Prospects of Manufacture of Paper And Board From Agricultural Residues

D. C. Tapadar

Introduction

The Pulp and Paper Industry in India is poised for big developments. The production of paper and board is expected to exceed 960,000 tonnes in 1973-74 and in order to meet the estimated demand the production will need to be 1.33 million tonnes by 1978-79, 1.95 million tonnes in 1983-84 and 2.64 million tonnes in 1980. The fibrous raw material required for making paper, paper board, Newsprint, Rayon grade and Paper grade pulps would be about 5 million tonnes in 1978-79 and 10 million tonnes in 1988-89. Sources of bomboo, sabai grass, wood and rags are likely to be severely strained to meet this requirement. Agricultural residues such as sugar cane-bagasse, cereal straw, jute sticks, corn stalks, and the like can be effectively used to supplement the usual raw materials.

Early History and Development:—

Cotton fibre has been used in India for paper making since 327 B.C. Tsai Lun of China used cotton, flax and hemp fibres in 105 A.D. Thus the use of agricultural products as raw materials for paper is as old as the history of paper making. Cereal straw has been tried in Europe in 1750. William Magaw of Meadville U.S.A., developed a commercial process of pulping straw with wood ashes in 1827. His associate, George a shrylock of Pennsylvania made straw board in mills scale operation in 1830. Use of straw for paper making was firmly established in United Kingdom in 1851 and continued till 1870, when agriculture began to turn on live-stock production and the growing cattle population absorbed the lesser volume of the straw grown. Since 1895 straw corrugated board found wide popularity for making shipping containers in competition with wooden boxes.

Sugar cane bagasse was tried in France as a raw material for Newsprint as early as 1844. It was successfully used for making pulp and paper in Peru in the year 1939. More than 40 mills were established in next 25 years based on bagasse alone or in admixture with other raw materials. A continuous pulping plant based on Pomilio process was started at Rohtas Industries, Bihar in early forties. It was one of the first few of its kind used any where in the world. Bagasse has been used successfully for making newsprint in Hawai and Cuba.

Stalks of soyabean and cotton have already been used as substitute for straw in making straw board. Jute sticks and Mesta or Deccan hemp (Kenaf) are being successfully used in this country for making paper and board since 1961. Hemp and flax stalks are quite readily usable. Corn stalks are very similar to sugar cane bagasse in both structure and composition, and when available can be used as its substitute.

Sabai grass has been successfully used in making fine papers in this country even before bamboo was introduced in 1919. These two materials do not fall in the category of agricultural products, but they belong to the same group of plants as bagasse and cereal straws. Bamboo has a cycle of 4-5 years and is easy to grow and raise as an agricultural crop although not as an annual crop. Plantation of bamboo as a fibre yielding plant has been proved economically viable. Its importance in the paper industry is well recognised. It is the only raw material which, to some extent, can substitute soft woods for supply of medium length fibres required for admixture with mechanical pulp as well as short fibered chemical pulp from hard woods like Eucalyptus and Salai.

Scope Expansion :—

The brief narrative given above should be sufficient to justify a comprehensive programme for establishing paper and board making units in suitable areas all over the country. The size of the mills need not be

Dr. D. C. Tapadar
Principal, Institute of Paper Technology, Saharanpur.

large, but the products will have to be chosen carefully according to the raw material available in a particular locality. Board mills based on bagasse, cereal straws, jute sticks and stalks of hemp, cotton and flax are comparatively inexpensive to establish and reasonably profitable. Mills of 2 to 4 tonnes per day capacity may adopt sun drying. Larger units should have automatic drying system so as to work round the year without break during the rainy season. The U.P. Small Industries Corporation Ltd. Kanpur, have prepared some schemes of making straw board and mill boards on small scales which can be used as guide lines. The Himalaya Paper (Machinery) Private Ltd. and Eastern Paper Mills Ltd. of Calcutta have specialised in making plant and machinery for small scale industries. There are many engineering firms in Calcutta, Kanpur, Jagadhari, Aligarh and Chandigarh who can manufacture machinery parts and auxilary equipment which may constitute the major part of an entire plant and effect a substantial saving in capital investment.

Paper Mills are more capital intensive and schemes for small mills need very careful examination both in regard to plant and capacity and type of paper. Cigarette tissue, codenser tissue, high-stretch papers, papers for bank notes and documents are some such varities which have ample scope for production on a small scale. Raw materials required for such paper namely, hemp, flax, cotton and to some extent jute are too costly as such, but are available as discarded or waste in various forms prices of which are not incommensurate with the quality and price of the speciality paper made out of them. Cotton linters from spinning mills, spinning waste, hosiery cutting, tailor cuttings, old clothes, old nets, sails, ropes, sacks and jute caddis are such discarded fibres which should be collected, sorted out and preserved carefully by all concerned and made available to paper mills who will be only too happy to pay for all the effort made. The cultivators and agricultural farms can contribute largely towards augmenting the supply of raw materials and lowering the cost of paper. The bast fibres of hemp, flax, sunhemp and jute plants preserved for seed are usually much inferior in quality and some times left unextracted due to unattractive price and also shortage of water required for recovery of fibres. These fibres and the dried 'bark' are excellent raw materials for several speciality papers and should fetch a fair price even if extracted in crude, hard and discoloured state. Under favourable circumstances the whole plant, i.e. the bast fibre and the 'wood' inside it, can be profitably used for making papers of fairly high quality and of better strength than those made from bamboo and hard wood. Reference has already been made to the successful use of the woody matter in such plants.

There has been a very commendable break-through in the recovery of chemicals recently communicated to the Ministry of Industrial Development, Government of India, according to which small or medium size paper mills can now use bamboo, wood and agricultural residue without losing the chemicals in washing out the spent liquor after the pulping operation. A continuous digester capable of pulping 25 tonnes of agricultural residue is also in an advanced stage of development. Paper Mills of 25-40 tonnes capacity based on such raw materials are now a complete possibility. The prospects of using agricultural residues for pulp and paper manufacture may therefore be studied with confidence.

Studies in Retrospect :—

Cereals and sugarcane belong to grass family under the broad group of monocotyledon, which cover all plants having parallel-veined leaves. Hemp, sann hemp, cotton, flax, jute mesta etc. are all dicotyledons having net-veined leaves. The long slender cells with relatively thick walls and narrow cell-cavity or lumen, present in the leaves and stems of both groups of plant, contribute strength and rigidity and constitute the fibres used in making paper and board. There are thin walled cells and vessels which conduct liquid in living plants. The distribution of conducting cells, vessels and fibers are different in monocotyledons and dicotyledons. In the former they occur in vascular bundles, thick and close near the circumference but more and more thinly towards the centre in the stem. The fibre bundles in the dicotyledons occur in unbroken rings. The bast fibres in hemp, flax and jute are considerably longer than the wood fibres inside the stem. Bast fibres may constitute 1-30% of the fibre yielding plants depending on the type, growth and locality. Cotton fibre is a seed fibre and

TABLE I. COMPOSITION AND FIBRES DIMENSION OF SOME TYPICAL RAW MATERIALS AVAILABLE IN INDIA

	COMPOSITION		FIBRE DIMENSION		
	Lignin %	Hemicellulose %	Cross & Bevan cellulose %	Ave. Length mm.	Ave. Diam. Micron
Seedfibre.					
Cotton (*Gossypium hirsutum*)	—	2.0	92.97	18	20
Bastfibre.					
Hemp. (*Cannabis sativa*)	5.2	5.5	79.3	22	30
Jute.					
(*Corchorus capsularis & olitarius*)	11.7	18.1	74.9	2.0	22
Softwood.					
Chir (*Pinus longifolia*)	28.6	7.2	53.5	3.60	52
Sikkim spruce (*Picea spimlosa*)	28.6	12.3	59.7	2.82	27
Fir (*Abies spectabilis*)	29.2	9.7	59.7	2.66	28
Hardwood.					
Rubberwood (*Heavea brasiliensis*)	20.5	14.3	51.3	1.12	21
Salai (*Boswellia serrata*)	27.3	13.0	50.7	0.88	24
Mysore gum (*Eucaluptus hybrid*)	24.7	14.1	50.6	0.73	12
Grass & Reeds:—					
Sabai grass (*Euliopsis binata*)	22.0	23.9	54.5	2.08	9
Kana (*Saccharum munj*)	20.5	23.7	58.2	2.06	15
Salia bamboo *Dendrocalamus strictus*)	27.8	15.1	59.9	1.65	12
Dava bamboo *Bambusa arundinacea*)	30.0	19.6	57.6	2.73	...
Agricultural Residue :					
Bagasse (*Saccharum officinarum*)	21.0	26.6	54.9	1.38	18
Rice straw (*Oryza sativa*)	25.5	21.0	53.5	1.13	16
Wheat straw (*Triticum sativum*)	21.5	23.5	51.5	1.10	12
Jute sticks (*Corchorus capsularis etc.*)	21.4	18.8	57.6	0.79	29

TABLE II. ANNUAL PLANT SPECIES WITH PREFERRED CHARACTERISTICS FOR PULPING

Monocotyledons	Dicotyledons	
Gramineae	**Apocynaceae**	**Leguminosae** (*Continued*)
Andropogon gerardi	*Apocynum cannabinum*	*Sesbania cannabina*
Arundo donax	**Asclepiadaceae**	*S. exaltata*
Bamboo (29 species)	*Asclepias incarnata*	*S. vesicaria*
Erianthus ravennae	*Asclepias syriaca*	**Malvaceae**
Gynerium sagittatum	**Compositae**	*Abutilon americanum*
Hyparrhenia hirta	*Eupatorium brevipetiolatum*	*A. trisulcatum*
Lygeum spartum	*Helianthus grosseserratus*	*Althaea rosea*
Miscanthus sinensis	*Helianthus scaberrimus*	*Anoda pentaschista*
Pancium virgatum	*Iva xanthifolia*	*Hibiscus cannabinus*
Paspalum arechavaletae	**Euphorbiaceae**	*H. Cisplatinus*
P. exaltatum	*Ricinus communis*	*H. eetveldeanus*
P. quadrifarium	**Leguminosae**	*H. esculentus*
Pennisetum typhoides	*Astragalus sp.*	*H. lasiocarpus*
Saccharum officinarum	*Baptisia minor*	*H. sabdariffa*
Sorghastrum nutans	*Crotalaria eriocarpa*	*Horsfordia newberryi.*
Sorghum almum	*Crotalaria incana*	*Malachara alceafolia*
S. bicholor (vulgare)	*C. intermedia*	*Sida rhombifolia*
S. halepense	*C. juncea*	*Sida sp.*
Stipa tenacissima	*C. mucronata*	*Urena lobata*
S. virdula	*C. spectabilis*	*Wissadula cincta*
Tripacum dactyloides	*C. striata*	**Moraceae**
Zea mays	*Dalea alonecuroides*	*Cannabis sativa*
	D. leporina	**Onagraceae**
	D. enneandra	*Oenothera affinis*
	Desmanthns sp.	**Thymelaeaceae**
	Desmodium nicara uense	*Gnidia oppositifolia*
	Lupinus formosus	**Urticaceae**
	Sesbania arabica	*Boehmeria nives.*

Source : Northern Regional Research Laboratory. U.S.D.A. Peoria, Illinois.

forms a class of its own, and is different from both fast fibres and wood fibres. The chemical constituents and fibre dimensions of some typical plants are shown in Table I.

The Northern Regional Research Laboratory, Peoria, Illinois, has prepared a list of annual plants with preferred characteristics for pulping (Table II). Many plants in this list are well known in India. A complete list of such annual plants should be prepared after careful study of their characteristics, yield and quality of paper pulp.

Present Aspects and Prospects :—

Sugar cane (Saccharum officinarum) contains a lot of pith or thin walled groundcells (parenchyma) carrying sugar juice. After extraction of sugar the dry bagasse may contain 20 to 30% of pith and 70–80% of fibres which are comparable to bamboo fibres. For making chemical pulp for fine papers, pith is usually removed before hand in order to save chemicals. India produced about 131 million tonnes of sugar cane in 1969–70, equivalent to about a fourth of world's production. Production in Uttar Pradesh alone was 61 million tonnes. The scope of utilisation of bagasse for making paper and board is enormous. Of course there are problems, particularly of supply of alternative fuel and installation of new steam boilers. But apart from supply of alternative fuels, rationalisation of steam consumption in sugar mills can alone save substantial quantities of bagasse.

India ranks first in the world in production of rice, fourth in wheat, sixth in barley and eighth in maize. Nevertheless the availability of straw for paper and board making is entirely dependent on local conditions indicated on cattle population. As Indicated earlier small units are best suited for utilisation of straw.

India is the leading jute growing country in the world. Utilisation of Jute stick (*Corchorous sapsularis and C. olitarius*) including mesta or kenaf (Hibiscus cannabinus) for making pulp, paper and board can contribute very substantially towards supply of raw materials for all times to come. As in the case of bagasse, size of the mills and type of product can be determined by the availability in a particular area. The use of waste jute or the whole plant can solve the question of supply of long fibres which is essential for successful utilisation of stalks in making paper.

74,000 tonnes of sannhemp (Crotalaria juncea) was produced in India in 1969–70 with an average yield of 450 kg. per hectare, the highest yield being 910 kg. in Andhra Pradesh. There has been a remarkable progress in the production of cigarette paper in the country based essentially on waste or secondary sannhemp fibres. The sannhemp is also extensively used as a green manure. In U.P.alone 46459 hectares of land was manured with this plant in 1969–70, which could have yielded 21,000 tonnes of fibre. The economics and advisability of replacement of such green manure with chemical fertilizer deserve careful study.

Another plant used as green manure is Dhanicha (Sesabina cannabina) which has immense possibility as a raw material for paper. In U. P. alone 15277 hectares of land was green manured with this plant in 1969–70. A very similar plant, jaint or dhandiain (S. Sesban) is grown as an annual to form a barrier round field crops. The wood responses very well to soda, magnesium bisulphite and neutral sulphite semi chemical pulping. Recent studies in Andhra Pradesh has established its potentiality as a good replacement of hard-wood both from the view point of economic plantation and use for pulp and paper making. The statistics of the production of flax or linen i.e. the bast fibre of linseed, (Linum usitatissimum) in the country has not been available. The production of linseed in 1969–70 was 415,000 tonnes with an average yield of 240 kg. per hectare. Like jute sticks, the stalks of linseed and sannhemp plants can be used for paper and board making. The whole plant after extraction of seeds are even more useful because of the associated bast fibres.

The position of true hemp (Cannabis sativa) is rather obscure. The mass production of this versatile plant is not generally favoured due to the risk of indiscriminate production of the drug (Bhang, Ganja, Charash, Hashish and Marijuana etc.) The female plants are known to be more powerful in regard to growth and size as well as drug content. The male plant, on other hand, produces more bast fibres which are unsurpassed in making speciality papers like cigarette tissue. The occurrence of the drug is also dependent on the climate and some complicated phenomena of genetics. It would be a very interesting and gainful subject

of research for the botanists to pursue so as to segregate males from the female plants during cultivation or to make the females less intoxicating. Once this problem is solved, the enormous wild growth all over the hills and plains in the country can be a very imortant source of the valuable commercial fibre.

References

1. Stephenson J. N. : "Pulp & Paper Manufacture" Vol. II McGraw Hill Book Co. Newyork.
2. Cassey J. P. : "Pulp & Paper" 3rd Vol. Interscience Publishers New York 1961.
3. Bulletin of Agricultural Statistics for Uttar Pradesh 1969–70.
4. Tapadar D. C. : IPPTA Souvenir on International Seminar on Raw material for more paper. April 1964, pp 137.
5. Oza G. M. : Indian Forester 98 (6) June 1972, pp 349-56.
6. Tapadar D. C. : "Pulping Processes-Present Status and trend." Symposium on Man Made Forests in India (Utilisation) Dehradun, June 8 to 10, 1972, Society of Indian. Foresters