Study on Uniform Bleaching of Bamboo & Mixed Hardwoods Pulp Blends

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With increased use of Mixed Hardwoods to supplement Bamboo, and with the practice of bleaching 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. This paper presents a study of bleaching Bamboo and Mixed Hardwoods pulps of varying Kappa Number, blended in 65:35 proportion, with a view to optimise the Kappa Numbers of the two pulps for uniform bleaching. The study reveals that the Kappa Number of Mixed Hardwoods pulp be kept higher than that for Bamboo pulp. The optimum Kappa Number of Bamboo is shown to be 27±1 and for Mixed Hardwoods 34±1, for bleaching together to yield satisfactory bleached pulp.

Another aspect of the study, presented here, is the effect of viscosity of bleached pulp on strength properties. It is shown that viscosity has a pronounced effect on the strength properties, especially on tearing resistance and folding endurance in the viscosity range of 15 to 3 (CED) cp, descending viscosity gives gradual drop in strength properties and at 6 cp. viscosity a sudden drop in tearing resistance and strength index occurs indicating the lower limit for strength properties.

Introduction

Due to ever growing 'raw material crisis' more and more hardwoods are to be processed for the survival of pulp and paper industry. This demands for the development of new processes so as to get good quality pulp without affecting the economics of the process. As we know bamboo is the main raw material for papermaking in our country. However a substantial part of it is being replaced with the use of local hardwoods. Pulping as such is one problem, whether to pulp bamboo and hardwoods together or separately is an open question which is haunting the minds of technologists and research workers of the country. Not only the production of unbleached pulp but bleaching, as well, is a problem to be solved. Works carried out in the Research Centre of W.C.P.M. Ltd. have clearly indicated different chlorine demands for bamboo and MHW pulps being 1/4th of Kappa No. for bamboo and 1/6th for Mixed Hardwoods[1]. This situation creates a serious problem if a blend of both the pulps is to be bleached. Any imbalance in chlorine application creates the deterioration of one component or the other. So if blends are to be bleached, a study of suitable Kappa No. of individual pulps becomes necessary, however its feasibility on the plant is also to be taken care of.

Wide fluctuation in bleached pulp viscosity have been encountered in our mill practices (4 to 15 cp. or so) due to one reason or the other. Accordingly the problem was taken up by the Research Centre to see the effect of such viscosity changes on paper characteristics.

It has been clearly mentioned in the literature that the decrease in paper strength properties has been related to the viscosity decrease[2,3]. Although the decrease in chain length of cellulose is likely to mean little to paper strength, viscosity is a good measure of the main progress of oxidative

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degradation, which is fairly parallel to the attack on the strength bearing elements of the fibers, whether being fiber wall layers, microfibrils. or the chain molecules of the hemicelluloses. Therefore a fair correlation exists between paper strength properties and pulp viscosity, hence viscosity determination is often used in bleaching control to follow the changes in paper strength of a certain pulp type, as correlation between strength and viscosity is different for different types of pulp. The degradation of the carbohydrates during the hypochlorite oxidation is also manifested in the decrease of viscosity and paper strength as well as increase in alkali solubility. The main influence on these properties, as on the carbonyl and carboxyl content is exerted by the amount of hypochlorite reacted as well as pH during oxidation[4]. The pulp consistency and temperature during bleaching are of little significance, though over bleaching not only decreases the viscosity and the strength of individual fibres but also reduces the strength of the paper made from such fibres[5].

Experimental

For this study, chips from plant hereafter is refered as BE containing Bamboo and Eucalyptus in the ratio 85:15 and Mixed Hardwoods were used. The chips size classification was carried out separately for each lot. Results are given in Table No. I.

Table No. I

Chips Classification

Particulars	BE* Lot No. 1	BE* Lot No. 2	Mixed Hardwoods Lot No. 1	Mixed Hardwoods Lot No. 2
Bulk density of chips (10% moisture) Kg/m³	—	235	—	275
Chips size distribution screen used				
Retained on 32 mm	1.7	—	2.2	1.0
—32 +25 mm	13.6	9.2	14.5	17.6
—25 +13 mm	52.4	59.5	51.3	61.0
—13 + 3 mm	28.0	30.7	28.7	20.0
Passed thro' 3 mm	4.3	0.6	3.3	0.4

* In all the text and tables of this paper Bamboo 85 : Eucalyptus 15 blend is refered as only BE.

The project was divided into two parts :

Part I—Optimisation of Kappa No. of BE and Mixed Hardwoods pulp for uniform bleaching.

Part II–Effect of bleached pulp viscosity on strength properties.

Part I—Optimisation of Kappa Number of BE and Mixed Hardwoods pulp for uniform bleaching.

For the above study cooks of different Kappa Numbers 19, 23, 26, 28, 30 and 32 for BE and 25, 31 and 32 for Mixed Hardwoods pulp were obtained. Pulping data are given in Table No. II. The unbleached pulps of B E of Kappa No. 19.6 was mixed with unbleached pulp of Kappa No. 25, 31 and 35 of Mixed Hardwoods, separately in 65:35 proportion and bleaching experiments were carried out by CEHH sequence for 50 gm. pulp. In a similar way B E pulps of different Kappa Numbers 23, 26, 28, 30 and 32 were mixed separately with Mixed Hardwoods pulp of Kappa Numbers 25, 31 and 35. Bleaching and viscosity data are given in Table No. IV. The optimum Kappa No. of unbleached pulp of Mixed Hardwoods required for blending with (Bamboo + Eucalyptus) pulp to yield high viscosity bleached pulp can be seen from Figure No. 1. Bamboo pulp of 27 and 41 Kappa Number and Mixed Hardwoods pulp of 27 and 41 Kappa Number were also bleached separately and results are given in Table No. III. Further large scale bleaching of blended pulps was carried out for pulp evaluation. In these experiments B E pulp of 23, 28 and 32 Kappa Number and Mixed Hardwoods pulp of 35 Kappa Number were taken and

Table No. II

Pulping Data of BE and Mixed Hardwoods for Lot No. 1

Particulars	BE						Mixed Hardwoods		
Cook No.	1	2	3	4	5	6	7	8	9
Moisture in chips, %	15.5	15.5	15.5	15.5	15.5	15.5	14.0	14.0	14.0
Chemicals added ($NaOH+Na_2S$), %	24	22	22	22	22	22	24	23	22
Cooking Schedule :									
70°C—120°C., Min.	45	45	45	45	45	45	45	45	45
At 120°C., Min.	60	60	60	60	60	60	60	60	60
120°C—170°C., Min.	75	90	90	90	90	60	75	75	75
At 170°C., Min	110	65	45	40	60	75	90	90	90
H—Factor	1990	1320	1080	1000	1315	1430	1608	1608	1608
Screened pulp yield, %	47.8	49.2	51.0	50.1	49.7	48.5	41.3	42.0	42 6
Rejects, %	0.25	1.3	0.65	1.50	0.6	1.9	0.9	1.4	1.9
Total yield, %	48.1	50.5	51.7	51.6	50.3	50.4	42.2	43.4	44.5
Kappa No.	19.6	23 2	26.4	28.0	30.4	32.4	25.0	31.0	35.0
Spent Liquor pH	10.7	10.6	10,4	10.6	10.4	10.7	10.1	10.7	10.5

Constant conditions :

1. All cooks for BE chips were carried out in Rotary digester and Mixed Hardwood chips were cooked in Research Digester.
2. White liquor sulphidity % was maintained 20 in case of BE and 23.7 in case of Mixed Hardwoods.
3. Weak Black Liquor was used as diluent.
4. Chips to liquor ratio was maintained – 1:2.7.

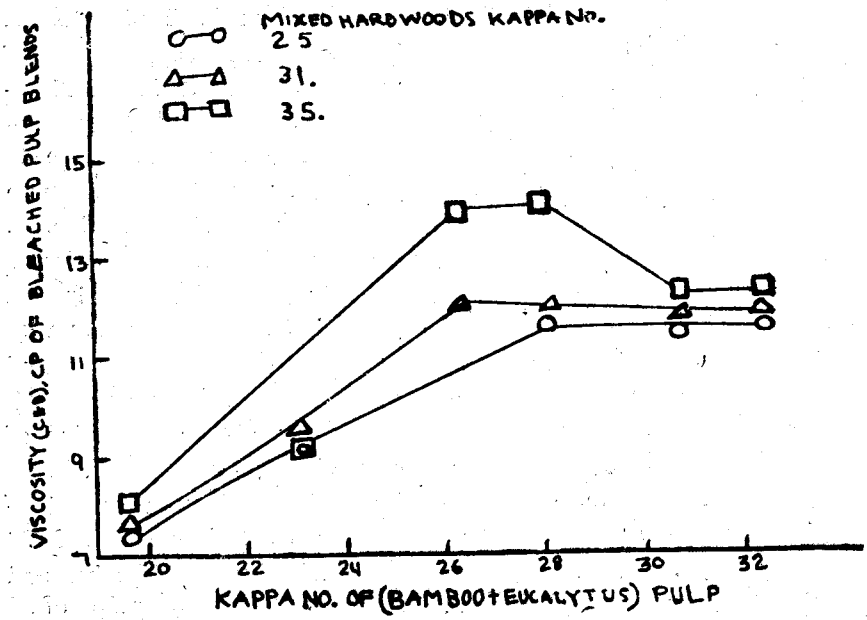

Fig. 1–Kappa No. &Viscosity of Bleached Pulp Blends

mixed separately before bleaching. The resulting blends were bleached and strength characteristics of 60 gsm standard handsheets made by British Sheetmaking Machine were evaluated. Bleaching dat and pulp evaluation results at constant Freeness 30°SR and 1.6 cc/g. Bulk are given in Table No. V.

Part II–Effect of bleached pulp viscosity on strength characteristics.

For the above study chips from Lot No. 2 were used and cooks of different Kappa Numbers of BE and Mixed Hardwoods chips were separately carried out.

Table No. III

Small Scale Bleaching of BE and Mixed Hardwood Pulps by CEHH Sequence

Particulars	BE		Mixed Hardwoods	
	Set Numbers		Set Numbers	
	1	2	1	2
Kappa No.	27	41	27	41
Chlorination :				
Cl_2 added, %	7.0	10.0	4.5	7.0
Cl_2 consumed, %	6.7	8.6	4 5	7.0
Extraction				
NaOH added, %	2.0	2.5	1.75	2.0
End pH	9.2	8.5	9.3	9.2
Hypochlorite Ist Stage :				
Av. Chlorine added, %	2.0	3.5	1.5	2.0
Av. Chlorine consumed,%	1.65	2.8	1.4	1.3
Sulphamic acid on pulp,%	0.07	0.07	0.07	0.07
End pH	6.8	6.8	6.8	6.9
Hypochlorite IInd Stage :				
Av. Chlorine added, %	1.0	1.0	1.0	1.0
Av. Chlorine consumed,%	0.6	0.45	0.66	0.7
Sulphamic acid on pulp,%	0.07	0.07	0.07	0.07
End pH	7.2	7.1	7.3	7.2
Total chlorine added, %	10.0	14.5	7.0	10.0
Total chlorine consumed,%	9.0	11.9	6.5	9.0
Shrinkage, %	4.4	9.6	8.8	10.4
Brightness, (Elrepho), %	82.5	83.5	77.2	77.1
Viscosity, (CED), cp.	13.4	11.6	8.4	13.4

Constant Bleaching Conditions :

For Table Nos. III, IV, V and VII.

	C	E	H	H
Consistency, %	3	5	5	5
Temperature, °C.	Room temp.	60	45	45
Time, Min.	60	60	60	90

Pulping data are given in Table No. VI. The resulting unbleached pulps of Bamboo and Mixed Hardwoods were blended in 65:35 proportion and bleaching experiments were carried out by CEHH sequence. Lower viscosities for BE and Mixed Hardwoods pulps of Kappa No. 36 mixed together before bleaching were obtained by overchlorination and unbuffered hypochlorite addition (sulphamic acid was not added). Higher viscosities were obtained by blending unbleached pulps of B E and Mixed Hardwoods of different Kappa Numbers. Bleaching data are given in Table No. VII. The resulting bleached pulps were beaten to 30°SR and strength characteristics were evaluated. Results are given in Table No. VIII, Figure No. 2 and Figure No. 3 show the viscosity versus strength properties at constant bulk 1.75 cc/g.

Results and Discussion :

Part I

Bleaching study of BE and Mixed Hardwoods pulp of Kappa No. 27 and 41 given in Table No. III clearly indicates different chlorine demands for the same Kappa Number of BE and Mixed Hardwoods pulp. It indicates that BE and Mixed Hardwoods pulp of Kappa Number 27 and 41 have the same chlorine demand and other pulp characteristics like viscosity. So the Mixed Hardwoods pulp Kappa Number should be on higher side than that of BE pulp.

As the Mixed hardwoods pulp of

Table No. IV– Pulp Bleaching (Small Scale)

Bleached pulp viscosity of pulp blends of various Kappa Numbers.

	Viscosity, (CED), cp.					
Kappa No. of unbld. BE pulp	19.6	23.0	26.0	28.0	30.0	32.4
Kappa No. of unbld. Mixed Hardwoods pulp						
25	7.6	9.1	—	11.7	11.7	11.6
31	7.7	9.7	12.0	11.9	11.9	11.9
35	8.1	9.1	13.9	14.0	12.1	12.2

Note :—1. Unbleached pulps of BE and Mixed Hardwoods were mixed together before bleaching in 65 : 35 proportion. 50 gm. O.D. pulp was taken and bleaching was carried out by CEHH sequenee.

2. a) 6-8% chlorine was added on pulp basis as per bleach demand.
   b) 1.7 to 1.75% of NaOH was added on pulp to get pH 9 ± 0.5.
   c) 2.5% Av. Chlorine was added on pulp in Ist hypochlorite stage and 0.6 to 0.75% Av. chlorine in IInd hypochlorite stage. 0.07% of sulphamic acid was added on pulp in both stages.
3. Brightness of bleached pulp obtained was 78 ± 1 (Elrepho), %.
4. Viscosity (CED), cp of bleached pulp for pulp blends of various Kappa Nos. are recorded above.

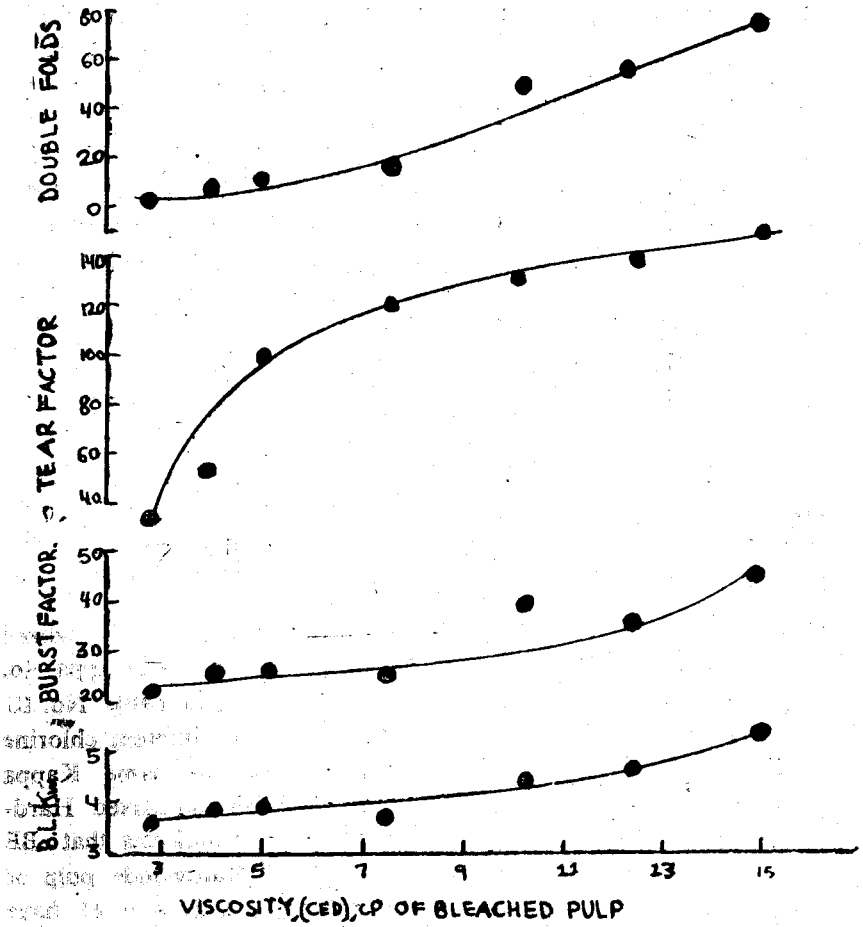

Fig. 2–Viscosity & Strength Properties at Bulk 1.75 cc/g

Kappa No. 41 was found shivy, the maximum Kappa No. 35 for Mixed Hardwoods pulp was chosen for further studies.

Further from the data given in Table No. IV it is seen that the blends of Bamboo and Mixed Hardwoods pulps of lower Kappa No. have given lower viscosities and after a maximum rise, viscosity drops with the pulp blends of higher Kappa No. The best results are obtained as shown in Figure No. 1 with the blends of BE pulp of 26 and 28 Kappa No. mixed with Mixed Hardwoods pulp of 35 Kappa No. This again confirms the earlier findings that the Kappa No. of Mixed Hardwoods pulp should be on higher side than that of BE pulp. Full evaluation of BE pulps of Kappa Nos. 23, 28 & 32 blended with Mixed Hardwoods pulp of Kappa No. 35 was carried out. The bleaching and pulp characteristics given in Table

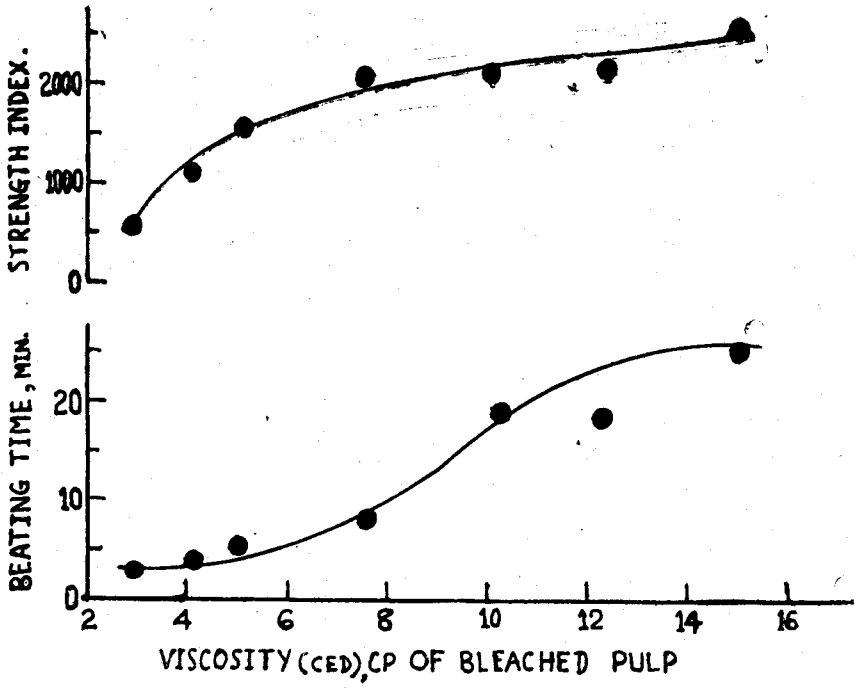

Fig. 3–Viscosity & Strength Properties at Bulk 1.75 cc/g

Table No. V

Large scale bleaching and pulp evaluation of pulp blends

Set No. / Particulars	1	2	3
BE pulp Kappa No.	23	28	32
Mixed Hardwoods pulp Kappa No.	35	35	35
Chlorination :			
Cl_2 added, %	6.5	7.0	8.0
Cl_2 consumed, %	5.7	6.7	7.8
Extraction :			
NaOH added, %	1.75	1.7	1.7
End pH	10.3	8.8	10.3
Hypochlorite Ist :			
Av. Cl_2 added, %	2.5	2.5	2.5
Av. Cl_2 consumed, %	1.6	2.1	2.0
Sulphamic acid on pulp, %	0.07	0.07	0.07
End pH	7.2	7.0	7.3
Hypochlorite IInd :			
Av. Cl_2 added, %	0.5	0.75	0.5
Av. Cl_2 consumed, %	0.3	0.3	0.2
Sulphamic acid on pulp, %	0.07	0.07	0.07
End pH	7.5	7.3	7.8
Total Cl_2 added, %	9.5	10.25	11.0
Total Cl_2 consumed, %	7.6	9.1	10.0
Shrinkage during bleaching, %	8.2	8.4	8.0
Brightness (Elrepho), %	78 6	78.3	79.4
Viscosity (CED), cp.	9.1	16.5	14.5

No. V, have also supported the above findings i.e., BE pulp of Kappa No 28 blended with Mixed Hardwoods pulp of Kappa No. 35 gave the maximum viscosity 16.5 (CED) cp. and higher strength characteristics. Bauer McNett Fibre Classification for the bleached pulps, having viscosities 9.1, 16.5 and 14.5 (CED) cp. have not shown any significant change.

Part II–

Viscosity results given in Table No. VII again confirms that in order to have a bleached pulp of high viscosity and good strength characteristics Mixed hardwoods pulp Kappa No. should be on higher side than that of BE pulp.

Further it is seen from Table No. VIII, Figure No. 2, and Figure No. 3 that Double Folds and Tear Resistance are the properties worst affected by the decrease inviscosity, Breaking length and Burst factor are not significantly affected. Double folds drop gradually from viscosity 15 to 6 (CED) cp. whereas tearing resistance and strength index show a sudden drop below 6 (CED) cp viscosity, indicating lower limits for strength properties. Beating time also decreases with decrease in viscosity.

Conclusions :

1) In order to have a bleached pulp of high viscosity i.e., 14-16 (CED) cp. and good strength characteristics, the optimum Kappa Number for the unbleached pulp of BE and Mixed Hardwoods are 27 ± 1 and 34 ± 1 respectively.

Table No. V (Contd.)

Set No. / Particulars	1		2		3	
Strength Characteristics at Constant Bulk 1.6 cc/g. and Freeness, 30°SR						
	Bulk cc/g.	Freeness °SR	Bulk cc/g.	Freeness °SR	Bulk cc/g.	Freeness °SR
Freeness, °SR	26	30	28	30	29	30
Bulk, cc/g.	1.6	1.61	1.6	1.58	1.6	1.5
Breaking length, km	5.5	6.0	5.7	6.0	5.5	6.0
Burst factor	43	43	50	50	48	45
Tear factor	71	72	90	88	96	95
Double folds (MIT)	40	20	70	65	60	55
Strength index	1700	1600	2020	2000	2000	1950

2) Viscosity has a direct relationship with the strength properties of the paper. Folding endurance shows a steady drop from 15 to 6 (CED) cp. viscosity and then the drop is more or less the same. Tearing resistance and strength index show a rapid drop below 6 (CED) cp. viscosity, whereas Bursting strength and Breaking length show a lesser drop. It indicates lower limits for strength properties is 6 (CED) cp. viscosity.

Table No. VI

Pulping data of BE and mixed hardwoods for Lot No. 2

Cook No.	BE			Mixed Hardwoods				
	1	2	3	4	5	6	7	8
Moisture in chips, %	11.0	11.0	11.0	12.5	12.5	12.5	12.5	12.5
Chemicals added as ($NaOH + Na_2S$)%	18	19	20	18	20	23	24	23
Maximum temp, °C	165	165	165	170	170	170	170	170
Cooking Schedule								
70°C—120°C, Min.	45	45	45	45	45	45	45	45
At 70°C–120°C., Min.	60	60	60	90	60	60	60	60
120°C–Maximum temp., Min.	75	75	75	75	75	75	75	75
At Maximum temp., Min.	20	30	30	60	60	60	90	90
Total cooking time, Min.	200	210	210	270	240	240	270	270
H—Factor	630	785	785	1255	1250	1250	1610	1610
Screened pulp yield, %	50.0	50.4	49.2	43.6	40.2	40.5	40.4	40.1
Rejects, %	2.0	2.2	1.0	4.0	3.0	2.6	1.8	2.0
Total yield, %	52.0	52.6	50.2	47.6	43.2	43.1	41.2	42.1
Kappa No.	41.2	36.0	27.0	51.0	41.0	36.0	33.0	27.0
Spent Liquor pH	9.7	10.8	10.4	10.1	10.6	11.0	11.0	9.8

CONSTANT CONDITIONS :

1. All cooks were carried out in Research Digester
2. White liquor sulphidity %—23.7
3. Weak black liquor was used as a diluent
4. Chips to liquor ratio was 1:2.7.

TABLE–VII

Large scale bleaching of BE and Mixed Hardwood pulp blends by CEHH sequence

Particulars	Set Numbers						
	1	2	3	4	5	6	7
BE Pulp Kappa No.	27	27	27	36	36	36	36
Mixed Hardwoods Pulp Kappa No.	51	41	27	36	36	36	36
Chlorination :							
Cl_2 added, %	7.5	7.0	6.0	8.5	9 0	10.0	10.0
Cl_2 consumed, %	7.5	6.7	5.5	8.0	8.1	9.0	8.35
Extraction :							
NaOH added, %	2.0	2.0	2.0	2.0	2.0	2.5	2.5
End pH	10.0	9.0	9.7	10.8	9.9	10.6	10.8
Hypochlorite Ist Stage :							
Av. Cl_2 added, %	2.25	2.0	1.75	2.0	3.0	4.0	5 .0
Av. Cl_2 consumed, %	2.1	1.8	1.5	1.7	2.55	3.2	4.6
Sulphamic acid on pulp, %	0.07	0.07	0.07	0.07	Nil	Nil	Nil
End pH	7.1	6.9	7.2	7.2	7.2	7.4	6.4
Hypochlorite IInd Stage:							
Av. Cl_2 added, %	1.0	1.0	0.8	1.0	1.0	1.5	2.0
Av. Cl_2 consumed%	0.45	0.6	0.4	0.6	0.65	1.2	1.95
Sulphamic acid on pulp, %	0.07	0.07	0.07	0.07	Nil	Nil	Nil
End pH	7.8	7 2	7 2	7.2	7.1	7.2	7.0
Total Cl_2 added, %	10.75	10.0	8.55	11.5	13.0	15.5	17.0
Total Cl_2 consumed, %	10.05	9.1	7 4	10.3	11.3	13.4	14.9
Shrinkage during bleaching, %	11.6	9 2	9.0	8.0	15.0	16 0	20.0
Brightness, (Elrepho), %	78 3	80.0	81.0	80.0	78.0	85.5	79.1
Viscosity (CED), cp.	15.0	12.3	10.2	7.6	5.0	4 1	2.9
Avg. Degree of Polymerization	1205	1080	964	810	580	490	340

Table No. VIII—Pulp evaluation of bleached pulps

Particulars	Set Numbers						
	1	2	3	4	5	6	7
Viscosity (CED), cp.	15.0	12.3	10.2	7.6	5.0	4.0	2.9
Final Freeness, °SR	29	29	28	30	31	30	30
Beating time, Min.	25.0	17.0	19.0	7.0	5.5	4.0	3.3
Drainage time, Sec.	6.0	5.3	5.3	6.0	5.5	5 5	5.5
Basis Weight, g/m^2	61.2	59.2	59.8	61.5	58.7	58.3	59.0
Bulk, cc/gm.	1.70	1.72	1.75	1.58	1.72	1 64	1 58
Breaking length, km	5.9	4.95	4.92	5.9	3.9	3.9	3.6
Stretch, %	3.6	3.4	3.4	3.1	3.3	2.9	2.0
Burst factor	47 0	38.2	41.2	39.0	26.8	27.0	23.0
Tear factor	147.0	135.0	130.0	115.0	102.0	53.6	29 4
Double folds (MIT)	114	71	51	55	15	10	2
Strength index*	2520	2220	2080	1980	1560	1130	605

*Strength Index = (Burst factor x Tear factor x Log Double folds$^{1/3}$ x 100)

Acknowledgements :

The authors express their gratitude to the Management of the West Coast Paper Mills Limited for permission to publish this paper. The authors are also thankful to Dr. R. S. Tripathi, formerly, Research Officer, The West Coast Paper Mills Limited for his help in this work.

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