Paper Machine was imported second-hand. It is 180" trimmed width and can run up to 200 metres/min. with a mechanical, line-shaft drive and standard DC motor, AC motor-generator prime mover. The machine was originally designed to make greaseproof paper and has an unusually long wire, 25 metres, which is an advantage for slow, straw-based stock. The wire section is of all foil type with a suction couch. There are two Venta grooved presses with top granite rolls. The dryers are as follows:- Pre-dryers, 14 - 5'-0" diameter, in two sections, with 2 felt dryers; a size press follows and 8 - 5'-0" diameter after dryers with 2 felt dryers. A 5 roll calender follows and an additional roll will be added because odd number roll calenders cannot use all rolls effectively.

Finishing

A Masson-Scott winder, one duplex and one simplex cutter, both of Indian manufacture, are installed. The duplex cutter has 5 unwind stands and the simplex cutter 8 unwinds. 75% of output is as sheets.

Services

Water is obtained from 3 boreholes and consumption is 20,000 g.p.h. Two boreholes are sufficient for normal consumption.

Power is purchased from the State Grid and 3,000 KVA capacity is installed. Average load is 2,200 KW, peaking at 2,500 KW.

Steam 2 Wansan (Indian) boilers are installed, each of capacity 5.65 TPH at 10 atmospheres pressure.

Effluent is treated with a primary clarifier, followed by aeration in lagoons. It is then discharged to the sea, just one mile away. Fibre recovery, over an inclined wire screen is incorporated. A consultant, Mr. Narasirnhan, of Cellulosic Consultants (India) Private Ltd., was engaged for mill design.

6.5.3 Product Range

In its first year of operation the mill produced 7,000 tonnes but the average substance was 45 gsm. This is exactly 70% utilisation but for the first years operation and such a light substance, a good performance indeed, because the design was for 30 TPD at 60 gsm. They have achieved 41.2 TPD but on unsized papers. (i.e. without the size press in use which adds 25% to drying capacity). Normally it is used with modified starch, purchased as such and cooked at mill.

The writing and printing papers are sold for Rs. 5,500/tonne ex mill average but they also produce blue match paper, of lighter substance and higher sales value. Transport must be paid by customer.

6.5.4 Manpower

The total number of permanent employees is 250 plus 100 casual labourers. Fringe benefits include free medical care, subsidised canteen and a bicycle per worker, which becomes his own property after 5 years' service. Graduate executives are paid Rs. 25,000/annum on average.

6.5.5 Financing

Total Project cost was Rs. 44,000,000 ($ 5,500,000) equivalent to less than $ 700/annual tonne. It was financed as follows :-

Loans	Financial Institutes	Rs. 22,000,000 @ 9.5% interest
	Deposit loans from paper distributors	Rs. 3,500,000 @ 9.0% interest
	Government subsidy	Rs. 1,500,000
	Equity	Rs. 11,000,000
	Total	Rs. 38,000,000 ($ 4,750,000)

This was the original estimate and, in consequence, there was a shortfall of Rs. 6,000,000. Of this, Rs. 1,500,000 has been paid back in the first year and it is confidently expected to clear the whole in the coming year. The indicated return on total investment is 12% and on equity 75%.

6.5.6 Comments

a) The profitability of this mill, in its first year is remarkable because its product, being surface sized, is above average in quality and the selling price is below average.

b) The low capital cost/tonne, about one third of that for a large scale mill is due in some measure to the second-hand machine, but not entirely - pulp mill, stock preparation plant and finishing cutters are of Indian manufacture, plus all services equipment.

c) The machine is above Indian average for producing quality papers, having foils for the wire part, Venta presses with granite top rolls and a size press, but there is nothing about it which could not be made in India and it should serve as a model. The first years' production, reaching the 70% standard of utilisation on such lightweight grades, is an indication of the improvements possible.

d) There is very little instrumentation or control in the mill and the absence is recognised by management and the executive staff as a priority to be filled when funds permit.

e) The significance of purchasing low grade long fibre pulp and bleaching it at mill should be appreciated. It is cheaper in capital and operating costs than rag pulp, the originally designed furnish and a real benefit to mills situated near a sea port as this mill is.

f) The Manager appreciates the value of the bagasse contribution and has plans to extend in this field but believes that paper mill and sugar mill should have common ownership and management for optimum benefit.

CHAPTER 7

IMPLICATIONS FOR DEVELOPING COUNTRIES

7.1 GENERAL

7.1.1 Appropriate Scale

The word 'scale' has several connotations bearing on the pulp and paper industry for developing countries and all should be taken into account when planning for present and future needs. Reference has been made earlier in this book to most of the factors which have a bearing on scale but the emphasis has been given to circumstances applicable to India. Many of these scale issues have a corresponding influence on other developing countries but some will be different. The paragraphs which follow are intended to cover all aspects believed to be applicable.

7.1.1.1 Population and Market

The population of India, 650,000,000 obviously represents an enormous and varied market potential. Although present consumption, per capita per annum, is only 1.8 Kg in India, it still represents well over one million tonnes of paper per annum. If large scale plants are viable anywhere, India would seem to be well suited to receive them, but they have been tried and cannot compete with the small mill on equal terms. If this is true of India, how much more true is it of developing countries with small populations. The writer was involved at one time in a feasibility study for a developing country in South America with population around 1,500,000. Consumption, in all grades was 20Kg/capita/annum and suitable fibrous material was available in abundance. All paper was imported and the government was understandably anxious to eliminate or reduce the adverse currency effect. An elementary calculation shows that one single machine mill of 30,000 TPA capacity would supply the total requirements, but such a mill would not have been practical for all grades involved. It is not good practice to mix brown and white grades in the same, single-machine mill. It was a stipulation that the plant should be to "most modern" Western technology. The resultant mill would have cost $100,000,000, would have required a duty protection of 40% or a total ban on imports and selling prices 25% above imported prices. Not surprisingly, the project was not considered to be feasible and imports continue. By Indian standards 3 - 10,000 TPA mills could have supplied the whole range of products at one third the capital cost; could have been strategically located where materials and market were most suitable; could have sold the products at <u>lower</u> prices than imports, taking into account the inland transport costs, and could have met the prime objective of reducing currency outflow. At that time, the small-scale integrated mill was considered to be a non-starter; consultants of international standing had said so! Now that it has been demonstrated beyond doubt that small mills in India are not only viable, but actually contribute by a levy (above taxes) to the government, developing countries of small population and demand can be assured that integrated paper manufacture is practical and viable. India can supply machinery and initial commissioning at prices impossible to match from Western sources.

7.1.1.2. Financing

The large mill can now be afforded, in developing countries, only by governments and even then, only on the basis of very favourable financing involving a large proportion of low interest long-term loans. The product almost invariably requires subsidy which usually takes the form of higher prices. The writer knows of such mills; large by Indian small mill standards, but relatively small by international standards, which, at the feasibility study stage, postulate duty protection up to 60% to ensure viability. Even where results match forecast (which is seldom the case) the outcome is expensive paper, defeating its first principle, that it should be cheap and available to the poorest. The small mill, as we have seen, given suitable conditions (not easy ones because 2:1 as loan: equity gearing cannot be considered easy) can be set up by private enterprise which offers several advantages. The first is speed of commissioning (2 years instead of 5); the second is location because the choice of sites is wider and the third, perhaps most important of all, is growth. The attendant advantages of employment and training have already been stressed.

7.1.1.3. Raw Materials

Few developing countries have natural wood resources sufficient for scale, even where scale can be accommodated by market. Some developing countries have forest areas of tropical hardwoods and see them as a means of affording scale by combined timber and pulping operations followed by reafforestation with quick-growing hardwood species with pulp potential, such as eucalyptus, gmelina or even some pines. The overall capital costs are enormous but are justified, at least at feasibility stage not by the home market but by future pulp export prospects, based on the premise that world demand for pulp must continue to grow at rates which have been experienced over the past ten or twenty years. The implication of these ventures are worth considering in more detail and will be reverted to later. The significant facts are that in straw and bagasse especially, the material to satisfy home needs is already available and harvested annually, not requiring infra-structure costs to any material extent. The international consultant, sincerely believing that only scale can be economic and knowing that even if available in the quantity required for a large mill, raw material transport and storage costs would be prohibitive, has largely ignored these materials for many years. Recently, in the absence of the giants, some attention is being given, particularly to bagasse which can have scale sufficient to justify consultants. The notion that a small mill can economically be supplied with straw or surplus bagasse and still be viable has yet to be accepted, understandably because acceptance, particularly with standardisation, implies a minimum of consultancy contribution. The small mill is suitable for agricultural residues, undoubtedly competitive in cost and can also be competitive in quality, within reasonable limits. The recent developments in pulping and recovery processes are likely to improve on this situation.

7.1.1.4 Appropriateness

The large mill has a prestige attraction for the governments of developing countries but it contributes little to its real socio-economic prosperity. For some of the poorer countries it cannot be considered at all; the sheer magnitude of cash requirements raises a barrier too high to surmount and the inevitability of imports is reluctantly accepted and paper for education becomes a luxury. Financial aid is not available for small mills because the principle has not yet been accepted as sound by international "experts". It is earnestly hoped that this book with its supporting evidence will bring about a change in attitude both from organisations giving aid and governments who need it, because the most practical way of introducing a paper industry is a number of small mills, where experience can be gained by many at a level of technology which can be absorbed and built upon.

The large mill needs expatriate technology for design, building, commissioning and in many cases operation. In addition there is an inescapable import committment for spares, clothing, roll-covering etc. Operational techniques apply as much to the sophisticated supporting services equipment as to the fundamental pulp or paper plant. In many cases they are as great a cause of breakdown or inefficiency. The small mill offers the opportunity of learning by easy stages, not simply how to make paper but how to operate boilers, water-treatment plant, electrical systems, maintenance workshops etc. and the learning is achieved by doing, not by watching. So long as the production is economically viable, as it is now shown to be, this must be the most practical way to start. Slowly, too slowly, this truth is being appreciated by organisations giving aid to developing countries and interest is beginning to be paid to the potential of smaller installations. The subject is worthy of closer and more urgent attention.

7.1.1.5 Imported Pulp

So far this book has concentrated on integrated, or waste-paper based mills, although one mill described in the case-study section used sulphite softwood semi-bleached pulp for the long fibre requirements, because it was cheaper than rag pulp, not intrinsically, but because the grade, unbleached sulphite, is obsolescent and evidently sold as contribution rather than profit. It was mentioned in paragraph 7.1.1.3 that in some underdeveloped countries with large tropical hardwood resources, the concept of building large-scale pulp mills for export pulp, improving the grade by afforestation, has been adopted and a number of such mills are in operation or under construction. Long-term viability is expected based on forecasts for increased pulp requirements. In turn these forecasts are based on the assumption that developed countries will continue to maintain or increase their current levels of production and underdeveloped countries less fortunate in wood resources will stimulate further demand. Both assumptions are suspect. The silicon-chip will almost certainly revolutionise communications in the developed world, at the expense of paper grades in the commercial world.

The small mill in developing countries if properly exploiting its natural resources, will not need to import pulp, as such, or paper. There could be a glut of pulp and paradoxically, this could assist the small mill in developed and underdeveloped countries. It makes it possible to consider importing pulp for starting an industry. This leads to the final observation:-

7.1.1.6 Modernity

Given the attention deserved to the development of processes for the small mill, rather than the present pressures to make large-mill processes fit small-mill circumstances, the economic and other advantages of 'small' will be enhanced and 'modern' technology will move in this direction. In developing countries higher manpower requirements have been quoted in this book as an advantage, not a handicap. It can be played either way. Given the same attention to low-cost controls the small mill can be labour-economic also, with greater effectiveness because management is more efficient. This has no immediate implication for developing countries but it has an interesting longer-term one. In the race for the big and giant industrial installations, the developing countries face an insoluble problem; they are behind and cannot reverse this situation. When small is efficient and standardisation more economic than innovation they can catch up. For paper, India could, with applied effort, lead the world.

CONCLUSIONS

1. Small paper mills ranging in capacity from 5 to 30 TPD are viable in India; their contribution to overall comsumption is currently approaching 20%, can be expected to reach 30% within the next 5 years and should continue to grow thereafter.

2. Whilst the rapid growth in the number of small mills over the recent years has been stimulated by official Government policy and encouragement, viability in absolute terms is not dependent on Government incentives. The ex-mill selling price of the papers produced would be competitive against imports.

3. Viability is principally due to the low investment costs per unit of production for the small mill; these are shown to be around one-third of the corresponding cost for the large mill. The burden of financing costs is proportionately smaller.

4. The combination of small scale and low investment costs per unit of production has created a field for private industry, accelerating growth with minimum government contribution and locating mills all over the country in areas where the demand exists.

5. Transport costs are greatly reduced when demand is satisfied by small mills strategically located. This factor has a reat influence on viability and can be expected to grow in significance with the inevitable increases in fuel costs.

6. The range of paper grades produced by small mills cover the whole field of requirements except for newsprint, which is less than one-third of the total, and is mainly imported.

7. Agricultural residues, in particular straws and bagasse, are available in quantity all over India and can be used to produce, with minimum long-fibre reinforcement, good quality paper.

8. The socio-economic benefits arising from the small mill policy considerably out-weigh those arising from the large mill philosophy. Direct employment is greater, approximately three-fold; is spread into rural areas; creates other supporting industries locally; promotes industrialisation at a rate which can be absorbed and minimises the need for imported expatriate services. Agriculture benefits directly from increased income and indirectly from improved services.

9. Machinery requirements can be satisfied by indigenous machine manufacturers who are increasing in number with the demand for small mills. Versatility and capacity have now reached the level where all the equipment for an integrated pulp and paper mill in the specified "small" capacity range can be obtained from Indian manufacturers. This further increases employment potential and provides opportunities for training skilled engineers and tradesmen.

10. The small mill in India can compete with the large mill, even when efficiency is low, but the current incentives do not encourage improvements. It is suggested that, having achieved the first objectives, the basis for incentives should be reviewed.

11. Improvements in efficiency and quality of product are possible with relatively low expenditure and should be encouraged. The small mill has inherent advantages in both aspects and should exploit them. Standardisation is recommended.

12. Improvements in pulping techniques for agricultural residues are emerging and should be encouraged.

13. The Indian experience in small mills can be repeated in other developing countries and is far more appropriate to their needs.

14. Indian machinery manufacturers can offer complete integrated mill machinery plus erection and commissioning services at very low cost by comparison with suppliers from developed countries, who are not competitive in the small mill field.

15. The "modern" large, sophisticated mill can only be financed by governments or large, multinational organisations which do not exist in developing countries. Financing may be made easy for governments by long-term, low-interest loans, so that the ultimate cost is lessened by inflation. However, the advantages are mostly to the seller who remains ahead in development, widening the industrialisation gap and drawing continuing income from spares and services. In socio-economic terms, the buyer loses and industrialisation is retarded.

TECHNICAL POSTSCRIPT TO 2ND EDITION

P.1. Current Situation

The first edition of this book was published in 1979; it was sold out by 1981 requiring this second edition to meet a continuing demand. The period of two years since the first publication is relatively short in terms of measurable progress and has coincided with the worst period of world-wide economic recession for at least 50 years, principally due to spiralling energy costs. Nevertheless, over this period when circumstances could hardly have been less encouraging progress has been made, greater in extent than was anticipated at the time when the first edition was written and the case for the small mill in developing countries has actually strengthened. The practical and economic range of products has also been widened, to the extent that for some grades of paper in favourable areas of the more developed countries the small mill is also making some impact. There are indications that the concept of small being viable and more appropriate for a significant proportion of the future world market has begun to interest some large internationally recognised organisations with substantial technical resources. If anything, the world-wide recession has enhanced the case for the small mill. As a first impression, over such a short period, this is a surprising outcome. Greater consideration, taking into account all the circumstances, suggests that we may be experiencing the first stages of an end to a profligate era dominated by large-scale expansion viable only under the impermanent conditions of low-cost energy and a sustainable export market for manufactured products from the affluent developed world to the poorer, more highly populated developing countries. As Carlyle remarked, referring to the circumstances which led to the French Revolution, "a lie cannot endure for ever". The age of under-valued energy has certainly passed and the third, developing world has neither the will or the resources to import products whose prices, substantially increased by higher energy manufacturing costs and labour costs struggling to maintain an unrealistic standard of living, are still further increased by rising transport costs. These conditions improve viability in developing countries for local manufacture from indigenous resources. Small scale is essential for market and financing reasons: experience is steadily demonstrating that it can compete with large-scale particularly in the pulp and paper field.

The purpose of this additional chapter to the second edition of the book is to indicate the progress which has been made since the first edition was published and what the prospects for further progress might be.

P.2. India

The first edition of this book was based on practice and developments in India because the small mill philosophy is most widely and successfully established there. To a large extent this has resulted from Government encouragement to private industry, not so much in positive subsidies, which even for special areas are relatively small, as in reduced restrictions and easier financing.

Under "Conclusions", page 142 of the book, the first paragraph reads:- "Small paper mills ranging in capacity from 5 to 30 T.P.D. are viable in India, their contribution to overall consumption is currently approaching 20%, can be expected to reach 30% within the next 5 years and should continue to grow thereafter.

A review made this year suggests that this was a very conservative statement. The proportion of overall production now contributed by the small mill is estimated to be nearer to 40% and is expected to reach 50% within the next 5 years. The January 1981 edition of the publication "Pulp and Paper International", under the heading "India" in its 1981 Preview states that to meet the forecast demand increase of 762,000 T.P.A. (based on 10% annual growth rate) by 1984-85, the end of the sixth 5-year plan, 529,000 T.P.A. will have to be created in the private sector from indigenous resources. The small mill emerges as the quickest and nationally least expensive means of meeting these objectives.

There have been two significant changes in Government encouragement. As from the end of May, 1981, import of second-hand paper machines is no longer permitted. Previously, import was allowed, subject to a limitation on price and capacity (not to exceed 30 T.P.D.) and guarantees of mechanical worthiness. Entrepreneurs were not slow to take advantage of the opportunities offered by this relaxation of import restrictions and it is probable that such machines were responsible for a significant proportion of the production increase referred to above. Two of the case histories outlined in the book (items 6.4. and 6.5., pages 126 et seq.) are based on imported machines. Overall capital costs are estimated to be 10% less and the overall time required for commissioning reduced to within one year from project launching. More significant, import of such machines has introduced designs based on technology of the 1960's or even later, a considerable improvement on indigenous design, based largely on standards applicable to the 1930's. U.S.A. and the Continent have been searched for suitable machines and the best of those available within the price limitations were quickly snapped up. M.G. machines in particular were greatly in demand. The Indian Government evidently consider that domestic manufacture can now cope with demand but the standards of design and workmanship have undoubtedly been improved by the introduction of the wide range of machines which were imported. As a side comment, the experience in India of installing reliable second-hand machines has been successful and their withdrawal from the field of purchase offers opportunity for entrepreneurs in other developing countries to follow the example.

Permission to import waste paper was also conceded in 1980 and this has had a stimulating effect on production, particularly in port areas such as Bombay. The timing was appropriate; the world-wide recession has led to a surfeit of waste paper and good quality supplies can be brought in at landed prices considerably below those applicable to indigenous manufacture. This advantage is, of course, soon lost by transport costs for inland mills and the current, relatively low-priced waste paper surplus may be a temporary phenomenon but the stimulus to production must strengthen the industry and widen its base for future expansion.

It is somewhat ironic to reflect that importing waste paper from developed to developing countries represents a reversal of the traditional trade flow. The developed world built its industries to a considerable extent by importing low-cost raw materials from undeveloped countries and exporting manufactured goods at added value prices. Waste paper is a raw material now returning from developed to developing countries. Its availability does, however, present opportunities for small-scale, low-cost mills to establish an industry which becomes increasingly self-dependent as levels of consumption increase. Where waste paper is processed it is worth considering that importing one tonne is really equivalent, in areas where waste collection is organised, to obtaining 1.3 to 1.4 tonnes of raw material because 30% to 40% can be expected to return to the mill for reprocessing.

P.3. Other Countries

It has been brought to attention, since the book was first published, that manufacture of small paper machines, capacity 5 T.P.D. and upwards continues in some European countries, chiefly for export to developing countries and a similar situation exists in Japan. Some companies, notably in Italy, now actually specialise in the very small and have developed effective designs for such machines which in terms of capital cost per unit of production are competitive with the larger units. Small tissue mills, of 5 to 10 T.P.D. capacity, for the production of facial and toilet tissue grades, represent perhaps the most popular field. If based on local or imported waste paper, the capital cost is small, within the field of private enterprise, the demand for resources of power and water are not excessive, effluent treatment requirements are minimal and operation is simple. Mills of this category can be sited close to population centres representing both the market and the source of raw material with minimum transport costs. The finished product has high added value ensuring overall viability with no long-term protection requirements. Installations in Africa, South Amercia, the Caribbean and other areas have been recorded in the trade press. Mills of this nature represent perhaps the best introduction to the paper industry, offering good returns on moderate investment at least risk. They also present opportunities for learning at a rate capable of assimilation by inexperienced labour. Turn-key, complete packaged-deal contracts, including commissioning can be obtained and are almost standard.

The same companies produce specialised small machines for other paper grades over a wide range. There are also some indications that the production of low-cost, fully integrated pulp and paper mills of small capacity based on straw or other agricultural fibre sources, is being studied by several organisations.

P.4. Technological

P.4.1. Pulping Processes

As the book has shown, in the examples quoted, Indian practice for small mills has been based almost entirely on the spherical, rotating, batch digestor which was the fundamental unit of the very early mills and remains so. It is produced very cheaply by a number of Indian manufacturers and predominates for bleached grade products from straw, or long fibre constituents from textile wastes such as cotton, jute, etc.,. For mills around 25/30 T.P.D. capacity however, up to six such digesters are needed and there are disadvantages, chiefly in uniformity and control which influence product quality and machine efficiency but also in excessive steam consumption. There is a case for an effective, continuous pulping process suitable for agricultural residues at low capacity, 10 to 30 T.P.D. To the writer's knowledge no Indian manufacturer produces such equipment but there are at least two such systems available from European source now being offered and their appeal, although applicable to the Indian market, is probably even greater for developing countries which do not have equivalent manufacturing resources. The spherical batch digester outside of India is almost four times the cost of the same unit in India.

P.4.1.1. The Sulzer Escher Wyss system, illustrated in Figure 14 is specially designed for small-scale continuous digestion of straw, bagasse, reeds, etc.,. Chopped and dusted straw is fed to a pulper to form a slurry at around 5% consistency. Caustic soda in the form of white liquor and a proportion of returned black liquor is added continuously under metered control and live steam to raise the temperature. Impregnation takes place and the rate of input and extraction is such as to ensure around 10 minutes duration in the pulper/impregnator. Continuous extraction is effected by a specially designed pump which feeds a dewatering screw under controlled pressure. The slurry consistency is raised to 15% and the extracted water is returned via a centrifugal cleaner to the pulper. The impregnated, dewatered straw then passes, under pressure maintained by the pump through three horizontal digester tubes in series. The first tube is the pre-pulper, the second tube the main pulper and the third tube the disintegrator. Each tube is equipped with a rotating spiked shaft to promote good mixing and forward pulp flow and each is fed with live steam at around 4

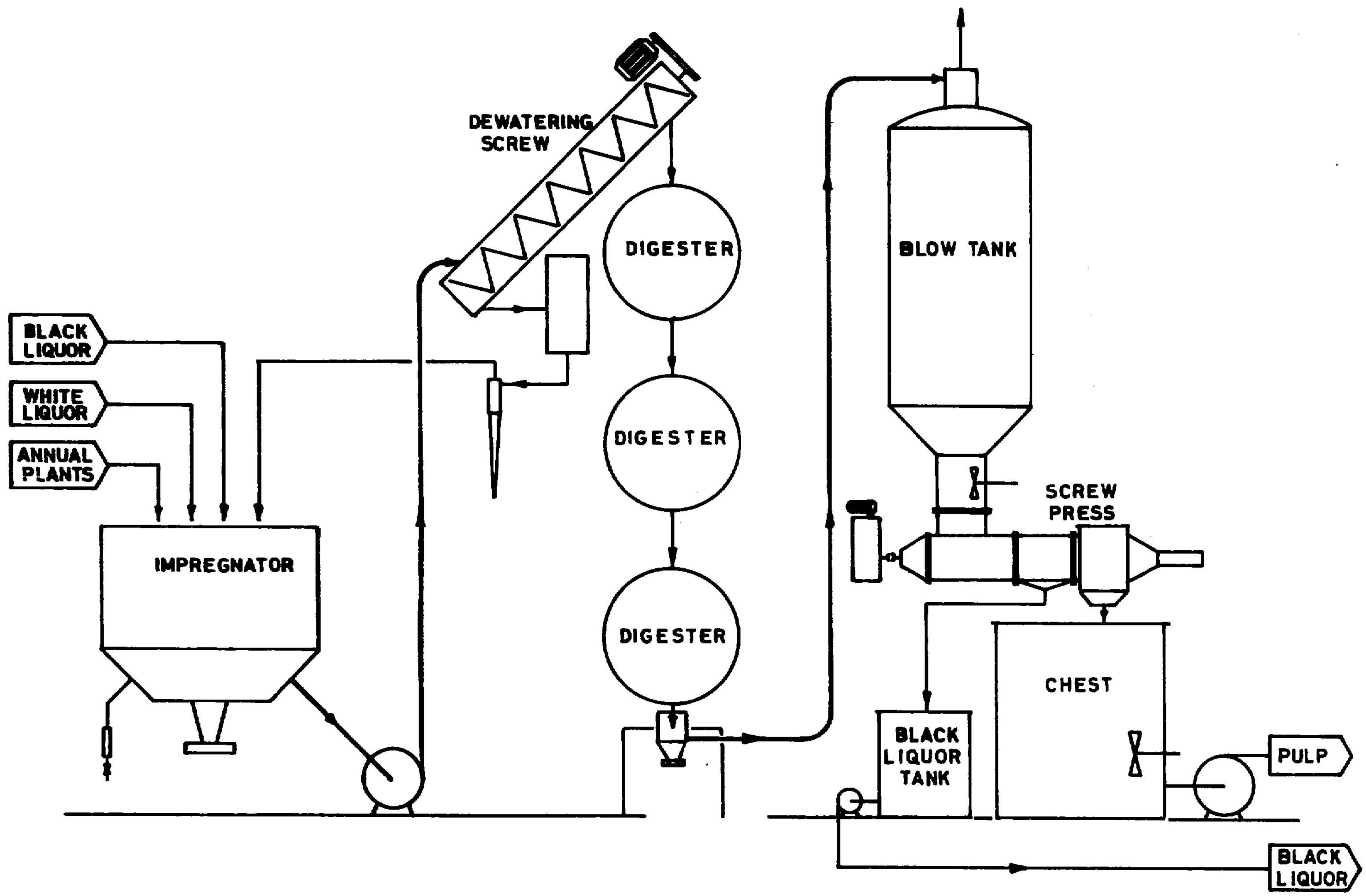


FIG 14 SULZER-ESCHER WYSS PULPING SYSTEM

atmospheres pressure. From the final digester the pulp passes through an expansion valve device to a blow tank vented to atmosphere and connected at the bottom to a screw press which expresses black liquor and sends the cooked pulp at about 25% to a storage chest where it is diluted to 5%. From this point on normal washing and cleaning procedures apply.

The advantages claimed are more uniform control with improved pulp quality, lower steam consumption, around 1.3:1 steam to bone-dry pulp (which is about 1/3 the quantity used by the batch digesters) lower maintenance costs, lower chemical consumption, lower labour requirements and better conditions for chemical recovery with higher black liquor concentration.

P.4.1.2. The SAICA process is illustrated in Figure 15. It handles straw direct from storage, the equipment including a hammer mill to reduce the material to an appropriate size for pulping and dislodge pith, grit, etc.,. The digester is an inclined, steam-jacketted vessel through which the straw is propelled by two slowly rotating internal screws. Caustic and some returned black liquor are introduced through a vertical entry impregnation chamber. Cooking is at atmospheric pressure, involving no special valves or seals and the cooking cycle is around 2 hours, which contributes to pulp quality and uniformity. Wash water is introduced at the exit end to provide a built-in, first stage of counterflow washing. This feature, combined with the atmospheric, indirect steam cooking eliminates the need for a blow tank. The cooked pulp is dewatered through a screw-press and the extracted liquor is re-introduced at the exit end of the digester to move, with the wash water, counterflow to the straw and the final black liquor emerges at the entry end concentrated for recovery or disposal. The system was primarily designed for high-yield corrugating medium production from straw and includes a shredder and refiner but it is also suitable for bleached pulp production from straw, bagasse, or similar materials. It is very economical in terms of steam, chemical consumption, water and boiler feedwater, is extremely simple to operate, having minimum controls and is capable of producing high quality pulp with minimum labour requirements in terms of numbers and experience. The digester and feeding equipment require no buildings, reducing capital costs, and maintenance is claimed to be minimal. The process has been working satisfactorily for many years at the SAICA mill in Spain where it was developed and an active research and development section has continously improved the performance to meet the exacting demand of European competition.

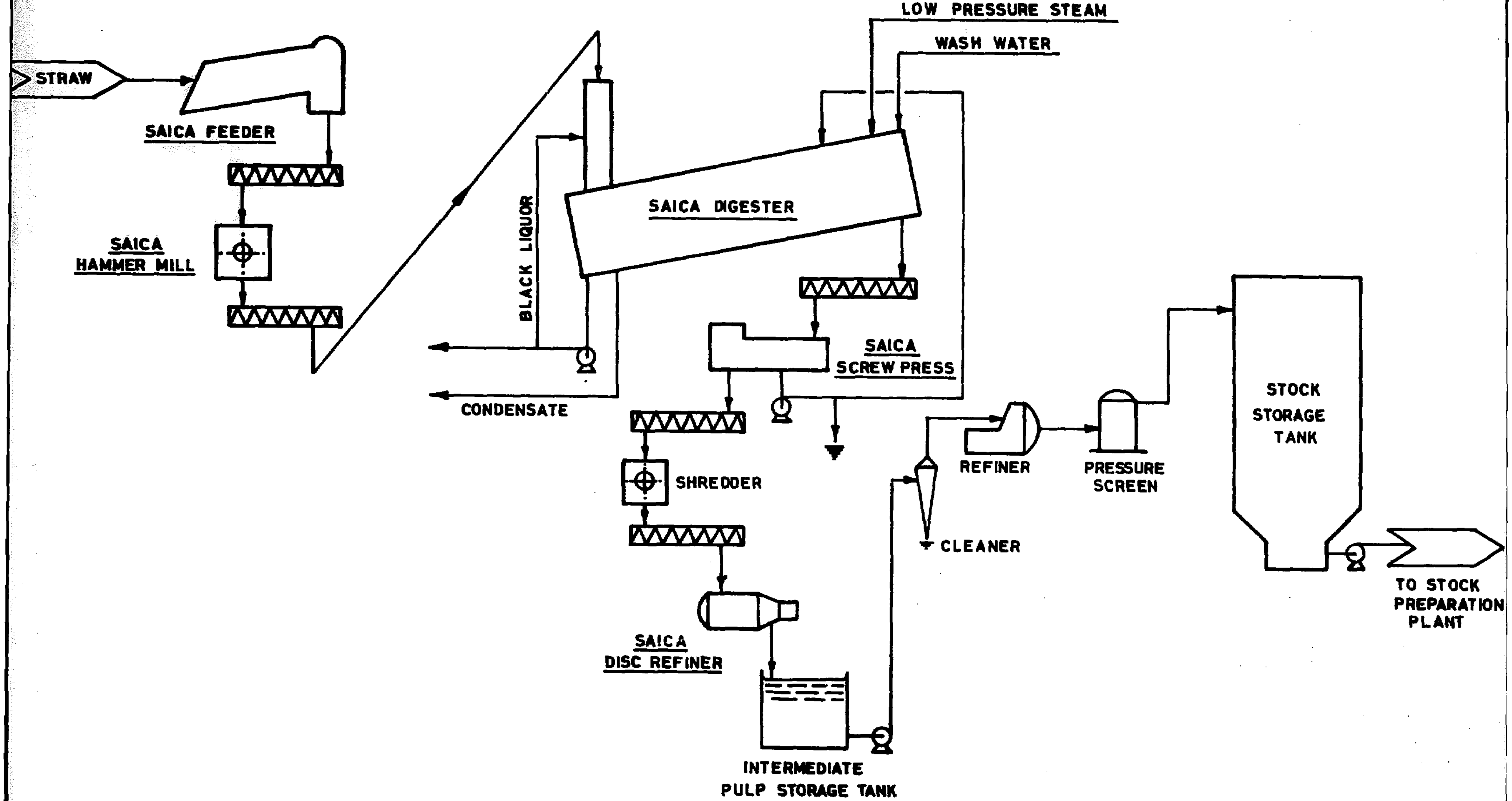


FIG 15 "SAICA" PROCESS BASIC FLOW DIAGRAM

P.4.2. Chemical Recovery

Article 5.1.8. of the book, pages 93/4 describes the processes and systems being employed in India at the time of publication and states that the small mill is disadvantaged in this respect. For the large mill, efficient chemical recovery is combined with steam generation to present an overwhelming economic case but the limit for combined chemical recovery and steam production has generally been recognised as around 100 T.P.D. of pulp. The "roaster" system described, though economic in terms of chemical recovery at around the 25 T.P.D. level and above actually requires steam for evaporation, significantly offsetting the potential economy. The book emphasises the need for more effective recovery capable of emulating large-mill performance in small mills and it is now possible to report that considerable progress in this direction has been made.

P.4.2.1. The Sulzer Escher Wyss system is illustrated in Figures 16 and 17 and is claimed to be effective for pulp mills of capacity down to 10 T.P.D. The black liquor is concentrated by a triple effect evaporator to 35/40% of solid matter at which level the problems of viscosity are avoided and the liquor is self-burning. (The capital cost is also reduced, compared with that required for 5-stage, higher concentrations.) Combustion of the concentrated black liquor takes place in a combustion chamber, completely closed, at a temperature of about 950°C. The furnace is equipped with a special burner which atomises the black liquor into very fine particles by means of compressed air at around 10 atmospheres pressure. After combustion the gases are mixed with cold gases and cooled to around 650°C. The mixture is homogenised inside the tranquillisation chamber, where all the particles solidify, forming a very fine dust. The gases containing the dust are sent into a fire-tube boiler of vertical construction and then through an economiser of similar construction. Both units are equipped with pneumatic, automatic cleaning systems. The gases are finally washed in a washing tower and the inorganic salts are dissolved producing green liquor which is sent on to the recausticising plant to be converted to caustic soda by the addition of lime.

30 T.P.D. CHEMICAL PULP

BLOCK DIAGRAM WITH MASS BALANCE IN T/Hr.

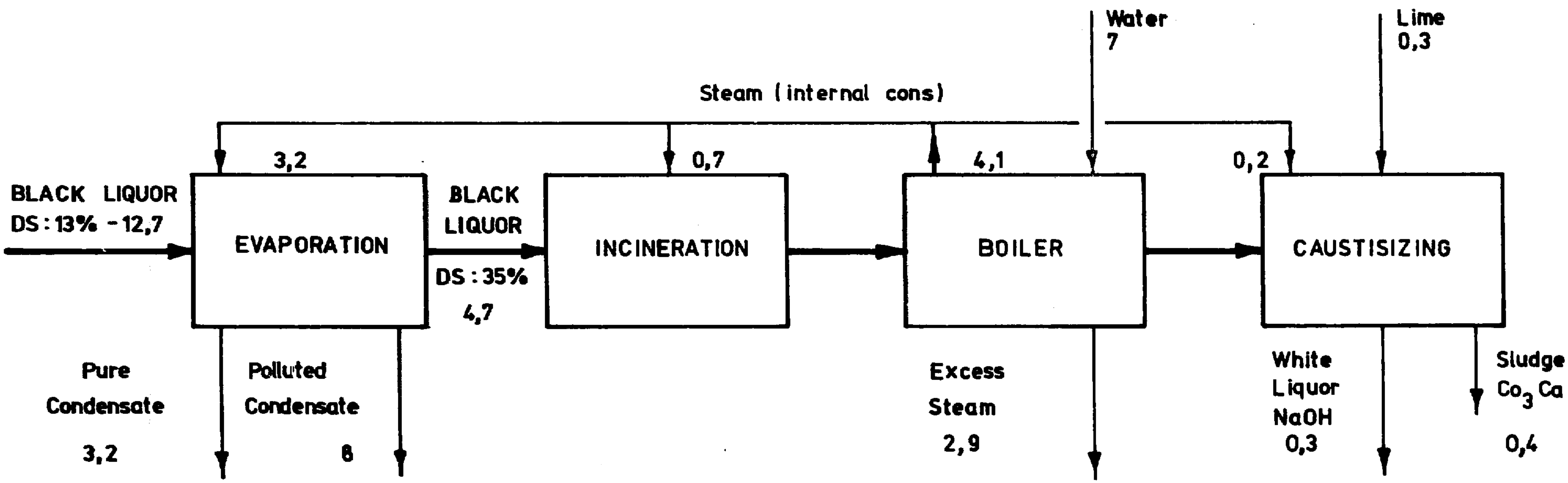


FIG 16 SULZER ESCHER WYSS RECOVERY SYSTEM.

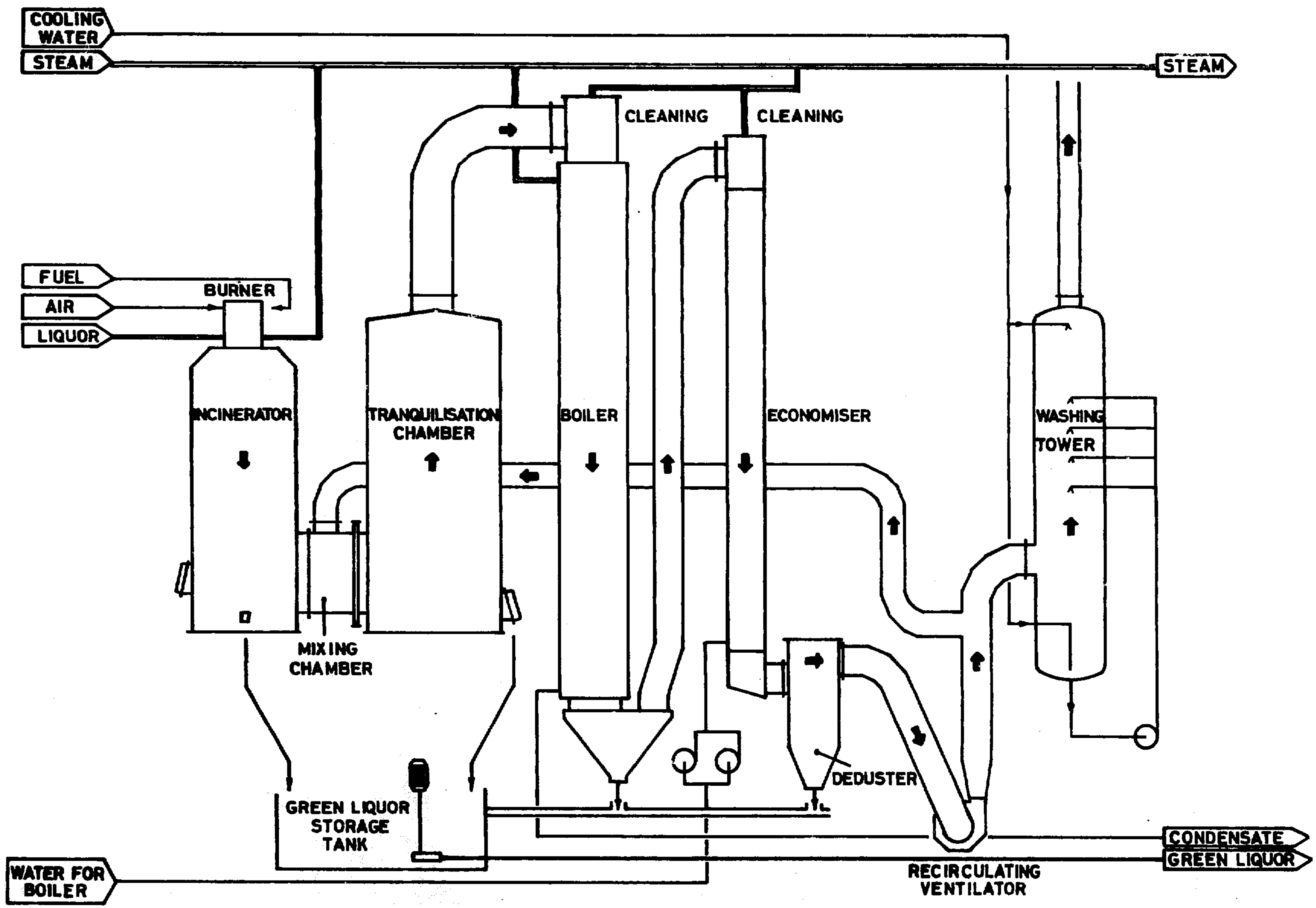


FIG 17 SULZER ESCHER WYSS RECOVERY SYSTEM

The plant ingeniously combines all the aspects of the standard recovery system but in separate compartments, with modified processing. The units are simplified resulting in competitive capital costs. The overall process efficiently recovers chemical and is self-sufficient in steam generation with some contribution to process. Development of the plant should be a significant contribution to the viability of the small, integrated mill, contributing simultaneously to lower chemical and energy costs and greatly reducing the effluent burden.

P.4.3. Anaerobic Fermentation

Extensive research and pilot plant operation now indicates that where full chemical recovery may not be practical or economic because of small scale or high yield pulp with too small a combustible organic content, it is possible to achieve a significant reduction in effluent burden with a contribution to fuel costs by anaerobic treatment. The SAICA company state that such treatment is successful provided that the effluent temperature is within the range $30^{o}/40^{o}C$, that a sufficiently high organic content is available ($B.O.D._5$ above 3,000), that the effluent is alkaline, contains some nitrogen and is virtually free of dissolved oxygen (less than 1 p.p.m.) and toxic products. As a generality it is stated that for an effluent with C.O.D. 10,000 to 70,000 (equivalent to $B.O.D._5$ 4,000 to 30,000) mg/litre of oxygen, at a temperature of $35^{o}/37^{o}C$ and pH 7 to 10, anaerobic fermentation by contact will require hydraulic retention times from as low as 2 days to as long as 6 days. A reduction in $B.O.D._5$ of 60% to 80% (40% to 60% in terms of C.O.D.) can be expected and methane gas production will be approximately 130 to 200 litres of CH_4 per kg of C.O.D. feed. The gas produced is 60% to 75% CH_4 and 20% to 30% CO_2. The calorific value is approximately 6,000 Kcal/litre.

It is appreciated that this is only a first stage and that further treatment may be required where statutory effluent standards are high but it is claimed to be an economic stage in terms of cost and yield and should have appeal for small mills which cannot justify full recovery but have obligations to reduce effluent pollution.

P.4.4. Newsprint

Under "Conclusions" Item 6 page 142 of the book it is stated that "the range of paper grades produced by small mills cover the whole field of requirements except for newsprint.......". The range is now complete; newsprint from bagasse has become an accepted product and it is understood that a project for India has now been authorised. The scale is not known but processes with a wide capacity range are being advertised and, unlike newsprint from wood, there are no intrinsic process limitations to preclude small scale. Bagasse-based newsprint is being produced commercially in Mexico and Peru, large-scale but the scale is set by the paper machine and market, not the process as such. There are interesting implications in this field for the small, integrated mill. The only remaining limitation is the internationally low selling price which makes other grades with greater added value more attractive but rising transport costs improve the economics of indigenous production and, with currency shortage may inspire investment in small-scale operations.

P.4.5. Process Improvements

Over recent years the use of anthraquinone (A.Q.) as a catalyst to improve pulping performance has become recognised and is an accepted technique now for many major producers of kraft pulp. The material is expensive but minute doses are claimed to produce significant gains in terms of yield and strength. Trials have recently been made to evaluate the effect of A.Q. on straw pulp, cooked by the caustic soda process. The results suggest that A.Q. is more effective with soda cooking and indicate significant benefits in yield, cooking time, chemical consumption and strength. All are of value to the small mill producing pulp by the soda process and claims made appear to justify the A.Q. addition on its own merits. However, where short-fibred raw materials such as straw are concerned perhaps the most valuable potential lies in the strength improvement because this book has emphasised the shortage and need for long-fibre substitutes in developing countries. To the extent that the inherent strength of straw, bagasse etc., pulps can be improved the proportion and expense of long-fibre support can be reduced and this could be a major contribution to the small mill. The tests reported to date have understandably been general in nature to determine the overall change in characteristics from varying A.Q. doses and they conclude that there is little gain in increasing A.Q.

much above 0.05%, a fortunate outcome because it is an expensive material. However, the tests also indicate that it may be possible to localise the gain by varying the other factors, for example chemical content, cooking time, pressure, etc.,. For wood-based kraft products improved yield may be the most desired result because strength is not a shortcoming. For the straw or bagasse based mill strength would be more important than yield. More work is obviously necessary to determine optimum treatment for any given fibre but the indications are that the small pulp mill could benefit substantially.

P.4.6. General

Technical progress is being made as the above examples illustrate and probably in other directions also. The examples given are, in the case of A.Q., a spin-off from technology originally developed for the large mill, and for the pulping and recovery treatments described, the outcome of design and development effort by large organisations with Research and Development resources. Although the case for the small mill can be seen to have strengthened in recent years, there is still room for improvement but it is unlikely to arise unassisted from within the ranks of small mill operators. The cost of research development and trials is high and for the small mill owner it cannot be offset against profits elsewhere. As a body, also, small mill owners are relatively inarticulate; their achievements or aspirations seldom attain expression in the leading technical journals. For these and other reasons progress up to recent years has been slower than desirable. The interest now being shown by some of the larger organisations is most promising and should be rewarding because the potential market is enormous. At the present time 64% of the total world population in the developing areas of Africa and Asia share less than 7.5% of the total world production in paper and board. These deprived areas actually produce themselves 75% of their own meagre consumption and cannot hope to attain more reasonable levels of consumption from imports. The small mill, based on indigenous fibre, is their only practical way forward; with application and comparatively small effort it should also prove the best, most appropriate way.

Acknowledgements

The writer is grateful to the Compagnie de Construction Mechanique Sulzer, Paris, France, and to Sener, Technica Industrial y Naval, Madrid, Spain, for information received in respect of the processes and equipment referred to in the foregoing and for permission to include the descriptions.

APPENDIX I

GLOSSARY OF TERMS USED

A.D. — Air-dry, i.e. containing moisture relative to the humidity obtaining. Standard levels are: market pulp is 90% dry and paper 95% dry in A.D. terms.

Ash — The incombustible residue after burning pulp or paper. It is used to determine filler content for paper or silica content for pulp.

Bagasse — The fibrous residue from sugar-cane after the sugar juices have been extracted by crushing.

B.D. — Bone-dry i.e. dried to the extent that all moisture has been removed.

Beating — The process of applying mechanical treatment to virgin pulp to improve its paper-making qualities. The name originated from the original "beater" used but can be applied also to treatment given by refiners.

Black Liquor — The wash-water obtained from washing cooked pulp. "Strong" black liquor is the same, concentrated by evaporation, ready for burning.

Bleaching — The process of "whitening" pulp or paper, improving its brightness.

Blow Tank — A closed vertical tank into which pulp cooked under pressure is blown to de-pressurise it, remove gases and dilute it.

Board — Normally multi-ply paper used where stiffness is required, as for cartons or boxes. The term can be applied to heavy single-ply papers.

Brightness — The degree of whiteness of pulp or paper. A measure, in numerical terms of the reflectance of light, as given by a photo-electric cell.

Brown Stock — Pulp which has been newly cooked and washed, but not bleached.

Calendar A stack of chilled iron rolls located at the end of a paper machine to even and smooth the paper surface.

Chemical Pulp Pulp which has been produced by chemical action on the raw, fibrous material. Normally a combination of chemical and heat is used.

Cleaners These are normally centrifugal separators, so designed as to remove very small sand or dirt particles from a pulp slurry. They can be used in stages, at high density (4/5%) or at low density (down to 0.25%).

Consistency The term is the measure of the amount of fibre held in suspension in a given quantity of water. A consistency regulator automatically controls consistency to maintain uniformity by adding water to a slurry which is too thick or heavy. It cannot remove water if the slurry is too thin.

Couch The last roll on a Fourdrinier before the paper sheet is separated from the wire is known as the couch roll and may be plain, felt jacketted or perforated with an internal suction box. The word is also a verb, to "couch off" describes the action of separating the formed paper from a wire wherever this is done, from a Fourdrinier, a former, a vat or a hand mould.

Crepe The word describes paper which has been separated from a roll or dryer surface before it is dry by a "doctor" or steel blade. The paper is "creped" or wrinkled.

Chemi-Mechanical The term describes pulp which has been partially cooked and brought to usable condition by additional mechanical treatment. The name "Mechano-Chemical" may also be used to describe this process.

Decker — A machine used to thicken pulp. The same process may include washing.

Defibring — The process of breaking down pulp, or recycled paper, into individual fibres.

Deflaker — A machine used for defibring; the rotating elements do not normally touch each other but preserve a small, sometimes adjustable gap.

Digester — The apparatus used to cook the fibrous raw material and produce pulp. It may be batch-type or continuous and is normally pressurised to cook with steam in the presence of chemicals. Liquid is used as a medium for the chemicals; steam heating may be direct, or indirect. The digester can be rotating (normal for batch straw or rags) or stationary, normal for wood.

Doctors — These are scraping blades used to "doctor" or clean press rolls or drying cylinders.

Fabric — The term has special significance, meaning a plastic substitute for woven bronze wires on Fourdriniers or screens, or for woollen or cotton felts used for the presses of dryers. A fabric press has a plastic woven wire running between the press felts.

Felts — These are endless blankets of wool, cotton or synthetic material used to support the wet paper in progress through the machine and, in the press section, to absorb expressed moisture.

Fillers — These are materials used to improve opacity, brightness or the printing qualities of paper. China clay, talc and, less frequently, titanium oxide are samples.

Flow-Box	The vessel at the beginning of the paper machine. Its purpose is to take the diluted paper stock and present it evenly distributed on to the wire at an appropriate velocity, free of flocculation. It is sometimes called the "Head-Box".
Foils	These are specially profiled plastic blades used to support the Fourdrinier wire upper surface. They remove water at a more controlled rate than tube rolls.
Formers	These are rotating cylinders covered with wire mesh, used to "form" paper instead of using an endless wire belt as in the Fourdrinier machine. They each have an incorporated flow-box which may be pressurised. They may have incorporated vacuum boxes or be gravity-drained.
Fourdrinier	The original continuous paper-forming wet-end comprising an endless wire mesh belt running on rollers. This design, with improvements, is still in use for modern machines.
Freeness	A term to denote the ability of a pulp slurry to lose water through a screen by natural drainage.
Green Liquor	This term is used to describe the solution of organic smelt and water resulting from chemical recovery by combustion of concentrated black liquor.
Groundwood	Pulp obtained by grinding wood in the presence of water is known as groundwood. The term "mechanical" pulp is synonymous. Refiner "groundwood" describes mechanical pulp produced by refiners.
G.S.M.	Grammes per square metre, a term used to denote paper substance or weight per unit area.

Hardwood	Wood from deciduous tress, normally short-fibre material.
Hydrapulper	Really a proprietary name to describe a machine used to slush pulp or waste paper. The name is loosely used to describe machines built for the same purpose, normally open tubs with rotors designed to break up and defibre the slurry.
Infrastructure	In paper or pulp terms this name describes the road, rail or other transport means necessary for the mill to function effectively. Canals, dock etc. may be included in some instances.
Kraft	The terms describes pulp made by the sulphate process, normally stronger than pulp produced from the same raw material by other processes.
M.G.	Machine-glazed, a term used to describe paper given a smooth surface on one side only by causing it to adhere to a ground, heated cylinder until it is dry enough to become detached. The term is loosely applied to the cylinder, although it may be used only for creped papers.
Pick-Up	The term describes the process of detaching the wet paper sheet full width from a wire or former. Normally suction is used and the term "vacuum pick-up" is applicable. Where natural vacuum occurs and is sufficient, as by a felt the term "lick-up" may be substituted.
Potcher	The term describes a relatively shallow vessel made usually of concrete or cast iron, divided by a mid-flatcher and containing a perforated roll to wash the pulp. It is used almost exclusively for washing rag-based pulp.

Pressing — The term describes squeezing wet paper between felts to express moisture. The process is static, for handmade paper but continuous on a paper machine. The press section of a paper machine comprises two or more sets of touching rolls through which the felt and paper pass under pressure applied by the rolls.

Recausticising — The term is used to describe the process of changing "green liquor" into caustic cooking liquor by adding lime and clarifying.

Refiners — These are compact machines used to "beat" or do mechanical work on pulp slurries to improve the paper-making characteristics to the degree required.

Rewinder — A machine used to rewind small reels of paper which otherwise could not be sold. The term is sometimes used loosely to describe a winder, because it also "rewinds" from the original machine reel.

Screens — These are devices to clean pulp slurries or to detach fibrous bundles. The pulp passes through perforations or slots and rejects remain behind. The screens may be open, vibratory, flat, drum-type or, now most common, pressurised with foil-section internal rotors.

Sizing — For writing and printing purposes paper is normally "sized" by adding rosin in solution. It then resists ink penetration. It may also be surface-sized using starch or other material at a size-press or tub-sized as a secondary process, using gelatine or other material.

Softwood — Wood from coniferous trees, normally having "long" fibres.

Suction Boxes — These are boxes with perforated or slotted tops located under a Fourdrinier wire to remove water from the paper above. They may also be used, with one continuous slot, on press felts to dry them continuously.

Suction Rolls — These are perforated rolls with a suction box inside. They can be used in the couch position or in the press section, to lift the paper from the wire or to remove water.

Supercalender — The term describes a machine used, as a secondary process, to impart high finish to paper or board. It is normally a vertical stack of rolls, alternately iron and cotton wool or other textile material.

Sulphite — A term used to describe chemical pulp produced by the sulphite process, once almost universal, now less popular.

Table Rolls — or Tube Rolls are relatively small diameter rolls supporting the Fourdrinier wire in the section immediately following the Flow Box. They also promote drainage.

T.P.D. — Tonnes per day.

T.P.A. — Tonnes per annum.

Twin Wire — An adaptation of the paper machine whereby paper is formed between two wires running in synchronism.

Winder — The machine following the paper or board machine. Its purpose is to rewind machine reels to reels of narrower width and smaller diameter and to remove faulty material. It is sometimes loosely termed a rewinder.

Wire — The endless woven wire (or plastic filament) used by a Fourdrinier machine to form the paper.

Woodfrees — The term is used to describe writing and printing papers containing no groundwood pulp, only chemically produced pulp.

Vats — Vats are used to describe the units used on a board machine to produce the individual plies in multi-ply board. The vat is actually the container for the pulp slurry in which the forming, cylindrical "mould" rotates.

Yankee Cylinder — An alternative term for the M.G. cylinder used to indicate its size, greater than normal drying cylinders.

APPENDIX II

SCHEDULE OF SMALL MILLS IN

OPERATION OR UNDER CONSTRUCTION

MAY, 1979

WEST BENGAL		Capacity per year.	Production during 1977.
1.	Western India Match Co. Ltd., Indian Mercantile Chambers, Nicols Road, Bombay.	7500 Tons Mill at Alam Bazar, Calcutta.	5062 Tons
2.	Shree Gopinath Paper Mills, 49/1, A.K. Mukherjee Road, Calcutta-50.	1080 Tons	131 Tons
3.	East End Paper & Board Mills, Pvt. Ltd., 18, Negaji Subhas Road, Calcutta 700001.	6000 Tons Barabaria, Hooghly Distt.	4320 Tons
4.	Priti Paper Board Mill Pvt. Ltd., 22 Burro Shivtola, Main Road, Calcutta 32.	1800 Tons. Mill at Sheorphall.	593 Tons
5.	P.G. Paper Mill Co. Pvt. Ltd., 20 Seven Tank Lane, Calcutta - 30.	1500 Tons	197 Tons
6.	Everest Paper Mill Pvt. Ltd., 32, Modhu Roy Bye La, Calcutta - 6.	3000 Tons	3606 Tons
7.	Indian Card Board Industries, 18, Netaji Subhas Road, Calcutta.	5500 Tons Mill at Calcutta.	5972 Tons
8.	Papyrus Papers Pvt. Ltd., 4, Netaji Subhas Road, Calcutta.	10000 Tons Mill at Kalyani	Under Construction
9.	Universal Paper Mill, Jhargram	10,000 Tons	New Unit
10.	Nudipur Paper Pvt. Ltd., Nudipur (Distt. Burdwan)	2,000 Tons	New Unit
11.	East Coast Paper, Calcutta.	1,500 Tons	882 Tons
12.	Supreme Paper Mills Ltd., Todi Mansion, P-15 India Exchange Place Extn., Calcutta 700073.	10,000 Tons	Factory under erection

MADHYA PRADESH		Capacity per year	Production during 1977.
1.	Alok Paper Industries, E/7 Industrial Estate, Polo Ground, Indore City.	1,200 Tons	862 Tons
2.	Acme Paper Mills, Sehora. (Formerly MANDADIP PAPER)	3,000 Tons	2,355 Tons
3.	Vidharba Paper Mills Ltd., 2nd Floor, Bank of Maharashtra Bldg., Abhyankar Road, Sitabuldi, Nagpur 1.	2,200 Tons	2,038 Tons
4.	Ashok Vaista Mills, Monena, M.P.	25,000 Tons	New Company
5.	C.C. Aggarwal, Narsinghpur, M.P.	10,000 Tons	New Company
6.	Shree Pulp & Paper Mills, 7, Great Nos. Road, Nagpur.		New Company
7.	Shri Mangeshi Pulp & Paper Mills Pvt. Ltd., C/O Nitin Paper Industries, Akalkot.	1,500 Tons	New Unit
8.	Sai Paper Mills Ltd., New Delhi, (Mills at Dewas, Industrial Area in M.P.)	2,200 Tons	New Unit

HARYANA	Capacity per year	Production during 1977
1. Venus Paper Mills, Faridabad.	2,000 Tons	1,381 Tons
2. Murari Paper Mills, Faridabad.	1,200 Tons	320 Tons
3. Delhi Pulp Industries, Faridabad.	4,300 Tons	3,209 Tons
4. Rajinder Paper Mills, Faridabad.	4,000 Tons	3,116 Tons
5. Haryana Paper Mills of Orient Steel & Wire Industries Pvt. Ltd., Faridabad.	3,000 Tons	2,430 Tons
6. Suri Papers & Chemicals Pvt. Ltd., Daruhera.	5,000 Tons	Under Construction
7. Premier Straw Board & Paper Mills Pvt. Ltd., Factory, 35-37, Sector 25, Ballabgarh. Office: 15, Khan Market, New Delhi.		New Unit
8. Perfectpac Limited, 21, New Industrial Township, Faridabad.	4,000 Tons	2,526 Tons

BIHAR	Capacity per year	Production during 1977
1. Thakur Paper Mills Ltd., Jitwarpur, Samastipur, DHARBANGA.	3,000 Tons	2,111 Tons
2. North Bengal Papers Mills, Nawadah.	10,000 Tons	Under erection

RAJASTHAN	Capacity per year	Production during 1977
1. Premier Paper & Board Mills, Udyog Marg, Kota 324003.		New Company
2. Saraf Paper Mills Ltd., Alwar. (H.O. 34, Pusa Road, New Delhi 110005)	10,000 Tons	Under erection

PUNJAB	Capacity per year	Production during 1977
1. Mukerian Paper Mills, Mukerian, Distt. Hoshiarpur, (H.O. S.C.O. 817 & 818, Sector 22-A, Chandigarh)	5,000 Tons	Under erection
2. Ratan Paper Mills, Amritsar.	3,000 Tons	Under erection
3. Vinod Paper Mills, Malerkotla.	9,900 Tons	
4. United Pulp & Paper Mills, 15/23 West Patel Nagar, New Delhi 110008. (Mills at Hoshiarpur)	15,000 Tons	New Unit

	UTTAR PRADESH	Capacity per year	Production during 1977
1.	Capital Paper Mill Pvt. Ltd., Ghaziabad.	1,440 Tons	Closed.
2.	Upper India Super Paper Mills Ltd., Masjid Bagh, Lucknow.	4,200 Tons	1,433 Tons
3.	Chemo Pulp Tissues, Ghaziabad.	3,000 Tons	Taken over by new management for normal production.
4.	Prem Spinning & Wg. Mills Co. Ltd., 33-A Near Marine Lines, Bombay.	3,000 Tons	New Unit - Straw Board Mill. (Mill at Ujhani, Distt. Badaun).
5.	Swatantra Bharat Paper Mills, Pilkua.	2,000 Tons	962 Tons
6.	U.P. Straw & Agro Products, Aghbanpur (Near Moradabad)	10,000 Tons	
7.	Gopal Paper & Board Mills, Ghaziabad.	1,500 Tons	195 Tons
8.	Ganesh Paper Mills (Delhi) Pvt. Ltd., B-19 Industrial Area, Ghaziabad.	3,000 Tons	New Unit
9.	Aggarwal Paper Mills, 16-A New Mandi, Muzaffarnagar.		
10.	Ansal Papers Ltd., 115, Ansal Bhavan, New Delhi 110001.	2,640 Tons	1,337 Tons Production started on 9.9.1976.
11.	Shivalak Cellulose Paper Mills, Village Gajraula, Distt. Moradabad.	10,000 Tons	Under erection
12.	Basant Paper Mills, Basant Nagar, Varanasi.	10,000 Tons	92 Tons
13.	Sarvodaya Paper Mills, Sikandarabad, U.P. H,O.: 705, Akash Deep, New Delhi.	10,000 Tons	Under erection

UTTAR PRADESH	Capacity per year.	Production during 1977
14. Gopal Paper & Board Mills, Ghaziabad.	1,500 Tons	195 Tons
15. Munish Paper Mill, Sahibabad.		
16. Aknos Paper Mills (Pvt.) Ltd.	1,500 Tons	827 Tons
17. Acme Papers Ltd., Herald House, 5-A Bahadurshah Zafar Marg, New Delhi.	3,000 Tons	

ANDHRA PRADESH		Capacity per year	Production during 1977
1.	Coastal Paper Mills Pvt. Ltd., 11-10-4 River Dale Compound, Grand Trunk Road, Rajahmundry. (Mill at Jagurupadu, E.G. Distt)	2,500 Tons	1,730 Tons
2.	Delta Paper Mills, Bhimavaram.	10,000 Tons	Under erection
3.	Surya Chandra Paper Mills Ltd., Mandapeta.	2,500 Tons	Under erection
4.	Kolleru Paper Mills, Village Bommuluru, Krishna Distt.	10,000 Tons	Under erection
5.	Nagarjuna Paper Mills, 10 Abid Shopping Centre, Hyderabad.	4,000 Tons	New Unit
6.	Telangana Paper Mills, Khamam.	10,000 Tons	New Unit

MAHARASHTRA & GUJARAT		Capacity per year	Production during 1977
1.	Sabarmati Paper Udyog (Pvt) Ltd. (Mill at Mehsana, Gujarat)	5,000 Tons	300 Tons
2.	IPCO Packings, Thana, Maharashtra.	5,000 Tons	
3.	Vapi Paper Mills, Bulsar, Gujarat.	5,000 Tons	827 Tons
4.	Mayur Paper Mills, Maharashtra.	6,000 Tons	Under erection
5.	Gujarat Paper Mills Ltd., Barajadi, Distt. Ahmedabad.	6,000 Tons	108 Tons
6.	Rohit Pulp & Paper Mills, Rohit Chambers, Choga Street, Bombay. (Mill at Khadki)	10,100	7,120 Tons
7.	Jayant Paper Mills Ltd. Resham Bhavan, 2nd Floor, Lal Darwaja, Surat - 3.	7,800 Tons	6,508 Tons
8.	Steadfast Paper Mills Ltd., Medows House, Bombay.	450 Tons	357 Tons
9.	Parekh Paper Mills, Gonda, Saurashtra.	1,000 Tons	435 Tons
10.	Speciality Paper Mills, Morai, Distt. Bulsar, (Via) Vapi. (Mill at Udwada)	1,440 Tons	1,562 Tons
11.	Associated Pulp & Paper Mills Bawla (Ahmedabad)	7,200 Tons	2,459 Tons
12.	Aggarwal Paper Mills Pvt. Ltd., Vapi.	1,600 Tons	2,315 Tons

MAHARASHTRA & GUJARAT		Capacity per year	Production during 1977
13.	Parasuram Paper Mills & Board Mfg. Co. Pvt. Ltd., Bombay.	2,100 Tons	
14.	Ellora Paper Mills, Dewala Khurd, Near Tumsar, Distt. Bhawdara.	12,000 Tons	Under erection
15.	Deccan Paper Mills Co. Ltd., Commonwealth Building, Poona.	3,600 Tons	1,654 Tons
16.	Pudumjee Paper Mills, Chinchwada, Poona.	5,000 Tons	6,321 Tons
17.	F. Pudumjee & Co. Pvt. Ltd., 60 Forbes Street, Bombay.	1,800 Tons	Closed.
18.	Providence Paper Mills Ltd., Bombay.	510 Tons	Shifted to Gujarat as Gem Paper Mills.
19.	Paper & Pulp Conversion Ltd., 1183, Shivaji Nagar, Fergusan Road, Poona. (Mill at Khapoli)	12,000 Tons	12,232 Tons
20.	Premier Paper Mills, 120, Dinshaw Vacha Road, Bombay.	2,200 Tons	2,258 Tons
21.	B.K. Paper Mills Pvt. Ltd., Kalpadevi Road, Bombay.	3,500 Tons	3,320 Tons
22.	Ajanta Paper Mills, Vadavali Road, Kalyan, Bombay.	6,600 Tons	4,596 Tons
23.	Phoenix Paper Products Pvt. Ltd., 6, Nagdevi Cross Lane, Bombay 400003 Factory at M.I.D.C. Industrial Area, Post Tupa, Distt. Nanded.		
24.	Aurangabad Paper Mills, Lentin Chambers, Dalal Street, Bombay 400023.	10,000 Tons	Under erection

	MAHARASHTRA & GUJARAT	Capacity per year	Production during 1977
25.	Nath Pulp & Paper Mills Ltd., Aurangabad.	6,000 Tons	Under erection
26.	Jyakawadi Papers, Aurangabad.	9,000 Tons	Under erection
27.	Alasson Pulp & Papers Ltd., Ratnagari.	10,000 Tons	Under erection
28.	Sugam Paper & Board Mills Pvt. Ltd., Sarbhon, Distt. Bulsar.	6,000 tons	Production started in November, 1977.
29.	Paper Products Ltd., Vaswani Mansions, 120 Dinshaw Vacha Road, Bombay.	4,200 Tons	3,100 Tons
30.	Bombay Pulp & Paper Mfg. Co., 109 Sheikh Mamon Street, Bombay.	4,000 Tons	1,160 Tons
31.	Laxmi Paper & Board Mills, 25, Raman Street, 3rd Floor, Bombay.	20,460 Tons	7,206 Tons
32.	Balkrishan Paper Mills Pvt. Ltd., Nagardas Road, Andheri, Bombay. (Mill at Ambivali, Kalyan Distt.)	4,500 Tons	5,165 Tons
33.	Vikram Paper Mills Pvt. Ltd., Vadavali, East Kalyan, Distt. Thana. (Mill at Thana)	4,800 Tons	
34.	Providence Paper Mills Ltd., New Standard Eng'g Compound, Santacruz, Bombay.	510 Tons	
35.	Afsons Industrial Corpn. Ltd., Princess Street, Bombay. (Mill at Kalyan)	2,400 Tons	715 Tons

		Capacity per year	Production during 1977
36.	Shri V.K. Lal, Ranjit Sales Pvt. Ltd., 111-A Mahatma Gandhi Road, Bombay 1. (Mill at Bangalore)	450 Tons	
37.	Shri Vinghya Paper Mills Ltd., Empire House, 3rd Floor, Dr. D.N. Road, Fort, Bombay 400001 (Mill at Aurangabad, Maharashtra)	10,000 Tons	
38.	Vijay Paper Products, Bombay. (Mill at Bombivili, Distt. Thana)	1,000 Tons	
39.	Shree Ram Paper Mills Pvt.Ltd., Mahidharpura, Surat.		
40.	Sun Coated Paper Co., c/o Caprihana India Ltd., Bombay.		
41.	Surat Board Mills, Surat.		
42.	Patel Paper Mills.		
43.	Dhavalgiri Paper Mills.		
44.	Sirdar Bagayat, Surat.		
45.	Hari Om Paper Mills, Surat, Gujarat.		
46.	Kodadra Paper Mills		
47.	Giriraj Paper Mills		
48.	Alipore Paper Mills		
49.	Aravind Board & Paper Mills		
50.	N.S.P. Straw Board Mills		
51.	Deshbandhu Paper Mills		
52.	Mahender Paper Mills		

MAHARASHTRA & GUJARAT	Capacity per year	Production during 1977
53. Ruby Paper Mills		
54. Deluxe Paper Mills		
55. Pranav Paper Mills.		

TAMIL NADU, PONDICHERRY & KARNATAKA

		Capacity per year	Production during 1977
1.	South India Paper Mills Pvt. Ltd., Nanjangud (Karnataka)	6,600 Tons	4,897 Tons
2.	Amaravathi Sri Venkatesa Paper Mills, Udumalpeth.	6,000 Tons	6,675 Tons
3.	Mandya National Paper Mills, Bangalore (Mill at Balgaula)	10,800 Tons	10,810 Tons
4.	Sun Paper Mill Co. Ltd., Post Box No. 2., Cheram Mahadevi, Tirunelveli. (Mill at Cherammahadevi)	15,000 Tons	6,831 Tons
5.	Gangappa Paper Mills, South Arcot District.	10,000 Tons	
6.	Senapati Whitley Pvt. Ltd., Bangalore	4,920 Tons	
7.	Meenakshi Paper Mills Ltd. (Mill at Kanaikal, Pondicherry)		
8.	Pondicherry Paper Mills, Pondicherry.	10,000 Tons	Under construction
9.	Tamil Nadu Cardboard & Paper Mills, H.O.: 3, Cathedral Road, Madras 600086. (Mill at Coimbatore)	3,600 Tons	
10.	Southern Agrifurani Industrial Corporation, Madiamakam (Tamil Nadu)	2,500 Tons	
11.	V.K. Boards (P) Ltd., Bangalore	450 Tons	276 Tons
12.	Shri Venkatesa Paper & Boards Pvt. Ltd., Madathukulam, Udamalpeth.	4,000 Tons	3,110 Tons

MYSORE	Capacity per year	Production during 1977
1. Kabini Paper Mills. Nanjangud.	3,000 Tons	

ASSAM	Capacity per year	Production during 1977
1. Kamrup Paper Mills, Gauhati, Assam.	1,500 Tons	434 Tons

LIST OF STRAW BOARD AND MILL BOARD MILLS IN PRODUCTION IN 1978-79 (PARTIAL ONLY)

S.NO.	NAMES AND ADDRESSES OF THE MILLS	LOCATION
1.	M/s. Meerut Straw Board Mills, Barapat Road, Meerut	Meerut
2.	M/s. Straw Board Mfg. Co. Ltd.,	Saharanpur
3.	M/s. Bharat Straw Board and Paper Mills Pvt. Ltd., 42 Industrial Colony, Naini, Allahabad.	Allahabad.
4.	M/s. G.T. Industries, 33-A, New Marine Lines, Bombay - 20.	Bombay Budaun.
5.	M/s. Mahabir Straw Board Pvt. Ltd., Power House Road, Mainipuri	Mainipuri
6.	M/s. Vishnu Industrial Enterprises Pvt. Ltd., 11, Moti Bhawan, Collectorganj, Kanpur.	Faridabad.
7.	M/s. Prem Spinning and Weaving Mills Co. Limited, Ujjain	Ujjain
8.	M/s. Dhampur Sugar and Board Mills Ltd., Dhampur, Distt. Bijanor.	Bijanor, Dhampur
9.	M/s. R.G. Paper & Straw Board Mills, Rani Mill, Hathras	Hathras.
10.	M/s Banki Bihari Lal Board Mills, C-33/2, Meerut Road, Industrial Area, (Site No.3), Ghaziabad.	Ghaziabad.
	WEST BENGAL	
11.	M/s. Himalaya Paper and Board Mills Ltd., Everest House, Calcutta.	Chughudnga
12.	M/s. Union Paper Board Mills Ltd., 4, Fairlic Place, Calcutta - 1.	Calcutta.
13.	M/s. Swastik Board and Paper Mills Ltd., 51, Stephen House, 4, Dalhousie Square East, Calcutta.	Belur
14.	M/s. Eastern Paper and Mills Ltd., 2, Dekshindari Road, South Dum-Dum, Calcutta.	Calcutta.

15.	M/s. Asiatic Board Mills Limited, 29/B, Bear Para Lane, Calcutta	Calcutta
16.	M/s. Priti Paper Board Mills Pvt. Ltd., Burro Sabtola Main Road, Calcutta	Calcutta
17.	M/s. Shree Durga Board Mills, P.O. & Vill. Khanyan(G.T. Road), Distt. Hooghly	Pandush

HARYANA

18.	M/s. Delhi Board Mills, Ghawri Bazar, Delhi - 6.	Faridabad
19.	M/s. Karnal Cardboard Industries, Kaithal Road, Chirao, Karnal, Haryana	Karnal

PUNJAB

20.	M/s. Chandigarh Paper Board Mills Pvt. Ltd., 26/Industrial Area, Chandigarh	Chandigarh

MAHARASHTRA

21.	M/s. Eastern India Paper and Board Mills Pvt. Ltd., L.B. Shastri Marg, Vikhroli, P.O. Bhandup, Bombay - 40.	Bombay
22.	M/s. Nirmal Rubber and Board Pvt. Ltd., Lahwarbhai Patel Estate, Gurgaon East, Bombay - 62.	Bombay
23.	M/s. Solid Containers Ltd., 361 Tiecitor House, Dr. E. Moses Road, Bombay - 11. (BC)	Kalyan

GUJARAT

24.	M/s. Arvind Board and Paper Products Ltd., Antalia, Bilimora.	Bilimora
25.	M/s. N.S.P. Straw and Paper Pvt. Ltd., P.O. Bigendranagar, Via, Rankava (W. Rly) Distt. Bulsar.	Bigendranagar
26.	M/s. Saurashtra Paper and Board Mills, Pattawai Building, M.G. Road, Rajkot.	Lakhinagar Rajkot

27. M/s. Cellulose Products of India Ltd., P.O. Maninagar, Ahmedabad — Bomol

28. M/s. Desh Bandhu Paper and Board Mills, Dungri, Tahsil Bulsar, Distt. Surat. — Dungri

29. M/s. Patel Paper Mills Pvt. Ltd., Post Gangadhra Taluka Palsana, Distt. Surat. — Gangadhra

MADHYA PRADESH

30. M/s. Straw Products Ltd., Chola Road, Bhopal — Bhopal

31. M/s. Ratlam Straw Board Mills Ltd., Mhow Neemuch Road, Ratlam — Ratlam

32. M/s. Madhya Pradesh Board and Paper Mills, Vidisha (Madhya Pradesh) — Vidisha

RAJASTHAN

33. M/s. Premier Paper and Board Mills, D-233, Behari Marg, Jaipur — Kotah Jaipur

KARNATAKA

34. M/s. Tungabhadra Pulp and Board Munirabad Mills Ltd., 111, Mahatma Gandhi Road, Fort, Bombay. — Munirabad

TAMIL NADU

35. M/a. Tamilnadu Cardboard and Paper Mills Ltd., Pungar, Bhavani Sagar, P.O. Coimbatore Distt. — Pungar

ANDHRA PRADESH

36. Andhra Pradesh Straw Board Mill Pvt. Ltd., Undi-534199, Bhimavaram. — Undi

NEW DELHI

37. Ajanta Offset & Packaging Pvt. Ltd.,
New Delhi

MADHYA PRADESH

38. Kewal Kishore Jaichand,
Distt. Betul.

39. M/s. Rampura Straw Board Mills,
Rampura.

40. M/s. Adarsh Putha Udyog Samakam,
Samity Ltd., Daudh, M.P.

UTTAR PRADESH

41. Adarsh Paper and Board Manufacturing Co.,
Bhagat Singh Road, Muzaffar Nagar (U.P.)

WEST BENGAL

42. Shree Durgal Board Mills,
West Bengal.

APPENDIX III

SCHEDULE OF EQUIPMENT SUPPLIERS

Name and address of supplier	Range of equipment manufactured
Automat Consulting Engineers, A-1/42, Panchsheel Enclave, New Delhi - 110017	Oscillators - roll doctors, showers. Wire & Felt Guides, Pneumatic Roll loaders, Consistancy Transmitters, Basis Weight Control Valves, Head box level controller.
Akay Industries, P.O. Box 86, Hubli - 580020 KARNATAKA	Chemflo Pumps and Valves of various types.
Asha Steel Industries, Plot No. 256, Sector 24, FARIDABAD.	Hydrapulpers, Other Pulp Mill Equipments.
Bengal Paper Machinery Manufacturers, Todi Mansion, P-15, India Exchange Place, Extension, Calcutta - 700012	Chilled iron rolls.
Bhartia Cutler-Hammer Ltd., 20/4, Mathura Road, Faridabad - 121006, HARYANA	Electrical drives.
Bakubhai Ambalal Pvt. Ltd., Kaiseri-Hind Bldg., 3rd Floor, Currimbhoy Road, Ballard Estate, Bombay - 400001	Digesters.
Bashimal Vinod Kumar, 132/134, Pradhan Bldg., S.V. Patel Road, Dongri Bombay - 400009	Industrial Knives, Refiner Tackle.
Bombay Alloy Steel Industries, Pvt. Ltd., 17, Nagdevi Cross Lane, Bombay - 400003	Industrial Knives.

Cifoods Limited, Madhupatna, Cuttack.	Recovery Plant equipment, Boilers.
Door-Oliver (India) Ltd., 16 Queens Road Bombay - 400020	Vacuum washers for pulp mill and bleaching plant. Continuous causticising plants. Water Purification Plants.
Dinesh Mills Ltd., P.O. Box 65, Padrua Road, Baroda.	Paper Maker Felts.
EIMCO-K.C.P. Ltd., 2/34 Kodambakkam High Road, Madras - 34.	Brown stock washers, Bleach washers, Disc Savealls, Re-causticising equipment like Slaker Classifier, causticiser white liquor clarifier, mud washer, Pollution Control equipment.
Easter Paper Mills Ltd., 2 Dakshindari Road, Calcutta - 48.	Complete pulp mill equipment. Also complete paper machine.
Elecon Engineering Co. Ltd., Vallabh Vidyanagar 388 120, Gujarat.	Reduction Gears.
Hindon Engineering Works, Clubley, Bajoria Marg, Saharanpur 247001 (U.P.)	Small Paper Machines, Refiners, Pulpers, Agitators, Thickeners, Centricleaners, Screens, Pumps. Also equipment for Mechano-chemical pulping.
HIMCO, 5-C Industrial Estate, Clutterbuckganj 243 502, Bareilly (U.P.)	Straw Boilers and Straw Cutters.
Indo Berolina Industries, Pvt. Ltd., I.B.I. House, S-86 Andheri Kurla Road, Bombay 400059.	Paper Machines.
Industrial Boilers Pvt. Ltd., C/8 Poona Apt, Dr. Annie Besant Road, Worli, Bombay - 40018.	Boilers.

Jessop & Co. Ltd., 63, Netaji Subhas Road, P.O. Box 108, Calcutta.	Paper Machines (coll- aboration with Walmsley, U.K)
J.D. Enterprises, 16, Syed Amir Ali Avenue, Box 16005, Calcutta 700017	Slitter/rewinders and grass-cutters.
Kishore Pumps Ltd., A-13/H, MIDC Industrial Area, Pimpri, Poona-18	Pumps.
Khalsa Engineering Works, 57, Girish Ghosh Road, Belur, Howrah.	Board Mill Machinery.
Krishna Engineering Works, 8712-13, Aram Ganj, Roshanara Road, Delhi - 110007	Gears.
K.M.W. Johnson Ltd., 10, Princep Street, Calcutta - 700013	Chippers, chip screen, bleach plant equipment, chest agitators, stock pumps, liquor pumps for digesters, vibratory knotters.
L.S. Engineering, Industries Pvt. Ltd., J-11/94, Rajouri Garden, New Delhi - 110027	Pulp Mill Equipment.
Lathia Rubber Mfg. Co. Pvt. Ltd., Sakinaka, Bombay - 400072	Rubber Rolls.
Mechano Industrial Suppliers, 2, Ganesh Chandra Avenue, Calcutta - 700013	Bamboo/wood chippers and screens, straw/rag cutters and dusters, Digestor, Blow Tank, knotters, beaters, deepers, agitators, pumps, screens, centricleaners, H.D. cleaners, refiners, pulpers, vacuum pumps, Paper Machines capacities up to 20 TPD.
Manco Engineering Corporation, E-53, Industrial Area, Yamuna Nagar, 135001	Pulp Mill Equipment.
Micro Mechanical Works, L.B. Shastri Marg, Vikroli, Bombay.	Corrugating equipment.

New Allied Capital Industries, 27, Industrial Area, Chandigarh.	Up to 10 TPD capacity board making plant.
Orient Steel & Industries Ltd., 1009, Ansal Bhavan, Kasturba Gandhi Marg, New Delhi 110001	Pulp mill equipment and parts for paper machinery.
PAS Engineering Co. Pvt. Ltd., 8th Floor, Madhuban, 55, Nehru Place, New Delhi - 110019	Evaporators, Recovery plant equipment.
Paper Engineering Services Pvt. Ltd., Vijayawada 520 007 (A.P.)	Rag/Straw cutters and dusters, rotary digesters, Beaters, Centricleaners, Thickeners, pulpers, De- flappers, Refiners, Agitators, pumps.
Polypick Industries, Bombay Mutual Building, Sir P.M. Road, Bombay 400001	Special plastic tops for suction boxes etc.
Pressels Private Ltd., Cuttack 753 010 (India)	Recovery Boilers, Boilers.
Paper Mill Plant and Machinery Manufacturers Ltd., Jogeshwari Estates, 181, S.V. Road, Bombay 60 NB	Complete Paper Machines for mini paper mills.
The Print & Paper (Sales) Pvt. Ltd., Post Box No. 394, 4/7A, Waterloo Street, Calcutta - 700001	Slitter Rewinders, Rotary sheet cutters capacity up to 100 TPD.
Porritts & Spencer (Asia) Ltd., 308, Kanchenjunga Bldg., 18, Barakhamba Road, New Delhi.	Felts for paper industry.
Paper & Pulp Conversions Ltd., Khopoli, Distt. Kolaba, Maharashtra.	Pulp Mill machinery and various parts for paper machines
Siyaji Iron & Engineering Co. Pvt.Ltd., Chhani Road, Baroda 390 002 Gujarat.	Spares for Pulp Mill.

Swelore Engineering Co., Ahmedabad 380 008	Pulp valves.
Swaroop Eng'g Corporation, Ali Mahajan Street, Nawabganj, Saharanpur.	Refiners, Deflakers, Screens, centricleaners, pumps, valves, thickener, cylinder moulds, Shower nozzles.
Saharanpur Engineers & Suppliers, Ali Majahan, Khalapur, Saharanpur.	Board Mill plants up to 5 TPD, hand-made paper units up to 300 kg per day. Beaters, pulpers, thickeners, agitators, screens, refiners, chilled rolls, centricleaners, pumps and valves.
Spinning Accessories (P) Ltd., 7 Chittaranjan Avenue, Calcutta - 700 013	Fourdrinier wires.
Shalimar Wires & Industries Ltd. 77 Netaji Subhas Road, Uttarpara, 27A camac Street, Calcutta.	Dandy Rolls, wires.
Sre Srinivasa Eng'g Works, Rajahmundry (A.P.)	Pulp Mill equipment.
T. Meneklal, Bombay.	Rubber covered rolls.
Tungbhadra Machinery & Tools Pvt. Ltd., 43/163 Narasimha Rao Peta, Kurnool - 518 004	Paper machines, evaporators, recovery equipment, straw, cutters, dusters, bagasse depithing plant, thickener for cut straw and depithed bagasse. Centricleaners, pulpers, refiners, agitators.
Utkal Machinery Ltd., Kansbahal 1770034, Distt. Sundergarh, ORISSA.	Technical collaboration with Voith, W. Germany. Paper Machines.
Wanson (India) Pvt. Ltd., Chichwad, Poona 411 019.	Boilers.

VIMA (India), 505, Churchgate Chambers, 5, New Marine Lines, P.O. Box 1509, Bombay - 400 029	Boilers.
Kakati Karshak Industries Ltd., 1-7-241, First Floor, Sarojini Devi Road, Secunderabad - 50003.	Vacuum Pumps, Gear Pumps, Non Clogging Centrifugal Pumps and Chemical Pumps.
AEROMATIC CORPORATION, Behind Gujrat Bottling, Ahmedabad - 380023	Vacuum Pumps.
J.B. Sawant Engineering Pvt. Ltd., Factory Unit No.1., Udyog Nagar, S.V. Road, GOREGAON (W) Bombay 400062	Vacuum Pumps.
Kirloskar Pneumatics Co. Ltd., Hadapsar Industrial Estate, PUNE, 411013.	Vacuum Pump-Compressor.
ATLAS COPCO (India) Ltd., 8-A DLF Industrial Area, Najafgarh Road, New Delhi 110015.	Compressors.
K. G. Khosla Compressors Ltd., 1 Deshbandhu Gupta Road, New Delhi - 110055.	Compressors.
Madras Industrial Linings Ltd., 25 Gilchrist Avenue, Harrington Road, Madras-600031.	Lining for Bleach Towers, Rubberised rolls, Drum filters etc.
Garlic & Co. Pvt. Ltd., Jacob Circle, BOMBAY - 11.	Filters.
Himalaya Paper Machinery Private Limited, 20 Seven Tanks Lane, Calcutta.	Board Mill Machinery.
Indian Paper Machinery Eng. Works Limited, 9 The Mall, Dum Dum, Calcutta.	Pulping Equipment.

M/s. Adya & Co. (Engineering) Pvt. Ltd., 158-F, Acharya Prafulla Chandra Road, CALCUTTA 700004.	Pulp & Paper Machinery.
Sud & Warren Pvt. Ltd., Plot 72-S, Sector 6F, Faridabad.	Rewinder.
M/s. Span Enterprises, Harivaush Plot No. 115, Sahakara Nagar No.2, Poona 411009.	Paper Testing Equipment.
M/s. S. D. Hardson & Co., 106/B, Raja Direndra Street, CALCUTTA 700004.	-do-
Universal Engineering Corporation, Sabri Mills, Ambala Road, Saharanpur.	-do-

POTENTIAL IMPROVEMENTS

IV.1. GENERAL

The foregoing case studies and the factual information contained in the earlier chapters demonstrate beyond reasonable doubt that the small mill represents the best investment for the paper industry in India, in terms of cost and optimum utilisation of resources. The greater value, however, lies in the opportunities presented by relatively small capital and good returns for private industry which, in any given situation moves faster than the less inspired State or large industry forces in taking risks when the potential is sufficiently encouraging. As has been demonstrated, for minimum investment the small mills have been able to supply a growing need and have been satisfied, in the majority of installations, to sell at lower cost and quality. The latter can be condoned to some extent by saying that the quality is good enough for the purpose and this is basically true. In the Western world, quality standards have been set more by the merchant than by the ultimate consumer, and much of the expensive sophistication now considered essential has been designed to meet unnecessarily high standards. The lower sale price adopted by some, but not all, small mills, is sufficient because the government imposes on designated small mills less of a levy than is borne by the larger mills. Both of these conditions are artificial, and peculiar to India. Neither can be regarded as permanent or applicable to developing countries without modification. These comments are not intended to belittle the contribution of the small mill in India. It is recognised, and indeed is the theme of this book, that India has set an example, in the development of small mills, to the whole world, and particularly to the developing countries whose needs and resources are similar to those of India. It is , however, obvious to the unprejudiced observer that improvements can be made without impairing the fundamental characteristics of low capital costs and greater national benefit. Higher quality standards will be required, though not to the extremes of Western countries. High efficiencies will be required because govermental price protection is a hazardous climate for long-term growth. The situation where viability at 65% utilisation can be achieved must be an impermanent one. Profitability at 75% utilisation is enhanced by more than the proportion indicated and it can be achieved by the small mill, providing more capital for further development. The object of this chapter is to suggest what improvements could be made or are impending.

IV.1.1. Policy Considerations

IV.1.1.1. Machine Capacity

The following comments apply only to India. The governmental encouragement given to the small mill has been described in this book and is of great value. Without doubt it has had beneficial impact on the industry and has created an impetus which will promote a thriving trade for a long period to come. In defining "small" by output per mill however, some of the impetus is lost and is leading to actions which are artificial and less beneficial, particularly long-term.

The designated limit is 25 T.P.D. for certain benefits and 30 T.P.D. for others. The incentives are, in fact, graduated according to scale up to these limits. But 25 T.P.D. of paper over the substance range 30 gsm to 50 gsm is very different from the same capacity over say, 80 gsm to 150 gsm. The former requires a larger machine, in terms of speed and drying if not width and the product commands a higher sales price. The same machine, if used for substances higher than specified would produce above the incentive limit and, presumably, fail to qualify for the incentives.

The tonnage limit also restricts development. In a number of cases, the simple addition of more dryers, or other aids to drying, such as better presses or hoods would increase overall capacity at relatively low cost, greatly enhancing viability and increasing much needed production, but if such obvious improvements take the machine above the tonnage limits the incentives will be forfeited and they will be diminished even where the limit is not reached. This seems to be counter-productive and worthy of re-consideration. Where a mill is near the limit, even improvements in efficiency, or deployment of versatility in producing heavier substances may be subject to penalty.

It would seem more sensible to define "small" in terms of machine width and speed, irrespective of output. If these desiderata were carefully selected to conform with criteria which can be established by calculation as representative of the optima (and this can be done) two benefits would follow:-

a) Each mill would have the inherent incentive to improve output, versatility and efficiency without the spectre of losing a greater, artificial incentive.

b) There would be a strong incentive and pressures to develop a standard machine which would give manufacturers a corresponding incentive to incorporate improvements or economies in order to be competitive. Apart from the benefits to the home industry, in terms of standardisation, operation, training and least capital cost it would be the foundation of a strong export trade, selling established machines of guaranteed performance.

IV.1.1.2 Mill Capacity

The definition of capacity used to define eligibility for incentives applies not to the machines, but to the mill. As a result, when an investor wishes to expand he has to be careful not to lose the incentive which led to the first investment. The problem is usually solved by the formation of another company which, to comply, must be a complete entity. It is possible to visit a single site where as many as three companies are separately operating, although the ownership is common. The disadvantages are obvious. Whilst recognising the advantages of small-scale where they are real and can be supported by evidence the subject is not one to be treated dogmatically. Scale does have advantages in some circumstances. So far as a paper mill is concerned a central pulp plant supporting three machines makes more sense than three plants, one per machine. The scale of the plant used is another matter altogether. For a central plant it may still be cheaper to use the standard digester, pulper or refiners than to adopt a single stream but to use the plant centrally offers best economy and versatility. The pulp mill can grow by the addition of small units and still serve more than one machine.

Similarly, a single management function has obvious advantages. Not the least is that it can support a technical development service which is nore comprehensive and effective than could possibly be afforded by the small, independent units.

The purpose of the Government incentives would be achieved by defining eligible scale in terms of machine size for mills growing by the addition of machines without losing any of its advantages. Some would, in fact, be added; in particular, more investment would result.

It is recommended that the definition of scale be reconsidered and the present standard, based on tonnage, be replaced by one based on machine size and speed. In the ultimate it is believed that this would result in more machines, better machines and cheaper paper. India has led the world in encouraging the small mill and the first impact has been highly successful. It should now be possible, based on positive evidence that small can be viable and self-supporting, to build on the foundation as firmly laid and achieve optimum efficiency as well.

IV.1.2. Instrumentation

Whilst the technology of the 30's is sufficient, in broad terms, for the small mill, (and not backward for its purpose on this account because many machines of that period are still operating and competing in developed countries) where positive improvements can be made economically they should not be ignored. Instrumentation is one major field of improvement which, so far as the small mill in India is concerned, has virtually been ignored and this should be changed.

None of the mills visited had operating instrumentation or control of any kind. When asked why this was so the answer given was always one of two: "We can't afford it" or "We have tried it and it doesn't work". Neither answer is satisfactory or correct. Up to a given level some degree of measurement and control is, beyond any doubt, economic. It is equally manifest that where properly installed and maintained, it does work.

Before condemning this negative attitude towards instrumentation and controls outright and attributing it to stubborn thinking it is worthwhile considering why these answers are given, sincerely and without prejudice. The writer, after much thought and discussion has reached the conclusion that the background is wrong. To clarify this statement it is necessary to go back in time and reflect on the manner in which instrumentation was introduced to the paper trade in developed countries. It began in the late 1940's with measurement, a need for which arose in turn from accountancy. The oil refineries had developed instrumentation and it was clear that much was applicable to paper mills. Water, steam, power, liquids could all be measured by fairly simple and inexpensive meters and progressively they began to be installed. Suitable recruits from the mechanical or electrical field were seconded to the calibration, operation and maintenance aspects and became instrument mechanics or engineers.

The measurement of paper stock was more difficult because it is not a Newtonian liquid. The flow could be measured by orifice meters to a reasonable degree of accuracy but if the consistency varied the liquid flow was not an accurate reflection of substance. Not only were the measurements unreliable in this respect but, as continuous stock preparation superseded batch methods, paper-making became more difficult. Sheet substance was difficult to control and, in consequence, so was drying.

A consistency regulator was needed and amongst the first to make an impact was the Salle, a mechanical type, really measuring viscosity but controlling it by adding water to maintain uniformity. It could not, of course, remove water when the stock was too thin or add more water under control than a limited amount if the stock was too thick and in the early days the saying "it doesn't work" could be heard many times. However, the dedicated perservered; stock was made initially to higher than normal consistency (which improved refining as a by-product) and a 2-stage, then 3-stage consistency control was introduced and the problem was ultimately solved. There were two effects; first, the paper-makers, accustomed to controlling consistency (and paper substance) by various indirect indices and experience, very quickly lost this skill (perhaps "art" is a better word) and dependence on the control became absolute. Secondly, and in consequence, the instrument engineer became a necessity. Since then there had been great progress in instrumentation. Instruments have become more accurate (and sophisticated and expensive) and control reached the stage where very expensive, fully computerised systems were introduced. This phase has passed and is being replaced by low-cost dedicated or mini computers, controlling substance, moisture and, in some instances, caliper.

The Indians in small mills have not passed through the learning stage and do not have a pool of experienced instrument mechanics to spread around the country, playing a part in actual production. Where some mills have purchased consistency regulators they "don't work" usually because the instruments are sophisticated and need experienced supervision which is not available; they are expensive so only one is purchased and at least two and perhaps three are needed in any line and, of course, there is understandable reaction and mistrust from the papermakers.

The small mills badly need measurement and consistency regulation. The first is a positive step towards economy of material utilisation; both are essential for optimum efficiency. The more advanced small mills around the 25/30 T.P.D. range would also benefit enormously from low-cost substance and moisture control which normally pays its total cost back in months, not years, but they must first resolve the problem of consistency control.

The writer now believes that the small mills should go through the learning process first experienced by the developed world. Salle regulators are very cheap, can easily be made in India, are mechanical and can be seen to work. Simple orifice meters are also cheap and reliable. Instrument mechanics have to be trained on-job and on the foundation suggested would quickly learn because Indian mechanics are skillful and adaptable. At least one of the more advanced and stable mills should be introduced to low-cost substance and moisture control under ex-patriate supervision initially. Success would inspire other mills. The problem must be solved, external assistance may be advisable initially but the potential rewards are high. The utilisation of materials in many small mills is less than 75%, while 95% would be considered bad practice in developed countries. There is no need for the small mill to be backward in this respect and much to be gained by a more positive approach.

Incidentally, Salle regulators still survive in many small mills operating successfully in developed countries.

IV.1.3. Machine Design

IV.1.3.1. General

This section refers only to the small machine manufacturer. The few companies capable of building large machines in India are linked with overseas companies who supply designs. Their products do not compete with the small manufacturer on equal terms but at the present time he is tied to them for essential items which cannot be produced other than by special and expensive tools. Drying cylinders and suction rolls are perhaps the best examples. There is a strong need to find a way round these limitations. Other objectives in revised machine design should be aimed at improving efficiency and quality without increasing the capital cost/unit capacity to an unacceptable level. It can be said at once that since operating efficiency for the small mill seldom exceeds 65% and should be at least 80%, it would be possible to spend 15% more on the machine and, providied that the operating efficiency did reach 80% the capital cost per unit of production would, marginally, be decreased. In the writer's opinion, based on the many mills examined, such an increase in efficiency is possible without 15% greater expenditure. All other considerations being equal, the small machine, at slower speed should be more efficient than the large, fast machine and usually is. It is important, therefore, first to establish where the weaknesses lie in order to suggest practical remedies. The following are suggested as weaknesses, and are accompanied by remedial recommendation.

IV.1.3.2. Breaks

If, in transit from the forming end of the machines to the final reel-up, the continuous sheet of paper breaks it is necessary to go back to the forming area and start again. The flow of stock on the machine is not interrupted but until the sheet can be fed back through the various sections to the reel again the stock falls into the couch pit and is recirculated as "broke". In addition the paper in the machine when the sheet broke first and that passed through until continuity has been achieved is also "broke" only now it is dry or semi-dry and must be repulped. "Broke" is neither as strong nor as quick-draining as virgin stock and too much in the sheet is conducive to more breaks. Good paper-making practice would consider 10 breaks per day excessive for most paper grades. 60 to 100 breaks per day are the norm for the Indian small mill! The reasons for this are, by the writer's observations:-

a) Inherent lack of "wet-web" strength in the stock.

Most mill-owners would accept this statement and attribute it to a lack of long-fibre furnish. This must be conceded but it is not the only reason, nor is it an unsurmountable one. If paper is made at all, it is evident that under favourable conditions it is strong enough. So it is necessary to isolate those factors which make conditions unfavourable and create "break" situations. Amongst these are:-

b) Lack of uniformity in the stock.

If the stock varies in consistency it will run heavy or light on to the machine. When light it is weaker and more prone to breaking. When heavy it causes change in the sheet tension, increasing it, assuming that the machine has been properly set for the correct substance. Paper-makers often blame the machine for speed variations which in fact are substance variations. For this reason consistency regulators are essential to obtain best efficiency.

c) Inadequate cleaning

In the weak, wet paper condition any contrary inclusion is a potential break, so cleanliness is vital. Cleanliness is a function of equipment and system and operation of the system. In the small mills visited and described in the book, equipment is usually adequate but systems and operation very seldom right. It would take too long to cover all of this subject in this paragraph and this book is not a manual but two aspects can be highlighted.

i) It is not possible to obtain uniform, optimum operation of centricleaners, which require constant conditions, when there is only one fan pump, serving the machine through cleaners and screen in series with changing flow and consistency conditions in the flowbox according to different grades or substances of paper. Two pumps are required, one under constant, optimum conditions for the centricleaners and the other for the potentially varying conditions of the screen and flowbox. No two-pump system was seen and if this is done for economic reasons the economy is false.

ii) Pressure screens, particularly where the stock is potentially dirty, which is the case for waste paper, rags or gunny, will only operate efficiently under continuous or controlled reject conditions. The reject proportion can be quite substantial, up to 40% of in-flow in some cases, but the fibre is not lost, it is recovered over an auxiliary, normally a vibratory, screen. If the pressure screen is only opened to rejects sporadically without control the plates block and the flow varies. Automatic, time-switch operation can be used for intermittent control and is effective and cheap but it is not correct for the screen immediately before the flowbox or equally timed variations will appear on the paper machine. Rejects at this point must be continuous and adequate, recovered stock from the rejects should also be introduced into the wire pit and not back to the beginning of the system or further irregularities will appear. Much more could be said on this subject; the systems seen and their control throughout the whole stock preparation area are generally capable of much improvement at very low cost.

d) Press Rolls

In very few mills visted was more than one of the two, or sometimes three, presses being operated. In consequence the paper was too wet and weak going to the dryers, causing breaks; it also coated the first dryers heavily, causing more breaks; it required more steam, uneconomically, for drying; it reduced output where capacity was dryer-limited (most often the case), and it impaired quality of the finished paper. The reason for not running all the presses was that each press and the almost universal "Stonite" top roll was considered to be a potential "break" area. Stonite rolls are very difficult to "doctor" or clean continuously because inexpensive steel bladed doctors at effective pressure cannot be used. Granite top rolls are far more efficient and manufacture in India should be considered. The technique is not difficult and granite is available. Stonite appeared on the paper-making scene when rolls became so large that granite of suitable blemish-free size became difficult to obtain. The small machinery manufacturer prefers stonite because he can make a steel-shell roll and have it covered. A leading doctor manufacturer once said that stonite rolls have presented more doctoring problems in the years since their introduction than all the granite rolls previously used for many years. There would be a considerable increase in efficiency if granite rolls were re-introduced to India and the small machine is ideal for their resurrection.

e) Design

The modern high-capacity paper-machine also had to resolve the weak, wet-web strength problem (which particularly applied to newsprint), in order to achieve speeds above 500/600 metres/minute without severe loss of efficiency. The vacuum pick-up was made practical in the mid-1950's (it had actually been used years before but its expense considered unjustifiable) and today various pick-up designs are available and no modern machine would be complete without one. It transfers the wet sheet full width from the wire to the presses, attaching it by suction to supporting felts so that it does not sustain tension until it has been consolidated and strengthened. Machines of this type often run days without a break if the stock is clean and controlled. A similar arrangement would, inexpensively, optimise the machine efficiency where agricultural fibres are involved. Once pressed sufficiently the problem is negligible, and when dried, except for wrapping grades, it does not exist at all; strength above that inherent in the paper is not required for its ultimate purpose. There are two possible solutions:-

i) The small machine can be designed with a combination pick-up press section. This solution would be slightly more expensive in capital cost because at least one suction roll must be included and the drive has to be more complex. It would also require more power. But it is not a solution to be ignored on these accounts because the gain would outweigh the cost, especially if advantage were taken of it to increase speed. But the latter would increase capacity and, for India at least, reduce or eliminate incentive. As has earlier been commented upon, the definition of "small" by capacity alone can be restrictive on development.

ii) Vat-type machines do not have this disadvantage. The sheet is picked up full width by a supporting felt and carried through the first presses. The early vats, however, were speed limited by centrifugal force to around 100/150 metres/minute so the design was restricted for many years to board machines and capacity obtained by substance, up to 700 gsm. The circular mould, the forming element in vat machines, has received considerable attention in recent years, to increase its speed potential and improve its performance, because cross-directional substance control is a factor of drum condition and difficult to maintain. A whole family of "formers" or "dry" vats has been developed, some very complex and expensive but capable of high speeds over wide substance ranges. The most simple "dry" former is limited to 200 metres/minute speed without applied vacuum but this speed is most economic in terms of energy per tonne of paper produced and is ideal for the small machine. The former has an inexpensive "built-on" flow box, controllable across the width and longitudinally to optimise formation and it can produce over a substance range up to 80 gsm on a single vat. If a higher substance is required two or more "formers" can operate on the same felt. It is now being claimed that most papers, of given substance have improved characteristics if made two or three ply and the former offers this advantage. It is simple to manufacture, simple to operate, easy to maintain, cheaper in clothing costs and it supports the wet paper minimising breaks. In the author's view this type of wet-end, for the speed given, has all the virtues of a vacuum pick-up plus some advantages in range and is actually less expensive, or should be, than the Fourdrinier. It deserves serious consideration for new machines; its potential has already made an impact on the Western, developed countries.

IV.1.3.3. Manufacturing Limitations

It has been stressed earlier in this book that the low capital cost of the small Indian paper machine is due to the small manufacturer, who, in fact does not make all the components in the machine himself. He does not have sufficient space, expensive tools or enough money to acquire either. He designs, fabricates what he can, machines up to the limits of the normal tools he can afford and sub-lets the rest to larger, better-equipped engineering companies not specially linked to the paper industry. His gears, large rolls etc can all be obtained competitively and to good quality in this manner. In two respects this procedure, otherwise admirable, does not work out so well. These are:-

a) Suction Couches or Press Rolls

Special castings and drilling tools are involved so supply can only be obtained, expensively, from the larger, specialised, paper mill machinery suppliers. The small manufacturer normally copes with this situation by avoiding suction rolls altogether, but his substitutes are not entirely satisfactory. The jacketted top couch roll is probably good enough for the 5 to 15 TPD machine and the forward wire roll with Baggely suction box good for sizes up to 30 T.P.D. so the wire section can be cope with. (The former wet end does not have the problem at all.) Plain presses, for speeds above 75 metres/minute are not so satisfactory, particularly with stonite rolls as has been stated above. Grooved press rolls could be used more effectively but are not recommended (except when the paper mill has grinding and good machining facilities, which is seldom the case) because unless the grooves are kept open and clear they are no improvement and they seldom stay effective for more than 3 months' operation. The fabric press, which uses only plain rolls, or the ribbed, synthetic felt are far more suitable and very effective, but, to the writer's knowledge India does not make fabric wires, felts or dryer screens.

There would be merit in encouraging manufacture, and permitting import until home facilities are adequate.

b) Drying Cylinders

These units are traditionally cast iron, 5'0" in diameter and about 6" wider than the widest sheet of paper made on the paper machine because the paper shrinks as it dries and must therefore begin the drying process wider than the finished sheet. It must also sustain a steam pressure, from 30 psi to 125 psi so manufacture is a specialised process, requiring large foundry facilities, special casting techniques and large machine tools. Such cylinders can be made in India but only by two or three suppliers with limited resources and they are a bottleneck to the small machine manufacturer. They need not be; rolled steel drying cylinders with fabricated end covers have been made successfully in Germany by a small manufacturer lacking foundry facilities and to the writer's knowledge, in Agentina, by a small manufacturer; of necessity in this instance because import at the time was forbidden. In each case, they were less expensive than the cast-iron alternatives and able to sustain higher pressures, improving the drying rate. It has been argued that they are more difficult to doctor with a steel blade but this has not been the experience and in any case not all drying cylinders need to be doctored, only the first few and the last one per section. It is also claimed that they are more prone to rust but again, this is a problem confined to the first cylinders only and not a serious handicap. If supply was limited to the cylinders after the first three it would cheapen the machine and relieve the bottleneck but the experience to date does not indicate this to be necessary. There must be many Indian engineering companies capable of rolling and welding steel cylinders and flame-annealing the welds to eliminate distortion. It is done successfully elsewhere and can be done in India.

c) Standardisation

It has already been established by several authorities that a width equivalent to the widest reel used anywhere in the world, around 2.25 metres and speed not exceeding 200 metres/minute is optimum for minimum capital and energy costs. The design can be of former type 1 to 3 stage, according to substance, or if preferred, of simple Fourdrinier and forward wire roll type but the formers should be less expensive and more versatile with no disadvantages. The most effective way of reducing capital costs, ensuring a reliable machine, a guaranteed performance and operation by unskilled labour in the shortest possible time, is to adopt a standard machine, whose component parts can be made in any competent workshop and will sell on price and quality. With the great needs of India ahead and the acknowledged part the small machine had to play in satisfying these needs there has surely never been a better opportunity than is now presented to adopt a standard machine and it is suggested that this is what the Government should encourage by incentives because it is not only the cheapest and best way to promote home industry, paper-wise and machine-wise but it offers an enormous export potential for other developing countries. The design should be government sponsored or subsidised because it cannot be expected to come from the smaller builder (or the large one!) If something organised in this manner is not done the small machines will vary unnecessarily from manufacturer to manufacturer and cost more. If it is done spares will be available anywhere and operators can be trained anywhere. It is believed that up to 30% economy can be achieved by standardisation. Until recently India only made one model of car, an impossible concept by Western standards but it suited the Indian economy admirably and had many maintenance and repair advantages. Is it impossible to consider small paper machines of one proven design also as being most appropriate for the future paper-making requirements?

IV.1.4. Energy

The small mill in India loses to the large mill in one definite respect. The latter is normally self-sufficient for power generation and more efficient in consequence because small mills invariably depend on the often unreliable State Grid. It used not to be so; the small paper mill with steam engine drive existed before State Grids. It is not suggested that the small mill should revert to steam-engines but small turbine drives for the paper machine are cheaper than the D.C. motor, AC/DC generator sets now in use and are easier to control and maintain. The whole steam/power balance for the small mill is worthy of study and the cause would be furthered by standardisation. A special case for study is also the sugar mill/paper mill complex to minimise fuel replacement and introduce power generation for both. Incidentally, many small-scale sugar mills have generation since the consequences of power failure can be drastic in particular parts of the process.

IV.1.5. Pulp Mill Design

IV.1.5.1. General

Apart from improvements which can undoubtedly be made in the cleaning and washing systems the small pulp mill as described could hardly be bettered from a basic equipment aspect. It is the only current economic unit of its scale, but though at present it admirably suits Indian and other developing countries' needs it cannot be regarded as perfect. A fundamental problem is associated with present designs: the absence of an appropriate chemical recovery, which is also economic and reliable at small-scale. Before elaborating on this deficiency it is pertinent to to review the recovery situation because recovery on the grand scale associated with large Kraft mills (wood-based), being so efficient in the recovery of chemical which otherwise would be an insupportable cost and effluent burden, and being also economic in fuel saving has been considered as a plus factor rather than as the palliative it really is. From another point of view it can be regarded as the reason why a basically unsatisfactory pulping process has survived when it should long ago have been replaced with something better. It saves up to 90% of the cooking chemical (but 10% loss to drain or atmosphere is still a lot of burden from a mill using hundreds of tonnes per day in circulation); it provides sufficient steam for its own and the pulp mill needs, but this is good only because the processes need such a quantity of steam and whilst there is no better use for the organic combustible elements of the pulping process; (which is questionable because they have been reduced to the lowest level of value, that of fuel). It adds enormously to capital costs which are justified in absolute terms because they enable an otherwise intolerable process to be tolerated. Is there no other way to produce pulp? A system which does not need chemical or only such as are not objectionable in the quantity required; which does not need steam but separates cellulose in the raw material from combustibles leaving the latter free for other than fuel purposes and does not require expensive, sophisticated and sometimes hazardous plant would be a great improvement on pulping as now practiced. Is it an impossible concept or has the success of recovery, large-scale, restricted progress towards a better answer? Many minds are considering this subject now because even the most modern recovery plant is objectionable to some degree and will not indefinitely be tolerated.

The functions of steam for temperature and chemicals are to accelerate the cooking process; does it really need acceleration? Time is on the side of the agricultural crop. For paper-making purposes the raw material spends most of its life in store. New processes working on these lines are being considered and will be mentioned later.

If recovery cannot be eliminated altogether, must it follow the present accepted form? Is there no other way of separating organic from inorganic material than by calcination? Finally, if there is no better way, can something be done about the high silica content of agricultural fibres to make the process more practical?

These are the issues which affect the small, agriculturally-based pulp mill. Answers are being sought and solutions will be found. Encouragement at high level, in practical form, should be given to development work already begun because the benefits could extend beyond the small mill into the pulp industry internationally.

IV.1.5.2. Pulping Processes

a) Long-Term digestion

Several methods of eliminating or reducing the heavy chemical requirements are being developed. One sensible approach is to question whether or not time and no chemical or very small chemical quantities cannot achieve some success. There are three promising approaches:-

i) Natural Digestion

In the Seychelles a process to use sugar cane for the sugar and cattle-feed simultaneously has been developed. The concept is revoluntionary, and worth investigation. The cane is not considered as a seasonal crop but an all-year round one because cattle must be fed daily. The sugar yield varies according to the time of cropping but in the overall economics this is not important. The outer cane fibre is 'indigestible' to cattle, so it is mechanically peeled off and discarded. The pith is crushed to extract sugar, but not to the maximum extent and the crushed pith is then allowed to digest naturally in a large unheated digester for 40 days. At the end of this period the pith has been pre-digested to a form where, with some added nutrients, it is good food for cattle. During the digestion period methane gas is generated in sufficient quantity to satisfy the sugar process fuel requirements so the discarded fibrous rind becomes, in fact, a disposal problem. A trial is now being made to crush the fibrous rind separately and extract sugar and to digest it separately for the 40 days as for pith. Gas will be generated sufficient as fuel for the sugar obtained but the residue will not be suitable for cattle-food. It is expected, however, that it will be suitable for paper, hopefully as is, but at worst, with greatly reduced chemical needs. Tests are being arranged; the process should produce results more suitable for the very small mill - up to 5 T.P.D. which hitherto has been considered too small to justify its own pulping plant except for high value, hand made paper.

ii) Long-term, minimum chemical, digestion

In his report to the 1978 UNIDO conference, Prior described work being done on long-term pulping with straw in storage. A mild chemical treatment is given and pulp suitable for beating with no further pulping process is said to have been produced, plus a cattle-food by-product. Work done elsewhere has indicated that 1.5% of nitric acid added to straw in solution before storage has produced pulp from which paper can be made with refining only after a suitable storage period.

iii) Biological Pulping

The processes mentioned above are promising but development work is limited by funds because they have not been sponsored by large companies or government grants. Biological pulping is being sponsored by larger organisations in Scandinavia and North America because the need for a permanently acceptable pulping process is recognised and the economic prospects are considered to be more rewarding. The by-products are food; human or for cattle, hence a much higher value for the organics than fuel. The chemical requirements are negligible, eliminating capital-expensive recovery plant. At the present time very little information on progress is available but it is expected that biological pulping will be economically established in the foreseeable future and is a "natural" for agricultural residues.

b) New Process - Ammonia Pulping

In 1974 J. Thillaimutha, published articles in Tappi and Pulp and Paper International describing a pulping process suitable for straw or bagasse, based on dilute ammonia 2% - 4%. It is, as described, a batch process, which separates the lignins from the cellulose. The ammonia can be easily recovered by distillation and recovery is claimed to be as high as 99.5%. The lignins can be evaporated for fuel or other purposes and no silica problems are experienced because it is not dissolved and the particles precipitate in the black liquor or are washed out of the fibre in the paper-making process. Yields are higher than with the soda-process and strength is said to be superior. To date it is only considered suitable for packaging grades of paper because bleaching is difficult but work is continuing. It offers considerable promise for straw and bagasse.

IV.1.5.3. Bleaching

From the equipment aspect the new Karlstadt stacked type diffusion process ought to be suitable and more economical in cost and space than the traditional separated 3-stage systems. It is known to be suitable for small-scale because it has been developed at pilot-plant level successfully. The design was, naturally, aimed at the large wood-based pulp mill for utilisation but there could be a substantial market for a standard 25/30 T.P.D. model in developing countries.

IV.1.5.4. Summary

The small mill has arrived in India at a time most appropriate for its further development. For much of the equipment produced the design is a copy of the technology of 30's because during the difficult years following Independence there was nothing better to copy available and manufacture was within the capability of engineering resources. There was nothing wrong in following this line; in the event the outcome has been better than would have been the case had a slavish adherence to Western philosophies been followed instead. The case for the small mill, based on recycling or agricultural residues has been established beyond reasonable doubt. Beyond this, the advantages of encouraging small-scale private investment have also been demonstrated. India's needs for paper are being met by the small mill to a significant extent now and will be satisfied by small mills in the future to an ever-increasing degree, particularly as the cost of transport increases, as it is bound to do, disproportionately to other costs. Whilst this is an outcome which can be viewed with some pride, it is not one which can be viewed with complacency. The small, second-hand machine is regarded as best value for money by those with whom the subject has been discussed, not simply because of the lower capital cost, but because it runs more efficiently, although it still represents in most cases technology of the 50's and 60's. There is not an unlimited supply of second-hand machines, certainly not sufficient to meet the small mill requirements which must arise in India, and other developing countries also have needs.

Nor can it be expected that mills operating at 65% efficiency and lower than necessary quality can have a permanent role in a developing country. There is now a need to consolidate the position. Small machines have capital cost and financing advantages; they also have inherent efficiency and quality advantages and these must be realised. The climate is favourable; all over the world existing techniques are being questioned and new techniques are emerging. Most of them are favourable to the small mill. This applies not only to machines but to pulping processes. There is need to sift out the best and to incorporate it in small mill technology, to be innovative and not to follow in all aspects. The development work should be organised and encouraged at Government level to avoid duplication of effort, minimise waste effort and to give adequate support to effective effort. A new look at the basis for incentives could have far-reaching results not simply for the home needs of India but for the developing world elsewhere because India has present advantages of experience and inexpensive skilled labour unrivalled in the small-scale paper mill field.

APPENDIX V

TRAINING

V.1. Forest Research Institute, Dehra Dun (U.P.)

The Cellulose and Paper Division in this research institute is equipped with pilot plant for pulp processes and paper-making. It also has extensive laboratories and can offer short or long-term training to candidates, normally sponsored by paper mills.

V.2. Institute of Paper Technology, Saharanpur (U.P.)

The Swedish government supplied most of the equipment required to set up this institute, founded in 1968 and made available six Swedish experts for five years plus training facilities in Sweden for ten Indian teachers. The Institute is affiliated to the University of Roorkee and awards degrees in Chemical Engineering with major courses in Pulp and Paper Technology. It also awards Diplomas in Pulp and Paper Technology and a certificate course for operators. All involved disciplines, including mechanical, electrical and instrumentation engineering are covered.

The Institute is open to foreign students and many are enrolled each year. Indian candidates are sponsored by mills belonging to the Indian Paper Makers Association and the All India Small Paper Mills Association.

PREFACE

The publication on small-scale papermaking in India entitled "Small-Scale Papermaking" by A.W. Western was commissioned by Intermediate Technology Industrial Services with the aim of identifying production levels more appropriate to developing country needs. As a supplement to this book, ITIS has compiled ten case-studies of actual mills either in operation or under construction.

These studies are intended to give detailed information on the technology and economics of a range of plant sizes from 1 to 30 tonnes per day. The economic data collected in early 1979 has been presented in Indian Rupees reflecting the general availability of much of the equipment in India (at present Rs. 8 are equivalent to US$1).

Although the case studies refer to actual mills, all references to names and places have been omitted in accordance with the entrepreneurs' general wish for anonymity.

The ten case studies demonstrate the economic viability of these small-scale units (defined as operating at capacities up to 30 tonnes per day). The return on investment before taxation ranges from 16½% for one unit operating at 30 tonnes per day to 40% for a unit operating at 1 tonne per day. The average return in 27%. Recent paper shortages in India have further raised finished paper prices in real terms, making investment in small-scale units to serve localised markets increasingly attractive. From the national point of view, these units are important sources of employment and income creation in rural areas and have generated significant levels of value added in these areas.

An interesting conclusion arising from the studies is the need for careful thought to be given to the financing structure of these small-scale units. On the whole, the debt:equity ratio of 2:1 has tended to be a little on the high side, and the use of short-term loans for working capital needs has tended to strain the cash flow in the initial years of commercial production. In this situation, there are positive advantages in raising a higher proportion of capital needs in the form of equity. However, this is not to deny that two substantial benefits of investing in small-scale as opposed to large-scale units are the shorter gestation period and the lower working capital needs per tonne of output of the former.

Small units serving local markets have tended to sell their production for cash, particularly in view of their ability to respond to the need for small sales' lots.

Finally, ITIS would like to acknowledge the considerable contribution made by Hangal Paper Consultants Limited (New Delhi, India) in compiling this information.

Ken Marshall
March 1980

NOTE ON METHODOLOGY

The profitability analysis in section 15 is presented on the basis of the internal rate of return on total project capital outstanding. This rate of return (IRR) is defined as that discount rate which equates the net present value of recurrent cash flow over the project life (taken as 12½ years) with the initial investment outlay. Gross profits before tax are taken as the recurrent cash flow for computation of this return on total capital.

A paragraph entitled "Sensitivity Analysis" has been added in Section 15 to show the effect on this total project return of variations in five key factors - namely, investment costs, selling price, production costs, project gestation period and rates of capacity utilisation.

The "payback period" analysis in Section 15 shows the number of years of commercial production necessary for the total capital outlay and for equity contributions to be recovered. To this figure must be added the gestation period of the project i.e. the time taken to clear land, instal services, equipment, etc., which is taken as 1 to 2 years.

TABLE OF CONTENTS

ABBREVIATIONS

AD	Air Dry
BD	Bone Dry
GSM	Grammes per square metre
MGD	Million Gallons per day
MS	Mild Steel
PS	Plate Steel
TPA	Tonnes per Annum
TPD	Tonnes per Day

SMALL-SCALE PAPERMAKING

CASE STUDIES

PART 1

CASE-STUDY

1 TONNE PER DAY (HAND-MADE)

1. Synopsis

This 1 tonne per day plant commenced operation in 1978 in the Tamil Nadu State of India. Total Capital costs were Rs.1.61 million, equivalent to Rs.4,880/annum installed tonne.

The main raw materials used are white tailor cuttings and white hosiery rags to produce high quality paper (especially water colour paper) for export.

2. Installed Capacity

The present pulping capacity of the plant is 500 kg/day based on 3 shifts. However, the firm intends to increase its capacity to 1 tonne/day by installing one additional Hollander Beater and one additional batch digester. The Company has at the moment 7 moulding vats. Typical output of each single vat is 20 to 25 kilos per 8 hour shift. Increasing the forming capacity is simple and inexpensive as additional moulding vats can be obtained at a very low cost and therefore the limiting factor in capacity of the plant is the pulping capacity.

3. Product Range

The Company makes following types of hand-made paper :-

a) Water Colour Paper
b) High Quality Bond Paper
c) High Quality Stationery papers
d) Printing Papers
e) Greeting Cards
f) Gift Wrapping Papers

The predominant product is the Water Colour paper which accounts for about 80% of the total production. Water Colour paper is sold in reams of 500 sheets (22" x 30") each. There are three standard ream weights of 90 lb., 150 lbs and 300 lbs. The 90 lbs ream is the most popular variety of Water Colour paper and accounts for about 70% of the output of Water Colour paper.

4. Brief Description of the Mill

Before setting up the plant the entreprenerus carried out an extensive study of the various forming techniques followed in Europe and Japan and did a thorough study of hand-made paper industries. Finally the firm settled on technology that was prevalent in Germany and with a lot of research and development modified this to suit local conditions. All necessary raw materials are available within a radius of 100 kilometres. Being located in an industrial area, power, water, etc., are easily available and there is no problem in obtaining suitable manpower. The plant is well connected by rail and road to important nearby cities.

5. Particulars of the Plant

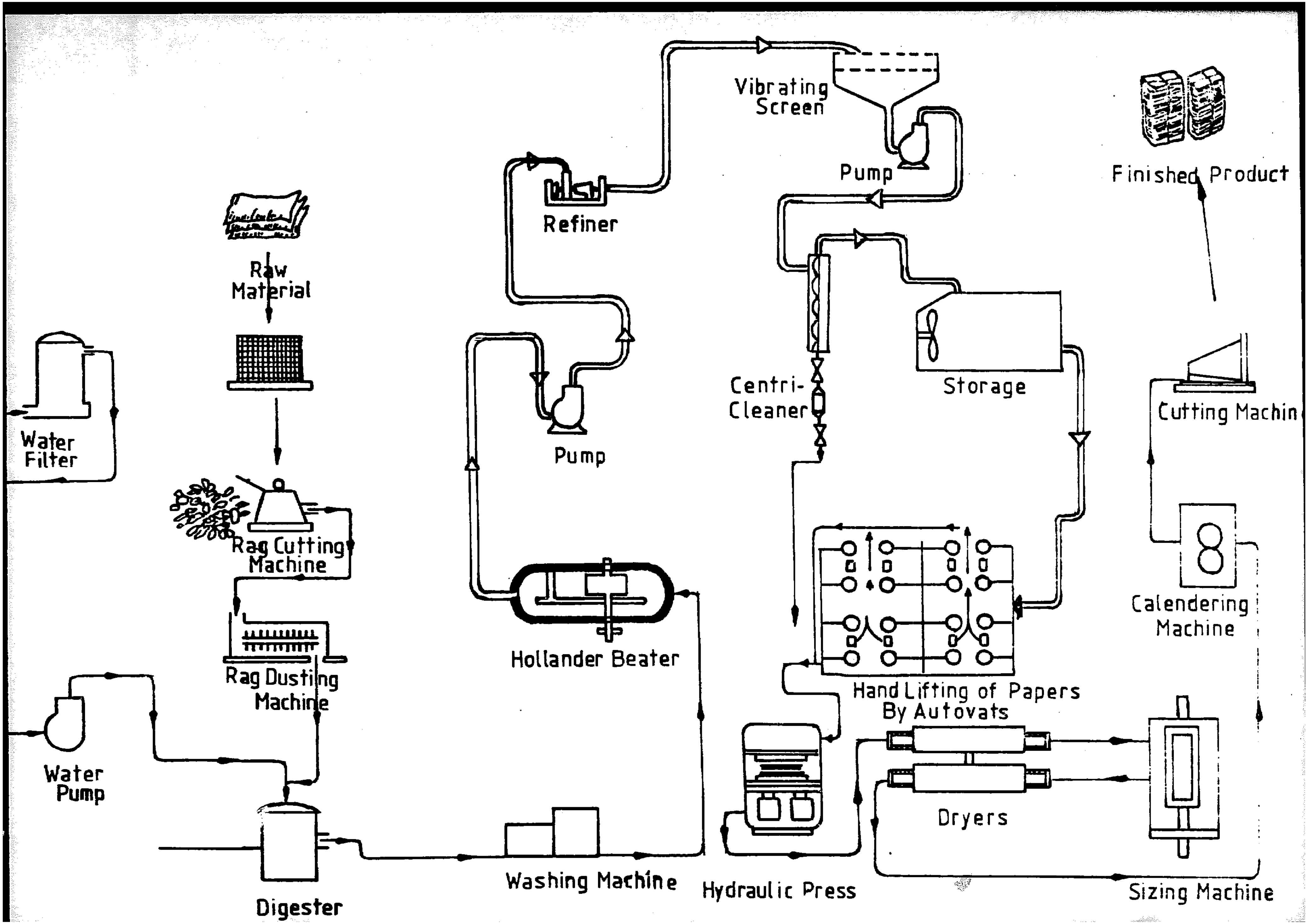
The mill has been in production for about six months. All the equipment required for the plant has been designed and fabricated by M/s. Farm Implements (Pondicherry). In addition to supplying equipment, M/s. Farm Implements are also in the process of supplying the complete plant and equipment on turnkey basis to about 4 other parties in the area.

This plant differs somewhat from most hand-made paper units. Like the latter, paper is formed in a vat and lifted by hand. However, this particular unit uses pulping equipment more commonly found in mini-mills.

6. Process of Manufacture

A complete flow scheme for the mill is given overleaf. White tailor cuttings and hoisery rags are chopped in a rag cutter, which has a capacity of 50 kilo-grams per hour. After the rags have been cut to suitable length, they are passed through a rag duster, which also has a capacity of 60 kg. per hour. Depending upon the quality of the raw-materials and the quality of the paper to be manufactured, the rags may be dusted as many as three times. The rag duster primarily consists of a central hollow shaft on which are mounted vanes. This shaft is centred in a perforated drum which rotates in a direction opposite to that of the shaft. The whole assembly is enclosed in an air-tight casing. The accepted rags are discharged at the far end of the duster and rejects are discharged at the centre. After dusting the rags are collected in a bag and manually charged into the digester, which is a stainless steel lined vessel with means for external heating. Cooking is done with 1% Caustic at 95°C to 100°C at atmospheric pressure. (1% Caustic may be too low, and a more common ration of caustic to pulp is 4% by weight). It takes about 1½ hours to load the digester with rags and to bring it to the required temperature. Retention time in the digester is typically 4 to 5 hours and discharge takes about one hour. About 150 to 200 kgs. of rags are cooked in the digester with 2 tonnes of water. Thus, one digester is capable of pulping about 500 kgs. of pulp on three shift basis. After the raw material has been cooked, it is washed in a washer which has a capacity of 50 kgs. per batch and up to three batches can be produced in a single shift. After washing, the stock is taken to a Hollander Beater which has a capacity of 150 kgs. per batch. The Hollander beater is lined with fibre glass and the consistency of the stock in the beater is around 5%. Process chemicals are added in the Hollander beater: 1% starch, 1% Sodium Silicate, 1% Talcum, 5 to 6 Alum, 3% Rosin, 2 to 3% Animal Glue and up to 1% titanium dioxide.

From the Hollander beater, stock can be taken into one of 4 storage tanks each about 10.5 metres (diameter) by 10 metres (height) where back-water is added for dilution purposes. This way four types of pulp can be stored in four different storage tanks and any desired pulp furnish obtained by mixing stocks from these tanks. After the desired furnish has been obtained, the stock is pumped into a refiner after which the stock flows by gravity to a circular vibrating screen. The larger rejects from this screen are sent back to the Hollander beater and the smaller rejects are sent to the refiner. The accepted stock from the screen is collected in a storage chest from where it is pumped to the centricleaners. After the stock has been cleaned in the centricleaners, it is pumped into an elevated storage tank ready for supply to the forming moulds.



Vibrating Screen
Pump
Finished Product
Refiner
Raw Material
Centri-Cleaner
Storage
Cutting Machin
Water Filter
Pump
Rag Cutting Machine
Calendering Machine
Hollander Beater
Rag Dusting Machine
Hand Lifting of Papers By Autovats
Water Pump
Dryers
Washing Machine
Hydraulic Press
Sizing Machine
Digester

All the piping in the plant is PVC and the Hollander beater and washer are fibre-glass lined. There is a single stainless steel stock pump,which, interconnected by various piping connections, transports stock between a number of different points. Centricleaners are of stainless steel construction and the digester has stainless steel lining. All the storage tanks are made of wood or RCC.

After the stock has been stored in the overhead storage tank it can be delivered by gravity to any one of the various forming stations.

The Forming Mould consists of a fine 40 to 60 mesh plastic wire backed by a coarser 6 mesh plastic wire. The backing wire is supported on a suitably stiffened wooden frame. Edges of the wire are clamped in between the top wooden frame and the bottom wooden frame and this assembly is held together by copper edgings and brass nails.

In the vat there is provision to place the forming mould between the slurry dam and the Sealing Chamber. The slurry dam is of simple wooden construction and it allows the top of the Forming mould to be isolated from the pulp slurry in the vat. This dam is about 5" high. The sealing chamber is of similar construction and is about 7" high. The whole assembly consisting of slurry dam, forming mould and sealing chamber can be moved vertically and laterally and is suspended in the vat by means of ropes. The ropes are connected by linkage to a foot operated bar.

At the start of the forming cycle, the clamped or hinged junction between the slurry dam and sealing chamber is brought out beyond the pulp slurry level in the vat. The forming mould is then placed in position between the slurry dam and the sealing box. The completed assembly is then lowered into the vat so that the forming mould is about 3" below the slurry level in vat. The pulp supply valve is opened and stock is measured and transferred to the top of the forming mould by means of buckets. Alternatively measured amounts of stock can also be delivered at the top of the forming mould through a flexible hose from a small measuring cylinder connected to the pulp supply line through valves.

After stock has been poured over, the complete assembly is lifted by the pedal mechanism while being gently shaken manually. The junction between the slurry dam and sealing is lifted past the slurry level in the vat so that the sealing box creates a small vacuum which improves drainage of the sheet.

After this, the forming mould is removed from the assembly and the sheet is couched off on a woollen or cotton blanket. For water colour paper a cotton blanket is used while for most other papers a woollen blanket is employed.

Following the above sequence, a number of sheets with blankets are piled on top of each other. After about 40 sheets have been collected they are taken to a hydraulic press. The hydraulic press is approximately 42" x 48" and has about 200 tons capacity. After pressing the sheets are approximately 65% wet.

At present drying of wet sheets is being done in air by hanging them on wires with wooden clips. However, the plant will soon have machine drying. The machine drying equipment has been developed by M/s. Farm Implements and they have already successfully tried this equipment. This equipment will primarily consist of endless felts between which the wet sheets will be squeezed and dried. The dryer is basically a tunnel type of dryer employing steam for heating purposes. After the sheets have been sized, they are again passed through the dryer.

If required, the dried sheets can be passed through a small calender before trimming them to desired size. Some customers for hand made paper prefer a deckle finish,and therefore, no trimming may be necessary. In order to produce deckle finish for small sized high quality stationery papers, properly spaced fine threads may be used on the forming mould.

7. Services

Power

Total installed H.P. for one tonne capacity hand made paper plant of this type is nearly 125 H.P. and the Company has a suitable L.T. connection of 440 volts for this prupose. The average price of electric power is Rs. 0.45 per KWH which is relatively high.

Water

For a one tonne per day hand made paper plant, the requirements of water would be approximately 75,000 litres of water per day. The factory draws water through a 1½" line. The water passes through a micro filter which filters water under pressure through a very fine screen. The filtered water is kept in a pressurised receiver at 40 psi ready for use in the plant. The charges for the water depend upon the number of connections and there are no meter charges. Because of this water charges per month amount to a flat rate of Rs.45/- only which is relatively inexpensive.

Steam

At present, the firm does not have machine drying. However, when the machine drying equipment is installed, there will be a 500 kgs per hour mini-boiler which should be quite adequate for a plant of 1 TPD capacity. The mini-boiler can be either coal or oil fired.

The typical price for such a mini-boiler (manually operated) inclusive of all accessories is Rs. 50,000.

Effluent

There is a separate drain in which the firm discharges its effluent which ultimately meets the drainage system of the industrial area. At present, there is no problem in terms of discharge of effluent.

8. Capacity Utilisation

The management is constantly trying to improve upon the equipment and the process involved in making hand made paper. Further improving the quality of the product is the main aim.

At the moment, there is a loss of fibre through spillage of pulp from vats and during manual feeding of pulp to the vat. Because of contamination, no effort is made to reuse this white water.

9. Raw Materials

The main fibrous raw materials that the firm uses are white tailor cuttings and white hoisery rags which are available within a radius of 100 kilometers. The price of white tailor cuttings is approximately Rs. 3000/- per M.T. whereas the cost of white hoisery rags is around Rs. 3,400/- per M.T. Freight is extra and would be around Rs.200/- per M.T.

Apart from the main raw materials, the firm also uses process chemicals like Talcum, Rosin, Alum, Starch and small amounts of Titanium Dioxide.

10. Labour

At the moment the firm employs nearly 50 people. However, when the plant attains its capacity of one tonne per day, the manpower requirement would vary from 80 to 90 at Rs 325/- per man per month inclusive of all benefits, etc,. The firm has set up its own training programme in order to train operating personnel for the plant.

11. Financial Structure

The firm operates as a partnership and the finance has been provided from the personal resources of the partners and by loans from commercial banks against plant and equipment. Debt equity ration of 2:1 can be taken as a typical financing pattern.

12. Capital Costs

The indicated breakdown of the total project cost for 1 T.P.D. project would be as follows :-

		Rs.	Rs.
1.	Land & Civil Cost		
	600 Sq. Metres of covered area(Shed in Industrial area).		300,000
2.	Plant & Equipment		
	Pulping Section	400,000	
	Forming Section	100,000	
	Drying Section	350,000	
	Finishing Section	50,000	
	Mini Boiler	50,000	
	Water Treatment	30,000	980,000
3.	Misc. Fixed Assets		70,000
4.	Preliminary & Pre-operative		50,000
5.	Working Capital (ca Rs 480/annual tonne)		110,000
6.	Contingencies		100,000
		TOTAL Rs.	1,610,000

13. Operating Costs

Based upon the information received from the company the estimated cost of production will be as follows :-

	Reqd/tonne of Paper	Unit Cost	Cost per Tonne of Paper	
Raw Materials	Tonnes	Rs/Tonne	Rs.	Rs.
White cotton cuttings	0.6	3200	1920	
White hoisery cuttings	0.6	3600	2160	4,080
Chemicals	Kgs.	Rs/Kg		
Alum	50	1.1	55	
Caustic (1%)	12	3	36	
Talcum	10	.6	6	
Rosin	30	12	360	
Animal Glue	25	13	325	
TiO2	1	20	20	
Sodium Silicate	12	1	12	
Starch	12	2	24	838
Labour				
90 men at Rs 350/man per month (per tonne rate at 70% capacity utilisation)				1636
Administrative overheads				
Rs. 100,000 per year (per tonne rate at 70% utilisation)				433

Utilities

Power	600 Kwh/tonne	.45/Kwh	270	
Water (per month)			2	
Heat for Drying (Fuel Oil)	400 Kg. of oil	1.20	480	752

Others

Packaging	Rs.200	
Consumables & Maintenance	Rs.100	
Forwarding	Rs.100	400
TOTAL		Rs. 8,139

14. Selling Price

The firm concentrates on making hand made paper of highest possible quality and caters to a very specialised and sophisticated market.

The average sales realisation per tonne of paper is about Rs 11,000 per M.T. It should be noted that there is not excise duty on any hand made paper in India.

The key to the success of the firm lies in its well established marketing arrangements. In fact all the hand made paper produced by the firm is for export purposes only and they have backlog of export orders.

The firm has appointed agents in Europe. In North America, the sale of hand made paper is done through Meri Cie, a marketing firm in California, U.S.A.

15. Profitability

Based on information collected, profitability of the 1 T.P.D. plant will be :-

	Rs. (million) p.a.	Rs/tonne of paper
Sales Revenue (at 70% of annual capacity of 330 tons)	2.541	11,000
Cost of Production	1.880	8,139
Gross Profits	0.661	2,861

Return on Capital

The internal rate of return on total capital is 40% before tax. After tax at 55% on profits (net of depreciation and interest payments), the return on total capital is 25%. Depreciation is calculated on a straight line basis at 8% p.a. on fixed assets of Rs. 1,050,000. Interest is calculated at 9½% of Rs. 1,000,000, repayable in ten equal installments over 10 years, for fixed assets, and at 16% of Rs. 110,000 repayable in 1 year for working capital purposes.

The return on equity is 50% over the 12 year period after allowance for interest and amortisation payments on the short and long term loans raised.

The availability of certain concessions (particularly, central cash subsidy of 15% of plant and equipment costs supplementing owners' equity; a tax-deductible development rebate equivalent to 25% of plant and equipment costs; tax allowances for profit reinvestments) will raise the above returns even further.

Sensitivity Analysis

The return on all capital of 40% is sensitive to the following variables :

Change	Change in IRR
10% increase in investment	- 4%
10% increase in revenue	+ 25%
10% increase in production costs	- 12%
10% increase in capacity utilisation	+ 7%
Increase in gestation period to 2 years	- 6%

The most sensitive variable is the selling price and in view of recent rises in this price (in real terms), the project is becoming increasingly profitable.

Packback Period

The cash flow generated would pay back total capital outlay within 3½ years and equity contribution within 2 years of the commencement of production. This pay-back analysis takes account of necessary tax and loan amortisation payments.

Comments

This unit is an example of a well-organised small-scale unit operating at the quality end of the hand made paper market. It has found a ready market for its high-quality products and this is reflected in the selling price of its paper and the 35% mark-up on production costs (before financing charges).

The return on investment is conservative in view of the availability of various development incentives.

CASE STUDY

5 Tonnes Per Day Papermill

ITIS, March 1980

1. Synopsis

This 5 tonnes per day plant operating in the Uttar Pradesh State of Indian commenced production in late 1978, manufacturing writing and printing papers. Total capital invested was Rs 4 million for an annual capacity of 1,650 tonnes, or Rs 2,420 per annual tonne.

Raw materials used are waste paper and bought-in pulp.

This particular case-study reflects the ability of entrepreneurs to substantially reduce capital costs by careful selection of suppliers and incorporation of an element of own design.

2. Installed Capacity

PULP MILL	Waste paper pulping equipment only Capacity 5 TPD.
PAPER MILL	One MF Fourdrinier paper machine Capacity 5 TPD. (The paper machine installed has a potential to increase paper mill capacity to about 10 TPD with only minor additions).

3. Products Range

The mill produces writing and printing paper of basis weight from 50 to 80 GSM. The mill has equipment to make both reels and sheets although at the time of writing of this report the mill was experiencing problems with the Duplex Paper Cutter which was designed by the mill and fabricated on site.

4. Brief Description of the Mill

The mill is located in the State of Uttar Pradesh. This unit has been selected for case study as it was set up with an extremely low capital cost and all the plant and equipment was procured from indigenous sources. The present capacity of the plant is only 5 TPD of writing and printing papers. However, the mill has reliable potential to increase its present capacity by adding straw pulping and some additional paper machine dryers and supporting equipment. This expansion will be financed by cash generated from current operations.

5. Particulars of the Plant

The mill went into commercial production in the last quarter of 1978. The paper machine for the plant was supplied by M/s Hindon Engineering Works. The Hydrapulper was also supplied by Hindon; the Hollander Beater, Johnson type vibrating screen, thickener chest agitating equipment, refiner and pumps, etc., were supplied by other manufacturers.

6. Process of Manufacture

This is presented diagrammatically overleaf.

7. Services

Power: The Company purchases power from UP State Electricity Board as the scale of its operations is not sufficient for its own power generation. The installed power connected at the mill is 375 KVA and average consumption is around 1100 KWH per tonne of paper produced.

Steam : The mill has one coal fired boiler of 3 tonnes/hour capacity. The boiler is a Lancashire type boiler and the cost was approximately Rs 1.75 lakhs in mid 1978.

Water: The Company has its own deep bore tubewell to meet water requirements. Feed water for the boiler is treated in the boiler house but there is no treatment for the water used in other processes.

Effluent: The company discharges all its effluent in the Minicipal drain and there is no equipment or facilities for treatment of effluent before its disposal.

The unit depends for power on the State Electricity Board. The situation regarding availability of power varies from State to State and power failures or load sheddings are regularly experienced. Availability of coal is also a potential bottleneck as the movement of coal is a problem due to shortages of railway wagons. However, the company stocks adequate quantities of coal to compensate for irregular supplies.

The unit with its own tubewells is self reliant for all water requirements. The only raw material required by the mill is waste paper which is readily available within a short radius. However, the prices of various grades of waste paper are rather erratic, being dependent on demand.

8. Capacity Utilisation

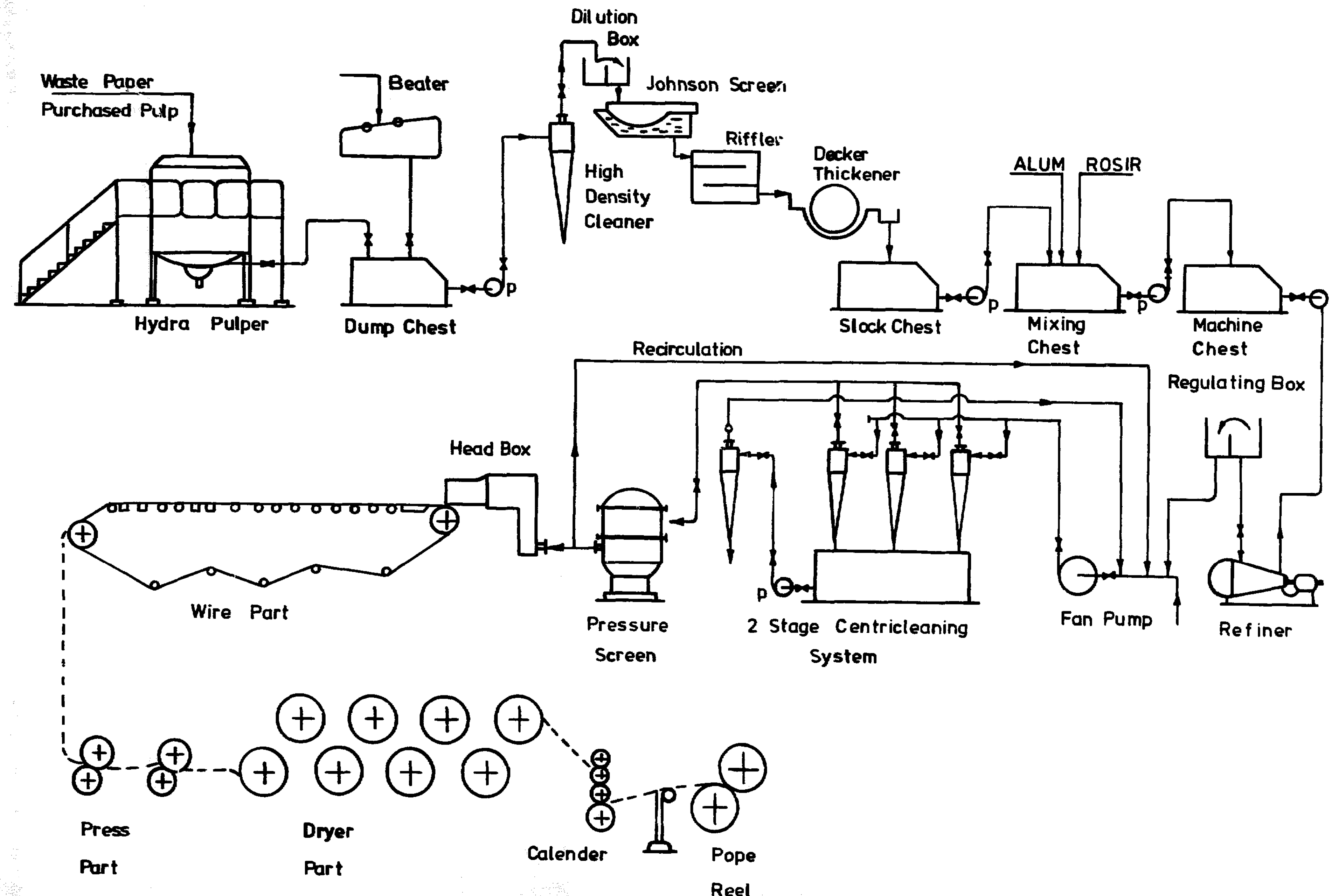
This is estimated as 70% of installed capacity reflecting start-up of the plant and possible unreliability of the power supply. Annual production of 1,155 tonnes is assumed.

9. Raw Materials

The company uses waste paper of various grades. The major grade of waste paper is printer's white cuttings. The daily requirement of waste paper is 5 to 6 tonnes and the company keeps a minimum of 15 days' supply which is stored, uncovered, outside.

10. Labour

The company employs about 150 personnel.



Waste Paper
Purchased Pulp
Hydra Pulper
Beater
Dump Chest
p
Dilution Box
High Density Cleaner
Johnson Screen
Riffler
Decker Thickener
Stock Chest
ALUM
ROSIR
Mixing Chest
Machine Chest
Recirculation
Regulating Box
Head Box
Wire Part
Pressure Screen
2 Stage Centricleaning System
Fan Pump
Refiner
Press Part
Dryer Part
Calender
Pope Reel

11. Financial Structure

	Rs Millions
Equity of promoters	2.05
Terms loans from financial institutions	1.95
Total investment cost:	4.00

12. Capital Costs

1. Land

2.5 acres of land	Rs 80,000

2. Civil Works

i) Pulp mill shed 85' x 56'	
ii) Paper m/c and stock prep. hall 180' x 40'.	
iii) Boiler House 30' x 60'	
iv) Roads & Drains	
v) R.R.C. Chests/silos	Rs450,000

3. Plant and Equipment

i) Paper m/c	
ii) Pulp mill equipment	
iii) Stock preparation	
iv) Boiler, Tubewell, etc	Rs300,000

4. Other Costs

i) Misc. Fixed Assets

ii) Preoperative expenses

iii) Margin money — Rs 470,000

Rs4000,000

13. Operating Costs

The cost of production per tonne of paper has been given as approximately Rs 4180/-. As the mill has gone into production very recently, no realistically reliable breakdown of costs is available. However, based on data collected, an estimate is given below :

	Quantity Required/Ton of paper	Unit Cost in Rupees.	Cost per Tonne of Paper in Rupees.
Raw Materials			
Waste paper	1.10	2300	2530
Chemicals			
Sizing chemicals			200
Utilities			
Coal (for steam)	1.00	220	220
Power	1100 KWH	0.3	330
Other Expenses			
Maintenance and consumables			150
Pkg. and Forwarding			80
Manpower			550

Administrative overheads	120
Total operating Costs	4,180

14. Selling Price

Average net sales realisation per tonne of paper is Rs. 5,200.

15. Profitability

Estimated profitability is given below :

	Per Year in Millions	Per Tonne of paper
Net sales realization after excise duty rebates (70% cap. Utilisation).	6.01	5200
Total Operating Costs	4.83	4180
Gross Profit Margin	1.18	1020

Return of Capital

The internal rate of return on total capital is 28% before tax. After tax at 55% on profits (net of depreciation and interest payments) the return on total capital is 17%. Depreciation is calculated on a straight line basis at 8% p.a. on fixed assets of Rs 3 million. Interest is calculated at 9½% of Rs 1,950,000 repayable in equal installments over 10 years.

The return on equity is 25% after allowance for interest and amortisation payments on the loans raised.

Sensitivity Analysis

The return on all capital of 28% is sensitive to the following variables :

Increase	Change in IRR
10% in investment	- 3%
" " revenue	+ 15%
" " production costs	- 14%
" " capacity utilisation	+ 5%
In gestation period to 2 years	- 4%

Payback Period

Total capital outlay is repaid within 5 years and equity outlay by the end of 4 years of commercial production (after payments for tax and loan amortisation where appropriate).

Comments

The 5 tonne per day unit typically uses waste paper as its main raw material input and this unit reflects the ability of entrepreneurs to cut capital costs by incorporation their own designs into the basic plant and also by buying equipment from more than one supplier.

As the sensitivity analysis shows, the unit is equally and very sensitive to changes in production costs and selling prices. In the light of recent rises in finished paper prices, the return on capital can be expected to rise.

The intrinsic value of the mill which serves a major industrial city is its short gestation period before production start - up and its ability to meet the demand for small production lots.

The willingness of customers to pay for the latter advantage in terms of making cash payments and undertaking own transportation keep small mill costs down and reduce working capital needs.

CASE STUDY

5 Tonnes Per Day

1. Synopsis

This 5 tonne per day mill commenced operation in 1977 in the Assam State of India. Total capital costs were Rs. 6.8 million or Rs. 4,120 per installed annual tonne.

The main raw materials used are waste paper and cotton rags to produce tissues and light weight MG papers.

2. Installed Capacity

Pulp Mill	:	5 TPD (Rag pulping and purchased market pulp processing plant)
Paper Machine	:	5 TPD (MG Lightweight Tissues)

3. Product Range

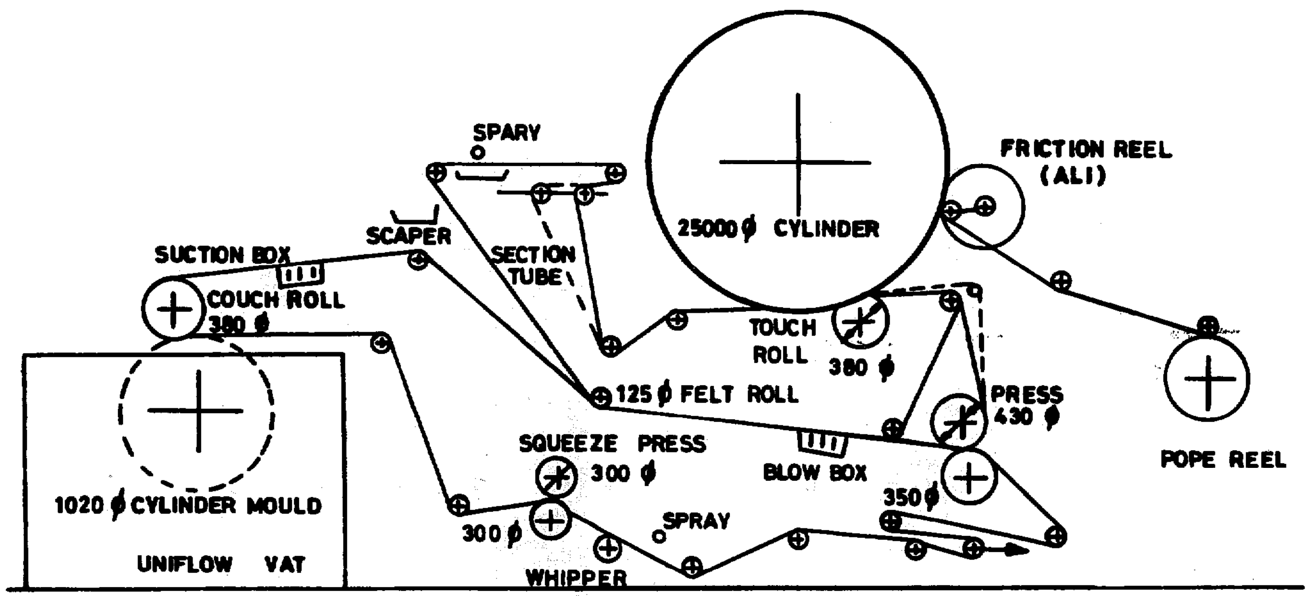
Light weight tissues and machine glazed (MG) poster paper of substabce range 25 to 40 gsm.

4. Brief Description of the Mill

The Company was incorporated in 1970 as a private limited company. In 1976 the Company was converted into a public limited company although no equity shares have yet been offered to the public. The Company does not share operations with any small or large sized pulp or paper mill and exists as a viable small sized mill on its own. The factory of the company is located in the state of Assam and is well connected with the transportation network in the area. The mill plans to expand its capacity by installing straw pulping equipment.

5. Particulars of the Plant

The mill went into commercial production in April 1977. The paper machine is a second hand imported MG machine obtained from Taiwan. All pulp mill equipment, stock preparation equipment and finishing equipment including sheet cutters have been obtained indigenously.


SPARY
FRICTION REEL
(ALI)
SCAPER
SECTION
TUBE
25000 ϕ CYLINDER
SUCTION BOX
COUCH ROLL
380 ϕ
TOUCH
ROLL
380 ϕ
125 ϕ FELT ROLL
PRESS
430 ϕ
POPE REEL
SQUEEZE PRESS
300 ϕ
BLOW BOX
350 ϕ
1020 ϕ CYLINDER MOULD
SPRAY
300 ϕ
UNIFLOW VAT
WHIPPER

6. Process of Manufacture

The mill has facilities to process cotton rags. The typical equipment involved for rag pulping is a rag cutter, rag duster, batch digester, pulp cleaning and washing equipment and pulp bleaching equipment. In the existing arrangement 20% rag pulp is blended with 90% of waste paper pulp. The MG paper machine is a simple paper machine with one cylinder mould and a Yankee cylinder. A diagram of the paper machine is shown overleaf.

7. Services

Power : The Company obtained its power requirments from the Assam State Electricity Board, the installed power connected to the mill is 690 KW.

Steam : The mill has one second hand coal fired boiler of Economic type which has a capacity of 2.5 tonnes per hour.

Water : The mill depends for water on tubewells at site. Two deep bore tubewells give approximately 12,000 gallons per hour of water to meet all the requirements of the mill.

Effluent : The Company discharges all its effluent into a public drain and there is no equipment for treatment of this effluent before its disposal.

8. Capacity Utilisation

The designed capacity of the plant is 5 tonnes per day. At the moment the company is utilizing about 70% of its installed capacity and producing on an average 3.5 tonnes per day. Availability of coal, periodic power failures and load shedding are the main constraints over which the mill has no control. The factory is located in the State of Assam which is in the far North East of India, considered to be a somewhat disadvantageous position regarding transportation of raw materials and finished goods.

9. Raw Materials

The main raw material is waste paper which is easily available from State capital of Gauhati near which the mill is located. The averate cost of mixed grades of waste papers is around Rs. 1,700/tonne delivered to site. In addition to waste paper, the mill also uses small quantities of market pulp. On average, 20% of the furnish consists of rag pulp. Rag pulp is obtained from a mixture of cotton linters and white hosiery cuttings and the average cost of this can be taken as Rs 3,000/ tonne.

10. Labour

The mill employs a total of 115 people which includes all the staff.

11. Financial Structure

For a standard 2:1 debt to equity ratio, the financing pattern of the company is as follows :-
(in Rs millions)

Long term debt	4.3
Working capital	0.4
Equity	2.1
Total invested capital :	6.8

12. Capital Costs

The total cost of the project was Rs. 6.8 million which included Rs. 400,000 for working capital. The capital cost per tonne of installed annual capacity came to Rs. 4,530. However, the capital cost per tonne based on an average annual production of 1155 tonnes is to Rs. 5,887.

13. Operating Costs

Based on the date collected from the mill, plus independent investigations, operating costs have been estimated at 1979 price levels. The detailed estimate of operating costs is as follows :-

	Quantity Required/ton of paper	Unit Cost in Rs.	Cost per tonne of paper in Rs.
Raw Materials.			
80% waste paper (90% yield)	.88	1700	1500
20% rags(80% yield) (hosiery cuttings -cotton linters)	.25	3000	750
Chemicals			
Cooking chemicals			
Bleaching chemicals			
Sizing chemicals			300
Utilities			
Coal	1.00	220	220
Power	1000	0.25	250
Other Expenses			
Maintenance & Consumables -			200
Packaging & Forwarding			100
Manpower			550
Administration			150

Per Tonne Operating Costs Rs. 4,020

14. Selling Price

The mill produces high value light-weight tissues and poster paper. The average net sales realization per tonne of paper can be taken as Rs. 5,500 per tonne.

It should be noted that net sales realisation is arrived at after taking into account excise duty rebate, freight and dealer commissions, etc.

15. Profitability

The profitability of the mill is based upon its current capacity utilisation of about 70% equivalent to an annual output of 1,155 tonnes.

	Total p.a. (Rs millions)	Per tonne of Paper in Rs.
Net sales realization after excise duty rebate	6.35	5,500
Total operating expenses	4.64	4,020
Gross margin	1.71	1,480

Return on Capital

The internal rate of return on total capital is 23% before tax. After taxation at 55% of profits (net of depreciation and interest payments), the return on total capital is 14%. Depreciation is calculated on a straight-line basis at 8% p.a. of fixed assets of Rs 4 million. Interest is calculated at 11% of Rs. 4.3 million, repayable in equal instalments over 10 years for fixed assets, and at 16% of Rs.400.000 for working capital purposed repayable in 1 year.

The return on equity is 18% after allowance for interest and amortisation repayments.

Sensitivity Analysis

The return on all capital of 23% is sensitive to the following variables :

Increase	Change in IRR
10% in investment	- 3%
" " revenue	+ 11%
" " production costs	- 8%
" " Capacity utilisation	+ 3½%
of gestation period to 2 years	- 3%

Payback Period

B oth total project capital and equity are paid back within 5½ years of commercial production commencing.

Comments

This unit typically using waste paper as its main raw material is relatively profitable and as the sensitivity analysis shows in view of the recent rise in paper prices, the return on investment will become more attractive to would be entrepreneurs. The cash flow would be even more favourable, if working capital needs were met through equity contribution in place of a high-interest loan. The recent inflationary spurt, however, has reduced the real cost of this short term loan.

This mill confers the benefit - on both the private entrepreneur and the local economy as a whole - of having a short gestation period before commencing commercial production. The willingness of its customers to pay cash for finished paper supplies will reduce actual working capital tied up and further improve the cash flow.

CASE STUDY

7 Tonnes Per Day

1. Synopsis

This 7½ tonnes per day plant commenced operation in 1964 in the Maharashtra State of India. Total capital costs were Rs. 5.7 million or Rs. 2,590 per installed annual tonne and Rs. 2,940 per actual annual tonne (based on average annual production of 1,940 tonnes over 1976-1978).

The main raw materials used are waste paper, wood pulp, rice straw and gunny waste to produce fine quality writing and printing papers.

2. Installed Capacity

The mill has an installed capacity of 7 tonnes per day of writing and printing paper made from waste paper, purchased pulp and rice straw.

The installed capacities are as follows :-

Paper Making	2200 M.T. per year
Pulping	2200 M.T. per year
Stock Preparation	3600 M.T. per year.

The annual production of paper for the last three years is as given below :-

1976	1842 M.T.
1977	2064 M.T.
1978	1913 M.T.

3. Product Range

The mill produces fine quality writing and printing papers in the range of 50 to 65 GSM. About 60% of all the sales are in the form of sheets and the balance of 40% is in the form of reels.

4. Brief Description of the Mills

This mill is owned by a public limited Company. The mill is located at a central point of the country in Maharashtra State. The mill is adjacent to a river and is well connected by rail and road transport to other parts of the country.

5. Particulars of the Plant

The project work for the mill was started in 1962 and the mill went into commercial production in April, 1964. All the plant and equipment required in the mill was obtained indigenously. The fourdrinier paper machine with a nominal capacity of 5 TPD was obtained from Paper Mill Plant and Machinery Manufacturers (Bombay) and is currently producing on an average 7 tonnes per day of paper. The finishing section consists of a cutting machine and a winder supplied by Print and Pack (Calcutta). The pulp mill equipment consists of a paddy straw cutter, a duster conveyor for the cut straw, a spherical digester, refiners, washers, vibrating screens, centri-cleaners, stock pumps and chest agitating equipment, which were all procured indigenously.

The stock preparation equipment consists of a beater, refiners, stock pumps and chest agitating equipment, all procured indigenously.

6. Process of manufacture

As waste paper is the main raw material, the process of manufacture is simple. Waste paper is slushed in a Hydrapulper and cleaned by centricleaners and a vibrating screen. The low consistency furnish which has been previously refined is fed to the paper machine head box. The wet sheet formed on the Fourdrinier machine passes through a press section and is dried on steam-heated drying cylinders. The dry sheet of paper is wound onto a reel and cut to commercial size.

7. Services

Power : Electricity is purchased from the State Electricity Board, as it is not considered feasible to have own power generation equipment to meet internal demand.

Steam : As the most economical fuel is coal, the company employs two Lancashire boilers to meet all its process steam requirements. The average cost per tonne of paper for both the electric power and steam is about Rs. 400.

Water : The company does not have its own tubewells and relies on public supply for water. Royalties paid for purchased water were approximately Rs. 37 per tonne of finished paper.

Effluent : The company discharges all its effluent into open ditches, and there is no major treatment given before disposal.

8. Capacity Utilisation

	Installed Capacity.	Actual Production.	Capacity Utilisation
Year 1976	2200	1842	84%
Year 1977	2200	2064	94%
Year 1978	2200	1913	87%
Average (1976-78)		1940	88%

The major constraint on achieving still higher utilisation of the capacity is the unreliable supply of electric power and poor availability of coal.

9. Raw Materials

The main raw materials used in production are waste paper, wood pulp and gunny pulp. Typical consumption of raw materials for the last 3 years is given below :-

	Waste Paper (tonnes)	Other (tonnes)
1976	2470	131
1977	2844	18
1978	2568	37

Fibre losses of the order of 25% have arisen, which is some 10% above the norm for waste paper.

From the above it can be seen that this mill is basically a waste paper based unit.The cost of waste per tonne of finished paper is given below :-

	Rs.
1976	1414
1977	1459
1978	2059

As can be seen from the above, there has been a sharp increase in the cost of waste paper.

10. Labour

The mill employs about 180 personnel. Direct labour costs have been indicated as Rs. 382 per tonne of finished paper.

11. Financing Structure

The authorised share capital of the company is Rs. 2,500,000 out of which Rs. 1,239,000 have been fully subscribed and paid for. The remaining secured and unsecured loans as of June 1978 were

Rs. 1,755,000. Reserves and surplus generated from operations after paying off term loan installments stood at Rs. 1,442,000 as of June 1978.

12. Capital Costs

Total fixed assets of the Company before depreciation stood at Rs. 5.7 million in June 1978, and a breakdown of this is as given below :-

	Rs.
Land	28,000
Site Development	14,000
Civil Work	1,078,000
Plant & Machinery	4,072,000
Electrical Inst.	181,000
Vehicles	232,000
Misc	100,000
TOTAL: Rs	5,705,000

Based on the total fixed assets of Rs. 5,700,000 and a 3 year average actual production rate of 1940 tonnes, the capital investment per annual tonne of paper actually produced comes to Rs. 2,938 per tonne at 1964 prices, equivalent to Rs. 9,540/tonnes at 1974 prices. Inflation is taken as 6.9% p.a. from 1964 to 1970, and 8.9% p.a. from 1970 to 1979 (Source: World Development Report 1979). It should also be understood that this mill has no pulp bleaching and chemical recovery facilities and is primarily a paper mill based on waste paper.

The Company is in a very healthy financial position. The Current assets exceed liabilities by Rs. 1.5 million and therefore, the company has adequate working capital generated from international cash flow to meet all its working expenses.

13. Operating Costs (Year Ending May 1978)

Raw Materials	Cost/Tonne of Paper
Waste Paper	2059
Purchase pulp and straw pulp	40
Chemicals, stores, consumables	555
Utilities	
Power & Fuel	392
Water	37
Other Expenses	
Maintenance and other misc. expenses	66
Manpower	383
Administrative overheads	203
Total Operating Expenses Rs.	3735 / tonne

14. Selling Prices

The company produces fine quality printing and writing papers. Average net sales realisation of finished paper is as given below :

1976	Rs. 3,666
1977	Rs. 3,570
1978	Rs. 4,468

The net sales realisation per tonne of paper around November 1978 was Rs. 5050 ($632) and further price increases have occurred since.

15. Profitability (Year Ending May 1978)

(Based on production in 1978 of 1913 tonnes).

	Per Tonne of Paper (in Rupees)	Rs. p.a. (millions)
Net Sales realisation after excise duty	4,468	8.55
Operating Costs	3,735	7.15
Gross Margin	733	1.40

Return on Capital

The internal rate of return on all capital before tax is 22%. This return is sensitive to the following variables :

Increase	Change in IRR
10% in investment	- 2%
10% in revenue	+ 17%
10% in production costs	- 16%
10% in capacity utilisation	+ 6%
of gestation period to 2 years	- 2%

However, as the bulk of the capital costs were incurred in the period 1962 - 1964, the capital investment required at 1979 price will be in the region of Rs. 18 million (using World Bank figures for inflation in India at 7% p.a. to 1970, and 9% p.a. since 1970). This reduces the return on capital to less than 1%. The relatively poor unit profit level of Rs. 733 tonnes is then unable to carry the fixed amortisation charges Rs. 1,080/tonne (assuming loan capital of Rs. 10 million, repayable over 10 years at 11%). The recent reported increase in selling price to Rs. 5,5000, however, has raised the unit profit rate and increased the return on all capital to 15%. To the extent that capital costs of Rs. 18 million (relatively high at Rs. 8,200 (annual installed tonne) can be reduced, this return can be considered pessimistic.

Production costs are also inflated by the high cost of waste paper - which costs Rs. 2,059/ tonne of finished product again relatively high at 56% of unit production costs.

CASE STUDY

10 Tonnes Per Day Papermill

1. Synopsis

This 10 tonnes per day plant operating in the Andhra Pradesh State of India commenced operations in March 1977, manufacturing writing and printing papers. Total Capital invested was Rs. 9.7 million for a licenced capacity of 2,500 tonnes per annum, equivalent to Rs. 3,880 per annual tonne. However, cost per actual annual tonne is Rs. 3,250 (based on 1978 production of 2,985 tonnes).

Raw materials used are straw, waste paper and small quantities of bought-in pulp.

2. Installed Capacity

The project has a licenced capacity of 2,500 tonnes per year of writing and printing papers.

Section-wise capacities of the plant:

Paper making	10-12 T.P.D.	
Pulping	Straw pulping & gunny waste pulping	10 T.P.D.
	Waste paper pulping	5 T.P.D.
Stock Preparation	15 T.P.D.	
Steam (generated in one coal fired boiler about 6T/Hr. steam)	144 t/day.	
Power (supplied by State Electricity Board).	1000 KVA	
Water (Ground Water)	1.2 M.G.D.	
Effluent discharged	0.24 M.G.D.	

3. Product Range

The mill is designed to produce industrial papers, including machine-finished (M.F.) plain kraft, blue match, cultural paper cream wove and colour printing.

4. Brief Description of the Mill

The project was promoted by a young team of technicians, who have more than ten years experience in the field of pulp and paper, the company was incorporated in December 1974 and the civil works and erection were completed in January 1977. The mill went into commercial production in March 1977, on a site only 2 kms. from a railway station.

5. Particulars of the Plant

The unique feature of this mill is that none of the machinery has been imported.

The paper machine was designed by the promoters themselves made in several places and assembled on site under their supervision. The machine is a Fourdrinier, with a trim width of 54" and a speed of 100-200 meters/min. It comprises open Head Box (made of wood), plain couch roll, 2 plain presses (the first press using double felt system), 24 drying cylinders, one calender stack and pope reel. There is a Baggely-design suction box on the wire before the couch. The wire part has a couch roll and a wire turning roll. All the felt rolls, wire rolls and press rolls were made in local workshops. Rubber lining was done in Bombay, drying Cylinders were supplied from Madras and all the frames were again made in local workshops. The Electric drive was supplied by Siemens India Limited, and the winder by Print and Paper (Sales) Private Limited, Calcutta.

All the pulping equipment, except the digesters, was fabricated in local workshops.

Steam generating plant was supplied by Wanson (India) Pvt. Ltd., Poona. Electrical equipment, transformer, panels, motors, etc., were procured from various Indian sources.

6. Process of Manufacture (see Diagram overleaf)

The process employed for manufacture of writing and printing paper uses conventional soda cooking of fibrous raw materials followed by screening, single-stage bleaching, waste paper pulping and stock mixing, prior to paper making on the Fourdrinier paper machine.

Rice straw is cut into pieces about 6" in length by a mechanical cutter. Cut straw is charged into a rotary spherical digester of $25M^3$ capacity, where caustic soda between 10% and 12% of A.D. straw is added and the batch cooked under pressure. The cooked stock is then dumped into a pit with false bottom, where it is partially washed. The brown stock is then charged to breaker beaters with washing drums, after which the pulp is transferred to a storage chest. It is then passed through a screening plant consisting of a dilution box, rifflers, Johnson vibrating screen and a gravity flow thickener. The thickened pulp is then stored and bleach liquor (calcium hypochlorite, purchase as such) is added. After sufficient retention time, the pulp is washed completely in the bleacher, where a washing drum arrangement is also available. The bleached pulp is then further refined in a refiner and stored in a chest.

Gunny waste is also cooked, bleached and refined similarly and stored in a chest.

Waste paper is slushed in a hydrapulper, screened and stored in a chest.

Bleached straw pulp, gunny waste pulp and waste paper pulp are mixed proprotionately in a mixing chest, where rosin, alum and talcum powder are also added. The mixed furnish is then transferred to the machine chest. From the machine chest, a pump transports pulp to a constant level head box. Paper machine back water is added at the fan pump to lower the consistency of the stock. The low consistency stock is passed through a battery of centricleaners and a pressure screen before running continuously onto the machine wire. The wet sheet, made on a Fourdrinier wire, is passed through 3 presses and is then dried on stean-heated drying cylinders. The dry sheet is finally wound on a reel and cut to commercial sizes.

7. Services

Power : Power is supplied by the State Electricity Board at 1000 KVA. There is a sub-station at a distance of 7 Kms from the site.

Steam : Steam is generated in a coal fired boiler of 6T/hr capacity at the site. Coal is available from local mines.

Water : A perennial water canal passes near the factory site. The mill could draw water from this canal but presently uses ground water. Three deep bore tubewells supply 400,000 gallons each per day, giving a total daily supply of 1.2 million gallons (5½ million litres).

Effluent : A natural drain which ultimately empties into the Bay of Nepal, passes near the mill site. Pulp mill effluent is discharged to this drain after passing through a series of clarifying lagoons. Paper machine backwater is fully re-used. There is a Marks' save-all for fibre recover.

The effluent discharge is about 250,000 gallons (1.1 million litres) per day.

8. Capacity Utilisation

The plant can easily produce more paper than the licensed or installed capacity of the plant. The mill is an extremely well managed mill and the technical efficiency of operations is very high. In 1978, production of 2,985 tonnes was 20% above declared rated capacity.

9. Raw Materials

The area in which the mill is located is well known for agriculture and, therefore, paddy straw is readily available. Waste paper and gunny waste are also easily available from nearby large cities.

The mill produced 2,985 tonnes of paper during 1977-78 and the consumption of various raw materials and other inputs during this period was as given below :-

	Annual Consumption (Tonnes)	Consumption per tonne of paper
A. RAW MATERIALS		
Waste gunny	1690	.566
Waste paper (white cuttings)	1340	.449
Straw/Bagasse/others	2570	.861
B. CHEMICALS		
Caustic Soda	97	.032
Alum	144	.048
Rosin	57	.019
C. UTILITIES		
Coal	3370	1.129
Power	4.43 million kwh	1.485 Kwh.

Fibrous raw materials worth Rs. 4,670,000 (US$580,000) were consumed for achieving this production. This is equivalent to a fibrous raw material cost of Rs. 1,561 (US$196) per tonne of finished paper. Similarly, chemicals and stores per tonne of paper amounted to Rs. 545 (US$68). Power and fuel costs per tonne of paper were Rs. 479 (US$60) per tonne of paper.

10. Labour

The mill employs around 300 persons. The annual wage bill was nearly Rs. 750,000 (US$94,000). Salaries and wages amount to Rs. 251 (US$ 31)per tonne of finished paper.

11. Financing Structure

The company has an authorised capital of Rs. 6,000,000 (US$750,000), out of which Rs. 3,800,000 or 637 have been fully paid up. A small proprotion (20%) of this paid up capital is in the form of preference shares and the balance is in the form of equity shares. The shares offered by the company to the public were fully subscribed and the State Industrial Development Corporation also participated in the equity capital.

The project was granted term loans by the Industrial Development Bank of India, the State Financial Corporation and Commercial Banks. The financing structure is given below :-

A.	SHARE CAPITAL			
	1. Equity by State Industrial Development Corporation	Rs	780,000	
	2. Promoter's Equity	Rs	750,000	
	3. Public Subscription	Rs	1,470,000	
	4. Preference share capital	Rs	880,000	
				3,800,000
B.	LONG TERM LOANS FROM FINANCIAL INSTITUTIONS			6,000,000
		TOTAL	Rs.	9,800,000

Interest on long term loans is 11% and the loan repayment period is 10 years.

12. Capital Costs

The company owns about 45 acres of land fenced all round. About 15 acres of this land was levelled and developed for civil constructions. There is an approach road from the main road to the factory site and there are internal roads to all the building blocks. Living quarters were constructed for essential staff.

The total covered area for housing all the plant and equipment i.e. pulp mill, paper machine, steam generation plant and electrical panels, etc., is about 3,864 sq. m (1 acre). Paper machinery is erected at ground level.

The breakdown of total project cost is given below :-

1.	a) Land	50,000	
	b) Site Development	17,000	Rs. 67,000
2.	Civil Works (all buildings, machine foundations, RCC Chests, Tankages, etc.)		Rs. 1,114,000
3.	Plant & Machinery (pulping, paper machine, steam, water, etc., inclusive of erection charges)		Rs. 5,981,000
4.	Misc. Fixed assets (furniture, vehicles, etc).		Rs. 198,000
5.	Preliminary and pre-operative Expenses		Rs. 1,816,000
6.	Contingency		Rs. 624,000
	TOTAL PROJECT COST		Rs. 9,800,000

Investment per tonne of installed annual capacity of 2,500 tonnes is about : Rs. 3,880

13. Operating Costs

The actual operating costs for one year ending on 30th September, 1978, were as follows :-

		Qty. Regd/ Tonne of paper.	Unit Cost in Rs/Tonne	Cost/tonne of paper in Rs.
A.	RAW MATERIALS			
1.	Waste Gunny	.566	686	388
2.	Waste Paper (white cuttings)	.449	2298	1032
3.	Straw/Bagasse/ Others	.861	170	146
B.	CHEMICALS AND CONSUMABLE STORES			
	Cooking chemicals, bleaching chemicals, sizing chemicals			545
C.	UTILITIES			
1.	Maintenance			34
2.	Salaries & Wages			251
3.	Administrative Expenses			126

TOTAL OPERATING COST/TONNE OF PAPER 3,000 Rs.

14. Selling Price

The average net sales realisation for the year 1977-78 was Rs. 3,911 (US$ 489) per tonne of finished paper. This takes into account excise duty rebate of Rs. 650 (US$ 81) per tonne of paper.

15. Profitability

Based upon information received from Company and their annual report for year ending 30th September 1978, profitability for one year of operation has been evaluated as below :-

	Rs.	Per tonne of Paper in Rs.
Net sales realisation, inclusive of excise duty concessions.	11,674,000	3911
Total operating cost	8,955,000	3000
Gross Profit Margin	2,719,000	911

Return on Capital

Internal rate of return on all capital is 26% befor tax. This is sensitive to the following variables :

Increase	Change in IRR
10% in revenue	+ 20%
10% in production costs	- 10½%
10% in investment	- 3%
of gestation period to 2 years	- 3%

After taxation at 55% of profits net of interest and depreciation, the return on all capital is 15½%. Depreciation is calculated on a straight-line basis at 8% p.a. of fixed assets, and 4% p.a. of civil work. Interest is calculated at 11% of fixed asset loans of Rs. 6 million, and at 16% of working capital facilities.

The return on equity over a 12-year project life will be only 11%, unless additional equity is injected into the capital structure for working capital purposes. Working capital needs of Rs. 750,000 in the second year of the project carry heavy interest charges of Rs. 120,000 which add to long term loan charges of Rs. 700,000 (interest from the first year of construction having been added back to the principal). This produces a deficit in the profit and loss account of Rs. 500,000. Increased working capital needs for the third year of the project (its first year of full production) push working capital interest charges to Rs. 340,000 on an outstanding balance of Rs. 2.1 million (4 weeks' sales, 4 weeks' purchases, previous year's loss). Repayment of this principal in this year depresses the overall return on equity and leads to a severe cash flow deficit of some Rs. 1 million. The unit gross profit level (of Rs. 911/tonne) is also on the low side, reflecting a relatively low selling price of Rs. 3,911/tonne. Raising equity by Rs. 1 million to cover working capital would raise the return on equity to 14%. However, amortisation charges per tonne are still high at Rs. 450 in the first year of production, falling to Rs. 230 by the end of the 10 year repayment period. Further substitution of equity for loan capital would reduce these fixed charges, thus raising the return to equity and also reducing the breakeven point.

Payback Period

For total investment, this is 5.1 years, and for equity is 8 years (net of tax and loan repayments).

Comments

Although the rate of return can be considered pessimistic in view of the ability of small-scale units to charge cash on sales and the likelihood that it can enjoy sizeable investment concessions, this will suffer from undercapitalisation, particularly in the form of its equity contribution. The relatively low price received for its finished product will have risen significantly, however, in the last year (1979) raising what is already a favourable return on total capital of 26% before tax.

CASE STUDY

12½ Tonnes Per Day

5. Particulars of the Plant

The plant as proposed will have the following facilities :-

i) Waste paper pulping

ii) Pulping of market pulp

iii) Stock preparation for waste paper pulp and for market pulp.

iv) Blending of different types of pulps

v) Paper machine section

iv) Finishing section consisting of paper cutter and rewinder etc.

vii) Utilities and service facilities

viii) Water Supply System

ix) Steam generation and distribution system

x) Electrical and power generation system

xi) Workshop

xii) Laboratory

xiii) Warehouse for pulp and finished product

xiv) Back-water treatment and fibre save-all

xv) Weigh bridge.

A second-hand paper machine is being purchased from West Germany. This machine was manufacturing 10 to 15 tonnes per day of 11 to 40 GSM tissue and other M.G. light-weight papers, at an average trimmed width of 2000 mm, average substance 25 GSM, speed 225 metre/per minute. The theoretical machine output per day at 100% efficiency is 16.2 tonnes and at 90% efficiency (assuming 10% finishing losses) 14.6 tonnes. The annual production based on 22 working hours per day (i.e. 13.4 tonnes/day) over 330 working days/year is 4420 tonnes. The expected production of 4125 tonnes per annum or 12.5 tonnes per day should be obtained.

6. Process of Manufacture

The process involves slushing of the market pulp in a hydra-pulper. After slushing, the market pulp will be stored in a suitable chest. In the same hydra-pulper waste paper will also be slushed by a batch process, and processed through a high density cleaner, deflaker, etc., prior to storage in another chest.

It is proposed to instal 4 beaters and beating of the two types of pulps will be done separately to obtain the desired degree of freeness. Beaten waste paper pulp and beaten market pulp will be mixed in the correct proportions and after finally passing through a machine refiner and cleaners, the stock will be fed to a modern selectifier screen installed ahead of the pressurized flow box of the paper machine. For improving the wet strength of certain class of tissues, (Melamine formaldehyde) resins will be added plus dyes, alum, etc., as required. For certain varieties of paper, wax emulsions may be used as beater additives. The paper machine selected for this project is a Fourdrinier, M.G. Machine.

The wire part has 12 foil units and 3 suction boxes to de-water the stock. The light weight sheet is transferred from the wire part to the M.G. Cylinder automatically by a "lick up" arrangement, which minimises wet breaks. The sheet passes through a press and then by means of a presser roll is attached to the surface of the highly glazed M.G. cylinder. After drying on the M.G. cylinder, the sheet passes through a Creping Doctor (when creped tissues are being manufactured) and then the paper is rolled.

The Jumbo Roll from the paper machine is cut into sheets on a paper cutter or re-wound on a winder to convert into necessary size reels.

7. Services

Power : Annual power requirement is 3.3 million Kwh, or about 800 Kwh per tonne of paper. It is supplied by Andhra Pradesh State Electricity Board.

Steam : The mill requires 4 tonnes of steam per hour and is taken from own coal fired boilers. Coal requirement is 5000 tonnes per year or 1.21 tonnes per tonne of paper and will be obtained from the local coal mines. (The distance to the proposed mill site from the mines is 80 Km).

Water : Water requirement is 25,000 gallons/hr. There is a perennial water canal on one side of the site. Water can be drawn from the canal throughout the year. The project is being designed for maximum re-use of backwater from the machine, to reduce consumption of water and conserve fibre. There will be a fibre recovery save-all; recovered water will be fully utilised.

Effluent : There will be no problem with the effluent in this mill. Since no colouring and bleaching chemicals are used the backwater from the mill will not be contaminated. All back water from the machine will be processed in a modern type save-all and fibre recovered for re-use.

8. Capacity Utilisation

As shown in Section 5, the capacity of the paper machine is conservatively anticipated as 4,125 tonnes of paper products a year. A capacity utilisation rate of 70% is assumed in the financial analysis.

9. Raw Materials.

A. Fibrous Materials

1. Waste Paper

2. Long/short fibre pulp.

The furnish will at the ratio of 1:2 for waste paper to purchase pulp.

B. Chemicals

1. Alum 4% on Paper - 165 Tonnes per year

2. Rosin 1% on Paper - 42 Tonnes per year

In addition, a small quantity of chemicals such as Soda Ash for cooking of Rosin and special chemicals for imparting wet strength, softness and absorbency etc., will also be required.

10. Labour

The manpower requirements of the Mill are as follows :-

Managerial	4
Administrative staff	19
Technical Staff	31
Labour	118
	172

11. Financial Structure

The project is being financed by long term loans, equity capital and a central cash subsidy as follows :

	Rs. (million)
Share Capital	2.7
Long term loans	6.6
Central Cash Subsidy	1.0
Working Capital Loan	1.0
	11.3

The long-term loan is repayable over 10 years at 9%.

12. Capital Costs

Summary of the estimated total project cost is given below :

			Rs.
1.	Land and Site Development		215,000
2.	Civil Work		1,230,000
3.	Plant and Machinery:		
	a) Imported	4,725,000	
	b) Indigenous	1,800,000	6,525,000
4.	Miscellaneous fixed assets		270,000
5.	Erection Labour		350,000
6.	Technical Services and Engineering Fees		250,000
7.	Preliminary and pre-operative Expenses		1,000,000
8.	Provision for contingencies		400,000
9.	Margin money for working capital		1,060,000
		TOTAL:	11,300,000

A detailed breakdown of some of the above costs is given in the following sections.

12. 1 Breakdown of Land and Site Development Costs

15 acres of land at Rs. 10,000 per acre	150,000 Rs.
Levelling and development of 10 acres of Land Rs. 1,500 per acre	15,000 Rs.
Fencing, gates, internal roads	50,000 Rs.
	215,000

12. 2 Breakdown of Building Costs

One shed 100m. long x 14m wide x 8m high with steel trusses and asbestos sheets will house all plant facilities. Two small buildings will house the boiler and electrical switch gear equipment.

Item	Floor area (M^2)	Cost/M^2)	Total Cost Rs.
Paper Machine Hall	560	450	252,000
Stock preparation with paper & pulp storage, etc.	560	450	252,000
Paper Go-down (with admin office on first floor)	560	475	266,000
Boiler House,	120	450	54,000
Power House	100	450	40,000
Silos, chests, etc (see below)			316,000*
Other Buildings.			50,000
	TOTAL Rs.		1,230,000

*Silos and Chests	M^3	No.	Unit Cost/M^3	Total (Rs)
Storage mixing & machine chests (tile-lined)	35	8	600	168,000
Beater Vats (tile-lined)	10	4	600	24,000
Centricleaner trough (tile-lined)	5	1	600	3,000
Wirepit and couch pit (tile-lined)	10	1	600	6,000
Clear Water Tanks	200	1	500	140,000
Other Tanks	30	1	500	15,000
			Total Rs.	316,000

12.3 Breakdown of Plant and Machinery Costs

A. Imported Equipment (Second-hand) Rs.

Paper Machine

Winder

Duplex Cutter

Waste Paper Pulping Equipment
(Hydrapulper, Deflaker, H.D. Cleaner,
Pumps and Chest Equipment)

(Beaters, Pressure Screen,
Centricleaners, Pumps and
Chest Equipment)

Other Miscellanous Equipment Total imported equipment at site after 40% import duty, freight and insurance etc.	4,725,000	

B. Indigenous Equipment

Stock Preparation Equipment	223,000	
Water Supply and Treatment Plant	275,000	
One 5 ton/hour Coal fired boiler and Steam distribution lines	575,000	
Electricals	700,000	
Other Misc. Equipment	27,000	1,800,000
TOTAL:		Rs 6,525,000

12.4. Breakdown of Misc. Fixed Assets

Weighbridge Equipment	85,000
Workshop Equipment	60,000
Vehicles	50,000
Engineering Tools inclusive of erection tools	25,000
Furniture	20,000
Lab. Equipment	20,000
Fire Fighting Equipment	10,000
TOTAL: Rs.	270,000

12.5 Breakdown of Preliminary and Pre-operative Expenses

Capital issue brokerage charge	75,000
Other Capital issue charge (legal, printing, etc)	125,000
Establishment charges	100,000
Rent, rates, taxes	50,000
Travel	75,000
Interest on borrowings	350,000
Insurance	75,000
Mortgage expenses, stamp duty, other legal charges	50,000
Start-up and Commissioning (2 days)	100,000
TOTAL	Rs.1,000 000

13. Operating Costs

Estimated operating costs are as follows :-

	Per Tonne of Paper.	Unit Rate	Cost/Tonne of Paper
A. Raw Materials	Tonnes	Rs/T	Rs.
Waste Paper Cuttings	.332	2500	830
Market Pulp	.661	3200	2115
B. Chemical & Consumable Stores:	Kgs.	Rs/Kg.	
Alum	40	1	40
Rosin	10	3.9	39
Misc. Chemicals			100
Consumable Stores			100
C. Utilities			
Coal	1.21	250	302
Power	800	.27	216
Water			10
D. Others			
Packaging and freight			100
Repairs and maintenance			60
Administrative Expenses			200

Salary and wages	300
Cost of production of paper	4412

14. Selling Price

Net sales realisation will be Rs. 5,800 per tonne after trade discounts, freight charges, etc.

15. Profitability

Profitability of the plant for its first year of operation has been estimated as below (at 70% capacity utilisation giving an annual output of 2,900T).

	Annual (Rs.millions)	Rupees per tonne of paper
Net Sales Realisation	16.82	5,800
Total Operating Cost	12.79	4,412
Gross Profit Margin	4.03	1,167

Return on Capital

The internal rate of return on all capital is 34% before tax. After taxation of gross profits (net of depreciation and interest) at 55%, the return on total capital is 21½%. Depreciation is calculated on a straight-line basis at 8% p.a. of fixed assets (including silos and chests) of Rs. 7,111,000. Interest is calculated at 9% of Rs. 6.6 million (repayable over 10 years), and at 16% of working capital facilities of Rs. 1 million (repayable within 1 year).

The return on equity (without the central cash subsidy) is 38%. By securing a central cash subsidy of Rs. 1 million, the return on equity rises to 51%.

Sensitivity Analysis

The return on all capital of 34% is sensitive to 5 key variables as shown below :

Change:

Increase in gestation period to 2 years	- 5%
10% increase in capital costs	- 2%
10% increase in selling price	+ 26%
10% increase in production costs	- 12%
10% increase in capacity utilisation	+ 6%

Payback Period

This is 4 years for all capital funds, and a very favourable 1.8 years for equity.

Comments

This mill will have the highest return on equity of all the ten case-studies if the cost estimates prove accurate. The favourable selling price (of Rs. 5,800/Tonne) has become a reality with recent price-rises due to paper shortages. Low capital costs for installed tonne of capacity and the favourable unit profit rate of over Rs. 1,160/Tonne of final output produce an attractive return on investment with a short capital payback period.

The ability of the unit to charge cash to customers collecting the product and its short gestation period are further advantages. Across-the-board inflation of cost would further benefit profitability as shown by the sensitivity analysis section.

SMALL-SCALE PAPERMAKING

CASE STUDIES

PART 2

CASE STUDY

25 Tonnes Per Day

1. Synopsis

This 25 tonnes per day plant is under construction in the Andhra Pradesh State of India. Total capital costs are estimated at Rs. 39.7 million, or Rs. 4,960 per annual installed tonne, or Rs. 6,620 per expected annual tonne at 75% capacity utilisation.

The main raw materials used will be bagasse and straw for the manufacture of good quality writing and printing papers.

2. Installed Capacity

Pulp Mill	25 T.P.D. (tonnes per day)
Paper Machine	25 T.P.D.

3. Product Range

(i)	Grease Proof Paper	500 Tonnes per annum
(ii)	Writing and Printing Paper	4000 Tonnes per annum
(iii)	S.S. Map Litho Paper	3500 Tonnes per annum

In general, small scale paper projects should concentrate on the manufacture of special grades of paper with higher added values. Some special grades of paper cannot be manufactured on high production machines running at very high speed. Small paper machines are ideally suited for manufacture of specialities such as banks, bond paper, manifold, air-mail paper etc. The mill in this case study intends to concentrate of the manufacture of such special quality high priced writing, printing and grease-proof type papers.

4. Brief Description of the Mill

The project has been promoted as a joint venture with Andhra Pradesh State Industrial Development Corporation which is participating in this project as co-promoters by investing in the Company's equity share capital.

The civil work for the project started in 1978. It is expected that the paper making and stock preparation sections will be ready by the middle of 1979. In the first phase, the mill is expected to go into commercial production based on the use of waste paper and purchased pulp. The pulp mill will be ready by the end of 1979 for manufacture of straw pulp by the chemi-mechanical process.

The district in which the Mill is located is predominantly an agricultural area with rice and sugar-cane as the two major crops. Therefore, both paddy straw and bagasse, which are the main raw materials for the mill, will be ava i lable within a short radius of the mill. The site is well connected by rail and road and is on the main national highway from Calcutta to Madras.

The mill is only 8 kilometres from a major district town and housing for the staff is available in this town. As the area in which the mill is located is mainly agricultural, there will be no competitive demands on the local labour from other sources.

5. Particulars of Plant

The project will use the chemi-mechanical pulping straw and bagasse. The mill has a second-hand paper machine imported from Sweden and all the remaining equipment has been obtained from indigenous sources.

The imported Fourdrinier paper machine has 2½ metres trim width and a speed of 200 metres per minute. The machine has a suction couch, one suction press, three palin presses, 31 drying cylinders and a rewinder. Vacuum pumps, some refining equipment for stock preparation and pulp screens have also imported from Sweden with the paper machine.

Reconditioning and overhauling of the imported equipment was undertaken at mill site. Equipment not imported from Sweden was obtained from a number of different sources in India. The hydrapulper type chemi-mechanical digesters were obtained from Hindon Engineering Works (Saharanpur), washing and bleaching equipment was obtained from Hindustan Dorr Oliver (India) Ltd., (Bombay), paper cutters from Print and Paper Sales Pvt. Ltd., (Calcutta), steam generating equipment from Wanson India Private Ltd. (Poona), the power distribution system from Kirloskar Ltd. (Bangalore), and other miscellaneous equipment, pumps, agitators, motors, tanks, etc., were procured from local workshops in the vicinity of the mill.

6. Process of Manufacture

The process to be employed for the manufacture of writing and printing papers is the chemi-mechanical pulping process, followed by 3-stage bleaching, stock preparation and paper making on a Fourdrinier paper machine.

Paddy straw/bagasse is chopped 4" - 6" length in a mechanical cutter and after dust is removed in a cyclone, the cut straw/bagasse is charged to a wet cleaner cum wet bagasse depither. The wet cleaned straw/wet depithed bagasse is then passed to a de-watering drum, where excess water is removed and the material is delivered to a shuttle conveyor, which takes it to the digesters, where 4% - 6% caustic soda, on BD basis, and black liquor are added. Steam at atmospheric pressure is added in the digester to raise the temperature. The cooking cycle is about 5 hours. The semi-cooked hot stock is transferred to a blow tank, and then to a hot stock refiner. The refined pulp is passed through a Johnson type vibrating screen, and then partly washed on a vacuum washer. The semi-washed brown stock is then screened and washed completely in another vacuum washer. The thickened pulp from the second vacuum washer is stored in a vertical chest.

Washed and screened brown stock passes to the bleaching plant consisting of the chlorine mixer, variable retention chlorination tower, chlorine washer, caustic mixer, caustic tower, caustic washer, hypo mixer and hypo tower. The bleached pulp, after hypo treatment, is screened through a Biffor screen and a battery of centri-cleaners, and then finally washed on a hypo stage vacuum washer and stored in a high density chest.

Purchased pulp/waste paper is pulped in hydro pulpers and screened by a vibrating screen, passed through a riffler, thickened and stored in a chest.

Bleached straw/bagasse pulp and waste paper/purchased pulp are refined separately in conical refiners and stored in separate chests. Refined straw/bagasse pulp and waste paper/purchased pulps are mixed proportionately in mixing chests where size, alum and dyes are added. It is then transferred to the machine chest. The stock is then passed through a brushing refiner to the fan pump, where machine wire backwater is added for dilution. The low consistency furnish is run continuously through a battery of centri-cleaners and a pressure screen to the paper machine head box. The wet sheet formed on the machine is pressed and dried on steam heated drying cylinders. The dry sheet of paper is wound on a reel and cut to commercial sizes.

Steam required for the process is generated in coal-fired boilers. Power is drawn from the State Electricity Board.

The pulping process for straw and bagasse to be used is of interest. Cooking of the raw materials is not done in pressure vessels but in open hydra pulper type equipments with specially designed rotors.

This factory is being planned so that it can also manufacture very high-priced papers such as grease-proof papers from bagasse/straw pulp and purchased pulp. The second-hand paper machine imported from Sweden was manufacturing grease-proof papers in the Swedish Paper Mill before it was dismantled for sale to India.

7. Services

Power : High tension power is available from State Electricity Board's sub-station, which is 10 Kms from the site. This will be stepped down to 420-440 volts through transformers to be installed by mill. 6000 KVA connection is being arranged by the mill.

Steam : The mill has 2 coal fired boilers, each of 5 T/hr. capacity. Coal is available from coal mines about 200 Kms from the site.

Water : All the water that is required for the factory process will be drawn from the factory's own bore-wells at site as the water table in this area is very high. Three bore-wells of 0.4 MGD capacity are being installed. Nearly 2 million gallons of water will be used per day.

Effluent : There is a natural drain passing by one side of the site in which the Mill's effluent will be discharged.

8. Capacity Utilisation

Plant capacity utilisation is assumed as 75% of installed capacity, or 6,000 tonnes per annum.

9. Raw Materials

The mill will use bagasse/straw pulp and purchased pulp for manufacture of special quality, high priced writing and printing paper, and Map litho papers.

The quantities per tonne of paper of different raw materials required by the mill are as follows :

		Grease Proof Paper	Writing & Printing Paper
A.	Raw Materials	Tonnes	Tonnes
	Paddy straw/bagasse	1. 734	2. 31
	Purchased pulp	. 43	. 215
B.	Chemicals		
	Caustic	156	208
	Chlorine	84	75
	Burnt Lime	110	97
	Alum	40	60
	Rosin	10	12
	Talcum		84

10. Labour

The Company has 9 members in the managerial staff, 42 in Administrative staff and 53 in technical staff. The company will also have a Labour Office, Welfare Office, security Office and Medical Office.

The labour requirement is as follows :-

Highly skilled	36
Skilled	54
Semi-skilled	62
Un-skilled	102
Drivers	4

11. Financial Structure

Total project cost is Rs. 39.7 millions .

The project cost is proposed to be financed as follows :-

	(Rs.m.)
Promoters' Equity	7.6
Public Shares	7.2
Unsecured loans	0.3
Term Loans	22.3
Working Capital Advance	2.3
	39.7

Rate of interest on long term loan is 11% and the principal will be paid back in 8 instalments - starting from the third year of operation.

12. Capital Costs

The detailed breakdown of project cost is given below :-

Description	Cost (Rs. thousands)
LAND AND SITE DEVELOPMENT	
Cost of Land (35 acres)	430
Fencing	50
Roads, Compound wall & site development	70

BUILDINGS - CIVIL COSTS

Paper Machine hall-Machine on first floor Size 110 x 15 M	1,650
Paper finishing house 40 x 15 M-Two floors	240
Raw Material preparation Bldg. 30 x 15 M	180
Pulp Mill for pulping and 3-stage bleaching - 35 x 15 M - three floor	930
Boiler House - 2 coal fired boilers, 35 x 11 M	150
Workshop 15 x 10 M	230
Paper Godown - 27 x 15 M	410
Stores & Chemical Godown 30 x 10 M	80
Raw Material storage shed 30 x 15 M	130
Living Quarters for staff near factory site	100
Sewers, drainage, etc.	50
Silos, R.C.C., Chests, etc, & foundation	1,300
Total Cost of Land, Site Development & Buildings	6,000

	Cost (Rs. thousands)
PLANT AND MACHINERY COSTS	
Imported Paper Machine cost C.I.F. Madras	3,183
Custom duty on imported Paper Machine	1,274
Customs clearance & Bank Guarantee for imported equipment	193
Cost of reconditioning & replacements of parts of imported Paper Machine	1,450
Machinery from Indian sources and spares	7,600
Erection cost of entire plant and equipment	1,800
	15,500
Miscellaneous Fixed Assets	
Workshop equipment	200
Electrical installation - Motors, Transformers, Cable station, Motor circuiting Panels	4,200
Laboratory equipment	50
Office Machinery	50
Water supply & installation of 3 own Tube Wells	750
Steam generating plant - Two coal fired boilers each 5T/hour	1,650

Effluent collection and Treatment	300
Miscellaneous	1,600
Furniture & Fixture	50
Fire-fighting equipment	100
Cars, trucks, etc.	150
TOTAL	9,100

a) Technical know-how and detailed engineering fees	800
b) Preliminary & Capital issue expenses	500
c) Pre-operative expenses till factory starts production	3,900
d) Contingencies	1,600
e) Margin money for working capital	2,300
	9,100

<u>TOTAL PROJECT COST</u> : 39,700

13. Operating Costs

The cost of production has been estimated as below :-

	Quantity Required Per Tonne of paper (in tonnes)	Unit cost in Rupees	Cost per Tonne of Paper (in Rupees)
Raw Materials			
Paddy Straw/Bagasse	2.274	200	455
Purchased Pulp	0.228	5,000	1,140
Chemicals			
Caustic Soda	0.205	2,000	410
Chlorine	0.075	650	49
Burnt Lime	0.098	300	29
Alum	0.059	800	47
Rosin	0.012	3,500	42
Talcum	0.079	400	32
Other Chemicals	0.079	400	200
Utilities			
Coal	1.66	180	299
Power	2700 Kwh	.25/Kwh	675
Water			10

Other Expenses

Maintenance & Repairs	70
Packaging & Forwarding	100
Administrative Expenses	100
Manpower	300
Total Operating Cost	Rs: 3,958

14. Selling Price

The net sales realisation will be about Rs. 5820/- per tonne of product sold in the market. At 75% capacity utilisation of the plant, sales are estimated as below :-

	Grease-proof Paper	Writing & Printing Papers	S.S. Map Litho	Total Sales
Production (tonnes)	375	3,000	2,625	6,000
Sales (Rs millions)	3.75	13.5	15.75	33
Less 7.5% Trade Discount		Rs.2.475m		
Add Excise Rebate		Rs.4.388m		
Net Sales Realisation		Rs.34.913m		
or		Rs.5820/- per tonne of paper		

The excise duty and rebate are calculated as shown below :

Excise duty rate is 30% on total sales realisation of all the three types of paper and equals Rs. 9.9 million . 50% exemption is given in excise duty by the Government for writing and printing paper and S.S. Map litho paper sold. This amounts to Rs.4.388 million.

	Bleached grease-proof paper (375 TPA)	Writing & Printing papers (3000 TPA)	S.S. Map litho (2625 TPA)
Sales in Rs. millions	3.75	13.5	15.75
Excise Duty %	30%	30%	30%
Amount of duty in Lakhs	1.13	4.05	4.73
Exemption		50%	50%
Amount		2.025	2.363

Total exemption = Rs. 4,388 million.

15. Profitability

The profitability has been estimated for the second year of running with capacity utilisation of 75% as :

	Total (Rs.m)	Per ton of paper in Rupees.
Net Sales realisation	34.91	5,820
Total Operating cost	23.75	3,958
Gross Profit Margin	11.16	1,862

Return on Capital

The internal rate of return on all capital is 26% before tax. After taxation of gross profits (net of depreciation and interest), the return on all capital falls to 16½%. Depreciation is calculated on a straight-line basis at 8% p.a. of fixed assets of Rs. 24.6 million, and 4% of civil works at Rs. 6 million. Interest is calculated at 11% on loans of Rs. 22.6 million repayable over 8 years, and at 16% on a 1 year working capital facility of Rs. 2.3 million.

The return on equity is 21% after tax and loan repayments.

Sensitivity Analysis

The return on all capital is sensitive to the following variables :

Increase	Change in IRR
10% in revenue	+ 10%
10% in production costs	- 6%
10% in capacity utilisation	+ 4%
10% in investment	- 3%
in gestation period to 2 years	- 3%

Payback Period

For total capital this is after 4.9 years, and for equity after 5 years of commercial production.

Comments

This project returns a healthy 26% on capital (before tax) and by selling high quality printings and wriging achieves an above average unit profit rate of Rs. 1,860/Tonne of finished product which compensates for the capital costs of partly imported equipment of almost Rs. 5,000/installed tonne.

It is likely that working capital needs will be reduced by the ability of such mills to charge cash to those customers wanting to buy relatively small lots of output. This will reduce high interest charges on short-term loan facilities.

CASE STUDY

30 Tonnes Per Day

1. Synopsis

This 30 tonne per day plant commenced operation in mid-1977 in the Uttar Pradesh State of India. Total capital costs were Rs. 46,5 million or Rs. 4,650 per annual tonne.

The main raw materials used are paddy and wheat straw to produce industrial papers, MF and MG Kraft papers.

2. Installed Capacity

Paper Mill	30 T.P.D.
Pulp Mill	30 T.P.D.

3. Product Range

Good quality MG/MF Kraft Paper
Basic Weight: 60 GSM to 180 GSM
All the output is in the form of reels only.

4. Brief Description of the Mill

Straw and Sabai grass are readily available in the vicinity of the mill. Rice straw is used in winter and wheat straw in summer. There is a good network of roads connecting the factory with important cities and there is a railway station close to the factory site. There is a drain by the side of the factory through which the effluent is discharged

5. Particulars of Plant

The mill started commercial production in July 1977. The project was planned to make maximum use of indigenous equipment and the paper machine was Indian built. The MG cylinder, Raffinator refiners and some laboratory equipment were imported.

6. Process of Manufacture

The process used is unconventional so far as India is concerned Cooking is done in open Hydra pulper type equipment by the chemi-mechanical process. Chemicals used are the barest practical minimum. A mixture of lime and caustic soda is used for cooking the raw materials of rice straw/wheat straw and sabai grass used in a ratio of 50:50 to manufacture good quality MG/MF kraft papers.

7.1. Raw Material Preparation:

a) Process of sabai grass preparation:

Sabai grass is chopped into 4" to 6" lengths in a rotary cutter installed in a shed and is then blown to a dust cyclone, where dust is separated. The grass is then stored in a silo.

b) Equipment Used:

(i) Grass Cutter
Capacity : 3T/Hr.
Rotary Drum type, with feed conveyor, bottom discharge.
Make: HIMCO (Yamunanagar).

(2) Blower
Capacity 3T/Hr.
Forced draught Fan type, pipe line of 8" dia. approx.

(3) Dust Cyclone
This is a conical vessel with top dust discharge and bottom material discharge.
The cyclone is fitted with a perforated plated at the top with oscillating brushes to clean the plate.

(4) Silo

This storage vessel is made from M.S. Plate with chutes to feed two digesters.

c) Process of Rice Straw/Wheat Preparation

Rice straw/wheat straw is chopped into 4" to 6" lengths in disc type cutters installed in an open space and then blown to a dust cyclone, where the dust is separated. The straw is then stored in a silo.

d) Equipment Used

(1) Straw Cutters (2)

Capacity : 1T/H

Rotary disc type, with feed conveyor

One with top discharge

One with bottom discharge.

The top discharge type cutter which was in operation when the site was visited is simple and effective. Straw is charged manually on the conveyor, is gripped between two rods and cut by a disc cutter with radially fitted knives. The cover can be removed easily to change the knives and the time for changing these is 30 - 45 minutes. The cutter is driven by a single motor.

(2) Straw Cutter

Capacity : 1T/Hr.

Make: Paper Mill Plant & Machinery Mfg. Ltd. (Bombay)

(3) Blower

Capacity : 3T/Hr.

Similar to the blower used for Sabai grass

(4) Dust Cyclone & Silo

Similar to that used for Sabai Grass

7.2 Cooking, Hot Stock Refining, Washing.

(a) Process in brief

Cut sabai grass is charged to chemi-mechanical digesters from silos. About 2.8 T. of air-dry, dusted grass is charged in one digester from the silo using a cloth chute. Nearly 1 hour is taken to load the raw material. 2.5% caustic and 6% lime are also added. Steam is blown to the digester to raise the temperature for cooking. Time taken for a cooking cycle :

1 hour for loading raw material
1 hour for steaming
1½ " for cooking
½ " for pumping

4 Hours total cycle.

The consistency at the beginning of the cooking cycle is 10% and at the end about 6%. Part of the black liquor from the decker washer is used in the digester. The yield from air dry raw material as cooked pulp is claimed to be about 63%. The semi-cooked pulp is pumped to a vertical storage chest, from where it is pumped to a Hot Stock Refiner through a junk trap to remove any foreign material.

There are two hot stock refiners (disc type). One is imported from Sweden and the other is from Paper Engineering Services, (Vijayawada). One refiner only is used in the process, the second one is a standby. The stock is then passed to a screening plant consisting of a dilution box, (where the pulp is diluted with back water from the 2nd stage decker) washer, and thickened pulp is stored in a chest.

Rice wheat/straw is also pulped, refined, screened and washed in a similar manner to sabai grass with 1% caustic soda and 6% lime in the digester. Two digesters are used at a time. Cooked straw pulp is passed through the same equipment for refining, screening and washing as used for sabai grass pulp in the batch process.

(b) Equipment Used:

1) Chemi-mechanical digesters .... 3 Nos
Capacity .... 25 M^3
Power............ 220 HP

The equipment is similar to a Hydra pulper in construction having a rotor inside, a steam ring at the bottom and a pneumatically operated discharge valve. The digester is completely insulated with boiler insulating material. On the top cover there is a sliding opening for charging the material. The digester rotor is driven by a V-Belt pulley with a bottom pedestal thrust bearing.

Initial consistency : 10%

Final consistency : 6%

2) Stock Pumps .... 3 Nos
Capacity ....75 Kg/Min. @ 6% consistency
Head .... 30 M
Capable of pumping hot stock from digester to Stock Chest.

3) Stock Chests .... 2 Nos
One for Sabai grass pulp
One for rice straw pulp/wheat straw pulp
Chest capacity : about 75 M^3
Consistency of stock about 5 to 6%

4) Stock Pumps .... 2 Nos
Stock pumps for the above chests to transfer the pulp to hot stock refiner.

5) Junk Trap .... 1 Nos
This is an M.S., circular tank with a conical bottom to collect all the foreign material in the semi-cooked pulp.

6) Hot Stock refiner (Disc. Type) ...... 1 used

Imported One :

Capacity .... 50 tons/day

Power .... 250 HP

Temp. of stock ...... 60^{o} to 70^{o} C.

Make: Asphund Refiner
Defibrator AB,
Stockholm (Sweden)

Indigenous one:

Capacity .... 30 tons/day

Power ....250 HP

Temp. of stock ...... 60^{o} to 70^{o} C

Make: Paper Engineering Services (P) Ltd.
Vijayawads.

7) Dilution Box .... 1 No

Capacity .... About $3M^{3}$

This is to dilute pulp from the hot stock refiner to feed to the vibrating screen.

Inlet consistency : about 5%

Outlet consistency : about 0.5 - 1.00%

8) Vibrating Screen .... 1 No

9) Riffler

10) Decker washer thickner .... 1 No

Capacity .... 30 TPD

Dia. of the drum .... Approx. 2. OM

Length of the drum .... Approx. 4. OM

M.S. Vat

Drum is driven by a reduction gear box

No of showers .... 1 No

Inlet Consistency .... 0.5 to 1.0%

Outlet Consistency .... 4 to 5%

11) Stock Chest .... 1 No
Capacity approx .... 45 M^3

12) Stock Pump for the above chest....1 No
Capacity ... 1.5T/Hr. @ 5% consist.

13) Decker Washer Thickener .... 1 No
Similar to item 10 above

14) Stock Chest .... 1 No
Similar to item 11 above

15) Stock Pump for the above chest . 1 No.
Similar to item No. 12 above

7.3 Stock Preparation and Blending of Pulps

a) Process in brief

Washed sabai grass pulp and rice straw pulp/wheat straw pulp are further refined separately in a series of conical refiners (two refiners of 100 HP each) and stored in storage chests. Then the two pulps are mixed in 50:50 ratio in a blending chest, where Rosin @ 1% and Alum @ 8% is also added. The mixed furnish is then transferred to a machine chest and through a constant level box to centri-cleaners, pressure screen and finally to the machine flow box.

b) Equipment Used

1) Conical refiners ....2 Nos.
Capacity .... 30 Tons/day
Power .... 100 HP
Type .... Voith (R1)

2) Disc Refiner
Not in use

3) Stock chest .... 2 Nos
One for sabai grass pulp
One for Rice straw/pulp/wheat straw pulp
Capacity .... about 50 M^3

4) Stock pumps for the above chests .... 2 Nos
Similar to item 12 above in washing plant.

5) Mixing chest .... 1 No.
Similar to item 3 above

6) Stock pump .... 1 No.
Similar to item 5 above

7) Machine chest
Similar to item 3 above

8) Stock Pump .... 1 No.
Similar to item 4 above

9) Constant level head box
Made of S.S. Construction with over flow back to Machine chest.

10) Fan Pump .... 1 No.

11) Centri cleaners - 3 stage .... 1 Unit

12) Pressure screen .... 1 No.

7.4. Paper Making and Finishing

a) Process in Brief

Pulp from a pressure screen is continuously run in to the flow box and on to the wire of the paper machine. It is then transferred to the 1st press, 2nd press and 3rd press. The wet sheet after pressing is dried on steam heated pre-drying cylinders and then dried on steam heated after-dryers and reeled on a pope reel. The couch broke, is thickened in a gravity type thickner and dry broke is pulped in a hydro-pulper and mixed in the mixing chest. Dry paper is rewound and slit to commercial sized on a slitter-rewinder and then packed for dispatch.

b) <u>Equipment used</u>

1) Paper Machine .... 1 No.

Capacity .... 30 Tons/day

Width .... 2.5 M

Speed (designed) .... 200 M.P.M.

Substance range .... 60 gsm to 150 gsm.

<u>Flow Box:</u>

An open flow box is used with two perforated rolls inside and two lips, the top lip having an arrangement to vary the clearance. The box is made of stainless steel.

<u>Wire Part</u>

Width .... 2.5 M

Speed .... 200 M.P.M.

The breast roll is rubber covered. There are 24 table rolls, 6 suction boxes and 8 rolls for wire return and stretch. There are 4 showers for wire cleaning.

The suction couch roll is imported and fitted with a lump breaker roll.

The 1st press is an imported suction type with two doctor blades on the top roll. The 2nd and 3rd presses are plain presses.

The 3rd Press is mounted on the dryer frame and driven by dryer gears.

There are 9 pre-dryers before the M.G. cylinder and 4 after dryers.

The machine calender has 4 chilled cast iron rolls.

There are oscillating doctor blades on the drying cylinders.

The wire part (except suction couch, pope reel and slitter rewinder) was supplied by Paper Engineering Services Pvt. Ltd., (Vijayawada). Drying cylinders and other equipment were supplied by Paper Mill Plant & Machinery Manufacturers in Bombay.

7. Services

Power: The factory takes power from the UP State Electricity Board through a 2500 KVA power connection. They also have a stand-by power generator able to provide up to 50% of the total electric power requirements for the factory. Power consumption is approximately 1800 KWH per ton of finished product.

Steam: One 12 tonnes/hour coal-fired high pressure water tube boiler supplied by Lipi Boilers is installed to supply the process steam required. Consumption of coal is approximately 1.5 tonnes per tonne of finished product. Coal has to be brought a very long distance from Bengal and Bihar States, against the allotment by the Government of India.

Water: The mill draws water from 4 tube wells located on the factory site. Nearly 3,360,000 gallons of water per day is pumped from the tube wells.

Effluent: There is a drain by the side of the factory through which the effluent is discharged after allowing a 20 hour retention time in lagoons. This effluent is used by the farmers of the adjoining fields for irrigation purposes. The retention time of nearly 20 hours in the lagoons reduces BOD and the effluent is suitable for irrigation.

8. Capacity Utilisation

This is taken 70% of installed capacity, although, as section 13 shows, the first 10 months of operation in 1978 were punctuated with stoppages because of power shortages.

9. Raw Materials

The mill uses straw and sabai grass as raw material for manufacture of MG/MF Kraft Paper. Quantities of raw materials used for the first ten months of 1978 were reported by the company as follows:

Item	Quantity
Waste Paper	200 tonnes
Straw/bagasse	6225 tonnes
Caustic soda	150 tonnes
HCL	243 tonnes
Lime	388 tonnes
Rosin	38 tonnes
Alum	380 tonnes
Kerosene Oil	17,550 tonnes
Coal	6700 tonnes
Electric power	4,213,276 units

10. Labour

Total number of staff and workers employed in 1977-78 was about four hundred.
Total salary and wages bill for 1977-78 was Rs. 1.88 million.
Expenditure on overtime for the same period was Rs. 58,000.

11. Financial Structure

For a standard 2 to 1 debt to equity ratio the financial structure would be as follows:

Rs Million	
Equity	15.5
Term Loans	31.0
Total	46.5

12. Capital Costs

The project is based on a capital outlay of Rs. 46,500,000. The details are given below:

1.	Land	400,000	
	Development	220,000	620,000
2.	Buildings and other civil construction		4,400,000
3.	Plant and equipment including steam water and power supply:		
	Imported	559,000	
	Indian	24,690,000	25,249,000
4.	Miscellaneous Fixed assets		4,598,000
5.	Preliminary and pre-operative expenses	5,240,000	
6.	Engineering and consultancy fees	1,000,000	6,240,000
7.	Provision for contingencies		3,000,000
8.	Margin money for working capital		2,393,000
	Total Project Cost	Rs.	46,500,000

13. Operating Costs

At the time of surveying this mill in April 1979 the mill had completed 10 months of the first year of operation. This ten month period included various trial runs to optimise the operations and attain full installed capacity. This time period was further affected by power and coal shortages which limited the operations of the mill. For these reasons no consistent or truly representative picture of the actual operating costs can be given. Based upon the information collected in the form of yields of various fibrous raw materials and the type of furnish, an estimate takes into account the actual experience of the mill and has been based on their latest (1979) cost factors. The following is the basis for calculating requirement of raw materials and chemicals per tonne of finished paper.

Basic Parameters

Furnish	50% sabai grass
	50% rice/wheat straw

Cooking Chemicals	i) 2.5% Caustic on A.D. (air dry) Material
	ii) 6% lime on A.D. material
Sizing Chemicals	i) 1% Rosin on finished paper
	ii) 8% Alum on finished paper

RAW MATERIALS

Item	Ratio	Screened yield (A.D.)	Air dry Raw Material Per tonne of finished paper
Sabai	.5	60%	.83 tonnes
Straw	.5	55%	.91 tonnes

Chemicals

(i) Caustic:	For Sabai Grass	2.5 of .83 tonne =	20.7 kgs
	For straw	2.5 of .91 tonne =	22.7 kgs
			43.4

per tonne of finished paper.

(ii) Lime: 6% of total raw materials of 1.74 tonnes = 104 kgs/ tonne of finished paper.

Based on the above operating costs would be as follows:

Item	Consumption/ tonne of paper	Unit cost	Cost/tonne of paper
Raw Materials	Tonnes	Rs/T	Rs
1. Sabai grass	.83	450	374
2. Straw	.91	230	209
Chemicals	Kgs	Ks/Kg	
1. Caustic	43	2.7	116
2. Lime	104	0.3	31
3. Alum	80	0.82	66
4. Rosin	15		90
Utilities			
Coal	1.5T	220	330
Power	1800 Units	0.26	468
Others			
Repairs, Maintenance, consumables			164
Packg. & forwarding			80
Salary and wages			194
Administrative Overhead			77
			Rs. 2199

14. Selling Price

Net sales realisation is Rs. 4,300 per annual tonne of paper.

15. Profitability

The profitability has been evaluated at 70% utilisation of the installed plant capacity of 10,000 per year.

	Per Year in Rs million	Per tonne of paper in Rs.
Net sales realisation	30.1	4,300
Total operation cost	15.4	2,199
Gross Profit Margin	14.7	2,101

Return on Capital

The internal rate of return on all capital is 24½% before tax. After tax at 55% of gross profits (net of depreciation and interest payments) the return on total capital is 16%. Depreciation is calculated on a straight line basis at 8% pa. of fixed assets of Rs.29.8 million and at 4% p.a. civil works of Rs. 4.4 million. Interest is calculated at 11% of Rs. 31 million repayable in ten installments to which interest due in the two year project gestation period is added back. Working capital is provided by the equity contribution.

Sensitivity Analysis

The return on all capital of 24½% is sensitive to the following variables:

Change	Change in IRR
10% increase in revenue	+5%
" " " product	-3%
" " investment	-2½%
" " capacity	
" " utilisation	+2½%

Payback Period

This is a favourable 4.6 years for all capital and 3.4 years for equity.

Comments

In spite of a low capital turnover rate (annual sales: capital employed = 0.6) the mill returns an attractive 24% on all capital and 25% on equity.

The relatively high profit rate (of 2,100/tonne) makes the return relatively insensitive to change of up to 10% in the four variables examined. This high rate is achieved by use of low cost agricultural waste products (rice and wheat straw) and further helped by the provision of equity to meet working capital needs, obviating the need for short term loans at 16% interest which often adversely affect the cash flow in the first year of commercial production.

The capital cost of Rs. 4,650/installed annual tonne is achieved by not using chemical recovery.

CASE STUDY

30 TONNES PER DAY

1. Synopsis

This 30 tonnes per day mill commenced operations in mid-1978 in the Andhra Pradesh state of India. Total capital costs were Rs.45.9 million, or Rs.4,590 per annual tonne.

The main raw materials used are straw and waste paper to produce writing and printing papers.

2. Installed Capacity

Paper Mill	30 T.P.D.
Pulp Mill	
i) Straw Pulp Plant	20 T.P.D.
ii) Rag Pulp Plant	6 T.P.D.
iii) Waste Paper Pulp Plant	4 T.P.D.

3. Product Range

Writing and Printing Paper of substance range to 120 G.S.M. Approximately 60% of sales is in the form of sheets; the balance in the form of reels.

4. Brief Description of the Mill

The project has been undertaken as a joint venture between private entrepreneurs and the State Industrial Development Corporation. The area in which the mill is located is regarded as the rice bowl of India. Paddy is the main agricultural crop, and this region is abundant in rice straw. Other raw materials such as rags and waste paper are available from large cities within a radius of 100 km of the plant. The mill is well connected by railway and fairly good all-weather roads to its markets. There is no shortage of skilled or unskilled labour in the area where the mill is located.

5. Particulars of Plant

The project was conceived in early 1976 and civil work was started in the middle of that year. The mill went into commercial production in the middle of 1978.

A second-hand fourdrinier paper machine, of 2.7m trim width with speed range 150-200 metres/minute, was imported from U.S.A. The machine has a pressurised head box, suction couch, 1st suction press, 2nd and 3rd plain presses and 30 drying cylinders (20 dryers before the size press and 10 drying cylinders after the size press). A second-hand rewinder was also imported with the paper machine. Paper cutters were purchased in India, as also were numerous auxiliaries for the paper machine such as thyrister-controls for the paper machine drive, vacuum pumps, pressure screen, centri-cleaners etc.

Pulping equipment, described in the flow sheet, was obtained from Indian suppliers. Rotary digesters, beaters, screw press and washing potchers are from Eastern Paper Mills Limited (Calcutta): vacuum washers are EIMCO-KCP Limited (Madras); straw and rag cutters are from MANCO Engineering Company (Yamuna Nagar); and vacuum pumps and centricleaners were supplied by Paper Engineering Service Pvt Ltd. (Vijayawada). Other equipment, pumps, waste paper pulping section, etc., were procured from local workshops.

Steam generation plant was supplied by Wanson (India) Pvt Limited (Poona) and electrical installations were supplied by Crompton Greaves Limited (Madras).

6. Process of Manufacture

Paddy straw is chopped to small pieces of about 4" length in a mechanical cutter, and after dust is removed in a dust separator, it is charged to spherical digester, where it is cooked with 10-12% caustic soda for about 3 hours. The resultant unbleached pulp is dumped in a pit with false bottom. The spent liquor is drained and collected in a tank. The pulp is washed partly in the pit with warm water. Part of the spent liquor is re-used, after fortification with fresh caustic soda, for further digestion.

The semi-washed brown pulp is further squeezed of black liquor in a screw press and dumped in a washing potcher, where the pulp is washed completely. The washed unbleached pulp is then passed through the screening plant, consisting of dilution box, riffler, Johnson vibrating screen, and a gravity flow thickener.

The thickened pulp is stored in a horizontal chest. The washed and screened unbleached pulp is passed to the bleaching plant consisting of chlorination tower, vacuum washer, hypo-tower and Hollander bleacher washer and stored in the chest. The bleached pulp is then passed to a screening and cleaning plant consisting of head box, centrifugal screening, centri-cleaners and decker thickener. The thickened bleached pulp is stored in a chest.

Waste paper cuttings are pulped in warm water in a hydra-pulper and cleaned through a high density cleaner. It is further screened in a riffler, Johnson vibrating screen, thickener and stored in a chest.

Rags are cut into small pieces in a heavy duty cutter, dusted and charged to a spherical digester, where they are cooked with 4 to 6% caustic soda. The resultant pulp is dumped in a drainer pit to remove black liquor. Rag pulp is then charged to breaker beaters to break the fibre bundles. About 1% chlorine, as available in calcium hypo-chlorite, is added to the pulp which is then washed. The washed pulp is further refined in refining beaters, screened, thickened and stored in a chest.

Bleached straw pulp, rag pulp and waste paper pulps in the desired proportions are blended ith alum and rosin for sizing, dyes for colouring and talcum powder for filling. The mixed furnish is then transferred to a machine chest and passed through a battery of centri-cleaners and a pressure screen. Additional details of straw pulping and rag pulping are given in Figures 2 and 3.

The furnish is then run continuously through the Flow Box to the paper machine. The wet sheet formed on the machine is pressed and dried on steam-heated drying cylinders. The dry sheet of paper is wound onto a reel, cut to commercial sizes and re-wound as tight reels for the customer.

Steam required for the process is generated in coal fired boilers.

7. Services

Power	A 4,500 kVA Power line, laid by the State Electricity Board, provides the mill's power requirements. Power consumption can be taken as 1500 Kwh per ton of finished product.
Steam	The mill has 3 coal fired boilers of 5 T/hour capacity each. Coal is readily available from mines situated in the neighbouring province. The estimated cost of the boiler and steam distribution system is approximately 2 million rupees.
Water	Water is available from a perennial canal which flows nearby. The mill draws 2 M.G.D. and no treatment is given to the water used.
Effluent	The mill discharges its effluents without treatment into a natural drain, which passes one side of the plant.

8. Capacity Utilisation

The mill went into production in the middle of 1978. The production report for October 1978 is as below:-

Total working hours 512 hours

Quality of paper manufactured	Tonnes
47 G.S.M.	193
52 G.S.M.	6.3
56 G.S.M.	44.5
60 G.S.M.	145.6
64 G.S.M.	27.9
90 G.S.M.	11.2
120 G.S.M.	1.5
Total production	430

Machine running efficiency : 91.7%

Average production per running hour : 840 Kgs.

9. Raw Materials

The mill uses paddy straw, rags of different types, waste paper and purchased pulp as raw material. A blend of 60% straw pulp and 40% waste paper pulp is being used.

10. Labour

No information on employment was collected.

11. Financial Structure

The project was financed by long-term loans from the Industrial Development Bank of India, State Financial Corporation and Banks, in addition to promoters' share capital and public subscription. The State Industrial Development Corporation, as a co-promoter, has participated in the promoters' share capital. The structure is given below:-

A. Share Capital

1 (a)	State Industrial Development Corporation's Equity	Rs. 4,590,000
(b)	Entrepreneur's Equity	Rs. 4,237,000
2.	Public Subscription	Rs. 8,827,000
B.	Long Term Loans	Rs.28,246,000
	TOTAL	Rs.45,900,000

Interest payable on long-term loans is at 11% and the loan repayment period is 10 years. Working capital facilities of Rs.2,100,000 carry interest at 16%.

12. Capital Costs

The project is based on a total capital outlay of 45,900,000 Rupees. The mill site has an area of around 20 acres and has been fenced. The total covered area for housing the plant and machinery in the pulp mill, paper machine hall, boilers, electricals and raw material preparation is about 12,000 sq.m. The total expenditure on civil works, factor buildings, non factory buildings and factory buildings and RCC chests and other tankages was Rs.6.2 million.

The expenditure on land, building, machinery, etc., is given below:-

1)	Land and Site development	Rs. 995,000	
2)	Factory Buildings	3,788,000	
3)	Non Factory buildings	1,225,000	
4)	Chests, tankages, silos, etc.,	1,150,000	7,158,000
5)	Plant and Machinery:		
	A) Imported Machine including reconditioning expenses	6,082,000	
	B) Indigenous Equipments:		
	i) Pulping Plant including raw materials preparation and bleaching equipment	17,580,000	
	ii) Boilers and steam distribution	2,000,000	

iii) Electrical installations	3,600,000	
iv) Other Misc. fixed assets i.e. workshop, furniture and fittings, fire fighting equipment, weigh bridge, etc.	1,000,000	
C) Erection of Plant & Machinery	1,700,000	31,962,000
6) Technical Consultancy and Engineering fees.	650,000	
7) Preliminary & pre-operative expenses	3,000,000	780,000
Working Capital		2,100,000
	TOTAL	Rs. 48,000,000

13. Operating Costs

Based on the data collected and current 1979 prices the cost of raw materials and other inputs is estimated on the basis of per tonne of paper production as follows:-

	Quantity regd/ Tonne of paper	Unit cost in Rs.	Cost per tonne of paper in Rs.
A. Raw Materials	Tonnes		
60% paddy straw	1.5	230	345
40% Waste paper (80% yield)	.50	2400	1200
			1545
B. Chemicals	Kgs.		
1. Caustic Soda	180	2.7	486
2. Bleaching Chemicals			150
3. Alum	60	.82	50
4. Rosin	15	6.0	90
5. Talcum Powder	100	.42	42
			818

	Quantity regd/ Tonne of paper	Unit cost in Rs.	Cost per tonne of paper in Rs.
C. Utilities			
1. Power	1500 KWH	.25	375
2. Coal	1.5 T	220	330
3. Water	0.066		
			705

D. Other Expenses

i) Packing and Insurance	80
ii) Repairs, Maintenance, Consumables	150
iii) Administrative Expenses	75
iv) Salaries & Wages	250
Gross Total	Rs.3,623

14. Selling Price

Net average sales realisation per tonne of paper was Rs.5,200.

15. Profitability

The profitability of the mill has been evaluated at 70% utilisation of the installed capacity of 10,000 tonnes/year.

This evaluation is based upon technical data collected from the mill and the most up-to-date cost factors.

	Rs. (Million) per annum	Per tonne of paper in Rs.
Net Sales realisation	36.4	5,200
Total Operating Cost	25.4	3,623
Gross Profit Margin	11.0	1,577

Return on Capital

The internal rate of return on all capital is 16½% before tax. After taxation at 55% of gross profits (net of depreciation and loan interest), this return falls to 11%. Depreciation is calculated on a straight-line basis at 8% p.a. of plant and machinery of Rs.31.9 million, and at 4% p.a. of civil works of Rs. 7.2 million. Interest is calculated at 11% of initial loans of Rs.28.2 million, repayable over 10 years, to which interest due in the first two years of project life is added back. Interest is calculated at 16% of working capital needs of Rs.2.1 million.

The return on equity is 12½% after tax and loan repayments.

Sensitivity Analysis

The return on all capital is sensitive to the following variables:-

Increase	Change in IRR
10% in revenue	+ 7 %
10% in production cost	- 5½%
10% in capacity utilisation	+ 3 %
10% in investment	- 1½%

Payback Period

This is 6 years for total capital and 7 years for equity.

Comments

The use of imported equipment (albeit secondhand) has raised the capital cost per annual tonne to almost Rs. 4,600, resulting in a less than average return on capital of 16½% in spite of the relatively favourable unit profit of Rs.1,580/tonne of finished product. This profit level is less than that achieved in two other 30 TPD units (in the case-study series) due to the use of high cost waste paper as 40% of the raw material furnish.

In addition, the capital turnover achieved (annual sales: capital employment = 0.8) is also relatively low in comparison with smaller scale units, suggesting the need to keep capacity utilisation rates at 70% and above.

CASE STUDY

30 TONNES PER DAY PAPERMILL

1. Synopsis

This 30 tonne per day plant is planned for operation in Hinachal Pradesh state in India. Total capital investment including chemical recovery will be Rs.65 million, equivalent to Rs.6,500 per annum tonne of paper. The basic raw materials will be straw pulp and conferous wood waste from a wood processing factory, owned by the paper company and producing such wood products as door and window frames, tea-chests and furniture panels. The chemical requirements for pulp wood are higher than for agricultural residues, thus entailing chemical recovery for both economic and environmental reasons. The main products will be fine quality writing and printing papers.

2. Installed Capacity

Paper Mill	30 TPD
Pulp Mill	30 TPD

3. Product Range

The mill is designed to produce fine quality writing and printing papers in the substance range of 45 to 70 GSM. About 60% of all the sales will be in form of sheets and the remaining 40% will be in the form of reels.

4. Brief Description of the Mill

This mill is still at the planning stage, but has been specifically included as a case study because it reflects most current prices and will adopt innovative and thus most modern, appropriate technology. As the selection of a site for a mini-mill is very important consideration, a number of factors were taken into account before deciding upon the proposed location.

The mill will be located near a railway station in Himachal Pradesh state which forms the north-west territory of India. By virtue of its location in a centrally-declared backward area, the project will be entitled to a central cash subsidy, lower rate of interest on borrowings and more favourable debt to equity ratio.

Coniferous woods in limited quantities are available in the state of Himachal Pradesh. These limited resources can only be employed towards end uses which offer the highest social and economic benefits to the people of Himachal Pradesh. Because of competition for use of this wood from higher value products like furniture, etc., royalty on the wood is high. Apart from this, because of the terrain, the extraction costs of wood are also very high.

The concept of this project is to set up a wood processing cum pulp and paper mill complex. The wood will be first utilised to make wood products of higher economic priority. Waste from the wood processing unit will be used for paper making. The main purpose of using coniferous wood waste is to provide long fibred pulp for the furnish so that good quality printing and writing papers can be manufactured. The balance of the furnish is reduced.

The plant will be near a waterway allowing carry-off of treated effluent. Sub-soil water of good quality is available and so it is proposed to dig tube-wells on site to meet the mill's requirements.

Mill capacity will be limited to 30 tonnes per day and use will be made of a chemical recovery plant to eliminate harmful effluent and to re-cycle chemicals.

5. Particulars of the Plant

A suitable 30 TPD second-hand paper machine will be imported for this project. All other equipment for pulping, stock preparation, finishing of paper, boiler plant and electrical equipment will be purchased from Indian sources. Low cost chemical recovery equipment for this 30 TPD mill will also be obtained from India and the total additional cost of this recovery equipment at current price levels will be around Rs.8,000,000 (US$ 1,000,000).

6. Process of Manufacture

The Company proposes to manufacture 10,000 metric tonnes of fine varieties of writing and printing paper annually in the notified backward area of Himachal Pradesh. The project will utilise, for the first time in India, wheat straw and own manufactured long-fibred wood pulp.

Wheat straw and coniferous wood will be processed separately to take advantage of their differing paper making characteristics. Both raw materials after preparation will be cooked by the conventional soda process followed by screening and multi-stage washing. The washed, unbleached pulp from straw and wood will be stored in large RCC tile-lined chests. It will be bleached through a conventional chlorine/caustic/hypochlorite continuous bleaching sequence using vacuum wash filters for each stage. The pulps will then be thoroughly screened and cleaned by centricleaners and stored separately in high-capacity storage towers. Next, the pulps from wood and straw will be refined separately in modern stock preparation plant to the desired degree of freeness and then blended together before feeding to the paper machine.

The refined and blended straw and wood pulp, after addition of required quantities of chemicals such as rosin, alum, dyes, talcum and other additives to impart desired characteristics to the paper will be finally diluted, screened and pumped to the flow box or the paper machine. After removal of water in the fourdrinier section the wet web of paper will be pressed and dried before winding on the machine reel after which it will be slit into desired widths and rewound. Reels for sheets will then be cut into suitable sizes, sorted manually and packed for despatch.

7. Services

Power

Electricity will be purchased from Himachal Pradesh State Electricity Board and a 7000 kVA connection will be taken for this purpose. The price of electric power in the State of Himachal Pradesh is relatively low at 20 paise per kWh (2.5 U.S. Cents per kWh).

Steam

The most economical fuel for raising steam is coal and the mill will have coal fired boilers. Approximately 7 to 8 tonnes of steam will be required per tonne of finished paper. To meet all the steam requirements of the plant, the boiler house will have up to 15 tonnes per hour steam raising capacity.

Water

The mill will have its own water supply obtained from deep tube wells. The quantity required will be around 2 million gallons per day.

Effluent

The mill will have its own chemical recovery system and therefore there will be no significant problems for disposal of effluent.

8. Capacity Utilisation

In view of the common problem of coal and electric power and taking into account initial start-up runs, the anticipated capacity utilisation in the first year will be approximately 70%.

9. Raw Materials

Waste wood from the coniferous wood process unit and straw will be the major fibrous raw materials. The forests of the Himalayan State of Himachal Pradesh can provide coniferous wood species of pine, fir, and spruce. In adjoining districts to the plant, sufficient quantities of wheat straw are available as these are among the established wheat growing areas of Punjab.

The estimated requirements of main raw materials are as shown below:-

Raw Material	% Furnish	Finished Paper A.D.Tonnes	Net Pulp B.D. Tonnes	Yield (Bleached)	Raw Material A.D. Tonnes
Wheat Straw	60%	6000	5400	33%	18,000
Wood	40%	4000	3600	38%	10,000

(A.D. = Air dry   B.D. = Bone dry)

The wood processing unit will receive 70,000 cubic metres of coniferous woods. From this, 50,000 cu.m. will be converted into wood products and the remaining 20,000 cubic metres (of approximately 10,000 tonnes) per year of wood waste will be used for paper making.

The estimated cost of wood received by the wood processing unit is given below:-
(all prices in Rs. per m^3)

	Royalty	Extraction Cost	Total at Mill Site
Deoder	270	350	620
Fir & Spruce	110	350	460
Kail	110	350	460
Chil	110	350	460

The price of waste wood generated from the wood processing unit has been fixed at Rs.350/tonne to the pulp mill based on the estimated economic value of this waste.

If the mill was based on the use of round logs ex-forest, the cost would be approximately Rs.2,400 (US$300) per tonne of finished paper. Absorbing the high cost of virgin wood to make higher value products and using wheat straw to the extent of 60% of furnish, the cost of raw material per tonne of finished paper is considerably reduced.

The estimated cost of fibrous raw material per tonne of finished paper is given below:-

	Required Pulp Quantity per Tonne of Paper.	Yield of Raw Material.	Required Raw Material per Tonne of Paper.	Cost of Raw Material in Rs. per Tonne.	Cost/Tonne of Paper. Rs./Tonne
Straw Pulp	0.6	0.33	1.818	210	382
Wood Waste Pulp	0.4	0.38	1.052	350	368
					750

10. Labour

One of the major benefits of this project is that it will create a large number of new jobs. Direct employment will be provided for 150 staff and around 1500 semi-skilled and skilled workers. The wood processing unit being more labour intensive will account for two thirds of the work force. 500 workers will be employed in the Paper Division.

The cost of extraction of timber is around Rs.350/- per cubic metre. For extracting 70,000 Cu.m. an estimated Rs. 24.5 million will be spent annually in Himachal Pradesh State. Most of this expenditure will be wages of workmen involved in timber extraction and transportation.

The cost of wheat straw is around Rs. 210 per tonne. A major component of this cost covers collection and transportation. Again, this will create employment opportunities and improve farm income.

Distribution of finished paper products, wood products and procurement of chemicals will also increase employment opportunities.

Taking all the above into consideration, it has been estimated that nearly 1,600 new jobs will be directly created, while potential secondary employment creation is estimated at some 6,500 for an initial project outlay of under Rs. 70 million (US$ 8.75 million). As the project gestation period is relatively short, these benefits will accrue in the near future.

12. Financial Structure

The financing pattern of the Paper Division will be as given below (in Rs. million)

Total project cost	65.0
Less: Central Cash Subsidy	
(maximum permissible)	1.5
Net Financing required	63.5

Long Term Debt	
(2.5 to 1 Debt:Equity Ratio)	43.4
Equity	17.4
Working Capital Facility	
(at 16%)	2.7
Total	63.5

The breakdown of equity of Rs. 17.4 million will be as follows:-

Public issue (60%)	10.4
Promoters' capital (40%)	7.0
Total equity	17.4

12. Capital Costs (Paper Division only) (Rs. Million)

1.	Land and site development (Total land 30 acres)	0.8
2.	Building and other civil construction	10.0
3.	Plant and Machinery including erection	29.5
4.	Misc. fixed assets including steam, water, power supply and electricals	10.8
5.	Technical know-how and preliminary expenses for company formation and capital issue, etc.	1.3
6.	Pre-operative expenses including interest till commencement of production	3.4
7.	Contingencies	4.1
8.	Working Capital	5.1
		65.0

13. Operating Costs

Item	Quantity per Tonne of Paper	Unit Cost	Cost/Tonne of Paper (Rs.)
A. Raw Materials	Tonnes	Rs./tonne	
Straw	1.8	210	378
Wastewood	1.0	350	350
B. Chemicals	Kgs.	Rs./kg.	
Caustic	160	2.5	400
Chlorine	122.4	.8	98
Lime	331	.35	115
Alum	60	.9	54
Rosin	15	5.0	75
Talcum	80	0.5	40
C. Utilities			
Coal	1.8 T	250/T	450
Power	1500 kWh	.2/kWh	300
D. Others			
Repairs			120
Consumables			100
Packaging			40
Manpower			360
Administration			120
Contingency			150
		Total Rs.	3,150

Calculation of quantities (for 10,000 annual tonnes of paper)

	% Furnish	Net Pulp (B.D.)	Yield (Bleached)	Raw Material (B.D.) Tonnes	Raw Material (A.D.) Tonnes
Raw Materials					
Wheat Straw	60	5400	33%	16,363	18,000
Wood	40	3600	38%	9,473	10,000

(A.D. = Air Dry B.D.= Bone Dry)

Chemicals

a) Caustic Soda

For Straw Pulp (8% B.D. Straw)		1,309
For Wood Pulp (22% B.D. Wood)		2,084
	Total	3,393 Tonnes
For Bleaching Operation (2.5% Bone Dry Pulp)		225
		3,618 Tonnes
Assumed Chemical Recovery		60%

Recovery = 60% of caustic soda used for cooking

= 0.6 x 3393 = 2,035

= 1,583 Tonnes

= Say 1600 Tonnes/Year

b) Clorine

Straw Pulp (12% B.D. Pulp)	=	648*
Wood Pulp (16% B.D. Pulp)	=	576*
		1224 Tonnes

*(Half of this will be used for bleach liquor preparation i.e. solution of Calcium Hypochlorite).

c) Burnt Lime (Approximate CaO content assumed at 70%)
For Bleach Liquor
Preparation: 1.25 tonnes/tonnes of chlorine : 765 tonnes

For Caustic Recovery: 1.25 tonnes/tone of
Caustic recovered: 2545 tonnes

Total: 3310 tonnes

Total 3310 tonnes of lime needed.

d)	Alum: 6% of Finished Paper	= 600 tonnes/year
e)	Rosin: 1.5% of finished paper	= 150 tonnes/year
f)	Talcum Powder: 8% of finished paper	= 800 tonnes/year

14. Selling Price

This has been estimated in detail below for the paper division only.

a) Per Tonne of Paper

Type of Paper — Bond, Duplicating, Map Litho, Ledger, Azurelaid and other superior grades over 65 GSM.

1.	Basic selling price per tonne (writing, exercise and tissue)	Rs. 5,600
2.	Excise Duty payable per tonne	Rs. 1,470
3.	Ex-factory price per tonne including Excise Duty	Rs. 7,070
4.	Excise Duty Rebate per tonne	Rs. 490
5.	Gross sales realisation to Mill per tonne including Excise rebate	Rs. 6,090

7. Freight per tonne Rs. 150

8. Net to Mill per tonne of paper sold Rs. 5,520

B) Total

Installed Capacity	10,000 Metric Tons/Year	
Plant Capacity Utilisation	100%	70%
Annual Production (Tonnes)	10,000	7,000
Net Sales	Rs. 38.6 million	

15. Profitability (in the Paper Division)

Profitability of the plant for its first year of operation has been estimated as below at 70% utilisation of installed capacity.

	Per Year (Rs. million)	Rs. Per Tonne of Finished Paper
Net Sales Realisation	38.6	5,520
Cost of production	22.0	3,150
Gross Profit Margin	16.6	2,370

Return on Capital

The internal rate of return on all capital is 21% before tax. After taxation at 55% of profit (net of depreciation and interest payments), this falls to 12½%. Depreciation is calculated on a straight-line basis at 8% of fixed assets of Rs.40.3 million, and at 4% of civil works of Rs.10 million. Interest is calculated at the favourable rate of 9½% on fixed asset loans of Rs.43.4 million, repayable over 10 years from the first year of commercial production. Working capital needs are met partly be equity contributions, partly by a 1 year loan facility at 16%.

The return on equity is 22% after tax and loan repayments.

Sensitivity Analysis

The return on all capital of 21% is sensitive to the following variables:

Increase	Change in IRR
10% in revenue	+ 7 %
10% in production costs	- 3½%
10% in investment	- 2½%
10% in capacity utilisation	+ 2 %

Payback Period

The total capital outlay is recovered with 5.2 years of commercial production, and the equity within 4.1 years.

Comments

The use of chemical recovery to economise on chemicals has raised capital costs per annual tonne to Rs.6,500 at least twice that of smaller units. However, a favourable profit rate per tonne of finished product of Rs.2,370 is achieved by intergrating the paper unit with a wood processing factory, which will supply the former with wood waste. This reduces raw material cost to a relatively low figure of 23% of production costs (net of financing charges).

The return on equity is 22% which can be considered pessimistic in the light of recent paper price rises, the use of higher cost (second-hand) imported paper machines, and the relative insensitivity of the return on capital to cost increases (capital and operating).