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PRACTICAL EXPERIENCES IN THE USE OF MIXED TROPICAL HARDWOODS FOR PRODUCTION OF PULP AND PAPER 1/

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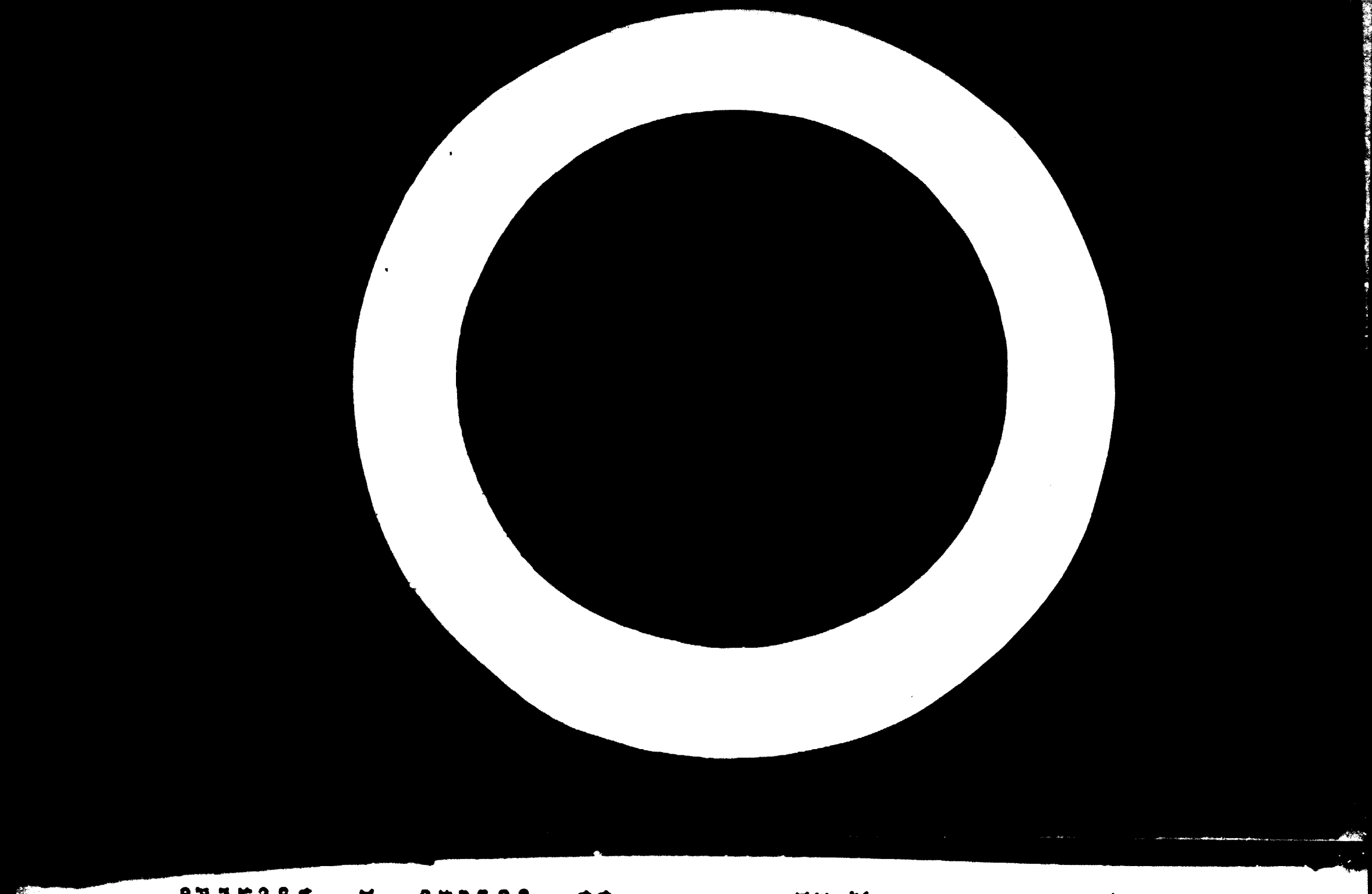

Introduction:

The demand of paper and board is increasing at a rapid rate every year through-out the world. This has been the result of the growing literacy, the intense competition for increased paper among newspapers, and the increasing industrial activity. It is predicted that the future demand for paper in India will be as follows:

Table 1

Estimated Production in Million Tons

Year	Paper Board	Newsprint	Chemical Pulp	Total
1975-80	2.00	0.45	0.40	2.85
1980-85	3.00	0.60	0.60	4.20

The corresponding yearly requirement of fibrous raw-materials would be -

Year	Million Tons
1975-80	7.2
1980-85	10.0

The basic problem in India has been to find out ways and means of increasing the availability of fibrous pulping raw-materials from the present figure of two (2) million tons to ten (10) million tons by 1985.

For the development of the pulp and paper industry in India the nonavailability of suitable raw-materials at reasonable cost has been a handicap. The Government of India with the assistance of UN Special Funds and FAO launches a project to survey the raw-material resources in order to assess the economic availability of suitable raw-materials mainly for the pulp industry. The results of the survey indicate that about 32 million tons of hardwoods spread over through-out the country can be made available.

The economic procurement of hardwoods is more attractive because of easy logging conditions, simple regeneration methods and easy terrain where forests grow.

Hardwoods, which are usually of shorter fibre length and larger cell wall thickness, had been neglected for use in the pulp and paper industry. The hardwoods contain more cell types (Libriform cells, ray cells, vessels, etc.). The libriform cells constitute 80% to 90% of the weight of wood and are less than 1.0 - 1.5 mm in length. Hardwoods have been on the whole considered as inferior pulping raw-material. Many hardwoods grow faster than softwoods and have a higher yield per acre. Most of the hardwoods are denser than softwoods and hence the digester capacity with hardwoods is more. Their lower lignin and higher hemicellulose

content make them suitable for high yield pulps by the kraft, cold caustic soda (CCS) and Neutral Sulphite Semi-chemical (NSSC) pulping methods. They improve bulk, opacity, formation and surface which are very important for writing and printing paper. These advantages have been realized by the paper technologists. With the easy availability of hardwoods at a relatively lower price and increasing demand of pulp fibres, new methods and techniques of processing have been developed to overcome the deficiencies of hardwood fibres such as shorter fibre length.

In the tropics, a large number of hardwood species grow in the same forest. A particular species of hardwood is rarely available in sufficient quantity for industrial pulping. It is, therefore, very necessary to use a mixture of hardwoods in whatever proportions they are made available to the pulp mills. The pre-investment survey of forest sources, Government of India, gives the distribution of forests under broad-leaved woods as shown in table (2) and the distribution of the major species and the percentage of volume to the total volume for the pulpable species of hardwoods in table (3). For selection of species for pulping a number of them have been tested in Forest Research Institute (FRI), Dehra Dun and at various mill laboratories and their pulping and paper making characteristics evaluated. The Indian pulp and paper mills in general had been shy of utilizing the hardwoods. However, during the last ten years more and more mills have been forced to consume hardwoods. Table (4) shows the increasing trend of hardwood consumption in Indian paper mills.

Table 4

Consumption of hardwoods in India for the pulp industry (in tons):

Year	1958-59	1967-68	1970-71
Mixed hardwoods	7,000	150,000	200,000
Salai	25,000	50,000	80,000
Total	32,000	200,000	280,000

The hardwoods available for pulping have a wide range of basic density, fibre dimension and chemical composition. The short thin-walled hardwood fibres have been used in the manufacture of a number of varieties of papers as these fibres impart favourable properties associated with printability. Short thick-walled fibres are not generally accepted as papers made therefrom possess poor strength properties. Thick-walled fibres have poor lateral conformability. Hence strength properties dependent on inter-fibre bonding are low in comparison to those made from thin-walled fibres. The thick-walled fibres have, however, higher stiffness, compressability and bulk. Hence papers which require these above properties and moderate strength can be made more economically with thick-walled fibres in the furnish.

Although wood density is not always related to the fibre wall thickness it is used generally as a parameter for grouping of various species of hardwoods. In general, the laboratory evaluation for pulping of mixed hardwoods is carried out by subjecting a particular species to a definite condition of cooking and finding out the yield and the physical strength properties of the pulp sheets. Tables (5-7) show results of a number of hard-woods of India.

The mixed hardwoods available for pulping may be classified according to the density as -

1. Mixed hardwoods of more or less similar density.

2. Mixed hardwoods of heterogeneous species widely differing in density.

It is generally believed that the heterogeneity of a mixture of hardwoods increases the pulp yield and the strength property of paper. However, many have shown that when the number of species in the mixture increases, the yield increases as well.[2] Work by the CCL Stockholm on mixed hardwoods (36 species) from India indicates that a good pulp yield by the sulphate process can be obtained and the pulp strength compares fairly well with those from short and thin walled pulps. The pulp from the mixture of Indian hardwoods has however high tear but low double folds.[3]

It may be more scientific to pulp hardwoods of similar species and of more or less similar densities. However, this may not be always practicable. Mills which use mixed hardwoods emphasize not on what is most suitable from pulping angle but on how much of the material can be procured at the mill site and its cost of collection.

The Indian pulp and paper industry not only practises the mixed cooking of tropical hardwoods, but it has gone a step further by following the cooking of bamboo and a mixture of hardwoods together in batch or continuous digesters using definite cooking conditions as chemical concentration and steaming cycle. This attitude of the industry is not due to any scientific or technical findings of the nature of the hardwoods, but mainly due to the circumstances in which it finds today regarding the fibrous raw-materials.

How should the mills be grouped? Should they be on the basis of hardwoods used? Should they be on the basis of the equipments used or should the basis be the overall processing technique? Classification on the basis of processing the major raw-materials is more practical and useful.

Practical Experience

According to the method of processing, the mixed hardwoods for the manufacture of pulp, the pulp mills may be classified into three main categories. They are as follows:

1. Mills adopting the cooking of a mixture of bamboo or pine with mixed tropical hardwoods together.

2. Mills preferring to cook the mixed hardwoods and bamboo or pine separately.

3. Mills applying the mixed cooking up to a certain percentage of hardwoods.

Separate cooking of the mixed hardwoods is carried out for any extra hardwood pulp consumed in a particular variety of paper.

The first category of mills using mixed cooking of bamboo and hardwoods have the advantage of easy operation due to a simplified single flow system. However, they believe that the quality of pulp can be improved by adopting separate cooking of mixed hard-woods and bamboo or pine.

In these mills bamboo is separately chipped in multi-knife disc chippers of either Sumner, Voith, KMW or Bigger make. For chipping of hardwoods a definite number of Voith or KMW chippers are reserved. In older mills it is usual to have a number of low capacity chippers for hardwoods which feed to the common chip belt conveyor through individual chip cyclones.

The hardwood logs are usually scantlings from the saw mills which are usually thin and of irregular size. Hardwood logs from the forest are of different shape and size, many of which contain knots, roots and are twisted and crooked. Such logs are cut to smaller sizes by Band Saw machines before feeding them to the chippers. In general, hardwoods are difficult to chip as they damage the chipper knives more frequently. A set of knives which would chip about 350 tons of bamboo chips is found to chip only 300 tons of mixed hardwoods. This necessiates frequent change of knives which results in more down-time of chippers. In general, hardwoods are difficult to chip as they damage the chipper knives more frequently. A set of knives which would chip about 350 tons of bamboo chips is found to chip only 300 tons of mixed hardwoods. This necessiates frequent change of knives which results in more down-time of chippers. For chipping hardwood the clearance between knife and disc has to be maintained less than that for bamboo. The KMW chippers are better suited for the chipping of mixed hardwoods. The power consumption for chipping mixed hardwood is higher by 20% than that for bamboo. The percentage of oversizes in mixed hardwood is slightly higher.

A comparison of chip classification by a KMW chipper for bamboo and mixed hardwood is given below:

	Percent by Weight	
	Bamboo %	Mixed Hardwoods %
Above 1½" mesh.	15.0	17.5
Between 1½" and 1" mesh.	20.0	20.0
Between 1" and ½" mesh.	37.5	42.5
Between ½" and 1/8" mesh.	25.0	17.5
Fines (Passing through 1/8" mesh.)	2.5	2.5

The higher proportion of over-size with hardwoods may be due to the irregular size of the saw-mill scantlings and the method of manual feeding.

The proportioning of bamboo and hardwood chips is a problem with this type of arrangement of mixing. The variations of the proportion of different chips in the mixture depend on the feed rate of the individual chippers which are carried out manually. These variations reflect on the quality of the pulp and the amount of rejects. A better method is to have separate silos for bamboo and mixed hardwoods from where chips are accurately proportioned by adjusting the individual RPM of the table feeders.

Mixed cooking of bamboo and hardwoods shows always a higher percentage of uncooked rejects originating predominently from the hardwoods. It is known that the thick walls of the fibre cells of hardwoods offer greater resistance to penetration of liquor. Hardwoods consume more chemicals than bamboo. However, the increased cost of chemical requirement for cooking is more than compensated by the higher yield of pulp from the mixture, lower energy consumption during beating and refining and the cheaper price of hardwoods.

In order to increase the rate of penetration in the hardwood chips a few mills have adopted chipping hardwoods to a comparatively smaller chip size so that during the mixed cooking of bamboo and hardwoods, the latter are fully cooked without overcooking of bamboo chips, resulting in lower percentage of rejects.

Another method adopted by some mills is the use of two-stage heating of the digestor instead of a straight-to-top temperature steaming cycle. The first steaming phase to a temperature of 120 to 130°C ensures better penetration and less over-cooking and under-cooking of chips. This reduces the amount of rejects and chives in the cooked pulp.

The permanganate number (P.No.) of unbleached pulp varies from mill to mill depending on the bleaching sequence and the efficiency recovery plant. For unbleached grade most mills maintain a P number of 21 ± 1. The P.No. of bleachable pulp in some mills is maintained at 15 ± 1 and in other mills 18 ± 1.

The pulp obtained from a mixture of bamboo and mixed hardwoods in a Kamyr continuous digester by sulphate method is relatively of superior strength probably because of the more uniform cooking due to liquor circulation and cold blow from the digester. On the other hand rapid cooking of the mixture in a Pandia digester yields a pulp of lower strength properties.

Washing of the pulp mixture has not presented much problems although they sometimes choke the screen plates of the screw press washer. The pulp from the mixture drains quite satisfactorily. Screening of the pulp mixtures does not show any unsatisfactory results. It is rather easier to process a pulp from a mixture of bamboo and hardwood in centricleaners.

Bleaching of pulp is carried out in three or four stages using C/D/E or C/D/E/H sequence. The brightness of bleached pulp for making better grade of paper is 77 to 80%.

The stock preparation in older mills consists of batch Hollander beaters and continuous conical refiners while in newer mills only continuous refiners exist. Beating of a mixture of bamboo and hardwood requires less energy than with bamboo only. A favourable effect of beating and refining of mixture of pulp is the increase of refining consistency without any pipe line or pump clogging. A refiner which used to be run with bamboo pulp at a consistency of 4.5% can now handle the pulp mixture at a consistency of 5.5%. This not only reduces the energy consumption during refining but also improves the fibrillation and the draining character of the pulp. The refining power required to reach the same draining rate in the paper machine with bamboo and a mixture of 70% bamboo and 30% hardwoods unbleached pulps are 27 and 20 H.P./tons/day respectively.

Mills under the second category having separate processing of different raw-materials had either already possessed the multiple flow lines or modified their old flow system to adopt to the separate cooking and refining. Since it is expensive to have separate flow system for each component, some mills prefer to cook bamboo and mixed hardwoods separately in batch digesters and then mix the different pulps in desired proportion in the blow tank. They use separate chip silos for bamboo and mixed hardwoods. This requires only separate lines for conveying the different chips. The mixed pulp is processed as usual in subsequent stages of operations. This method eliminates the damage to the fibres during cooking only. Mills making use of mixed hardwoods for manufacturing kraft wrappings and corrugating kraft liner can use this system with much advantage. However, this is not convenient for mills using more than 30% of hardwoods in the mixture or using pine in greater quantity (more than 10%).

There are mills which prefer to apply mixed cooking of all fibrous raw-material up to a limited percentage of hardwoods. In order to use a still higher proportion of hardwoods (more than 30%) they prefer to cook the hardwoods separately and mix them in the main furnish before final refining. The reason for not exceeding a definite percentage of hardwoods in mixed cooking is to have a limited deterioration during cooking. This system has also the advantage to feed different pulp furnishes with varying percentage of hardwoods to different paper machines for making different grades of paper. The mills coming under the third category have also the added advantage of using greater percentages of hardwoods.

Blends of bamboo and mixed hardwood unbleached pulps up to 50% do not present any appreciable difficulties on the four-drinier paper machines. In fact, 10 to 15% of hardwood pulp in admixture with bamboo is free draining permitting lower head-box consistency. The formation of sheet and bursting strength are improved. However, larger percentage of hardwoods do affect the runnability of paper machine and the strength character of paper. Due to bamboo shortage one mill had to use hardwood pulp up to 80% in the pulp mixture. In these runs, the major difficulties were following:

1. Clogging of the suction couch box and reduced vacuum.

2. Reduced life of press felts due to the clogging of the pores in felt.

3. Higher press picking and more frequent wet breaks.

4. Reduced strength properties of paper.

The tendency of falling vacuum in the suction couch was noticed after a run of one month. The usual cleaning cycle for this couch running with a mixture of bamboo and hardwood (30%) is 8 to 9 months. It was feared that high proportions of hardwood pulp would increase the cleaning cycle frequency. The life of the first press felt was reduced from the usual 40 days to 10 to 20 days. Synthetic needled felts were tried without much success. Use of a very porous felt showed felt markings on the paper. In the second and third presses there were fibre deposits, which had to be removed more frequently. In order to reduce the breaks of the wet web the machine had to be run on a higher basis weight. This helped in maintaining the production rate on the paper machine.

Runnability on a Yankee Machine making lighter paper did not show any difficulty with 60% hardwood furnish as on the four-drinier machine. In fact, the glaze of the sheet improved.

The fibre contents in the white water of all machines increase with use of hardwoods. In order to increase the fibre retention as well as the wet strength of the web, starch is added to the refined stock at the fan pump. Since starch reduces the drainability of the stock on the wire, proper care should be taken to adjust the refining. Tamarind seed power (TSP) is found to be a cheaper substitute for starch. TSP must be cooked at 90°C and the solution is screened in a 100 mesh screen before using in the system. TSP is being regularly used for improving the runnability of a high speed four-drinier paper machine running at 600 m/min. without breaks.

The dilute black liquor from the brown stock washers contains fibre fines and cells from the hardwood pulp. These cells find their way to the evaporating plants and form deposits on the heating tube surfaces of the evaporators.

In order to maintain proper heat transfer through the tubes frequent cleaning is necessary. Many mills clean once a day the tubes of the last two bodies (first and second effects) of the multiple effect evaporator set with dilute black liquor. A few mills have also a filter for removing the fines and cells from the black liquor before feeding to the evaporators. This eliminates more frequent cleaning of tubes. Black liquor obtained from a mixed hardwood cook is more viscous and contains higher organic to inorganic ratio than that from bamboo. The following results show the comparison of ratio of organic/inorganics of the two black liquors obtained from bamboo and hardwood with exactly similar conditions of pulping in laboratory:

	Organics	Inorganics
Hardwood (Sal)	70	30
Bamboo	65	35

Hardwood black liquor has a higher calorific value than that of bamboo liquor. However, hardwood black liquor is relatively more sensitive to storage. Combustion of black liquor in the spray furnaces has been better with liquors of mixed cooking than with bamboo alone. A mill using mixture of pine wood and hardwood reports imperfect combustion conditions in the furnace, due probably to the lower calorific value of the black liquor relative to pine wood digestions.

Case histories of a number of selected pulp and paper mills in India have been made with regard to the processing of mixed tropical hardwoods. Among these are a mill using cooking of bamboo and mixed hardwoods together in a Kamyr continuous digester with hi-heat system, a mill cooking bamboo and mixed hardwoods together in a Pandia continuous digester, a mill using separate cooking of pine wood and mixed hardwoods, a mill using mixed cooking of bamboo with a limited amount of mixed hardwoods and making bleached grades of paper on a high speed four-drinier paper machine and lastly a mill using both separate and mixed cooking depending on the percentage of hardwoods in the chips mixture.

Much emphasis has been given to the sulphate pulping system as most of the mills use this process for pulping. One or two mills have started using cold caustic soda pulping method for mixed tropical hardwoods. However, we have yet to gain experience on this pulping system.

Suggestions for Future Action

The following can be recommended for improved working of the various operations of pulp and paper mills using larger proportions of hardwoods:

1. **Procurement of raw-materials:**

   (a) Classification and grouping of the tropical hardwoods on the basis of density and chemical composition should be made through-out the country with a view to make it easy for the pulp mills to collect their raw-materials from the forests on the above basis.

   In many cases it may not be possible to procure on a sustained basis hardwoods of more or less similar density. In such cases arrangements should be made in the forests as well as in the mill wood yard to collect and store woods of a particular species in segregated lots so that the mill technicians can exercise their choice for the desired lot for a particular paper. This would at least reduce the inherent draw-backs of mixed cooking of widely differing raw-materials.

(b) Procurement of wood consisting of stumps, roots, and deformed trunks should be avoided both on economical and technical grounds.

2. Chipping of raw-materials:

(a) In order to help penetration of cooking liquor into the hardwoods their chip size should be made smaller. Continuous feeding of logs is necessary for obtaining better chip classification from the chippers.

(b) Accurate proportioning of different raw-materials is best done by installing separate chip silos provided with either table feeders or para-screw type feeding arrangement.

3. Digestion:

(a) For mixed cooking a two-stage steaming cycle is preferable to a straight-to-top temperature cycle.

(b) For batch digesters liquor circulation is a must.

(c) Continuous pulping with a Kamyr type digester with hi-heat system is advantageous because of more uniform cooking and cold blow which retains the inherent fibre strength in the pulp.

(d) Rapid pulping methods by the sulphate process as carried out in a Pandia continuous digester yield an inferior pulp. More investigation should be conducted to find out the effect of chip size for any rapid pulping process for minimising pulp deterioration.

(e) Mixed hardwoods are more suitable for production of high yield pulp by the NSSC and CCS processes. Hardwood semi-chemical pulps can replace kraft pulp in production of kraft liner and corrugating medium and chemical pulp in production of newsprint paper.

(f) In manufacturing CCS pulp from mixed hardwoods it is preferable to impregnate the chips with cooking liquor under pressure. Pressure impregnation reduces the power consumption and shives content of the pulp. This would be very much desirable for high yield pulping of hardwoods with differing densities and low moisture content.

4. Stock Preparation:

(a) Short and thick walled hardwood fibres are best refined in disc refiners at moderately high consistencies. Use of refiners with lava stone bars (e.g. Strecker Refiner) is also advocated.

(b) Use of starch or its substitute for reducing the fines deposits on the presses has been useful.

5. Paper Machines:

A future paper machine to be run with hardwood pulp mixture should have the following equipments and arrangements:

(a) Drainage foils and plastic wire in the wet part for more gradual drainage of the stock with better formation.

(b) Arrangements of chemical cleaning for the suction couch roll and suction press felt.

(c) Suction pick-up arrangement for transfer of wet web from the wire to the press part.

(d) Press angle take-off control system to control the take-off angle at the press in order to reduce the paper breaks initiated by the press section. This is essential for high speed paper machines. Similarly web tension control is also desirable.

(e) Size press to eliminate the vessel picking problem associated with hardwood pulps. This is essential to improve the surface properties of all printing papers.

6. Cold Recovery:

(a) In order to arrest from the black liquor the fibre fines originating from hardwood vessels a Kalone type filter with barometric leg or a Porr Oliver DM Screen, should be incorporated before the liquor is fed to the evaporators.

(b) A five-effect or six-effect multiple evaporator is generally used for black liquor concentration. An extra body is incorporated in the evaporator system to take care of the down-time of any body for tubes cleaning.

(c) Hardwood black liquor should be stored in closed tanks provided with agitators to take care of its sensitiveness to aging.

Final concentration of black liquor can be carried out by flash evaporation rather than in a disc or cyclone evaporator.

Conclusion:

In utilizing mixed hardwoods the strength and quality aspects of paper made from such furnish are of less importance in India. The upper most consideration is at present the economic aspect of manufacturing the paper. One of the main factors contributing to the total production cost of paper is the maintenance, repair and replacement of spare parts or equipments, some of which have to be imported. Another factor is the smooth running of the paper machine resulting in higher machine productivity. Costs of wires and felts which are mostly imported constitute not so less important an item.

In order to encourage increasing use of hardwoods in the existing pulp mills the specifications of strength properties of various grades of paper should be made less rigid so that market acceptability and co-operation are ensured.

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CASE HISTORY I

Production Capacity .....100 tons/day
Pulping Process .....Sulphate
Papers made .....Bleached Printing, Writing and Pulp Boards

This mill has a Kamyr continuous digester with hi-heat diffusion washing system with a capacity of 100 tons of unbleached pulp. It uses a mixture of 60% bamboo and 40% mixed hardwoods. Of the total quantity of mixed hardwoods 70% Sal (Shorea robusta) and 30% of a mixture of the following:

1. Bute Monosperma
2. Anthocephalus Cadamba
3. Pterocarpus Marsupium
4. Anogeissus latifolia
5. Pterocarpus Marsupium
6. Soymida febrifuga
7. Diospyros Melanoxylon
8. Lagerstroemia Sp.
9. Sacopetalum Sp.

The logs of hardwoods are of 3" to 9 feet in diameter and two feet to twelve in length. The logs are cut into suitable sizes in a saw-mill before feeding them to chippers. There are three five-knives Wigger and three six knives Voith chippers of 150 and 135 h.p. motors. A vibrating screen removes the fines and over-sizes. The later are fed to rechippers. Accepted chips of bamboo and mixed hardwoods are stored in silos side by side separated by walls. At the bottom of chip silo, para screws are provided to take measured quantities of bamboo chips and mixed hardwood chips. The proportion of bamboo and mixed hardwood chips are easily controlled by adjusting the revolutions (R.P.M.) of the individual para-screws. A strong magnet removes any metalic pieces from the chips. The mixed chips are transported to a hopper. A chip weightometer is provided to control the feed rate of the chips to the digester. The mixed hardwoods had the following chips analysis:

	% by weight
Passing through 1½" mesh and retained on 1" mesh	18.0
Between 1" and 3/4" mesh	25.0
Between 3/4" and 1/2" mesh	29.0
Between 1/2" and 3/8" mesh	16.0
Between 3/8" and 1/4" mesh	13.0

The chips go first into a low pressure fedder and then to the steaming vessel, where they are heated by steam from the first stage flash tank and fresh steam of 1.5 kg/cm^2 (125°). The steaming of chips helps to remove air and gases as well as to have a uniform moisture of chips. The chips then fall into a chip chute where a constant liquor level is maintained. The chips are drawn into a high pressure feeder which feeds the chip to the top of the digester. A separator at the top of the digester moves the chips downwards and keeps the inside screen clean. Liquor is drawn through the screens and recirculated back through the recirculation pump and pressure feeder. White liquor and black liquor are added to the digester in the impregnation zone. The cooking zone is divided into upper and lower zone. In the cooking zones liquor is drawn through the screens and then passed through the heat exchanger and fed back to the centre of the digester at a point just above the strainer plate.

By addition of wash liquor into the centre of the digester just above the extraction plates the cooking process is stopped. Weak wash liquor from the filter washers is introduced into the bottom of the digester thereby ensuing cold blow. The counter-current flow of liquor and pulp ensures proper washing.

The pulp is discharged into blow tank from where it goes for a hot screening (Jönsson from Knotter). There is a single brown stock filter. Rejects from the Knotter is used for repulping. The washed unbleached pulp is stored in a pulp chest and then processed in a C/E/H/H. multi-stage bleaching plant.

Cooking conditions in the Kamyr digester are as follows:

Impregnation time	30 mins.
Cooking time	60 mins.
Hi-heating washing	30 mins.
Cooking temp.	165°C

During the initial stage of operation the impregnation temperature was 165°C. There was a good amount of rejects and shives in the unbleached pulp, which originated mostly from mixed hardwoods. At present the impregnation temperature is 125°C. Cooking chemicals as active alkali are 15.0% Na2O on air dry chips (12% moisture). The K.No. of unbleached pulp 18 to 19. By maintaining the impregnation temp. at 125°C, penetration of cooking liquor into the chips is improved and the resultant pulp shows lower amount of rejects and shives.

By increasing the amount of active alkali the yield was reduced. The impregnation temperature does not seem to have much effect on the physical strength properties of pulp.

This mill has got six paper machines making different grades of paper. There is a plant for making rag pulp which is used for admixture with the main pulp to make better grades of paper in some of the machines. This mill has a high speed paper machine (maximum speed 480 m/min.). The stock preparation for this machine has hydrating and cutting refiners. This machine is provided with a size press. The printability of the finished paper is quite good. Sometimes IBM tag board and other pulp boards are also made from this pulp.

CASE HISTORY II

Paper production	60 tons/day
Pulping process	Sulphate
Types of paper made	Unbleached kraft and wrapping papers, bleached writing and printing paper and boards.

This mill has a Pandia Continuous digester and had provisions for cooking bamboo and bagasse. Due to shortage of bagasse and some operational difficulties in using bagasse pulp the mill was compelled to use the following hardwoods in admixture with bamboo:

1. Erythrina Suberosa (Dadup)
2. Acacia Arabica (Wattle)
3. Pararubber Hevea Brazeleenes (Rubber wood)
4. Eucalyptus Globulus (Blue gum)
5. Hybrid (Eucalyptus)
6. Albecia Lebec (Albesia)

Chipping of bamboo and mixed hardwoods is carried out in two summer chippers and one KMW chipper. Chips are screened, over-sizes are recycled through a Jaffrey Rechipper. The chips have the following classification:

	% by weight
Retained on 2" mesh	13.0
Passing through 2" and on 1" mesh	16.0
Passing through 1" and on ½" mesh	52.0
Passing through ½" and on ¼" mesh	16.0
Passing through ¼" and on 1/8" mesh	2.0
Fines and dust	1.0

Cooking of the mixture of bamboo and mixed hardwood chips is carried out in Pandia Continuous digester at 9.5 kg/cm2 (140 psi) with a cooking time of 32 minutes. The percentage of mixed hardwoods in the chip mixture is up to 25%. 15% of active alkali as Na_2O is given on O.D. weight of chips. The permanganate No. of pulp is maintained about 18 - 20. Cooked pulp is continuously blown through a discharger to a blow tank and washed in a series of three brown stock washers (D.O. vacuum filters). Screening of pulp was done through three primary centri-screend with one secondary screen for handling the rejects from primary screens. The accepted pulp from the primary screens is processed through a set of centri-cleaners, thickened and stored. Since the amount of rejects has increased, a tailing screen has been added to recover the tailings for use back in the digester.

The usual bleaching system - consists of C/H/H. There is a 4th Hypochlorite stage for bleaching to higher brightness.

Pulp obtained from the rapid continuous digester probably contains certain colouring matters which need oxidation rather than alkali extraction. Alkali extraction produces a dark colour without reducing the permanganate number of the chlorinated pulp. These pulps contain substances which are most probably something other than lignin. This mill prefers the C/H/H sequence with caustic buffer in the hypochlorite stages. The pulp brightness is maintained between 65 - 70%. Increase of sulfidity from 18 - 25% increases the bleachability of pulp.

The wattle wood gives a comperatively denser pulp. The use of rubber wood is limited due to pitch problem in the paper machines.

CASE HISTORY III

Paper production capacity	65 tons/day
Pulping process	Sulphate
Types of paper made	Unbleached kraft and wrapping paper; bleached writing and printing papers (from Sabai grass).

This mill has batch vertical digesters making unbleached kraft and wrapping papers. The raw-material constitute 50% of pine and 50% mixed hardwoods for manufacture of kraft paper. This mill was previously cooking hardwood and soft-wood together fully knowing that cooking these two species of wood with different morphological structure and chemical composition are unscientific. The cooking of a heterogeneous mixture of chips resulted in over-cooking of one component and undercooking of the other component. The resulting pulp was non-uniform and contained a large percentage of screenings. This mill has switched over to separate cooking of pine and mixed hardwoods. The individual pulps are refined separately to the desired freeness and mixed in the machine chest before the final refiner. This mill is known for making a good quality of kraft pulp.

The cooking conditions for pine and mixed hardwoods are as follows:

	Pine Wood	Mixed Hardwoods
	%	%
Chemicals, Na2O as act. alkali	18	20
Time to maximum temperature, min.	60	90
Time at maximum temperature, min.	120	90
Maximum temperature °C	170	165
% Sulphidity of cooking liquor	20	20
Permanganate No. of pulp.	22 - 24	18 - 20

CASE HISTORY IV

Production capacity	200 tons/day
Pulping process	Sulphate
Types of paper made	Unbleached kraft, writing, printing, bleached and unbleached multiply boards

This mill has batch vertical digesters. For the last four years it has been using increasing quantities of mixed hardwoods. The mixed hardwoods contain the following species:

1.	Shorea robusta	(Sal)
2.	Terminalia Tomentosa	(Sahaj)
3.	Cleistanthees Collinus	(Karala)
4.	Pterocarpus Marsupium	(Bija)
5.	Tectona Grandis	(Teak)
6.	Boswellia Serr	(Salai)
7.	Salmalia Malabarica	(Semul)

Most of the hardwoods obtained in this mill are in form of scantlings from the saw mills and off-cuts, twisted stumps, roots and crooked bolts. The average percentage of moisture of hardwoods is 15 to 40%. Some of these woods also come in form of logs which are cut to small pieces by band saw machines before feeding to the chippers. There are a number of chippers reserved for chipping of mixed hard-woods. These chippers are of Voith and KMW type. For the chipping of mixed hardwoods a few adjustments of the clearance between knife and disc are made. For chipping of bamboo Voith, KMW and Jigger chippers are used. Chipping of bamboo

in Kiger chipper is most efficient. The chips of bamboo and mixed hard-woods go to the same beltconveyor and screened together and sent for storage in the chip silos. The over sizes of the chip mixture are fed to a set of crushers. These crushed over sizes are chipped in a small rotary multi-knife disc type chipper of Voith design. The chips obtained from over-sizes go to a separate silo from where it is fed to the digesters only for kraft pulping.

The accepted chips from main chip flow are used for pulping of kraft pulp. The pulping conditions are as follows:

A.A. as Na_2O	11.5 % (O.D. chips basis)
Liquor to chip ratio	3.5 : 1
First steaming up to	135°C - 1 hour
at	135°C - 1 hour
Second steaming up to	165°C - 1 hour
at top pressure	- 1 hour

Direct heating is used all through-out the cooking cycle. Permanganate No. of pulp is maintained at 22 ± 1.

The pulp is blown to a blow tank. After hot screening on Johnson screens it is washed in a series of three rotary vacuum filters, then screened in Trimby screens, passed through a sand trap and finally cleaned in a series of centri-cleaner units. The cleaned pulp free from shives and screenings is stored in a pulp chest. Beating is done in a number of batch type hollander beaters followed by Jordan refiners. Usually for making ordinary kraft paper for use in the corrugating industry the ratio of bamboo to hardwood chips is maintained at 70 to 30. For making unbleached wrapping papers of 30 to 50 gms/m2 the proportion of mixed hardwoods is increased to a maximum of 60%. However, in order to make a pulp of 60% hardwood and 40% bamboo the mixed hardwood is cooked in separate digesters using the same cooking conditions as for mixed chips. The pulp of mixed hardwoods is blown to a separate blow tank and processed separately for washing and screening. The screened pulp is stored in a separate chest. There are two refiners (stock-makers) for beating this pulp only. The partially refined pulp is stored in a pulp chest. The partly beaten pulp is mixed with the main beaten pulp in the intermediate pulp chest. By this way the main pulp flow consisting of hardwoods to a maximum of 30% is maintained for the other machines. This flexibility of operation is possible when a separate flow line is maintained. This flow line is also used processing pine pulp which is used in the pulp furnish of some of the comparatively stronger kraft pulp. Due to acute shortage of bamboo during a few months in this mill, mixed hardwoods and bamboo in the ratio of 30 to 20 have also been used. Although the strength properties were adequate the runnability of the paper machine with such high percentage of hardwoods was not satisfactory.

For bleachable grades, mixed hardwoods are generally not used in this mill. Only a few selected varieties of hardwoods of lighter density have been used up to a maximum of 15%. The reason for this limitation is the low folding strength of the bleached hardwood pulps. Besides, the absence of ise presse in the machines making bleached grades of paper and board does not allow use of dense hardwoods due to their inherent property of possessing fluffiness.

Salmalia Malabarica (Semul), which has a low density and favourable cell wall/lumen diameter ratio is used along with bamboo for making bleached grades of paper. Semul pulp can be easily bleached and requires light load during beating. It has also higher folding strength, which makes it suitable for bleached grades of writing and printing paper.

The cooking conditions for bleachable pulp are:

Chemicals as Na2O Active Alkali		17
First steaming:	Time to 135°C, Min.	60
	Time at 135°C, Min.	60
First steaming:	Time to 165°C, Min.	60
	Time at 165°C, Min.	30
% Sulphidity in cooking liquor		20
Chips to liquor ratio		1:3.5
Heating - Direct Steaming		
permanganate no. of pulps		15±1

Bleaching is carried out in 4 stages of C/D/E/D sequence to get a pulp brightness of 78%.

CASE HISTORY V

Production capacity	210 tons/day
Pulping process	Sulphate
Type of paper made	Wire paper (writing and printing) unbleached kraft paper.

This mill has a single high speed paper machine running at a maximum speed 600 m/min. 10 to 15% mixed hardwoods in admixture with bamboo are used for pulping. The mixed hardwoods mainly consist of

1. Dalbergia sissoo (Salai)
2. Shorea robusta (Sal)
3. Terminalia tomentosa (Saj)

Chipping of bamboo is done in 3 drummer chippers. Hardwoods are chipped in two disc chippers. The hardwood chips mix with the bamboo chips in the main chip belt conveyor and the whole mixture is screened in vibratory and rotary screens. The proportioning of bamboo and mixed hardwood chips is controlled roughly by the ratio of number of chippers for bamboo and hardwoods. The chips classification are as follows:

	% by weight
Above 1" length	7.0
Above 1/2" and below 1"	40.0
Above 1/8" and below 1/2"	50.0
Below 1/8"	2.5

Chips are washed before they are stored in the chip silo. They are then blown to modern batch vertical digesters. The cooking conditions for both bleachable and unbleached kraft pulp are same and are as follows:

Chemicals, Na2O active alkali	13.5
First steaming: (indirect)	
Time to 135°C, min.	120
Time at 135°C, min.	60
Second steaming: (direct)	
Time to 170°C, min.	60
Time at 170°C, min.	15

The modern digesters, each of 150 m^3 capacity, are well instrumented and the cooking cycle controlled very accurately.

Pulp washing system consists of 3 Kamyr filters. Rejects (unbroken chips) are removed by a Sunar knotter before brown stock washers. The screening system consists of two-stage centrifugal screens and the screened pulp finally cleaned in a 3-stage Bird centri-cleaners and then thickened and stored in a pulp chest.

The bleaching system consists of three stages with C/D/E sequence. The pulp brightness is maintained at +60. Beating is carried out in two stages, first with three Jones Majestic Lava refiners (hydrating) and later with two Jones Majestic refiners with 8 mm. bars. The machine is run with pressurised head-box and suction pick-up arrangement.

This machine is first of its kind to be run on bamboo pulp at such a high speed. Initially there were frequent breaks and fine deposits in the second and third presses. It was difficult to run with low basis weight and high speed. Addition of starch in stock preparation system almost eliminated the pick-up problem.

Addition of mixed hardwoods was supposed to cause certain deposits inside the head box which creates certain fluctuations in the head-box pressure. The quantity of hardwoods was limited initially only to 5% of the total chips. After experiencing these difficulties it was proposed to go for higher percentage of hardwoods. The average percentage of hardwoods used now are 10 and 15% for bleached and unbleached grade of papers respectively.

CASE HISTORY VI

Production capacity	210 tons/day
Pulping process	Ground-wood, sulphate and cold caustic soda (CCS)
Type of paper made	Newsprint

This mill was using 60% of mechanical pulp from Dendrocalamus Strictus (Bamboo) and 40% kraft pulp from Dendrocalamus Strictus (Bamboo). The mill has been expanded from 30,000 to 75,000 tons/year. It shall now use a furnish of mechanical and cold caustic soda (CCS) pulp from Salai and other hardwoods and chemical pulp from bamboo. The types of hardwood species used for CCS pulping unit are:

1. Acacia Auriculiformis
2. Albizzia procera
3. Cassia Siamia
4. Diospyros Melonoxylen
5. Melia Azedarch
6. Pithecolobium Saman
7. Poinciana Regia
8. Terminalia Arjuna
9. Terminalia Tomentosa

CCS pulp could provide 1/3 of the total furnish.

Debarked freshly cut logs are fed to a spiral chipper to cut to a chip size of 25 mm. width and 5 mm. thickness. Chip screening and re-chippers have been omitted. Chips are pneumatically conveyed to either the storage bin or directly to the rotary spherical digesters. For impregnation 4 to 5% NaOH solution at high pressure will be given in the digesters. Ring type screens are fitted inside digesters to remove excess liquor after impregnation. There is a live bottom bin to collect the treated chips from where chips are conveyed at a constant rate to the disc refiners through a distribution and metering device. Chips are refined in two stages. There are two primary refiners and two secondary refiners.

After washing in a rotary vacuum filter the refined pulp is screened by centrifugal screens and finally cleaned by a 3-stage centri-cleaning system. The pulp is then bleached with Calcium hypochlorite in towers. Bleached pulp is then processed in the central stock preparation separately.

CASE HISTORY VII

Production capacity	100 tons/day
Pulping process	Kraft and cold caustic soda (CCS)
Type of paper made	Unbleached kraft, printing and writing paper

This mill which has a capacity of 100 tons/day uses bamboo for the kraft pulping system and mixed hardwood for the cold caustic soda (CCS) pulping system. The cold caustic soda semi-chemical pulping plant has a capacity of 35 tons pulp per day. The basic equipments are supplied by Sprout Waldron and Co., Inc., USA, the raw-materials used are -

1. Boswellia Serrata
2. Adina Cordifolia
3. Mangifera Indica
4. Bombax Malbaricum
5. Xanea Grandis
6. Casuarina

Debarked wood is chipped in conventional disc chippers to 15 to 25 mm. chips size and stored in chip silo. Chips are metered by rotary table feeder and by means of a pneumatic conveyor fed to a S.H. fractionator where about 20% caustic lye is given. The match stick size chips from the fractionator go to a soaking bin which works as a continuous impregnation vessel. Further caustic lye is added to the soaking bin along with chips. The following are the condition for impregnation.

NaOH on O.D. chips	6%
Chips to liquor ratio	1:5
Retention time	1 to 2 hours
Temp.	Ambient temp. (30-45°C)

Impregnated chips at a consistency of 4 to 5% are conveyed by means of a pump to a stainless steel rotary drainer from where they come out at 15% consistency and defibred by means of a single disc refiner. The stock is deluted to 5% consistency and further refined in a twin flow pressurised refiner to 25 to 35°SR. The pulp is then washed in a vacuum filter and processed through a centrifugal screen. The screened pulp is thickened and stored.

The mill has used this CCS pulp in the manufacture of duplex liner board by means of a secondary head-box on the F.G. Machine.

TABLE 2

Distribution of Hardwood Species Occurring more Frequently

Name of species	% volume to the total volume
Terminalia tomentosa	13.1
Shorea robusta	11.0
Anogeissus latifolia	10.6
Diospyros melanoxylon	8.0
Madhuca latifolia	5.8
Cleistanthus collinus	5.7
Tectona grandis	5.0
Pterocarpus marsupium	4.8
Boswellia serrata	2.9
Lagerstroemia parviflora	2.8
Xylia Xylocarpa	2.3
Syzigium cumini	1.7
Buchanania lanzon and latifolia and angustifolia	1.7
Lannea grandis	1.6
Terminalia chebula	1.4
Schleichera trijuga and oleosa	1.4
Dalbergia paniculata	1.2
Emblica officinalis	1.1
Schrebera swietenioides	1.1
Other species having less than 1% volume to the total	19.2
Total	100.0

TABLE 3

State-wise Distribution of Forests under Broad-leaved Woods

Name of state	Forests under broad-leaved woods (area in sq. miles)	% forests under broad-leaved woods
1. Andhra Pradesh	26324	100.0
2. Assam, excluding NEFA	17429	99.9
3. NEFA	16773	100.0
4. Bihar	12936	100.0
5. Gujarat	6607	100.0
6. Maharashtra	25313	100.0
7. Jammu and Kashmir	7963	71.9
8. Kerala	4060	100.0
9. Madhya Pradesh	70431	100.0
10. Madras	6254	100.0
11. Mysore	13374	100.0
12. Orissa	25335	100.0
13. Punjab	3770	68.4
14. Rajasthan	16790	100.0
15. Uttar Pradesh	20080	89.9
16. West Bengal	4702	97.3
17. Andaman and Nicobar	8500	100.0
18. Himachal Pradesh	1901	36.9
19. Manipur	1975	84.9
20. Tripura	2438	100.0
Total for India	328648	96.6

Table 5

Proximate Chemical Analysis of Fibrous Raw-materials (% on oven dry basis)

Species	Ash (%)	Cold water sol. (%)	Hot water sol. (%)	1% NaOH solubility (%)	Alcohol-benzene Sol. (%)	Ether sol. (%)	Pentosans (%)	Lignin (%)	α and β Cellulose (%)
1. Dendrocalamus Strictus (Bamboo)	2.35	3.29	6.19	21.35	3.13	0.23	15.06	27.85	59.71
2. Hardwoods:									
i) Shorea Robusta (Sal.)	1.00	5.20	7.10	18.40	6.00	1.20	13.40	24.30	56.00
ii) Boswellia Serrata (Salai)	1.30	6.30	8.30	15.30	4.35	0.70	13.00	27.30	50.70
iii) Eucalyptus Hybrid (Eucalyptus)	0.44	0.62	2.10	13.40	6.30	---	15.10	30.80	53.41
iv) Albizzia Lebbek (Siris)	0.72	3.13	6.16	20.38	4.12	1.75	17.00	22.30	52.47
v) Casuarina Equisetifolia (Casuarina)	0.80	3.30	6.50	21.70	3.40	2.30	19.20	23.20	56.70
vi) Anthocephalus Cadamba (Kadam)	1.27	3.42	5.31	19.77	2.32	1.00	15.55	23.03	59.82
vii) Dalbergia Sissoo (Sissoo)	1.07	5.34	5.92	16.77	2.31	1.35	14.93	24.20	54.26
viii) Leucaena Granitis	1.60	3.31	6.53	18.34	1.53	1.16	15.40	26.11	53.27
ix) Sterculia campanulata	1.01	1.47	2.53	17.94	1.46	1.30	15.51	23.83	59.50
x) Trewia nudiflora Pagyrifera	1.08	4.20	7.33	17.96	1.98	0.99	16.43	23.26	59.13
xi) Heliotropes Isora	1.68	6.13	6.47	19.15	5.63	0.43	16.00	13.60	51.40
3. Pinus Longifolia (twisted chir)	0.25	1.62	3.36	13.13	2.15	3.41	7.29	23.56	53.46

TABLE 6

Proximate Chemical Analysis of Different Hard-woods

Kind of wood	Specific Gravity	Alc and Benz solubility (%)	Ash free Lignin (%)
B. Stricta (Bamboo)	0.60	3.13	27.85
Shorea Robusta (Sal)	0.68	6.00	24.30
Boswellia Serrata (Salai)	0.46	4.30	27.30
Salmalia Malabarica (Semul) (round - pcs)	0.37	4.50	23.34
(Planks)	0.39	3.20	27.22
Eucalyptus Hybrida	0.71	6.80	30.20
Tectona Grandis (Teak)	0.64	7.40	29.10
Terminalia Tomentosa (Saja)	0.72	10.30	27.40
Diospyros Tomentosa (Semlu)	0.61	-.-	-.-
(Kokbot)	0.42	3.60	30.70
Gmelina Arborea (Gambhari)	0.43	4.30	-.-

TABLE 7

Laboratory Pulping of Hardwoods and Strength Properties of their Pulp

Name of woods	Alkali added A.A. as Na2O (%)	Wood liquor ratio	Screened yield	Pulp Quality: K. No. 25c.c.	Pulp Ash (%)	Physical Strength Properties: Jokro Mill Beating time (mins)	Freeness CSF	Br.length (Meters)	Burst factor	Tear factor	Double fold
Sal	18	1:3	40.6	21.37	3.4	30	37	3311	25.0	83.0	10
Eucalyptus	18	1:3	---	19.90	1.9	14	35	4507	35.06	69.0	43
Semul	18	1:5	43.7	19.22	2.9	7.5	37	3623	35.6	71.0	35
Kokhat	18	1:5.5	41.0	22.2	3.0	5	36	3237	19.3	54.0	3
Gambhari	16	1:5	46.0	19.3	2.0	8	29	3851	52.7	66.0	451
Bamboo	15	1:3.5	41.8	21.0	---	27	36	6070	45.5	119.0	86

TABLE 8

Strength Properties of Nigerian Hardwoods Pulps (Pilot Plant Trials)

Unbleached Pulp:	Gmelina	P. Superba	Mixture (1:1)
Unbeaten Freeness °SR	16.5	16.0	16.0
Beating Time, min	23.0	23.0	23.0
Beaten Pulp Freeness °SR	52.0	42.0	47.0
Breaking Length, Km.	7.30	8.25	8.33
Burst Factor	55.4	74.4	75.2
Tear Factor	79.4	83.2	80.0
Double Folds (M.I.T.)	602.0	1333.0	1120.0
Bleached Pulp (C/C/H):			
P.No. of Pulp	21.6	21.0	21.3
Pulp Brightness	82.8	82.2	80.7
Beating Time, min.	32.0	30.0	35.0
Pulp Freeness, °SR	44.0	44.0	44.0
Breaking Length, Km.	5.72	5.4	4.9
Burst Factor	43.4	47.2	57.3
Tear Factor	64.0	47.0	58.4
Double Folds (M.I.T.)	26.0	80.0	68.0

CASE HISTORY VIII (est Africa) Pilot Plant trials only.

In a paper mill in Nigeria, the author, in consulting capacity, had undertaken studies of possibilities of utilizing various indigenous hardwoods for pulp and paper making. This mill had a full fledged pilot plant for pulping trials with a capacity of 1 ton a day.

The Tropical Products Institute of England and the Forest Research Institute of Nigeria have studied a number of West African hardwoods to assess their suitability for pulping. The only paper mill in Nigeria situated in Kwara State is 200 miles off from the coast and hence the cost of imported pulp is too high for economic use in the mill. Hence two major hardwoods, which are available near the paper mills and best suited for pulping trials were selected and pilot plant trials conducted.

Gmelina arborea is native of South Eastern Asia but has been planted and grown in Nigeria and other parts of West Africa for many years where it is widely used as fire wood. Its fibre length is 1.11 mm.

Another species is Terminalia Superba, which is native of West Africa. The laboratory pulping trials indicated that a good quality of paper can be made from these two species in Nigeria ranges of 95%.

The fibre dimensions are as follows:

	Gmelina	T. Superba
Fibre length, mm.	1.01	1.13
Fibre diameter, mm.	0.0270	0.0341
Cell wall thickness, mm.	0.003	0.00465
Lumen diameter, mm.	0.02	0.0250
Density (% moisture)	0.48	0.61

Freshly cut logs of Terminalia Superba and Gmelina with a moisture content of 50% are cut in a rotary disc chipper to 25 mm size chip length and screened in a two-deck vibratory screen. The accepted chips are charged in a tumbling digester with a capacity of 4 m^3 and tumbling speed of 1.32 RPM. The cooking conditions for the individual woods are as follows:

Kraft Cooking Conditions

	Gmelina	T. Superba	Mixture
% Active alkali, Na2O	15	15	15
Maximum Temp. °C	168	168	168
Time to reach max. temp., min.	60	60	60
Time at max. temp., min.	120	120	120
% Sulphidity of white liquor	25	25	25
Chips to liquor ratio	1:3.5	1:3.5	1:3.5

The pulp is blown at the end of digestion to a digester pit, which is also used for washing the pulp. The pit is equipped with an intermediate floor of perforated screen plates to dewater the pulp. It is then screened in a Johnson vibrating screen and a Biffar centrifugal screen and finally washed in a rotary vacuum filter. The screened pulp is further cleaned in a three-stage centri-cleaner system and finally wet laps are made in a deaerating filter, with press rolls. The continuous pulp sheet is further dewatered by a pulp press consisting of two superposed pressing rolls. The felt and the sheet lying on it are lead through rollers and are moved on to a reeling machine.

The tests on pulps of the individual chips as well as a mixture of equal proportions of both are given in Table (6).

About six tons of pulp were made and processed in mill scale trial in the refiners as well as the paper machine with a capacity of 40 tons paper production per day. During the mill trial of about three hours, only two hours were with the indigenously made pulps.

The pulp showed easy beatability and the machine operations did not show any anormal results. The pulps are beaten to about 400CSR in a set of two conical refiners. The trial showed that these hardwoods are quite suitable for pulp and paper making for bleached and unbleached grades. Although the fibre length of the woods were short they showed excellent strength properties except the tear resistance.

General Impressions of Pulp and Paper Industry in Australia and Japan.

The author had recently been on a study tour of pulp and paper industries in the above two countries. Some of the general observations have been noted below:

Australia:

The existing pulp mills in Australia are utilizing only a part of the pulp wood resources of the country. At present six mills are pulping eucalyptus.

(a) Australian Paper Manufacturers, Maryvale, Victoria - Kraft and NSSC pulp.

(b) Associated Pulp and Paper Mills, Burnie, Tasmania - Soda and CCS pulp.

(c) Australian Newsprint Mills, Boyer, Tasmania - Groundwood, chemi-ground wood and CCS pulp.

(d) A.P.M. Port Huon, Tasmania - NSSC pulp.

(e) A.P.P.M., Wesley Vale, Tasmania - CCS pulp.

(f) SCI, Victoria - NSSC and CCS pulp.

The eucalypt and acacia species used for pulping by various companies are as follows:

APM., Maryvale - E.regnans, E. Capitellata, E. obliqua, E.eugenioides, E. muelleriana, E.consideniana, E.sieberi, E. fastigata, E.delegatensis, E. viminalis, E. Baliata, E.brigesiana, and E.cypellocarpa.

APM., Port Huon- E.obliqua, E.regnans with minor amounts of E.globulus, acacia dealbata and E.delegatensis.

APPM.: E. delegatensis, E.obliqua, E.viminalis, E.amygdalina with minor amounts of E. regnans, E.Ovata, and Acacia dealbata.

APM. E.regnans, E.obliqua, E.delgatensis

Smorgons: E.regnans with minor amounts of E.obliqua, E.delegatensis, E.sieberi.

Papers in which these pulps find use in substantial quantities are - writing paper, printing paper, liner boards, corrugating medium, wrapping paper and newsprint.

Within a range of Eucalyptus pulp yield is found to decline with increasing basic density. 4 - 6 older wood of a species of an individual tree has higher density than young wood.

Hence Australian pulp makers have been extremely choosy about the use of various eucalyptus differing in density. Until very recently they were reluctant to make use of certain varieties of high density and overmatured eucalyptus. The practice in Japan to use all varieties of wood chips imported from Australia has stimulated interest in those species which were previously considered suitable for paper-making.

As in Japan, so also in Australia separate refining of eucalyptus pulp and pine pulp is practised. The common practice in Australia is to beat the hardwood pulp to about 200 to 150 CSF. This is done to get the best strength and surface properties of paper. In order to get good runnability on the paper machine soft wood pulps are added to the furnish, which also improve drainage, wet strength and tearing resistance of paper.

Japan:

The pulp mills in Japan are using a wide variety of raw-materials ranging from domestic hardwoods, red and black pine, spruce, douglas fir, hemlock, eucalyptus, lauan, rubber wood. It is common to find a range of pulping processes in use in the same mill premises and a variety of papers. This diversity in raw-materials, pulping processes and paper products - allows best opportunity for utilisation of mixed pulping, blending of pulps for the appropriate end use. Japan has been forced to use increasing quantities of hardwoods which are pulped by sulfate, NSSC., CCS., methods. In 1950 no hardwood was used as pulp wood in Japan. By 1969 hardwood and softwood were consumed in the ratio of 58 to 42 percent. They have great experience in hardwood pulping and use of hardwood of pulps paper making. In many cases paper is made with 80 to 100 per cent hardwood pulp furnished. The pulp is very lightly beaten to a CSF of 350 to 400 in order that the drainage rate and the runnability for fast machines are not impaired.

Japanese paper industry is reluctant to beat hardwood pulp to a low freeness in order to have good dimention stability of paper.

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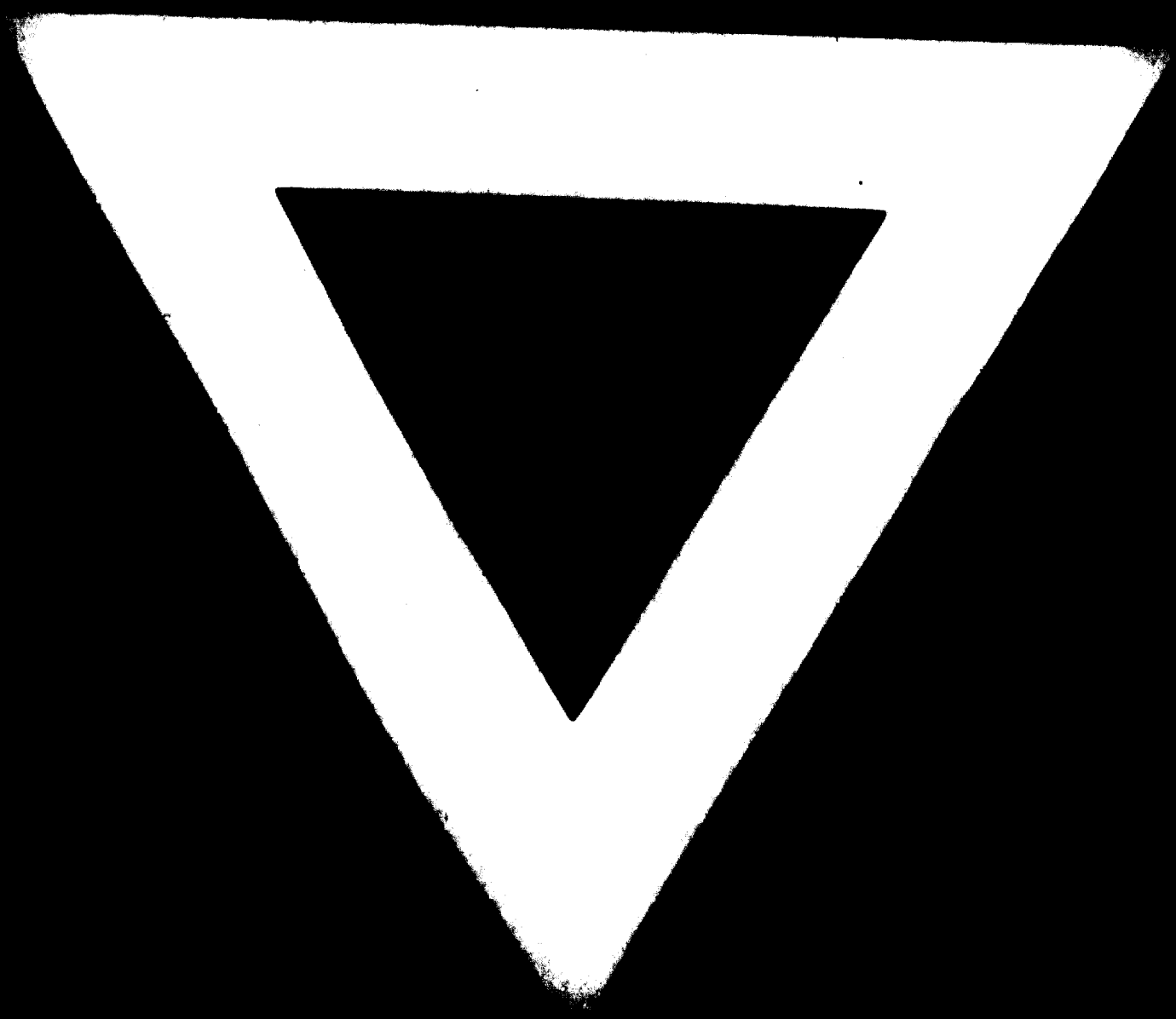

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