Degree of Cooking Versus Yield and Bleachability of Bamboo Pulps

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Experiments were carried out to determine the effect of the degree of cooking as measured by P. No. on pulp yield and bleachability of bamboo pulps. Unbleached sulphate pulps of permanganate number 16, 18.5, 21 and 26 were made by varying cooking temperature and active alkali on chips. The unbleached pulps were analysed for total yield, percentage of screenings and permanganate number. The pulps were bleached by using sequences C/EH/H and C/E/H. When using C/E/H sequence, the chlorine consumption for pulps of permanganate number 18.5-26 was lower by about 1.0-2.6% to C/EH/H sequence. However, with a pulp of permanganate number 16, the difference in total bleach consumption using C/EH/H and C/E/H sequences, was insignificant. Because of variations in pulp yield and bleach requirement with pulps of varying permanganate numbers, emphasis is laid on major factors, viz. the cost of the cooking and bleaching chemicals, raw material, recovery of the usable fibre from the rejects, the dissolved solids load (inorganic and organic) and the capacity of the recovery section, while arriving at optimum permanganate numbers for bleachable pulps.

INTRODUCTION

The effective utilization of bamboo is the most urgent need of the paper industry today. One simple way of doing this is to increase the pulp yield from bamboo chips either by raising the permanganate number or by adopting processes which will selectively dissolve out the lignin. As the conventional alkaline pulping processes are not very selective in their action towards the lignin, the carbohydrate losses are unavoidable during the delignification process. To some extent the carbohydrate losses can be minimised if the lignin-hemicellulose relationship during the delignification process is known and if necessary by terminating the cooking reaction at a somewhat higher degree of cooking than normally used. The additional increments in yield of unbleached pulps obtained in this way (i.e. by raising the degree of cooking) does not presnt any special problems as long as the quality of the product is consistent with the requirements. However, for bleachable pulps the cost of chemicals involved in bleaching and the increments in bleached pulp yield obtained go together. If the increments in yield are sufficient to offset the cost of chemicals involved in bleaching, a harder pulp may be preferred. On the other hand, if with increasing hardness, the fibres get loaded with more of lignin than cellulose, bleaching of such pulps to high brightness by conventional bleaching agents may not be economical. It is thus obvious that the optimum pulping for unbleached and bleachable pulps may not necessarily be the same. In the study reported below some of these points have been brought out for consideration so that every pulp and paper mill should work out the optimum degree of cooking for unbleached and bleachable pulps.

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EXPERIMENTAL

Flowered dowga bamboo (Bambusa arundinacea) chips were collected from the chip silo. Hand sorting of the chips was done to ensure chip size uniformity. A portion of the chips was used for moisture determination after which a number of charges equivalent to 1.5 kg. (o.d) were weighed out. The pulping was carried out in an electrically heated rotary digester of 16 litre capacity, tumbling at 2 r.p.m. For making up the liquor to chips ratio, water was used as a diluent. The digester was relieved to atmospheric pressure after the cooking was over and the contents of the digester were immediately quenched in a large volume of water. The cooked material was defibred in a laboratory mixer, washed and dewatered several times to remove all the dissolved components. The washed pulp was thickened in a hydra-extractor to a consistency of 25-26% and then granulated. The uncooked pieces (rejects) were removed by hand picking. The granulated pulp, free of rejects, was weighed. The total and screened pulp yields were determined. The pulps were analysed for permanganate number according to TAPPI standard (T 214m-50). The conditions of pulping used and the results obtained are given in table I.

Bleaching of the pulps was carried out using pulps equivalent to 50 gm (o.d.) for each experiment. The sequences employed were C/EH/H and C/E/H. The bleached pulps were analysed for yield, brightness and viscosity. The chlorine and caustic consumption during bleaching was also determined. The conditions of bleaching

TABLE I

Pulping of bamboo chips to different permanganate number

Constant conditions :

Moisture in chips, %	15
Chips/liquor ratio by volume (including moisture in chips)	1:3
Sulphidity, %	21
Time to raise max. temperature, mts. (for cook No. 1-4)	120
Time at max. temperature, mts. (for cook No. 1-4)	60
Total time, hours : min.	3:0

Cook No.		1	2	3	4	5*	6*
Active alkali added (NaOH + Na_2S)	%	18.5	20	21	22	22	22
Initial concentration of chemicals (NaOH + Na_2S)	g/l	61.6	66.6	70.0	73.3	73.3	73.3
Cooking temp.	°C	150	160	160	165	165	165
Total yield	%	55.4	52.9	51.3	50.0	49.4	48.4
Screened yield	%	50.8	50.2	49.8	49.0	48.7	47.4
Rejects	%	4.6	2.7	1.5	1.0	0.7	1.0
$KMnO_4$ No. (40 ml)		26.4	21.0	18.5	16.1	16.8	12.7

* In cook numbers 5 and 6 a predigestion step was employed in which delignification was first carried out at 130-145°C and then the temperature was raised and further cooking accomplished at 165°C.

Temperature schedules :

Cook No. 5 :	30-145	+	145	+	145-165	+	165°C
	90 min		150 min		165 min		225 min

Total time hrs : min 3 : 45

Cook No. 6 :	30-130	+	130	+	130-165	+	165°C	+
	60 min		120 min		155 min		275 min	

Total time hrs : min 4 : 35

TABLE II

Bleaching of pulps of different permanganate number by C/EH/H sequence

Permanganate (K) No.		26.4	21.0	18.5	16.1
Chlorination stage (a)					
Cl_2 added	%	12.5	7.5	7.0	6.0
Cl_2 consumed	%	12.2	7.4	6.7	5.6
Final pH		1.10	1.30	1.35	2.60
Extraction + Hypo stage (b)					
NaOH added	%	3.0	2.0	2.0	2.0
Cl_2 added*	%	5.0	3.0	3.0	2.0
Cl_2 consumed	%	4.98	2.69	2.70	1.64
Final pH		7.5	7.1	7.3	9.0
Hypo stage (c)					
Cl_2 consumed	%	0.72	0.71	0.65	0.63
Final pH		8.5	8.3	8.3	8.4
Total Cl_2 added	%	19.0	12.0	11.5	9.5
Total Cl_2 consumed	%	17.9	11.0	10.1	7.9
Elemental Cl_2 consumed	%	12.2	7.4	6.7	5.6
Cl_2 consumed as OCl^-	%	5.72	3.60	3.35	2.27
NaOH consumed	%	3.3	2.3	2.3	2.3
Brightness	%	78	78	78	79
Tappi viscosity, cp		55	42	40	31.5
Yield of bleached pulp on screened unbleached pulp	%	90.9	92.0	92.0	93.7

Permanganate (K) No.		26.4	21.0	18.5	16.1
Yield of bleached pulp on bamboo chips	%	46.2	46.2	45.8	45.9

(a) Consistency, %	3.5	(b) Consistency, %	5	(c) Consistency, %	5
Temp. °C	28	Temp. °C	50±1	Temp. °C	40±1
Time, mts	60	Time, mts.	60	Cl_2 added, %	1.5
				NaOH added, %	0.3
				Time, mts.	120

* Chlorine added as calcium hypochlorite.

TABLE III

Bleaching of pulps of different permanganate number by C/E/H Sequence

Permanganate (K) No.		26.4	21.0	18 5	16.1
Chlorination stage (d)					
Cl_2 added	%	12.5	7.5	7.0	6.0
Cl_2 consumed	%	12.2	7.4	6.7	5.6
Final pH		1.10	1.30	1.35	1.60
Extraction stage (e)					
NaOH added	%	3.0	2.0	2 0	2.0
Final pH		11.0	10.5	11.2	11.35
Hypo stage (f)					
Cl_2 added	%	4.2	3.5	3.5	3.0
Cl_2 consumed	%	3.1	2.6	2.4	2.0
NaOH added	%	0.6	0.5	0.5	0.5
Final pH		8.3	8.4	8.2	8.4
Total Cl_2 added	%	16.5	11.0	10.3	8.7
Total Cl_2 consumed	%	15.3	10.0	9.1	7.6
Elemental Cl_2 consumed	%	12.2	7.4	6.7	5.6
Cl_2 consumed as OCl^-		3.1	2.6	2.5	2.5
NaOH consumed	%	3.6	2.5	2.5	2.5
Brightness	%	79	78.5	79	79
Tappi viscosity, cp		46	37	38	28.5
Yield of bleached pulp on screened unbleached pulp	%	91.2	93.1	93.3	93.8
Yield of bleached pulp on bamboo chips	%	46.3	46.7	46.4	45.9

(d) Consistency, %	3.5	(e) Consistency, %	5	(f) Consistency, %	5
Temp. °C	28	Temp. °C	50±1	Temp. °C	40±1
Time, mts.	60	Time, mts.	60	Time, mts.	120

and the results obtained are given in table II and III.

Results and discussion : It could be seen from the results given in table I and graphically in fig. 1 that the total pulp yield continuously decreases as the active alkali added on chips was increased from 18.5-22%. However, the screened yield was relatively unchanged. It only showed a downward trend in cook No. 4 when the permanganate number of pulp was reduced to 16. The relatively constant screened yield for cook Nos. 1 to 3 indicates that under the conditions of pulping used, the rate of pulping of rejects far exceeds the rate of dissolution of pulp and it is the former which is contributing in maintaining the screened yield. This could be also seen from the rejects percentage which is continuously decreasing. The permanganate number also shows a continuous decrease with increase in the amount of active alkali added.

A comparison of the results in table II and III illustrates the effect of bleaching sequence, viz. C/EH/H and C/E/H on total bleach consumption and pulp viscosity. By using the sequence C/EH/H the bleached pulps were obtained with somewhat higher viscosity when compared to where C/E/H sequence was used. One of the disadvantages of using the former sequence is that for achieving the same final brightness of the pulp, the total bleach consumption is more. This implies that some of the available chlorine is unnecessarily consumed in bleaching the coloured extracted products in EH stage. For this reason it is concluded that the sequence C/EH/H is not favourable and economical for bleaching pulps of higher permanganate number (18-26). A significant observation which could be made from this study is that when the permanganate number of the pulps was raised from 16 to 26, the bleached pulp yield calculated on the basis of screened unbleached pulp yield, was unaffect-

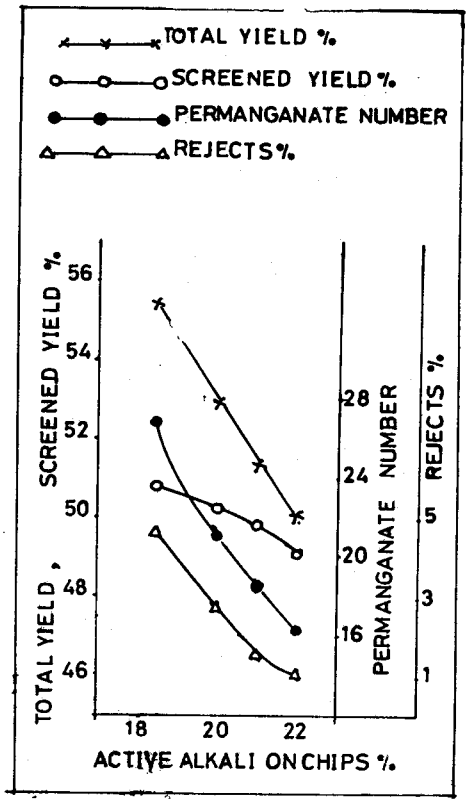

Fig. 1 — Effect of active alkali added on chips to total pulp yield, screened pulp yield, reject percentage and the permanganate number of pulps.

ed. However, there is consistent lowering of the pulp quality as measured by the viscosity for low permanganate number pulps. The difference in viscosity of the bleached pulps is significant when the permanganate number of the starting unbleached pulps was 26 and 16. About 38-42% reduction in viscosity was observed in the latter case. The considerations, viz. the amount of cooking chemicals and the lowering of the pulp quality when preparing and bleaching pulps of permanganate number 16 lead us to conclude that it is not justifiable to prepare in mill practice pulps of permanganate number 16 or lower. Now, the choice for optimum pulping for bleachable pulps is left between the permanganate number range of 19-26. Here, the important considerations are (i) method of recovering the usable fibre from rejects, (ii) cost of the raw material and the cooking and bleaching chemicals and (iii) the maximum capacity of the soda recovery unit to handle the black liquor solids etc. The optimum pulping to a permanganate number of 26 for producing bleached pulps may be considered in a situation where (i) the usable fibre from the rejects is recovered by mechanical action rather than by repulping, (ii) the cost and availability of the raw material is an important factor and (iii) in mills trying to step up their production and have the limitation of handling the maximum solids in the soda recovery unit. A harder cook in the above situation will give the advantage of high un bleached and bleached pulp yields, reduced raw material and cooking chemicals cost, and will enable to raise the production of pulp as the total solids per tonne of pulp going to soda recovery will be less. On the contrary, where the pulp from the rejects is recovered by repulping, there is no limitation of handling black liquor solids and the cost of the bleaching chemicals is an important factor, a softer cook of 19-21 permanganate number may be preferred.

CONCLUSIONS

1. Under the conditions of pulping studied, pulp cooked to a high permanganate number (26) have given bleached pulp of higher viscosity and may show better strength properties.
2. A pulp cooked to a high permanganate number requires excess amounts of alkali in EH and E stages for maintaining same final pH thereby indicating higher alkali requirement when compared to pulps of permanganate number 16 or 18.5.
3. A difference of about 2.6% in total bleach consumption was observed for a pulp of permanganate number 26.4 when bleaching by C/EH/H and C/E/H. For pulps of permanganate number 18.5 and 16, the difference in bleach consumption is by 1% and 0.3% respectively, showing that the differences become narrower with low permanganate number pulps.
4. The optimum pulping for bleachable pulps has to be worked out by each mill depending on individual circumstances, viz. the method of recovering the fibre from rejects, cost of the raw material and the cooking and bleaching chemicals load on the soda recovery etc.