Kraft Pulping and Bleaching Studies on Adina cordifolia (Haldu) Alone and Admixed with Bamboo

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SUMMARY

With increased use of mixed Hardwoods to supplement Bamboo and with the practice of bleaching of bamboo and mixed hardwood pulps together, a wide fluctuation in both the bleachability of pulp as well as the viscosities and other properties of bleached pulp are encountered in the mill operation. Haldu (*Adina cordifolia*) one of the hardwoods was cooked alone mixed with bamboo and cooked by sulphate process suing same cooking cycle and same alkali percentage to know the effect on pulping and bleaching characteristics of the pulps. The optimum chlorine demand of unbleached pulps were find out to avoid high losses of pulp during bleaching operation under C/E/H sequence.

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INTRODUCTION

The pulp and paper industry [1] is on the threshhold of big developments. It's growth and future course would depend largely on how effectively and successfully the problem of raw material supply is tackled and solved. When the stake for future planning are the attainment of self sufficiency in the production of pulp, paper and newsprint, it would be natural and fair to give this question of raw materials its due importance and put in a proper frame.

The projected demand [2] for pulp, paper and newsprint for the country in 1988–89 has been placed at nearly 3.8 million tonnes as against the 1973–74 figure of 1.26 million tonnes. The breakup by different items is:

Paper & Paper Board	— 2,600, 000 tonnes
News Print	— 700,000 "
Paper grade pulp	— 215,000 "
Rayon grade pulp	— 300,000 "

Out of the projected demand of 2.6 million tonnes of paper and paper board in 1988–89, Madhya Pradesh could claim a share of 400,00 tonnes which would work out to nearly 15 percent of all India figure.

The total raw material [1] requirement for the above capacity would be one million tonnes. The furnish of bamboo and hardwoods on the basis of a ratio 60:40 would be 600,000 tonnes and 400,000 tonnes respectively. In case the ratio is taken as 50:50 then the same quantity of 600,000 tonnes of bamboo would account for total capacity of 500,080 tonnes of finished product.

In the development of pulp paper and newsprint industry bamboo resources have been recognised to be the main constraint [2]. It has been stressed by the planning commission study that the proportion of bamboo in the raw material furnish have to be progressively lowered from 70 percent to 50 percent within the next fifteen years. At present our mill is using mixed hardwoods to the maximum extent of 30% for manufacturing of about 200 tonnes of paper per day. The government is imposing restriction for increase in amount of bamboo so naturally we will have to use more hardwoods in near future.

EXPERIMENTAL

Fresh and sound scantlings of *Adina cordifolia* (Haldu) were collected from the wood yard and converted into chips in a K.M.W. chipper. The chips were screened in a William Chips Classifier. The screened chips were used for carrying out pulping experiments.

PROXIMATE CHEMICAL ANALYSIS

Haldu chips (250g) were converted into dust in a Raymond Mini Mill for carrying out proximate chemical analysis. The dust passing through 40 mesh and retained on 60 mesh was utilised for proximate chemical analysis employing Tappi Standard Methods. The result obtained after the analysis are given in Table-I.

TABLE-I

PROXIMATE CHEMICAL ANALYSIS OF ADINA CORDIFOLIA (HALDU)

Sl. No.	Particulars	Percentage on oven dry basis
1.	Pentosan content	15.90
2.	Alcohol Benzene solubility	4.50
3.	1% NaoH solubility	12.67
4.	Cold water solubility	3.59
5.	Hot water solubility	10.54
6.	Lignin content	26.76
7.	Ash content	0.60
8.	Holocellulose	70.00

BULK DENSITY AND SPECIFIC GRAVITY OF ADINA CORDIFOLIA (HALDU)

Standard procedures were followed for the determination of bulk density and specific gravity of Haldu chips. Bulk density of Haldu chips was fouund 248.7 kg/m^3 and specific gravity 0.49 g/cc.

FIBRE DIMENSIONAL STUDY

Fibre dimensions of Haldu pulp was measured under a microscope using Herberg stain for staining purpose. 200 readings of fibre length and fibre diameter were recorded separately. The results are given as follows :

1.	**Fibre length (m.m.)**	
	(I) Maximum	1.924
	(II) Average	1.469
	(III) Minimum	0.806
2.	**Fibre Diameter (m.m.)**	
	(I) Maximum	0.0318
	(II) Average	0.0277
	(III) Minimum	0.0173

The average slenderness ratio (L/D) of Haldu pulp is 53.00.

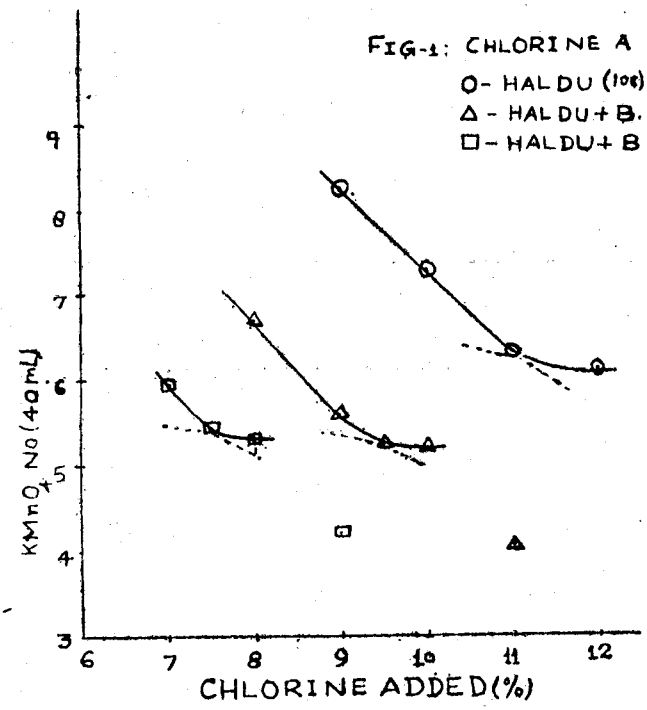
KRAFT COOKING OF HALDU CHIPS

Pulping trials were caried out by the sulphate process, taking 10 kg. chips on o.d. basis in a steam heated pilot digester using 16% chemicals and material

liquor ratio 1:2.7. Mixed cooking of Haldu chips were carried out with 50 and 75 percent bamboo using 16% chemicals (total cooking cycle 270 mts; 90 minutes at 165°C). Knots and shives were removed in a laboratory flat screen. The unbleached pulp (o.d. basis) was beaten in a laboratory valley beater to 45 °SR freeness. Standard sheets of about 60 g.s.m. were made in a British Sheet Making Machine and were pressed and dried using rings and plates. Finally the strength properties were determined. In cook No. 1 and No.2 where K. No. (25 ml) exceeded 20, K. No. (40ml) was determined. Cooking conditions, yield etc. are given in Table-II and physical strength properties in Table-III.

BLEACHING OF HALDU PULP UNDER C E H SEQUENCE

The chlorine demand in the first stage bleaching is very important as it removes lignin selectively. The over chlorination and under chlorination effect the quality of pulp. The chlorine demand of pulps were determined according to the method of Baldauf and Lehto [3]. The chlorine dosages for each pulp under constant conditions of time, temperature and consistency were applied to get optimum chlorine demand. Chlorinated pulps after alkali extraction under constant conditions were analysed for K. No. (40 ml). The lignin removal after alkali extraction stage is dependant on the quantity of chlorine added (Fig. 1). With the increase



in quantity of chlorine the removal of lignin increases linearly upto certain point beyond which the lignin removal with respect to chlorine addition is very less i.e. the curve flattens. The optimum chlorine demand was determined by plotting a graph between percent chlorine applied and K. No. (40 ml) after alkali extraction (Fig. 1). The results of different sets of each cook are given in Table -IV

CHLORINATION OF UNBLEACHED PULP : Chlorination of unbleached pulp Haldu (100%), Haldu & Bamboo (1:1) and Haldu & Bamboo (1:3) in plastic buckets were carried out at 3% consistency using the optimum chlorine doses in the first stage for each pulp. The pulps were shaken occasionally and after an hours time the pulps were analysed for residual chlorine.

ALKALI EXTRACTION OF CHLORINATED PULP: Alkali extraction of different pulps was carried out under constant conditions of time, temp. and consistency. Each pulp was analysed for end pH and K. No. (40 ml) after an hours time of reaction.

HYPOCHLORITE TREATMENT OF ALKALI EXTRACTED PULP : Hypochlorite treatment of each alkali extracted pulp was carried out at 5% consistency, temp 40 ± 1°C, pH 8.5-9 was maintanied for a period of two hours by adding buffer to the extracted pulp. The pulp was finally analysed for end pH, pulp brightness % P.V., viscosity (CED) cps and shrinkage of pulps. The results for different pulps are given in Table-V.

The bleached pulps (360 g.o.d. basis) were beaten in a laboratory valley beater to 45 °SR freeness. Standard sheets of about 60 g.s.m. were made, dried and pressed using rings and plates. Finally the physical strength properties of the pulps were determined (Table-VI)

RESULTS AND DISCUSSIONS

Haldu is a medium density wood. It has bulk density 248.7 kg/m³. So loading capacity per digester will be nearly equal to bamboo or sal wood.

Fibre dimensional study shows that the fibre length is quite good (average 1.429 m.m.) and fibre diameter (0.0277 m.m.) The slenderness ratio of Haldu pulp is 53.

Haldu chips (100%) were cooked with 16% chemicals as Na_2O for 4.5 hours (90 minutes at 165°C). The K.No. (40 ml) of washed pulp was found 28.68 which was on a higher side so the wood will consume more chemicals to bring down K.No. The total yield found 47.32 and rejects 6.25%. The rejects percentage was on a higher side.

Haldu chips when mixed in 1:1 ratio with bamboo and cooked with 16% chemicals as Na_2O for 4.5 hours (90 mts at 165°C) gave K.No. (40 ml) of unbleached pulp 26.6. The K.No. was still on a higher

TABLE–II

COOKING CONDITIONS FOR HALDU CHIPS & MIXED BAMBOO CHIPS

S. No.	Process details	Cook No. 1 (100% Haldu)	Cook No. 2 (Haldu+Bamboo) 1:1	Cook No. 3 (Haldu+Bamboo) 1 : 3
1.	Chemicals used			
	(i) Alkali used as Na_2O (%) on o.d. basis of chips	16	16	16
	(ii) White liquor conc. T.A.A. (g/L)	86.8	86.8	86.8
	(iii) Sulphidity (%)	17.1	17.1	17.1
2.	Bath ratio	1:2.7	1:2.7	1:2.7
3.	Weight of chips taken (kgs) on o.d. basis of chips	10	10	10
4.	Cooking cycle in Pilot-Digester			
	(i) 30–135°C (minutes)	60	60	60
	(ii) at 135°C (minutes)	60	60	60
	(iii) 135–165°C (minutes)	60	60	60
	(iv) at 165°C (minutes)	90	90	90
5.	Residual Alkali (g/L)	13.95	15.5	16.05
6.	°Tw at 60°C	11.5	12.0	14.0
7.	Yield (%) rejects free	41.07	41.40	41.80
8.	Rejects (%)	6.25	4.58	2.91
9.	Total yield (%)	47.32	45.98	44.71
10.	K.No. of pulp	—	—	17.66
	(i) 25 ml $KMnO_4$	28.68	26.60	22.8
	(ii) 40 ml $KMnO_4$			

TABLE–III

STRENGTH PROPERTIES OF UNBLEACHED PULP

S. No.	Particulars	Cook No. 1 (100% Haldu)	Cook No. 2 (Haldu+Bamboo) 1 : 1	Cook No. 3 (Haldu+Bamboo) 1 : 3
1.	Initial Freenest (°SR)	12	11	12
2.	Final Freeness (°SR)	45	45	45
3.	Beating time (minutes)	40	38	38
4.	Basis weight (gsm)	58.7	58.2	60.0
5.	Caliper (microns)	88	88	90
6.	Bulk (cm^3/g)	1.362	1.512	1.600
7.	Tensile strength (kg/cm^2)	4.37	4.43	4.7
8.	Breaking length (k.m.)	4.963	5.083	5.232
9.	Bursting strength (kg/cm^2)	2.17	2.22	2.45
10.	Burst factor	36.9	38.2	40.2
11.	Tearing strength (g/cm)	44	46	48
12.	Tear factor	74.9	78.9	80.0
13.	Double fold	68	80	108

TABLE—IV

OPTIMUM CHLORINE DEMAND FOR THE FIRST STAGE BLEACHING UNDER CEH SEQUENCE OF HALDU PULP AND HALDU+ BAMBOO PULPS.

Sl.	Bleaching conditions	Haldu pulp (100%) K. No. (40ml) = 28.68				Haldu + Bamboo (1 : 1) K. No. (40ml) = 2·960				Haldu + Bamboo (1 : 3) K. No. (40 ml) = 22.8			
1.	Set No.	C_1	C_2	C_3	C_4	C_1	C_2	C_3	C_4	C_1	C_2	C_3	C_4
2.	**Chlorination Stage (C)** Constant condition: Cy% = 3.0, Temp = 30±1°C, retention time = 60 minutes												
	(i) Chlorine added (%) on o.d. pulp	9	10	11	12	8	9	10	11	7	7.75	8	9
	(ii) Chlorine consumed (%)	8.92	9.88	10.85	11.52	7.93	8.88	9.48	10.59	6.72	7.15	7.38	7.83
	(iii) Chlorine consumption (%) on added basis	99.10	98.82	96.18	96.06	99.10	98.67	94.80	92.49	96.60	95.31	92.25	86.44
3.	**Caustic Extraction (E)** Constant Condition : Cy% = 5, Temp = 55 ± 1°C NaO H (%) on pulp = 2.5												
	(i) End pH	10.7	10.7	10.6	10.6	10.9	10.8	10.7	10.7	10.6	10.5	10.5	10.4
	(ii) Pulp loss (%) on o.d. basis of CE stage	4.2	5.0	6.5	8.6	2.5	4.5	6.4	8.3	4.0	5.0	5.5	6.5
	(iii) K. No (40 ml)	8.21	7.32	6.28	6.1	6.68	5.60	5.18	4.08	5.96	5.46	5.26	4.26

TABLE–V

BLEACHING OF HALDU PULP AND HALDU + BAMBOO PULPS UNDER CEH SEQUENCE

S.No.	Particulars	Haldu pulp (100%) K. No. (40 ml) = 28.68	Haldu + Bamboo (1:1) K.No. (40 ml) = 26.6	Haldu + Bamboo (1:3) K.No. (40ml) = 22.8
1.	**Chlorination (C)** Constant Conditions as in Table -III			
	(i) Chlorine added (%)	11.0	9.5	7.5
	(ii) Chlorine consumed%	10.58	9.22	7.14
	(iii) Chlorine consumed on added basis (%)	96.18	97.02	95.31
2.	**Alkali Extraction (E)** Constant Conditions as in Table-III			
	(i) NaOH (%) on O.D. pulp	2.5	2.5	2.5
	(ii) End pH	10.5	10.7	10.6
	(iii) K.No. (40 ml)	6.28	5.27	5.46
3.	**Hypo stage** Constant Conditions: Cy% = 5.0, Temp = 40 ± 1°C retention time = 120 mts			
	(i) Hypo added (%)	2.5	2.5	2.5
	(ii) Hypo consumed%	2.36	2.38	2.4
	(iii) Hypo consumed on added basis (%)	94.0	95.20	96.0
	(iv) End pH	7.6	7.7	7.7
4.	**Results**			
	(i) Brightness (%) P.V.	78.0	77.5	77.0
	(ii) Viscosity (CED) cps	6.13	6.31	6.58
	(iii) Total chlorine added (%)	13.50	12.00	10.00
	(iv) Total chlorine consumed	12.94	11.60	9.54
	(v) Shrinkage of pulp (%)	10.1	8.94	8.28

TABLE-VI
STRENGTH PROPERTIES OF BLEACHED PULP

S.No.	Particulars	Haldu Pulp (100%)	Haldu+Bamboo) (1:1)	Haldu +Bamboo (1:3)
1.	Initial Freeness (°SR)	14	15	15
2.	Final Freeness (°SR)	45	45	45
3.	Beating time (minutes)	35	30	30
4.	Caliper (microns)	88.0	85.0	90.0
5.	Basis weight (g.s.m.)	61.0	58.0	61.0
6.	Tensile strength (kg/cm²)	4.04	4.11	4.40
7.	Breaking length (k.m.)	4.412	4.729	4.816
8.	Bursting strength (kg/cm²)	2.22	1.68	2.27
9.	Burst factor	33.27	28.90	35.28
10.	Tearing strength (g/cm)	44	44	46
11.	Tear factor	72.13	77.0	74.6
12.	Double fold	148	154	184

side. The total yield was 45.98% and rejects 4.58%. The total yield has little come down.

Haldu chips were cooked with bamboo in 1:3 ratio with 16% chemicals for 4.5 hours (90 mts at 165°C) gave K. No. (25 ml) 17.66 but the total yield has come down to 44.71% and rejects percentage 2.91%. It gives good strength properties when cooked alone or mixed with bamboo. The strength properties in the mixed pulp increases as the percentage of bamboo was increased. Haldu needs higher than 16% chemicals for getting K. No. (25 ml) around 17.

The unbleached pulps were bleached under CEH sequence. Adding the optimum amount of chlorine is one of the pre-requisites for efficient bleaching both for economic and quality considerations. Pulps treated with in sufficient amount of chlorine in chlorination stage consumes more chlorine as hypochlorite[4] for a certain brightness level which is both detrimental from the stand point of quality and the economics of the process as the cost of available chlorine as hypochlorite is much above than part of elemental chlorine. The over chlorinated pulps also do not show any greater reduction in chlorine requirements in the hypochlorite stage. On the contrary there is a loss of chlorine, because of excessive amounts which is both a waste and undesirable from the health consideration of the people. The over chlorinated pulps are also degraded to a great extent. It was felt therefore that a test such as chlorine demands of the pulps should be introduced for mill pulps.

The unbleached pulps of Haldu (100%), Haldu + Bamboo (1:1) and Haldu + Bamboo (1:3) obtained under the same cooking cycle and same alkali percentage were given different chlorine dosage to get optimum chlorine demand for each pulp (Table-IV). The optimum chlorine demand of Haldu pulp (100%), Haldu+Bamboo (1:1) and (1:3) ratio were 11%, 9.5% and 7.5% respectively in the first stage bleaching (Fig. 1). Haldu pulp (100%) when bleached with 11% chlorine in the first stage & then alkali extracted gave K. No. (40 ml) = 6.28. The chlorine consumption was 96.18%. The alkali extracted pulp was given 2.5% chlorine as hypochlorite under constant conditions of time, temp, and consistency. The pulp brightness (%) P.V. was found 78. The total pulp shrinkage during bleaching stages was 10.1% and total chlorine consumption 12.94%. The pulp was having viscosity (CED) cps 6.13. The total chlorine consumption was high due to high K. No. The physical strength properties of the bleached pulp were quite good (Table-VI).

In the mixed pulp bleaching (Bamboo+Haldu (1:1) 9.5% chlorine was given in the first stage to obtain K. No. (40 ml) 5.27 after alkali extraction. The alkali extracted pulp was given 2.5% chlorine as calcium hypochlorite to get pulp brightness 77.5%. The pulp viscosity (CED) cps was found 6.31. The total pulp shrinkage in the bleaching stages was 8.94% The physical strength properties were found better than Haldu pulp alone.

The mixed bamboo pulp (Haldu+Bamboo (1:3) was given 7.5% chlorine in the first stage and 2.5% in the third stage bleaching. The alkali extracted pulp has K. No. (40 ml) 5.46. The total chlorine consumption was 9.54%. The bleached pulp has pulp brightness 77% P.V. and viscosity (CED) cps 6.58. The physical strength properties of the bleached pulp were still better than Haldu pulp (100%) and Haldu+Bamboo pulp (1:1).

If we have to use more Haldu (50%) we will have to increase alkali to bring down K.No *d*nd reduce bleach consumption.

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