Mixed Tropical Hardwoods For Pulping And Paper making

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The use of mixed tropical hardwoods for pulp and paper making is the necessity to meet the ever increasing demand of pulp and paper and their products. In the light of information available, the general stand taken over the years that mixed tropical hardwoods are not suitable for pulp and paper making is not valid today. The mixed tropical hardwoods from natural forests could be utilised in high proportion for producing, if not all, a wide variety of papers. Advantages and disadvantages of utilisation of hardwoods are presented and successful utilisation of this vast resource demand controlled forest management, proper selection of the process and equipment coupled with uniform mechanical treatment of the fibre.

The purpose of this paper is to present information on some aspects of utilisation of hardwoods from natural forests for pulp and paper making which may vary in individual conditions and as such be used only as a guide line.

The utilisation of hardwoods in the Indian Pulp & Paper Industry is of comparatively recent origin. Naturally the emphasis on utilisation of this forest resource has arisen out of necessity as the mills are facing shortage of bamboo, the only well established fibrous raw material of the paper industry. It may not be an exaggeration to say that any substantial expansion of the pulp and paper industry will not be immediately possible without greater utilisation of natural mixed hardwoods forests. Mahalaha[1] in a report on "Pulping material for tomorrow" made the reference that the hardwoods from the mixed forests of the country is perhaps by far the most attractive not so much because of the suitability of the material, but by virtue of the volume of the available produce. The most conservative estimates have put the total availability for the whole country at 32 million m^3. It is therefore, obvious that if any produce which is likely to meet the total requirement of tomorrow, it is only the hardwoods which will provide the bulk of the material for the paper industry.

Utilization of mixed hardwoods is resorted to varying extent in the Indian Pulp and Paper Industry. The experience is of great value and knowledge is slowly obtained to understand in greater depth the technical and economic implications of greater utilisation of hardwoods in the existing mills and planned future mills.

Utilization of hardwoods in the mill offer advantages and disadvantages both. With the use of hardwoods in the existing mills based primarily on bamboo, many new problems have cropped up. These are found in all areas of pulp and paper making and also black liquor evaporation. The problems are relevent to the hardwoods species only and also because they have to be used in conjunction with bamboo (chips/pulp) in the mills. Looking at the hardwoods only, the differences in their basic density and the heterogenity in wood mix makes it difficult to obtain uniform quality pulp. Segregation of the wood species is not possible as the number of species to be found in the mixed forest are many.

However, it is desirable to exclude the wood species which are most difficult to process and use the rest mixed hardwoods for pulp and paper making

Improvements in forest management, process and equipment have provided a new dimension to

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mixed tropical hardwoods pulping. Colombia is already exploiting tropical hardwoods most successfully and even with simultaneous use of heterogeneous woods it has been possible to obtain uniform quality sulphate pulp and semi-chemical pulp. The proposal of Stora Koppar Berg. A.B. Sweden to build a market pulp mill of 250,000 tonnes per annum in Gaben, Africa based on utilisation of mixed hardwoods for which extensive laboratory and commercial trials have been taken in a swedish mill, is an important step towards utilisation of mixed hardwoods for pulp and paper making. Similarly a project (fibre and chemical Malaysia SDN, BHD) to be set up in Malaysia by Birla Bros. envisages the utilisation, by clear felling of mixed hardwoods for pulp and paper making and in the cleared forest will be planted fast growing suitable pulpwood species.

A discussion on utilisation of mixed tropical hardwoods for pulp and paper making with emphasis on medium to heavy hardwoods is the subject of this paper.

Raw Material

Tropical hardwoods are found only in developing countries in the equatorial region. As most of these are mature hardwoods they have a higher specific gravity. Wood species like *Xylia Xylocarpa, Terminalia tomentosa and Terminalia Paniculata* which are dominent species in mixed forest in certain regions of the country are hard to very hard, heavy to very heavy with an average weight of 850-880 kg/m^3 (53-55 lb/ft^3) at 12 per cent moisture content. In addition these wood species have high heart wood content, high lignin and extractives content. The proximate analysis for a typical hardwood mix, which possibly excludes *Xylia Xylocarpa Terminalia tomentosa and Terminalia Paniculata* and used in a paper mill is given in Table I.

Debarking

A satisfactory method of mechanical debarking has not been found for mixed tropical hardwoods. Small diameter and crookedness of the logs combined with varying nature of bark makes mechanical debarking difficult. At present debarking of tropical hardwoods is mostly done by hand and there is strong need to have a process/equipment which will take care of the variability in size, quality of wood/bark etc.

Chipping

As already mentioned tropical hardwoods usually have higher specific gravity. As a result of the usually high average density, the average hardness of the wood is high as well. The effect of high density manifests itself in heavier than usual wear on the chipper knives which accordingly need more frequent sharpening than with conventional pulpwood. High resistant steel is required or preferred for chipping the mixed tropical hardwoods.

Pulping

Sulphate chemical or semi-chemical pulping is mostly preferred. Hardwood semi-chemical pulps obtained by kraft process are

Table I

Proximate Analysis of Mixed Hardwood Chips

Wood meal passing through 60 mesh was used.

All values expressed on 100 gram oven dry material.

	Percent
Ash	2.3
Cold water solubility	4.8
Hot water solubility	6.3
1% NaOH solubility	20.6
Alocohol Benzene (1 : 2) solubility	4.0
Hollocellulose* uncorrected for ash and residual lignin	66.9
Alpha cellulose	36.8
Beta cellulose	7.6
Gamma cellulose	15.4
Total pentosans	13.6
Klason lignin	27.0

*Hollocellulose was determined by sodium chlorite method—Five treatments were given.

dark brown in colour. Its strength ranges from 50 to 60 per cent of that of unbleached kraft pulp and it is especially superior in compressing strength. It is most suited when used for lining corrugated board. The sulphate semi-chemical pulping results for a mixture of mixed hardwood chips are given in Table II.

Table II

Kraft semi-chemical pulping of mixture of *Xylia Xylocarpa. Terminalia tomentosa Terminalia Paniculata, Anogeissus latifolia* and *Largerstroemia lanceolata chips*. 20% each

Cook No.	1	2
Active alkali on chips % ($NaOH+Na_2S$ as such)	17	14
Liquor to chips ratio	3:1	3:1
Sulphidity %	18.5	18.5
Cooking temperature %	160	160
Time to get max. temp. minutes	120	120
Time at max. temp. minutes	60	60
Disc defiberizing of the treated chips		
Total unbleached pulp yield %	54.8	63.3
Kappa number	112	148
Physical strengths of Hand Sheets at 40° SR		
—Basis weight, g/m^2	126	127
—Bulk, cm^3/g	1.69	1.85
Concora medium Test CMT, kg.	33	20
Scan Bending stiffness, g cm./15°	3.2	2.9

The important variable which affect the pulp quality as measured by the permanganate number, pulp yield and the amount of screening are the following :

(1) Chips Size

Though the importance of chip physical characteristics as evaluated by their overall size, grain length and thickness has been mentioned by various workers in literature, this attaches greater significance in tropical hardwoods pulping. Chip thickness determines the degree of kraft liquor penetration, since penetration is approximately equal in all directions under alkaline conditions. Kraft chips should not be greater than 4 or 5 mm thick with 3 mm or less being ideal. With hardwoods in order to obtain a satisfactory pulp with less screenings, all efforts should be directed to producing chips of 3 mm or less thickness. It is important that over size chips should be separated on a basis of thickness preferably by a slotted screen and not a round screen. The presence of even a small fraction of oversize chips necessitates intense cooking conditions like the higher chemical charge (increased liquor concentration) and increased cooking time resulting in loss of pulp quality and this is reflected adversely in the runnabilility of the pulp on the paper machine. This can be seen from the pulping results obtained using the same wood mixture as used in proximate analysis. The mixed hardwood chips which were obtained from the plant and contained 8–10 wood species were subjected to chips size classification and pulping test as given below :

Table III

Chip Size Classification Data for the Mill Chips

Moisture in Chip, %	17.0	
Bulk density of chips, kg/m^3 (A.D.)	261	
Williams Chip Classifier : Sample	A	A_1
Screen mesh opening, mm + 32	6.4	—
— 32 + 25	15.5	18.5
— 25 + 22	9.4	11.8
— 22 + 19	11.7	12.7
— 19 + 16	14.4	14.4
— 16 + 13	13.6	13.6
— 13 + 6	22.6	22.6
— 6 + 3	4.8	4.8
— 3	1.6	1.6

A_1 — +32 mesh fraction cut and mixed again.

The results show that in order to reduce the rejects percentage in Cook No. 2 to the same level as in Cook No. 3 the extended cooking time (increased "H" factor) considerably reduced the viscosity of pulp, resulting in loss of pulp quality, a consequence of the presence of oversize chips.

The importance of the chip dimensions especially chip thickness can be seen from a pulping process called the MM process which utilises thin flakes with a uniform thickness of 0.4 mm instead of standard chips. The process has been in operation in Argentina for several years, it is said to result in higher yields and recommended to be specially useful for pulping of mixed hardwoods :

Table IV

Pulping Conditions and Results

Sample	A		A_1
Cook No.	1	2	3
Active alkali on chips % ($NaOH + Na_2S$ as such)	24.0	24.0	24.0
Liquor to Chips ratio (weak black liquor as diluent)	3 : 1	3 : 1	3 : 1
Sulphidity %	19.3	19.3	19.3
Maximum temperature, °C	170	170	170
Time at max. temp., minutes	75	120	75
'H' factor	1445	2160	1445
Screened pulp yield, %	41.0	41.8	41.9
Rejects on chips, %	2.6	1.6	1.7
Rejects on pulp, %	6.3	3.8	4.1
Kappa number	32.8	28.8	34.4
Viscosity cps. (CED)	15.3	10.3	15.1

Temperature Schedule

70–120°C in 45 minutes
at 120°C for 40 minutes
120–170°C in 80 minutes

(2) Chemical charge

Chemical charge is normally higher than that required for bamboo and eucalyptus pulping.

(3) Sulphidity

A high sulphidity is generally not desirable in hardwoods pulping. As the effective alkali is reduced with increasing sulphidity, it would be necessary to use a higher active alkali charge to maintain constant effective alkali on chips. This will not be preferred as the load on soda recovery is unnecessarily increased. A sulphidity of 15–20% may be preferred.

(4) "H" factor

Since temperature and time could be considered as a single variable by the application of "H" factor, this could well be applied for controlling the degree of delignification in the hardwoods pulping.

(5) Liquor to Chips Ratio

Because of the addition of higher amount of chemicals, for a fixed concentration of white liquor, it will be necessary to add greater volume of white liquor which will result in the volume of the diluent viz black liquor to be added for adjusting the bath ratio to get reduced. The effect of this reduction of amount of black liquor to the charge of chips and white liquor on the pulping process have not been probably investigated, especially in hardwoods pulping.

(6) Blowing

Hardwood pulps are much more difficult to blow clean than the bamboo or pine pulp. This is an area which needs careful study.

PULPING RESULTS

(1) Pulp Yield

It is generally observed that pulp yield on the basis of weight of wood will be lower for high density wood, but in some circumtances pulp yield per unit volume will be a significant economic factor and this will tend to favour woods of higher density.

(2) Kappa Number

Optimum pulping degree as measured by Kappa Number for producing strong bleachable pulps appear to be approximately 35. In a set of experiments where the Kappa Number was varied by changing the "H" factor, loss in pulp quality was observed when pulps are cooked below the Kappa Number of 32–35.

(3) Screenings

In order to be able to cook the hardwood chips to the Kappa number of 32–35 and still keep the amount of screenings to the lowest possible, so that the size will be the determining factor.

(4) Washing

The hardwood pulps offer greater filtration resistance and as such for equal washing efficiency the filtering area requirements will be higher compared to that of bamboo pulp. Alternatively aside from the vaccuum created by straight barometer drop legs, the headers of the washers are connected with a large sized vacuum pump, to assist in increasing the vacuum to improve washing efficiency and filtration rate of the spent liquor. The dilution factor in case of hardwood pulp washing will be also more and the volume of the spent liquor per tonne of pulp will be greater when compared to 100% bamboo pulp.

Bleaching

When bleaching of only hardwood pulp is carried out, no special problems are felt. However, when resorting to mixed bleaching of bamboo and hardwoods pulp, it would be necessary to have the pulps for both bamboo and hardwoods with uniform bleach demand. Since at comparable Kappa numbers the chlorine requirement in the chlorination stage for mixed hardwoods sulphate pulp is 1/6th of the Kappa number and for bamboo pulp 1/4th of the Kappa number,[2] it would be necessary to cook the hardwoods to higher kappa number when compared to bamboo to have the same chlorine demand.

Black Liquor

With hardwoods black liquor, experience and problems encountered have been different. The Eucalypt sp. of course from plantation forest show an abnormal increase of viscosity of concentrated black liquor and in order to prevent such abnormal increase, the preheating cooking was recommended[3]. Setting of preheating stage (120°C, 45 min.) before raising temperature was reported to be quite effective for preventing viscosity increase as well as for improving combustion properties in the Recovery furnace. Information based on commercial experience on this aspect is lacking though many paper mills in the country are using a preheating stage in eucalytus and other hardwoods pulping.

With certain type of hardwoods black liquor, on evaporation above 3% dissolved solids content separation of lump/granules is observed resulting in increased fouling and sometimes plugging of tubes. In addition other consequences of the use of heavy hardwoods in the mill are :

(1) Total solids per tonne of pulp is higher than that of bamboo. Value as high a 2 to 2.2 tonnes per tonne of pulp may be obtained compared to 1.5 to 1.7 tonne for bamboo.

(2) Properties like swelling, index, burning profile index, time required for ignition of black liquor solids which has an effect on the combustion show that these properties are not as good as those obtained for bamboo or pine sulphate black liquor. This is shown in Figures 1 and 2.

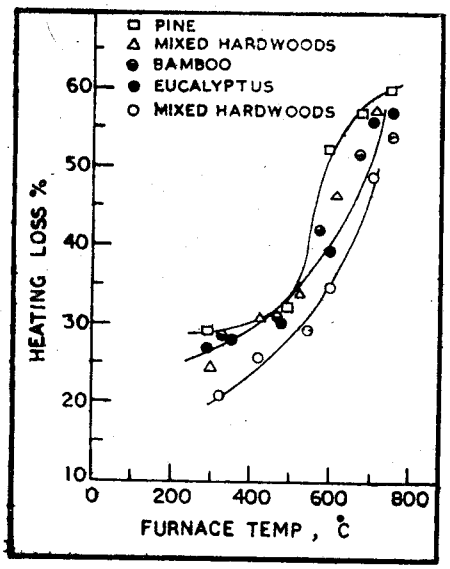

Fig. 1

Heating loss percent against Furnace Temp. for sulphate black liquor from different raw materials.

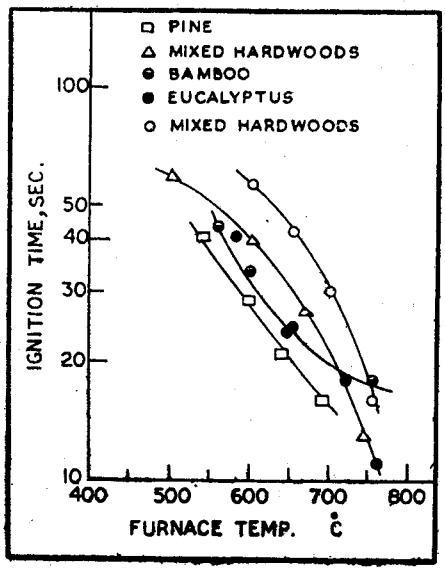

Fig. 2

Ignition time, seconds, against Furnace Temperature.

Mixture of following hardwood species was used :

Lagerstroemia lanceolata, Kydia Calycina, Grewia tiliaefolia, Anogeissus latifolia, Terminalia balerica, Adina cardifolia, Tectona grandis, Dipterocarpus indicus, Calophyllum tomentosum, Mitragyna parviflora.

Except Lagerstroemia lanceolata which was 25% by weight in the mixture, all other wood species were used in equal proportion (8%) each.

Xylia Xylocarpa, Termenalia tomentosa, Terminalia paniculata, 33 percent each.

These are mostly heavy to very heavy hardwoods.

Stock Preparation and Paper Making

Convincing evidence is available to show that mixed tropical hardwoods could be utilised in high proportion for production of good quality unbleached and bleached papers. A mistake which was made in the use of hardwood pulps when first they are introduced was to give them in-sufficient treatment in the beaters or refiners. This was due to the short initial fibre length of the hardwood pulps which gave the impression that they would not respond to the beating treatment. This led to a number of difficulties on the paper machines, one of the most commonest being the picking of the surface of the paper on the drying cylinders. The experience with eucalyptus has been that if the eucalypt component is not beaten below about 300 csf "picking" of the eucalypt fibre at the first press is often observed[4].

Vessel picking is a problem specically related to the use of hardwood pulps and is one that has acquired much effort to overcome. Satisfactory results are now being obtained by controlling freeness in the range of 200 to 250 csf and by adding starch to the furnish to increase internal bonding (*Ibid.*) An observation of significance is the realisation of fact that hardwood pulps show marked increases in strength on beating. Further during the initial stages of beating both the breaking length and tear factor increases and it is only after continued beating, the tear factor begins to drop. Compared to coniferous pulps this is an advantage where the tear factor drops already after mild beating.

For achieving optimum results in refining of hardwood pulps emphasis has been laid recently in disc refiner design and operating parameters for hardwood pulps[5]. KOZICH[6] found that the double disc refiner achieves better results with hardwood pulps than a conical refiner because of its ability to produce a higher number of bar contacts per revolution. When hardwood pulps are refined for maximum development of strength the disc pattern used should contain as many narrow bars as possible and

the refiner speed should be as high as practical depending on the disc diameter However, the specific power per unit of refining area must be kept low to obtain gentle treatment of the fibre. High consistency refining followed by a low consistency treatment is to be preferred if optimum strength values are to be reached.

The utilisation of mixture of tropical hardwoods offers many favourable properties during paper making. Besides the economic necessity of using the tropical hardwoods in mixtures, containing many species, this technique offers definite technical advantages as both thin walled—flexible and thick walled—relatively stiff fibres make the furnish for paper. Thin walled flexible fibres offer scope for developing high physical strengths mainly dependent on inter-fibre bonding and thick walled fibres contribute to high bulk, high tear and high opacity even when well beaten fibres are used. In this respect both the optical and physical properties of the writing and printing papers could be very well balanced. This effect is somewhat similar to that given by the presence of spring and summerwood in temporate zone wood. The extent of variation in fibre dimensions for some tropical hardwood species is shown in Table V.

Table V

Morphological Data of Hardwood Fibres of Bleached Sulphate Pulps

	Particulars	Average length mm (L)	Average fibre dia microns (D)	Average wall thickness microns (T)	Slenderness ratio L/T	Average wall fraction %
1.	*Terminalia paniculata*	1.32	15.70	3.90	84	45.50
2.	*Anogeissus latifolia*	1.00	10.70	3.40	96	66.50
3.	*Grewia filiaefolia*	1.35	12.60	3.30	107	53.50
4.	*Lagerstroemia lanceolata*	0.91	15.90	4.60	57	60.00
5.	*Adina cordifolia*	1.58	17.20	5.00	92	66.00
6.	*Mitragyna parviflora*	0.65	16.80	4.50	39	57.00
7.	*Terminalia balerica*	1.31	13.50	3.40	97	51.50
8.	*Calophyllum tomentosa*	0.90	15.90	3.00	56	36.00
9.	*Dipterocarpus indicus*	1.22	17.30	5.10	70	64.50
10.	*Tectona grandis*	0.70	15.00	3.20	47	44.00
11.	*Dillenia pentagyna*	1.50	16.50	3.90	91	43.00
12.	*Eucalyptus hybrid*	0.76	14.50	3.60	52	50.00

Summing up the above discussion, it would be logical to conclude that in view of the serious work undertaken at leading pulp and paper research Institutions all over the world as well as reports from Pulp and Paper Mills utilising mixed tropical hardwoods, the utilisation of mixed hardwoods in high proportion is a distinct possibility.

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