THE WOOD AND PULPING PROPERTIES OF CHIR PINE (*Pinus roxburghii* Sarg.) PART III. PILOT SCALE PULPING STUDIES

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Abstract

The laboratory studies of wood and pulping properties of chir pine trees of different age groups were described in the earlier articles in this series. These studies indicated the superiority of 36-45 year old trees for pulp manufacture. Therefore, 200 trees of this age were procured for pilot scale pulping and paper making tests. Approximately 41.5 tons of chir pine wood in green condition was chipped on multiple knife chipper with 0.7, 1.5, 95.0 and 2.8 % production of knots, oversize, acceptable chips and fines respectively. Energy consumption was found to be 9.75 kWh per ton of green wood. Three digesters, each containing 6 tons of wood on oven dry weight basis were cooked. Average screened pulp yield was found to be 46.3 % with a Kappa number of 25. After washing and screening, three stage bleaching of pulp was carried out by chlorination, alkali extraction and hypochlorite bleach. Facilities for the fourth stage were not available and therefore, a low pulp brightness of 75 ^{o}G E was attained. The bleached supphate pulp was evaluated in the form of mixed furnish for the manufacture of different grades of paper and paperboard and its quality was compared with imported long fibre pulp used for the same purpose. The strength properties of paper and board containing chir pine pulp in the mixed furnish were comparable to that which had imported long fiber pulp. However, folding endurance and breaking length were lower in the former than the latter.

Introduction

The natural range of distribution of chir pine (***Pinus roxburghii Sarg.***), its growth habit and wood and pulping properties were described in Part I and II of this series (1,2). The laboratory studies on wood and pulping properties of chir pine were carried out on trees from Batrasi Reserved Forest of Siran Forest Division. These studies indicated that trees of 36-45 year age were superior as compared to trees of other age groups. Therefore, pilot scale pulping studies were carried out on trees of this age group and 200 trees were procured from compartment 1 (i) of Baz Khan Reserved Forest of Siran Division. The tree growth conditions in Baz Khan Forest are almost indentical to those in Batrasi Reserved Forest from where wood samples for laboratory tests were obtained. This paper presents results of pilot scale pulping studies of chir pine wood.

Material and Methods

General

Only dominant and co-dominant trees were selected for pilot scale studies. The trees were felled at ground level after putting breast height (1.5 m or 4.5 ft) mark on them. They

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were converted into billets and brought to the Pakistan Forest Institute, Peshawar in January 1981. Debarking with hand debarkers and sawing of billets into suitable sizes (12x12x1.5 cm) were done at the Institute. Subsequently, about 41.5 tons of debarked and sawn chir pine wood in green condition was transported to Adamjee Paper and Board Mills, Nowshera, for pilot scale studies.

Chipping

Chipping was done on a Swedish KMW Chipper type HH - 220 - S of 1000 r.p m. using four knives . Wood was fed manually in the chipper. Chips were screened on an inclined shaking platform of 3.4 m x 1.5 m size at 105 rpm. The openings in the sieve fitted on the platform were 1 cm. square in size. The chips retained on the screen consisted of two fractions (acceptable size and oversize). Oversize chips including knots were separated fron the acceptable chips by hand picking. The chips which passed through the sieve were taken as fines.

Later on, 1 cm square opening sieve was replaced by that with 0.5 cm square opeining and the fines were rescreened on it to recover all usable chips. The size of acceptable chips for pulping was 25–30 mm in length and 3–5 mm in thickness.

10 representative samples were taken fron each of oversize, accepted chips and fines and the percentage content of each fraction was determined on the basis of oven-dry weight of the original wood. Total chipping time was recorded and energy consumption was computed both on green and over-dry wood basis (kWh/ton).

Pulping

Kraft (Sulphate) pulping was done in a stainless steel, direct steam-heated tumbling type batch digester of 35 m3 capacity, rotating at the rate of one rotation in 2.5 minutes. Green chips equivalent to 6 tons of oven-dry wood weight were charged for each cook. Three digester cooks were carried out under identical cooking conditions which were determined in the laboratory studies (Table 1). Pressure was released twice in each cook, firstly at 110 ^{o}C and then at 150 ^{o}C, each time for one minute. After completion of the cook, the cooked material was blown into a blow tank.

Pulp washing and screening

Pulp washing was carried out on a brown stock washer filter of size 7165 x 2133 mm with 40 holes/cm. The filter had a vacuum of 14 inches of Hg and a washing efficiency of equivalent of one ton oven-dry glass pulp per hour. Due to shortage of water, the required pulp consistancy of 1 to 1.5% could not be maintained. Filter lifted the pulp in patches instead of pulp blanket which resulted into longer washing time than ordinarily needed. Pulp was passed on to a Jonsson screen fitted with a 4 mm perforated plate. Because of high pulp consistancy it could not work efficiently resulting in overflow of th pulp. The pulp was therefore transferred to Finkh fine screen for screening after sufficient dilution. This worked efficiently and screening was completed at this stage. Rejects were collected from the Finkh fine screen and screened pulp was collected in stock chest. Average values of rejects, screening closses and

screened pulp yield were determined for the three cooks through pulp consistancy (average of three determination) and total volume of the pulp stock in the chest.

Bleaching

A three-stage bleaching (chlorination, alkali extraction and hypochlorite bleach) was carried out for each cook under identical bleaching conditions (Table 2). At each stage, bleaching was carried out.

Table 1. Pilot plant pulping conditions for chir pine wood

Sl. No.	Conditions	Cook No. 1	2	3
1.	Active alkali as Na_2O on oven-dry wood, %	18	18	18
2.	Sulphidity as Na_2O, %	25	25	25
3.	Maximum temperature, ^oC	173	173	173
4.	Time to maximum temperature, minutes	100	110	125
5.	Time at maximum temperature, hours	3	4	4
6.	Steam condensate, tonnes	4.6	4.9	5.2
7.	Liquor to wood ratio			
	(i) Initial	3.76:1	3.76:1	3.76:1
	(ii) Final (after steam condensation)	4.5:1	4.6:1	4.6:1
8.	Kappa number of screened pulp	22.9	24.1	27.9
9.	pH of black liquor	10.5	11.0	11.4
10.	Residual active alkali as Na_2O, g/lit.	2.2	18.6	21.7

Table 3. Comparative strength properties of paper produced from chir pine and imported wood pulp

Quality	Wood free writing paper	Wood free writing paper	Wood free writing paper	Wood free typing paper yellow	Wood free typing paper yellow
Standard Grammage g/m^2	58.0	58.0	58.0	42.0	42.0
FURNISH					
Chir pine pulp %	100	15	–	20	–
KAMLOOP (imported) pulp %	–	–	15	–	15
Lickerin pulp %	–	60	60	50	55
Grass pulp %	–	15	15	20	20
Brokes Rejects %	–	10	10	10	10
PROPERTIES					
Grammage g/m^2	58.2	58.6	58.2	42.0	42.5
Thickness microns	82.0	80.0	78	68.5	69.5
Bulk cm^3/g	1.41	1.36	1.34	1.63	1.64
Burst factor	12.5	15.8	14.1	11.4	10.9
Breaking length					
MD metre	3910	4110	4900	4415	4175
CD	2060	2580	2660	2375	2400
Tear factor MD –	42.0	49.4	54.3	64.5	57.0
CD –	47.1	58.0	63.0	68.2	65.7
Folding endurance					
MD D/F	20	9	18	17	13
CD D/F	9	8	9	9	6
Cobb test FS/g/m^2	20	40	18	22	21
WS "	23	45	23	24	25
Porosity – Sec/ 100 ml	73	120	120	68	79
Brightness – ^{o}GE	72.5	71.5	72.5	–	–
Opacity – %	76	78	77	66	67
Ash content – %	8.0	11.5	11.5	9.0	9.5

Values are based on conditioned weight of paper at 23 + 1 ^{o}C temperature and 50+2% relative humidity.

Table 4. Comparative strength properties of M.G. White Duplex Board made from chir pine and KAMLOOP (imported) wood pulps

Quality		Normal Board	Normal Board
Standard grammage	g/m^2	235	235
FURNISH			
Chir pine pulp in T/L	%	25	–
Imported long fibre pulp T/L	%	–	25
Grass pulp in T/L	%	75	75
PROPERTIES			
Grammage	g/m^2	234	245
Thickness	microns	344	349
Bulk	cm^3/g	1.47	1.42
Burst factor	–	18.5	19.4
Breaking length	MD metres	4700	4140
	CD "	2200	2120
Stiffness factor	MD –	187	183
	CD –	79	82
Folding endurance	MD D/F	9	26
	CD "	8	11
Bendtsen roughness	– ml/Sec.	830	995
Cobb test	$- g/m^2$	40	39
Brightness	$- {}^{o}GE$	72.3	72.2
Moisture	– %	6.4	7.0
I. G. T. test	Max. cm/Sec.	56/EX 110	48/EX 110
Picking/Blistering	Min. "	40/EX 110	40/EX 110
	Av. "	46/EX 110	43/EX 110

Values are based on conditioned weight of paper board at 23± 1 ^{o}C temperature and 50 ± 2 % of relative humidity.

Energy Consumption

Energy consumption for chipping 41.54 tons of green chir pine wood was found to be as follows:

Total weight of green wood, tons	=	41.54
Oven-dry weight of wood, tons	=	20.77
Total chipping time, hours	=	6.75
Power of chipper's motor, kWh	=	60
Energy consumption, kWh/ton green wood	=	9.75
Energy consumption, kWh/ton oven-dry wood	=	19.48

For chipping, energy consumption values of about 6-7 kWh/ton solid wood have been reported in the literature (5). The energy values for chir pine in this study are rather high and this may be due to the manual feeding of the wood pieces to the chipper in a discontinuous process and the chipper worked without the feed at intervals. The chipping time was also long for the same rason.

Pulping

Originally it was planned to carry out only two cooks on pilot-scale under pulping conditions found to be suitable for chir pine in the laboratory tests. However, considerable difficulty was faced during pulping of cook No. 1 and in all three cooks were prepared on pilot scale. The pulping and paper making equipment of Adamjee Paper and Board Mills is fairly old and rusty. Different valves and fittings can withstand only mild pupping condition of NSSC process used for pulping of baggasse, grasses and lickerin (cotton waste). The blow valve joint of the digester broke when cook No.1 containing chir pine wood was in progress for three hours at maximum temperature. As a result, the steam valve started leaking and damaged rubber ring of the digester. Therefore, cooking could not be completed and blowing of digester was delayed by 20 hours for cooling. Necessary precautions were taken for cook No. 2 and 3 to avoid break-downs and pulping was done in them on schedule.

As shown in Table 1, both Kappa number and residual active alkali are low in Cook No. 1 as compared to the other two cooks. This is due to long cooling period of the digester during which pulp was over-cooked and chemicals were lost through leakage. Average pulp yield was found to be approximately 46.3% after its screening. The quantity of rejects retained on the screen was negligible e.g. about 0.1 percent.

Bleaching

Only three stage bleaching (chlorination, alkali extraction and hypochlorite bleach) was carried out for each cook in the Mills as facilities were not availavle for the fourth stage bleaching by hypochlorite. The details of bleaching conditions are given in Table 2. The bleached pulp yield was 42.1 % against unbleached pulp yield of 46.3 %. The corresponding

brightness values were 75 and 26°GE respectively. Only small variation was observed in the brightness of pulps from different cooks before and after their bleaching.

It may be mentioned here that the brightness of sulphate pulps of chir pine wood after three stage bleaching was not comparable to that of fully bleached commercial pulps. The commercial pulps are generally bleached in more than three stages. However, present study has shown the bleach demand of chir pine pulp, the problems encountered in its bleaching, and loss in pulp yield and strength properties during bleaching. The results of this study suggest that brightness of 75 °GE of chir pine pulp after three stage bleaching could be further improved to 85 °GE by using more efficient bleaching sequence including Chlorine dioxide e.g. CEHD. In addition, a low PH of 8 was also observed in reaction during hypochlorite bleaching. At this stage, pH 9 is generally maintained by addition of sodium hydroxide. This could not be done at Adamjee Paper and Board Mills. Under the circumstances reduction in strength properties of bleached chir pine pulp and its colour reversion in storage is to be expected. Adequate heating facilities were also not available at the Mills for maintenance of high temperature during bleaching; 60-70 °C and 30-40 °C for alkali and hypochlorite stages respectively.

Pulp evaluation

Bleached sulphate pulp of chir pine was evaluated in the form of mixed furnishes for manufacture of different grades of paper and paper board and its quality was compared with similar products using imported long fibre pulp in identical proportions. One machine run for each of writing and typing (yellow) papers as well as M.G. white duplex board was carried out by blending chir pine pulp with locally made lickerin (cotton waste) and grass pulps. Similar runs were made for imported bleached kraft long fibre wood pulp 'KAMLOOP' from U.S.A. One machine run was also carried out with 100% chir pine pulp for production of writing paper. The composition of pulp furnishes for both paper and board beating data, machine parameters, and solid contents of wet at various stages of production are given in a separate report (6). In general, the runability of chir pine pulp was normal and no difficulty was faced in this regard. Brokes were also normal. Reel was found to be compact and tight. The strength properties of each paper and board type containing chir pine pulp and imported long fibre pulp are compared in Tables 3 and 4.

Writing paper:—The data in Table 3 show that both burst factor and cobb test are higher and breaking length, tear factor and folding endurance are somewhat lower in paper sheet containing chir pine pulp as compared to that which has imported long fibre pulp. However, the reducdtion in breaking length and folding endurance is more pronounced than in tear factor. This may be due to loss in strength properties of chir pine pulp during bleaching at low PH. It is also apparent in sheets made from 100% chir pine pulp in which the stength properties are much lower than those made of mixed furnish containing 15 % chir pine pulp only. In the mixed furnish, lickerin pulp enhances the overall strength properties and grass pulp reduces the bulk and porosity of the sheet.

Typing paper (yellow):—Two types of papers were manufactured; one containing 20% chir pine pulp and another 15% imported long fibre pulp. On comparison of strength properties of these two types of papers (Table 3), it is observed that the former is superior due to a

higher content of long fibre pulp in it than the latter.

P.M.G. White Duplex board:—The surface sizing of the board was carried out with sizing slurry containing starch, leucophor, glycerine and soapstone. Top layer of the board retained 0.645 gm/m^2 of total solids whereas bottom layer retained 1.0 gm/m of total solids. Except for lower folding endurance, board containing chir pine pulp had better or identical strength properties as compared to board containing imported pulp in the furnish. The data are given in Table 4.

Summary and Conclusion

This series of articles present the results of pulp and paper experiments on chir pine from natural forests in Hazara. Detailed analysis of wood and pulp qualit of this species was done at laboratory and pilot scale. Bleached sulphate pulp of chir pine was evaluated in the form of mixed furnishes for the manufacture of different grades of paper and paperboard and their quality was compared in the pilot scale experiments with imported long fibre pulp used in the manufacture of these products. On the whole, chir pine pulp was found to be a satisfactory substitute for imported long fibre pulp for this purpose. Tree age did not significantly affect wood and pulping properties and only small differences were observed in this regard between trees of different age groups. Resin in chir pine wood also did not constitute any special problem during its pulping.

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