Bagasse Based Paper Mills Some Indian Experiences & Financial Aspects

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The growing demand for paper and Board is indicated by the per-capita consumption which is around 2.2 Kg. and in the year 20Ͻ0 AD it would be 4 5 Kg This figure wauld appear to be very low when compared to 252 Kg. for U.S A. and 129 Kg for Japan, The increasing literary, social advancement and industrialisation invites the immediate attention of the industry in this country to grow up to meet this demand. In this context the Planning Commission has estimated that requirement of different variety of paper and boards in the 6th and 7th Plan period as 18,95,(00 and 26,45,000 tonnes respectively.

Against the projected demand of over 26,45,000 tonnes of paper & Board by the year 1990, the installed capicity in India has been 18,50,000 tonnes and the atcual production 13,50,000 tonnes. This projects a very wide gap botween demand and supply. This calls for augmenting the production of Paper and Paper Boards by nearly 100% during the next 8 years by creating necessary capacity to meet the demand.

To augment such a capacity, the situation calls for a mammoth effort to mobilise the raw material required to extent of 1,21,50,000 tonnes per annum by 2000 AD.

As it could be seen, most of the raw material requirement is met with forest basedraw material, which has resulted in ecological imbalance and has disturbed environmental equilibrium.

SUGAR MILLS–A SOURCE OF RAW MATERIAL FOR PAPER

It has now become necessary to go in for planned afforestation, and collection of other non-conventional raw materials like bagasse, a sugar cane waste of sugar industry and other agricultural residues.

Bagasse is a very promising raw material, because of its availability in sugar mills Collection of bagasse to meet requirements of paper industry does not pose any problem. However, the availability of bagasse at sugar mills is still limited owing to the cautious attitude of the Sugar mills in dispensing with boilers for the reason that the procurement of coal in the country is a big problem. To convince sugar mills to install coal fired boilers, it becomes very necessary to assure sugar mills the availability of coal and the higher thermal efficiency achieved by using coal fired boiler. This would enable sugar mills to release all the bagasse generated in their factory.

It is very essential to install equipments necessary for improving the thermel officiency of sugar mills, so that the bagasse utilization as main fuel for their boilers are considerably brought down, so that the surplus bagasse can be created and spared for paper making. Example is the utilization of waste heat lost through flue gases is used for drying of bagasse, as being contemplated in Mysore Sugar Company, and other progressive mills.

From the economic point of view the concept of installing a paper mill adjoining sugar mills would minimise waste during collection, handling losses during transportation and storage. It is however very important in the national interest that sugar mills will take up the issue of releasing all the bagasse generated by installing coal fired boilers for their steam generation.

REQUIREMENT OF RAW MATERIAL FOR PAPER

The raw materials requirement for the projected capacity will be enormous. The Natinal Commission on Agriculture has estimated the requirement of raw materials for pulp and paper during the years 1985 and 2000 as follows :

	Lakh tonnes	
	Year 1985	Year 2000
1. Bamboo	31.23	35.46
2. Hardwood	30.80	82 04
3. Soft wood	6.46	23.90
4. Bagasse	0.82	7.20
5. Waste Paper, agricultural residues and others	5.38	22.85
Total	74 62	171.45

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1) **Bamboo**

The extent of bamboo utilisation is restricted due to bamboo growing stocks being extensively depleted for one or the reasons like :—

(a) clearance for cultivation

(b) clearance of forest for raising plantations of commercial species like teak etc.

(c) inadequate protections against fire and grazing specially after gregarious flowering.

(d) being a major raw material for paper/pulp making.

2) **Hardwoods**

The extent of hardwood utilization by the year 2000 AD will increase manifold. However the hardwood species present in the national forests, are many and present in intimate mixtures preventing selective fellings. Some of the species are not suitable for pulping. Therefore, replacement of existing valueless growth by raising plantation of fast growing species in a big way is necessary.

3) **Softwoods**

The extent of hardwood utilization by the year 2000 AD will also increase manifold. However, proper and selective fellings are very essential for soil conservation coupled with existing national forest regeneration, which should be protected against evil practices of excessive grazing, till they are established. The basic problem relating to the exploitation of coniferous woods for pulping, is the inaccessibility of mountain regions, where these forests exist. Therefore, it is necessary to develop the infrastructural facilities in these hilly regions, to tap the softwood sources. The timber extraction methodology should be reviewed to include whole tree utilization as an important development for economy measure.

4) **Waste paper**

Waste paper utilisation for paper making is increasing and about 20-25% of raw materials for paper making at present comes from this source. Better efforts are essential to increase recycling of waste paper including de-inking process.

5) **Agricultural residues like straw**

The extent of utilisation of these raw materials by the year 2000 AD should also be substantial. Their availability at present, is restricted because of their secondary usage, poor performance in their collection and transportation costs. Therefore, it is necessary to determine their potential availability and to determine a suitable technology, so that their usage is maximized by the year 2000 AD. With respect to cereal straws like wheat and paddy though the acrage under cultivation is very extensive, their use in paper making is limited because of the follawing :—

(a) Use of straw as a fodder for cattle, witch has a priority need.

(b) Scattered and seasonal availability.

(c) Because of bulky nature, increase in cost of collection and transportation from larger areas.

(d) Short fibre quality of the straw.

6) **Bagasse**

The use of bagasse for making paper is extremely desirable, in the present situation of inadequate availability of raw matsrials due to depletion of forest areas. Bagasse can be available from a cluster of sugar mills. It is in this context that Government of India have announced a 100% excise rebate on paper made out of a furnish containing not less than 75% bagasse pulp.

However, bagasse utilisation for paper making, is restricted due to—

(1) its use, as main fuel for generation of process steam in sugar mills, and

(2) the restriction imposed by Government of India on the emergence of new sugar mills, so that the lands used for grain production is not diverted to sugar cane production.

To circumvent these two basic problems, it is necessary to take active steps and planned participation of all concerned so that the extent of bagasse utilisation by the year 2000AD is maximised and thus save forest. The availability of bagasse for paper making by the year 2000AD should be augumented.

Therefore, emphasis is now in improving the potential availability of bagasse for paper making.

BAGASSE GENERATION IN SUGAR MILLS

The total sugarcane cultivating area in India in the year 1979–80 is estimated at 6.6 million acres and the sugarcane produced is 128 million tonnes. This is increasing as sugar demand is increasing.

Around 300 sugar mills are in operation in the year 1980 and crushing 40 million tonnes of sugarcane at an average recovery of 9.88%.

Based on the above, out of 40 million tonnes of sugar cane crushed in sugar mills, about 12 million tonnes of mill wet bagasse is available with 50% moisture. For one tonne of bleached pulp, about 5.5 tonnes of mill wet bagasse is required. About 2.2 million tonnes of paper could thus be produced if all the bagasse is made available.

Sugar Mills have to depend on the bagasse for their fuel requirement and hence part of available bagasse is burnt in the sugar mill bagasse boilers for generating steam, leaving behind the surplus bagasse available for paper making. By improving the thermal efficiency of the sugar mill bagasse fired boiler and by operating at optimum levels it is expected that sugar mills can release at least 10–15% of bagasse additionally for paper making.

SURPLUS BAGASSE

Excepting for the surplus bagasse, management of the sugar industry is not inclined to part with substitute bagasse for coal, as the dependency on coal availability has been uncertain augmented by transportation problems from pit heads to consumer points as well. If bagasse is to be released for paper making, the paper mills must undertake nationally to supply steam to sugar mills in exchange for bagasse, by incurring additional expenditure for installation of coal fired boilers and bagasse handling equipment at sugar mills premises and also undertake to supply coal to these boilers. It is not practical for the paper mills, to operate these boilers exclusively under their management. These additioaal costs, increase the cost of production of paper. In the circumstances, to make bagasse an important and economical raw material for paper making, more incentives have to be offered to the paper industry. Thus the ecology of the country will improve and pressure on forest will be reduced. This can be achieved if the paper mills based on bagasse, have their own sugar mills as a diversion programme by integrating the power and steam units and other service facilities of paper as well as sugar mills, for better performance. In this situation the entire bagsse will be available for paper making.

MNPM ROLE IN UTILISATION OF BAGASSE

MNPM is the only mill working successfully from the past 20 years and of late it is a very happy to note that many sugar mills and many entreprenuer have taken up steps to start paper mills with bagasse as raw matrial. Mandya National Paper Mills have associated with Sri Laxmi Saraswathi Paper Mills, Nizamabad, a 30 TPD bagasse based paper project by, extending their expertise, on advisory consultancy basis. Shri Laxmi Saraswathi Papers have entered into agreement with Nizam Sugar Mill of Hyderabad for procuring bagasse by installing a coal fired boilar at the sugar mill and obtain all the bagasse released in exchange to coal. It is worthwhile to mention here that Mandya National Paper Mills Ltd., with their experience of 20 years are offering consultancy services for bagasse based paper mills. Collabboration with equipment manufacturer is also underway.

Also planning to install a 1250 TCD sugar mill complex for captive generation of bagasse for paper making in their expansion/diversification programme is mooted.

TAMILNADU NEWSPRINT PROJECT

The Tamilndu Government under the leadership of Sheshasayee Pulp & Boards have taken a big step for setting a News Print cum-Writing and Printing paper mill from bagasse. The project cost works out to Rs. 190 crres and proposed to manufacture 50000 annual tonnes of News Print and 40000 annual tonnes of Writing and Printing paper- Six sugar mills in the radius of 100 KM of the proposed factory have agreed to release the required bagasse for the mill. The News Print factory will be installing coal fired boilers in these sugar mills and will be operating the same for supply of steam to the sugar factory in exchange for bagasse,

MPM NEWS PRINT PROJECT

The Mysore Paper Mills Ltd. Bhadravati has expanded its production to 37000 tonnes per annum of writing and printing paper and 75000 tonnes per annum of News Print, then becoming the biggest paper making unit in the country. The pulp furnish for Newsprint is seventy per cent cold soda refined mechanical pulp based on Eucalyptus, 30% chemical pulp based on bamboo. In order to meet the requirement of cellulosic raw material the Mysore Paper Mills are installing a 2500 T.C.D. sugar mill integral with the Paper Mills complex for full use of by-product bagasse for paper making, based on its philosophy of maximum conservation of forest based cellulosic raw material and shifting the emphasis to the extent possible from forest to easily renewable agricultural waste material They have also planned to augment the sugar mills capacity to 5000 T.C.D.

The areas of intgration will be in the steam generating plants, power generation and distribution, water supply effluent disposal and others so that there will be energy saving in terms of steam and power generation, economy in operation of water distribution and effluent disposal which will be minimised as a result of this integration. It can also be seen that entire quantity of bagasse which is released in the sugar mill will be available for making chemical pulp instead of being burnt for steam production in boiler of the sugar mills

Thus MPM is the first of its kind to achieve the maximum integration for the best of economics.

TECHNOLOGY

Bagasse—Physical and Chemical composition

Bagasse, which forms about 30% of the sugar cane, consists of 50% moisture and 50% fibre along with pith cells The fibre content of this bagasse is around 65% and pith around 30% and solubles around 5% However, when allowance is made for a reasonable amount of dirt and other non-fibrous fines, the typical actual dry composition of bagasse coming from the sugar milling process will be as follows : –

TABLE – 2
DRY COMPOSITION OF BAGASSE[2]

a)	Whater solubles	8-10%
b)	Pith, dirt, epidermis and other fines (nonwater solubles)	35%
c)	Good clean fibre (nonwater Solubles)	55%

The bagasse if purchased on a moisture free water insoluble basis has the following approximate composition as it leaves the sugar milling process :—

TABLE—3
COMPOSITION OF BAGASSE ON MOISTURE FREE WATER INSOLUBLE BASIS[2]

a)	Pith, dirt, epidermis and other fines (non-water solubles)	39%
b)	Good clean fibre (non-water solubles)	61%

TABLE – 4
PROXIMATE ANALYSIS OF BAGASSE & BAMBOO[3]

Particulars	Units	Bagasse	Bamboo
Ash	%	1.8	3.1
1% NaOH solubility	%	30 2	28 3
Alcohol – Benzene solubility	%	1.9	4.2
Pentosans	%	24.1	19.3
Lignin	%	24 2	19.4
Alpha cellulose	%	41.9	46.6
Holocellulose	%	73.2	67.2

The good quality fibre length in bagasse is about 1.0 to 1.5 mm, and its diameter its 19-22 microns. The dimensions of bagasse fibre compared with other raw materials of pulp and paper as follows:—

TABLE—5
COMPARISON OF FIBRE DIMENSIONS

Particulars	Average length (m)	Average Diameter (M)
Temperate coniferous wood	2.7—4 6	32—43
Tropical hardwood	0.7—1.6	20—40
Bamboo	3.0—4 0	14
Bagasse	1.0—1.5	20
Rice Straw	0.7—1.5	9—13

As shown in the tables above, bagasse has comparatively short fibres for paper pulp, resembling tropical wood and rice straw. Being a fibre of open structure it is easy for pulping while higher content of cellulose indicates that it can be used as raw material for paper making.

Drying of Bagasse

Mill wet bagasse as received from sugar mills contain around 50% moisture, with a calorific value of about 3900 BUT/lb, compared to 7650 BUT/lb of bone dry bagasse, A reduction in its moisture content will lead to substantial savings in the consumption of bagasse in sugar mill boilers, thus releasing additional bagasse to paper mills. The sugar industry will stand to gain by way of increased calorific value of bagasse and increased sale of surplus bagasse attendent with other advantages. The calorific value of bagasse, can be estimatd from the following:

TABLE—6
CALORIFIC VALUE OF COMPONENTS OF BAGASSE[4]

Sl. No.	Particulars	Calorific Value (BTU/lb)
1.	Fibre	8280
2.	Sugar	7120
3.	Water	—
4.	Impurities	7380

Water has nc calorific value. The value for sugar and impurities are almost the same and hence the net calorific value of bagasse can be estimatd by the following formula :

Net calorific value=7650—21.6 sugar—87.3 water Btu/lb.

It can be seen from the above formula that the calorific value of bagasse can be improved substantially by reducing its water content. Hence it is desirable to explore the possibilities of drying bagasse to the advantage of both sugar and paper mills. Normally bagasse at sugarmill is baled and stored in open yard. If the bagasse is not baled, not only it is hazardous, but also more expensive in handling for reuse. Using of the waste heat lost through flue gasses to heat the ambient air, in a air to flue gas heat exchangers and use the heated air to dry bagasse, when it is being conveyed, is an important method that can be adopted to dry bagasse to about 35% moisture content.

Transportation

There are several methods of transportation of bagasse.

1. Paper Mills adjacent to the sugar mills can receive their supply of bagasse by :

1) a. Belt conveyors.
   b. By pneumatic conveying.

2) a. By bulk road carriers of 16 MT pay load.
   b. Moist depithed bagasse in loose form transported by trucks with a pay load of 15 MT covered by fishing nets.

Normally, bagasse is released by sugar mills at the sugar mill site. Moist depithing of bagasse at sugar mills will improve the release of bagasse fibres. The average load of the road carriers at present is between 7 to 10 tonnes, and that of railway waggons between 3 to 7 tonnes in our case. The advantageous dimension of bagasse bale will be 70 cms. long by 30 cms. width by 30 cms. high and approximately weighs 22 kgs for easy handling and manual stacking. It is preferable to think of large trailors for transporting bagasse, which gives improved economies. Stacks of bagasse are not covered generally. The average stack dimensions would be around 40 M long by 30 M wide by 6 M high to accommodate about 1000 Metric tonnes of bagasse. Sufficient space should be provided in between two stacks (22.87 Metrs. as per insurance stipulations) to avoid fire hazards. The stacks must be provided with clear air space for ventilation. The yard must have adequate fire hydrants. It is observed that the outer surface of the stack may become black, without any appreciable adverse effect on bagasse quality.

STORAGE & PROTECTION :[4]

1. Krausa—Maffei Method : Depithed bagasse stored in bulk form without any deterioration.

2. Dr. Cusi process : Baled bagasse is stored as such with well ventilatd stacks provided with sufficient air space. The pith cells present in the whole bagasse protects the cellulose fibre from deterioration, and moisture content also drops down from about 50% to about 30 to 35% in a matter of 40 to 45 days.

After allowing sufficient time, say, 45 days after completion of stacking, the bales are removed for process. Any loose bagasse generated after removal of bales will also be recovered.

3. At one Mill in Mexico, bagasse will be depithed, mixed with water and then pumped onto an asphalted s-urface platform with a pronounced inclination for drainage of water. Reclamation of bagasse is done by front end loaders.

Ritter biological pre-treatment process :

The general principle of the Ritter process, developed by the E. A Ritter and others. involves the impregnation of the bagasse (moist depithed preferably), with a biological liquor and flushing the suspension to a bulk storage area through elevated channels or by means of a pump-up device. The addition of a small amount of molasses to the initial culture solution provides adequate biological liquor for treatment of incoming bagasse and refortification of the liquor used for flushing the bagasse to storage. The flushing liquor is recycled.

The advantages are preservation of bagasse fibres, elimination of fire hazards, elimination of dust nuisance, lower power consumption, lower chemicals consumption in cooking and bleaching, higher yield of bagasse pulp.

This method though is very ideally suited, involves initial higher investment and continuous import of biological liquor.

Fungus delignification of bagasse

Recent studies conducted by Fungus Research Institute, Kerala. (a subsidiary of Hindustan Paper Corporation), have brought out the selective delignification by fungi, on bamboo and eucalyptus. Further research is taken up to study such fungus attack by selective dissolution of pith and lignin. In fact 2 fungi have been idenified for this selective removal of pith and lignin. Furthrer work on this is in progress. The advantages of such selective pith and lignin removal of bagasse will be, production of quality fibers, lower power consumption in final depithing operation and in refining stages, lower chemical consumption in cooking and bleaching, due to absence of pith. Also load on chemical recovery boiler will be reduced.

Bagasse Preparation

Pith separation from fibre is necessary to upgrade bagasse. Pith constitutes about 30% of bagass, the rest being celiulose fibre (63%) and solubles (5%). The chemical properties of fibre and pith are more or less similar, but they differ vastly in physical and morphological properties. Pith contain lot of soft thin-walled, irregularly shaped parenchyma, cells; has more ash and high absorbing property. Due to its high absorbency, it consumes more alkali during cooking. Because of its soft, thin-walled irregularly shaped fibrous cells, the pith fine swell, make a dense sheet on paper machine wire and with slow drainage. These pith fines would be picked in presses, dryer felts causing press stickiness bringing down machine runnability.

DEPITHING OF BAGASSE

Pith has the same calorific value as that of whole bagasse and its burning in sugar mill boilers (Bagasse fired) does not pose problems other than fly ash. Therefore, it is desirable to separate the pith at least partially, by primary depithing at the sugar mill and return the same fraction for use in the sugar mill boiler with the following advantages :

1. Saving in transportation cost of unwanted pith to paper mills.
2. Partially depithed bagasse forms a compact bale.
3. Disposal of pith at paper mill would be reduced considerably.

METHODS OF DEPITHING BAGASSE :

Methods of depithing bagasse would fall into three categories :

a. Dry depithing method.
b. Moist depithing method.
c. Wet depithing method.

1. Dry depithing method

Hammer shredders, disk mills or the like are used in the separation of pith from bagassc fibre. The loosened pith is screened by either vibratary or rotating screens. The dry pith can be used as fuel in the boiler. The imbibed pith will still remain with the main bagasse fibre. Adequate precaution and protective measures have to be adopted for meeting the dust pollution problems.

2. Moist depithing method

The mill wet bagasse with about 50% moisture is subjected to mechanical abrasion and is carried out at sugar mill. The resultant free pith is used in their boiler as fuel. Thus releasing more bagasse. The resultant fibre then baled and brought to the paper mill. The residual sugar left with the remaining pith will naturally ferment during storage and escape bringing about the necessary heat generation to dry the baled bagasse. Indigenous depithing machinery manufacturing is contemplated by MNPM.

3. Wet depithing method

This method is more applicable at the pulp mill for the final cleaning and depithing just before bagasse enter the digester. In a hydra pulper, the bagasse is thoroughly wetted and broken up and then the pith, dirt and water soluble materials are thrown out in depithing machines. A very clean and uniform bagasse fibre is available for subsequent operations.

A typical analysis of depithed bagasse will be as folIows :

TABLE-7
FIBRE AND PITH CONTENT OF BAGASSE

Sl.No.	Particulars		Whole bagasse	Depithed bagasse
1	Fibre	%	62.0	86.2
2	Pith	%	32.0	9.6
3	Solubles	%	6.0	4.2

However, it is observed that about 9–10% of total pith will still be carried forward into the digester.

PULPING PROCESS

Practically all types of pulp can be produced from bagasse. These range from mechanical type of pulp similar to ground wood pulp to high quality bleached pulp of high brightness. Therefore, the process to be used as well as the type and amount of cooking chemicals depend upon the end product required.

Bagasse pulp with or without mixing with long fibred pulp is now used practically in many grades of paper like toilet, tissue, towelling, glassine, corrugating medium, printing and writing papers, and newsprint. Compared to coniferous wood fibres, bagasse fibres are much more bulky, more open, with lower lignin content resulting in quicker penetration of coking liquor. Consequently bagasse fibres require relatively low amounts of pulping chemicals and short cooking time. Continuous pressure pulping for bagasse as well as other agricultural fibres give rapid and well controlled cooking cycles.

Because of low bulk density of bagasse, a relatively high liquid to solid ratio will be needed and provision must be made to agitate the material by rotating the digester or by circulating the liquid or by using built in conveyors or agitators. For production of fully cooked chemical pulp from bagasse, either unbleached or bleachable grades, sulphate, soda and neutral sulphite methods are all applicable and all give good pulps. In case of small pulp mills operating without recovery, the use of caustic soda, as the sole cooking chemical would involve lower chemical cost, than the use of caustic soda with sodium sulphide as in kraft pulping process.

Regarding high yield semi-chemical pulp for corrugating medium the chemicals and cooking process, most commonly used are straight caustic soda and neutral sodium sulphite (buffered with alkali). Both these processes produce high grade bagasse pulp for corrugating medium and the choice between these two processes, depend upon the relative cost of the chemicals. The kraft process will also produce a suitable bagasse pulp for corrugating medium.

High yield bagasse pulp suitable for insulating board or hard board is produced by steaming and subsequent softening rather than chemical pulping. Small amounts of soda ash or caustic soda is added in the digester for pH control, but the principal action is softening so that fibre bundles are made flexible for subsequent mechanical action. Therefore, the pulp required for insulating board more closely resembles the mechanical pulp than the chemical pulp.

The acid sulphite or bisulphite process has been proved by many investigators to be unsuitable for bagasse, because this process tends to give a brittle pulp of low strength properties as compared to bagasse pulp by alkaline process. This process was first tried in Taiwan and subsequently it was abondoned in favour of the neutral sulphite process and then switched over to kraft process.

Methods used for pulping bagasse :

The present pulping methods in use are as under :–

1. Batch pulping process using rotary spherical digesters of tumbling type digesters, under elevated temperature and pressure.
2. The mechano-chemical process using hydropulper at atmospheric pressure as the digesterwith either soda or kraft methods.
3. Rapid continuous pressure digester using horizontal tube digesters with screw feeder and continuous discharge (Pandia continuous pulping) and variation thereof.
4. Crown-Zellerbach Mechanical process for the manufacture of newsprint from ground bagasse pulp and bleached kraft wood pulp.
5. de La Rosa chemical process for the manufacture of newsprint using whole bagasse.

6. Ayotla process using chemical bagasse pulp, bleached with sodium hypochlorite, and mixing it with ground wood pulp for the manufacture of newsprint.
7. The Simon-Cusi process and modified cusi process by mild caustic soda digestion, fractionation and refining to manufacture newsprint.
8. Peadco process using continuous pressurized digestion for pre-hydrolysis of depithed bagasse and cooking with sodium bisulphite and sodium silicate, to manufacture newsprint.
9. Asplund Defibrator Thermo-mechanical pulping to manufacture newsprint.

Following table shows the strength properties of unbleached bagasse pulp (Produced in a laboratory-digester with caustic soda as the cooking chemical) :

TABLE 8
STRENGTH PROPERTIES OF UNBLEACHED & BLEACHED PULP

	Unbleached pulp	Bleached pulp
Initial freeness °SR	20	22
Beating time-Min.	30	30
Final freeness °SR	45	47
Bulk	1.68	1.7
Burst factor	30.3	29.2
Breaking length	6300	5870
Double folds	29	25

Washing :

The bagasse has a higher degree of hydration as compared to bamboo or wood. Hance the area required for washing should be high. The loading factor for wood pulp is about 0.16 Mt/sft/day and for bagaasse it should be around 0.6 mt/sft/day. A counter current washing system is suitable for efficient washing. The dilution factor will be slightly bigher and the total solids will be about 10% and a free alkali of about 5-6 gpl in washed black liquor obtained.

Screening :

Centrifugal type screens can be used for screening the extraneous materials like sand, dirt, wire pieces etc.

Bleaching :

C-E-H bleaching sequence is suitable to get a brightness of around 80° GE. The total chlorine demand will be about 5-6% with extraction demand of about 1-1.5% alkali on pulp.

Following table represent the strength properties of sheet madeout of bagasse pulp at different freeness and also the fibre classification :

TABLE—9
STRENGTH PROPERTIES[3]

Sl. No.	Particulars	Unbleached Pulp			Bleached pulp		
1.	Beating time. Mts.	15	25	35	15	25	35
2.	Freeness °SR	39	56	77	40	57	76
3.	Bulk	1.9	1.8	1.5	1.9	1.7	1.4
4.	Burst factor	24.6	31.8	33.1	25	32	34.2
5.	Breaking length	3598	4868	5542	3799	4792	5641
6.	Double folds	9	13	18	10	13	18

TABLE—10
FIBRE CLASSIFICATION[3]

Sl. No.	Samples	Retained on +45mesh	+65mesh	+100mesh	-100mesh
1.	Unbleached pulp	40	22.2	14.8	23.0
2.	Bleached Pulp	37.5	21.2	13.6	27.6

STOCK PREPARATION

Bagasse fibre, during the process of pulping and bleaching develops slow drainage characteristics due to high absorption of chemicals and hydration of fibres, therefore requires little refining. However, to bring about fibre uniformity out of heterrogenous fibre bundles of bagasse, the pulp may require mild refining instead of developing hydration. Electrical energy consumption for stock refining is therefore low and the refining HP will be around 3—5HP/day/tonne of installed capacity must be adequate. Treatment of bagasse pulp through finishing jordans, along with the blended refined long fibre pulp, is sufficient to give necessary defibration and dispersion of stock on the machine wire to provide good sheet formation.

It may be better to use disc refiners in place of jordans. Due to slow drainage charaeteristics of bagasse, it may be required to mix about 10 to 20% of long fibres of either bamboo or wood pulp to obtain proper drainage at the machine. It is better that the long fibre pulp is refined and mixed with the bagasse pulp for greater flexibility of operation, closer control on the degree of refining and for the preparation of stock for various grades of paper. Due to unique fibre characteristics and excellent bonding properties, bagasse pulp requires much less rosin-size compared to paper made with conventional fibres. The alum requirement however exceeds the quantity normally used for conventional paper making mainly due to low pH conditions required in the white water system to prevent press stickiness. Use of bagasse pulp to the extent of 50% in the fibre furnish along with long fibre hardly makes any diffe rence in the paper making operations compared to the paper produced with hard wood, bamboo or soft wood fibres. However, as the proportion of bagasse increases and approaches 80% considerable changes in the machine design and operation are necessary to maintain high degree of machine efficiency.

Paper Machine:

When high proportion of bagasse pulp is used in the fibre furnish it is necessary that the Fourdrinier machine should have a longer wire part compared to a conventional design. Also the wire part should be equipped with multiple blade foil system and more number of suction boxes to facilitate better drainage and permit low stock consistency at the head box for improved sheet formation.

Suction pickup or similar arrangement should be provided for web transfer to the press section from the wire part so that the web would not break during the transfer because of low wet strength. The degree of water removal normally achieved with conventional fibres at press section is not applicable to bagasse pulp. The water holding capacity of bagasse pulp is somewhat different compared to other conventional fibres and hence, to achieve better dryness at the press section, it is necessary to try several modern press arrangements. More open type felts are required to maintain enough porocity for better drainage. Adequate felt cleaning devices should be provided to keep the felts and the suction roll perforation clean, to maintain uniform drainage. Due to excessive fines and fibre debris these felts tend to clog up rapidly and therefore arrangements for high pressure showers with automatic controlled movements are critically needed in these areas.

The drying section should be designed to provide more drying surface due to more water carry over with the paper web resulting after the press section. Also smaller dryer groups are preferred to provide better control on drying rates. The evaporation of water in the dryers out of the paper web for bagasse pulp behaves differently compared to conventional fibres because of the stock is more hydrated. It is necessary to have a uniform temperature, over an extended number of dryers compared to conventional fibres. The drying curve is greatly flattened compared to the hyperbolic curve required normally obtained on a conventional fibres. The other features of the paper machine design and operations are similar to conventional paper machine.

Given below is a comparison of strength proper ties of different grades of paper produced with bagasse pulp at our Mill:

TABLE—11

STRENGTH PROPERTIES OF DIFFERENT GRADES OF PAPER :

Quality	Cr. Wove	Unbl Prtg.	MFKraft	Duplicating (semi—absorbent quality)				
Basis wt. G/M2	58.1	65.9	124.4	68.5	71.5	74.2	63.0	63.4
Caliper Microns	85	95	125	110	115	120	105	105
Bulk	1.46	1.44	1.40	1.61	1.61	1.62	1.67	1.66
Burst pressure Kg/cm²	—	—	—	0.87	0.85	0.90	0.64	0.62
Burst factor	—	—	--	12.70	11.89	11.88	10.16	9.78
Tensile strength in Kgs. MD	3.11	3.07	5.04	3.62	3.72	3.73	3.93	2 94
CD	1.75	1.71	3.70	2.34	1.94	2.27	1.79	1.37
Breaking length in Mtrs. MD	3569	3106	2691	3523	3468	3352	3206	3091
CD	2007	1811	1980	2277	1809	2039	1894	1441
Double folds MD	4.5	4.0	7.7	5.0	6.0	5.0	5.0	4.0
CD	1.5	2.0	3.2	2.0	2.0	3.0	2.0	1.0
Mean	3 0	3.0	5 5	3.5	4.0	4.0	3.5	2,5
Ash%	9.7	11.2	12.8	13.8	14.2	12.4	14.5	—
One Min. cobb Gm/m2 min.	21.3	26.9	—	25.6				

SODA RECOVERY

The spent liquor from the washing stages, in case of soda or sulphate pulping of bagasse, contains a very valuable chemical sodium salt & organic matter, which is combustible. Therefore it is normal practice for any paper mill of medium size to instal chemical recovery plant, comprising of :—

1. Evaporator, multiple effect LTV type, to concentrate the spent liquor of weak strength to a desirable concentration, say 50-55%, by means of steam, so that it can be easily pumped to an incenarator or incenarator-boiler.
2. In the incenarator or incenarator-boiler the concentrated liquor dries, the organic part burns with the help of air, thus releasing hot flue gases and the sodium as sodium carbonate. The sodium carbonate flows out of the incenerator as smelt, and after dissolving in water or weak sodium carbonate solution is sent for further processing. The hot flue gasses transfer their heat, through a waste heat boiler, thereby generating valuable process steam. Further catchalls/collectors are introduced to collect the chemical dust going through the flue gases, as the dust is also valuable.
3. The sodium carbonate solution is causticized by lime solution to form sodium hydroxide, which is the main cooking chemical in a soda process. The sludge, calcium carbonate is settled in a series of clarifier, Thickeners and finally filtered out on a rotary drum filter to recover the valuable alkali. The sludge calcium carbonate is either wasted or converted into active calcium oxide either in a fluidized bed calciner or in rotary lime kiln.

   For the sulphate process, sodium sulphate is mixed with concentrated spent liquor before it enters the incenarator wherein it is converted into sodium sulphide, under reducing atmosphere.

Our effluent system

A study has been conducted by National Environmental Engineering Research Institute, Nagpur, at our Mills.

Effluent is genrated in the following departments :

1) Bagasse preparation section
2) Digestion section
3) Brown stock washing and screening section
4) Bleaching section.
5) Recovery section and utilities section
6) Paper machine section.

The characteristics of combind effluent will be as follows:

TABLE—12

CHARACTERISTICS OF COMBINED EFFLUENT

Description	Units	Qty.
Flow	Cu.M/Ton paper	401
pH		6.3
Alkalinity	Mg/lit	218
C.O.D.	ppm	1128
B.O.D.	ppm	340
Dissolved solids	ppm	716
Suspended solids	ppm	648

The combined effluent is amenable for treatment by standard methods : such as

1. Primary clarification combined with aeration lagoon.
2. Primary clarification with secondary treatment by trickling filter method
3. Primary clarification with secondary treatment by activated sludge recirculation method.
4. Any variation of above.

Treatment for colour removal is rather unwieldy and expensive.

LAYOUT

A typical layout plan for a 50 TPD paper mill is enclosed. The bagasse preparation plant, pulp mill and paper machine can be located in one line whereas utilities, recovery section can be located in adjacent parallel line.

The interdepartmental process plant and machinery can be arranged as per the flow of materials in a sequential manner so as to avoid unwanted handling of raw materials and usege of pipe lines. The storage and handling of raw materials is located to reduce unnecessary handling and transport to their consumption points.

The boiler house, and power plant is located adjacent to the pulping plant and paper machine section to reduce the cost of yard piping, coal storage and crushing will be located near the boilerhouse to facilitate quick and easy handling. Control laboratory and workshop facilities are located well within reach of main plant.

Effluent treatment clarifiers and aeration lagoons be located taking advantage of topography and the points where the treated effluent has to be finally letout. Separate drains from different sections must be envisaged and combined effluent can be taken to the treatment plant preferably by gravity. Treated effluent will flow to its discharge points by gravity. Asphalted roads with flow to its discharge points by gravity. Asphalted roads will be provided within the mill premises and to approach the mill area from the main road.

Adequate area must be provided for future expansion.

Direct causticization of black liquor in digester

Direct causticization of black liquor in the digester by adding lime solution, can be considered for regeneration of caustic soda from sodium carbonate solution, being formed during lignin separation in the digester. Research work is already over and efforts to take up mill trials are being planned.

Auto causticization of black liquor of Ferrite Process

Recent research work at CPPRI, Dehradun, has paved the way of eliminating the causticization of sodiam carbonate to sodium hydroxide, by addition of ferricoxide directly to the concentrated spent liquor after evaporation and fired in a suitable furnace or incenarator. Ferric oxide combine with sodium salt and forms sodium, ferrite, which on hydrolysis releases sodium hydroxide solution and ferrie hydroxide as a precipitate. The precipitated ferric hydroxide can be regenerated as ferric oxide by directly passing hot air over it. This may eventually eliminate the causticiating section and disposal of solid waste calcuim carbonate. Mill trials are being planned in our factory.

Application of RO/UF Technology

Research work conducted at Indian Institute of Technology, Bombay has proved that RO/UF technology can be successfully applied to reduce the effluent load to the treatment plant considerably, by filtering the black plant effluents through a semipermeable membrane under pressure, thereby increasing the recycle of waste water within the system. Research work is now being considered in our Mill to apply the same principle to concentrate the spent liquor, thereby saving the steam used for evaporation process.

Smokeless Briquetted Fuel from Pith

Pith, which is released during depithing has same Heat value as bagasse. Dry pith can be burnt in boilers, however, it is advantageous to convert into briquette form, so that its handling and burning will be easier.

Dried pith, at a moisture content of 25-35% undergoes partial pyrolysis or carbonisation, under controlled condition. During this process, liquid gases and solid char are produced. The gases, being combustible, are recycled & burnt to give the heat of pyrolysis and hence no harmful pollutants would be discharged. The char is then moistend, mixd with suitable binders like clay and briquetted in a simple machine into any convenient shape or size. These wet briquettes are then dried by external source preferably waste heat from flue gases,

Pilot plant work is under progress.

Financial aspects

Profitability outlook

A profitability outlook has been worked for three alternatives, mainly for the production ot quality printing and writing papers :

01 35 TPD or 10,500 TPA
02 50 TPD or 15,000 TPA
03 100 TPD or 30,000 TPA

The results are enclosed in the following table:

TABLE—13

PROFITABILITY OUTLOOK

Sl. No.	Description	Units	1	2	3
1.	Capacity	TPD	35	50	100
	,,	TPA	10500	15000	30000
2.	Investment	Rs Lakhs	1260	2475	5400
3.	Selling price of paper-average	Rs/T	8759	8759	8759
4.	Less:Variable cost	Rs/t	5193	4650	4444
5.	Contribution	,,	3566	4109	4315
6.	Less: Fixed over-heads incl. interest on short-term loan	,,	1115	941	716.5
7.	Profit	,,	2451	3168	3598.5
8.	AnnualProfit	Rs Lakhs	257.35	475.20	1079.5
9.	Less:Depreciation	,,	72.20	141 82	309.43
10.	Cash Profit	,,	185.15	333.38	770.12
11.	Less: Interest on Long Term Loan-average	,,	66 50	130.16	283.99
12.	P B T	,,	98.75	203.82	486.13

The financial analysis is worked out on the current cost prices of raw materials, chemicals and others.

The operating norms and input requirements for the cost analysis is appended as Annexure 1,

Earnings and Profitability

The earnings and profitability are tabulated as follows:—

TABLE—14
EARNINGS & PROFITABILITY

Sl. No.	Description	Units	35TPD	50TPD	100TPD
01	ROI	%	20.42	19.20	20 00
02	PBT: EQUITY	%	23.66	24 63	25.34
03	BEP (Break-even point)	%	68 3	67.0	62.4
04	Pay back period		8 Years	7-7½Yrs.	6½-7Yrs.

Benefits :

Besides utilizing bagasse, a waste or surplus material of sugar industry for the manufacture of quality papers, which is in short supply, will lead to potential social and economical benefit to areas surrounding the location of the project.

Conclusions :

Bagasse is a very good raw material for paper, because it needs low chemicals for cooking and bleaching, low steam requirements for cooking & lower power requirements for stock refining. It is also observed that, high percentage of bagasse pulp in the fibre furnish for paper production gives good sheet formation and opacity with comparable printable characteristics for paper. Bleached bagasse pulp can be free of shives and specks and can attain high degree of brightness, without appreciable degradation of strength properties.

Various grades of paper both in medium and light weights can be manufactured using high percentage of bagasse pulp in the pulp furnish. For writing and printing paper, bagasse pulp can be used upto 80% generally.

Considering its potential availabilly, importance must be given to maximize the usage of bagasse for paper manufacture.

Acknowledgement

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ANNEXURE-1

OPERATING NORMS AND UNIT COSTS BY PRODUCTION LEVELS

Production or service units		Units	1	2	3
1	**PAPER**				
01	Daily Production	T	35	50	100
02	**Production pattern**				
	Creamwove 56-60 gsm	%	40	40	40
	Duplicating 70	%	30	30	30
	Ledger Azure 70	%	30	30	30
03	Ash-Average on paper	%	10	10	10
04	Pulp Requirement Average on paper	%	91.5	91.5	91.5
05	**Pulp furnish**				
	Bagasse pulp	%	80	80	80
	Waste paper pulp	%	20	20	20
06	**Paper chemicals**				
	Alum	%	5	5	5
	Rosin	%	0.8	0.8	0.8
	Soapstone powder	%	10	10	10
07	**Packing materials**				
	Hessian	m	215	215	215
	Gum tape rolls	No	0.5	0.5	0.5
	Jute twine	Kg	0.75	0.75	0.75

(Contd.)

Production or service units		Units	1	2	3
08	**Utilities on paper**				
	Steam	T	12	11	11
	Electricity	KWH	1300	1300	1300
	Water	M.cft.	0.018	0.018	0.018
	Furnace oil	L	130	50	50
2	**INPUTS ON PULP**				
02	**Raw materials-yield**				
	Bagasse-BD	%	36	36	36
	Paper cuttings	%	90	90	90
	Soapstone powder	%	50	50	50
03	**Chemicals-caustic soda for cooking**				
	on Bagasse B.D.	%	13	13	13
	on UB Pulp	%	1.5	1.5	1.5
	Chlorine for bleaching				
	As chlorine	%	3	3	3
	As Chlorine in hypo-chlorite	%	3	3	3
	Burnt lime for causti-dizing and hypo prepn.				
	on Caustic soda	%	130	130	130
	on Chlorine in hypo chlorite	%	150	150	150
3	**FUEL**				
	Coal per tonne of steam generated	T	0.222	0.222	0.222
4	**CHEMICAL RECOVERY**				
01	**Alkali losses**				
	Brown stock washer	%	6.5	6.5	6.5
	Evaporator	%	1.0	1.0	1.0
	Recovery furnaee	%	20.0	15.0	6.0
	Causticizers	%	2.0	2.0	2.0
	Miscellaneous	%	0.5	0.5	0.5
	Total losses	%	30.0	25.0	15.0
02	Overall chemical recovery	%	70.0	75.0	85.0
03	Purchased caustic per tonne of paper	%	0.092	0.078	0.051
04	Recovery boiler steam generated per tonne of paper	%	3.0	4.0	4.3

TABLE 2 UNITS COSTS

Production or Service Units		Units	1	2	3
1. **Paper** Daily production		T	35	50	100
2. Cost of sales-ex-factory incl. CED & Cess–	Cr. wove	Rs./T	8800	8800	8800
	Duplicating	,,	8600	8600	8600
	Ledger wove	,,	8900	8900	8900
	Average	,,	8770	8770	8770
3. **RAW MATERIAL**					
Bagasse B.D.		,,	500	500	500
Paper cutting		,,	3684	3684	3684
Soapstone Powder		,,	540	540	540
4. **CHEMICALS**					
Caustic soda		,,	6265	6265	6265
Liquid chlorine		,,	1825	1825	1825
Burnt lime		,,	590	5	590
Alum		,,	1050	1050	1050
Rosin		,,	11000	11000	11000
Misc. Dyes & chemicals on paper		,,	50	50	50
5. **FUEL**					
Coal		,,	425	425	425
Furnace Oil		Rs./KL	3030	3030	3030
6. **UTILITIES**					
Water		Rs /M.C. ft	700	700	700
Power		Rs.KWH	0.4	0.4	0.4
7. **Packing cost**					
Incl. wrapper on paper		Rs./T	180	180	180
8. **Machine wires & Cloth on paper**					
Wires		,,	44	42	42
Felts and genl. stores		,,	95	95	95
9. **REPAIRS & MAINTENANCE**					
Incl. Spares.		,,	288	270	255
10. Selling expenses		,,	130	100	70

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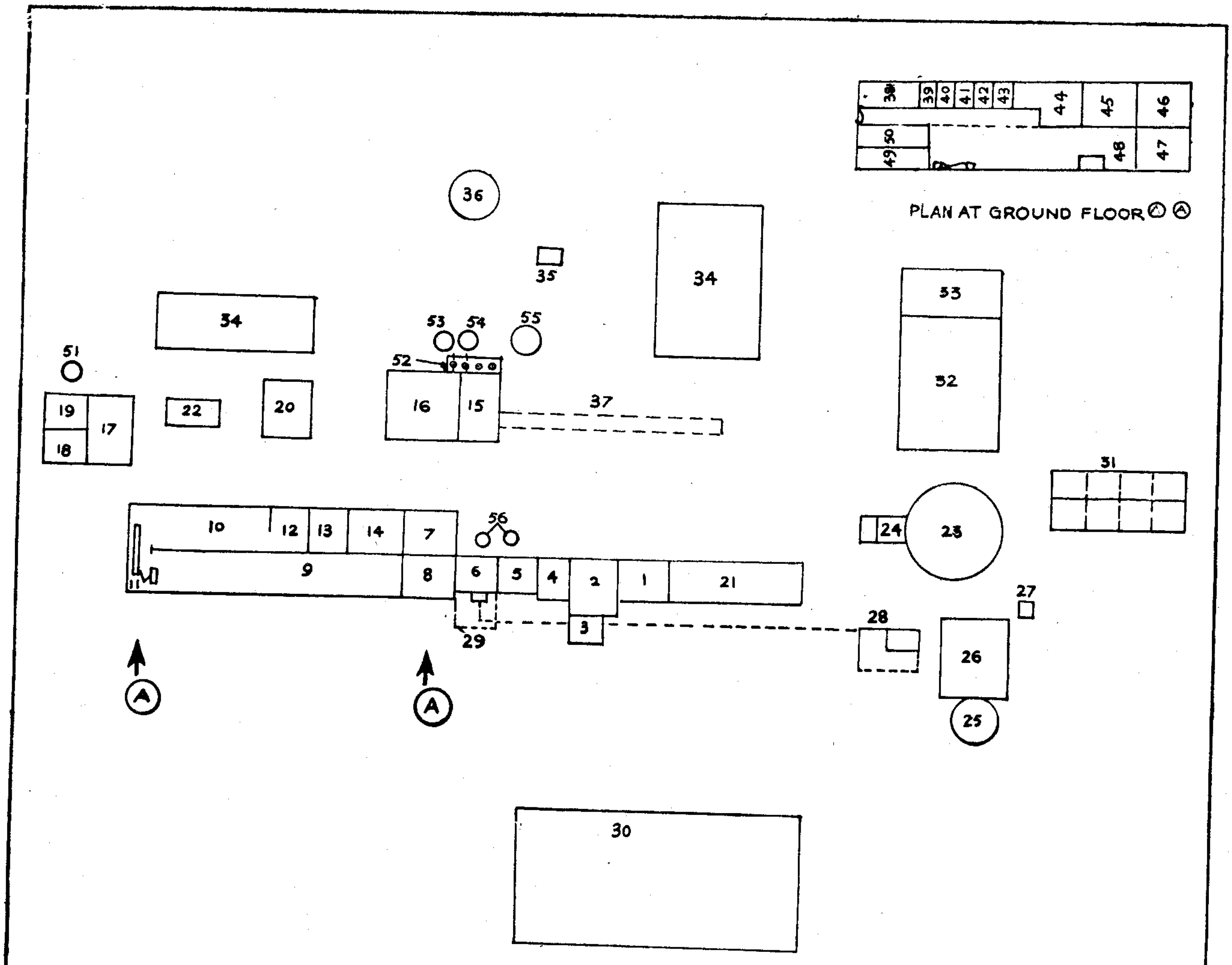

S. No.	DESCRIPTION	S. No.	DESCRIPTION	S. No.	DESCRIPTION	S. No.	DESCRIPTION
1.	Waste Paper Godown	15.	Coal Fired Boiler.	29.	Switch Board Room.	43.	Core m/c room.
2.	Waste Paper Pulping.	16.	Recovery Boiler.	30.	Bagasse Storage Area.	44.	Paper Godowns.
3.	Bagasse Treatment.	17.	Hypo Preparation.	31.	Sludge Drying Bed.	45.	Chemical preparation.
4.	Bagasse Digestion.	18.	Lime Alum Storage.	32	Lagoon with Aerat.	46.	Bleach Plant Chests.
5.	Washing.	19.	Caustizer Plant.	33.	Polishing Lagoon.	47	Machine Chests.
6.	Screening.	20.	Power Boilers & Power Plant.	34.	Coal Pices 2 nos.	48.	Compressore.
7.	Bleaching.	21.	General Stores-1	35.	Oil Pump House.	49.	Roll Grinding room.
8.	Stock preparation.	22.	General Stores-2	36.	Oil Storage Tank.	50.	Engineering office.
9.	Paper machine	23.	Effluent Clarifier	37.	Coal Gentry.	51.	Shite Liquor Tank.
10.	Finishing House.	24.	Effluent Sump.	38.	Paper Godown Distributaion.	52.	Evaporators.
11.	Equpts Rewinder & Cutter.	25.	Hydro Treator.	39.	Paper Godown.	53.	Thick liq. tank.
12.	Finishing House.	26.	Reservoir & Pump House	40	Paper M/c spare parts	54.	Black Liq tank.
13.	Paper Godown.	27	300 KVA Transformer.	41	Instrument workshop.	55.	Thin Liq. tank.
14.	Chemical Preparation.	28.	UKV/440 V Sub-station with DP	42.	Electrical workshop	56	Unbleached high density.

TYPICAL LAYOUT : 50 TPD BAGASSE PAPER PLANT