Effect of Fines on the Optical Properties of Bamboo Pulp

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ABSTRACT:-- The fines in bamboo unbleached pulp amount ~30%. The fines contain more of lignin, Alcohol-Benzene extractive and ash than the fibrous fraction. In the 'whole' pulp, the fines consume bleaching chemicals more than the fibrous part. Though the fines have comparatively poor optical property, namely P.C.no. of 15 and 20.2; brightness 67 and 79% El with copper no. of 2.4, they do not deteriorate correspondingly the optical properties of the whole pulp. The localization of these fines in the void spaces created by the long fibres in paper, has been conceived. As the fines remain shielded in between the long fibres, the light scattering property of paper remains practically uneffected due to the presence of fiber fines. There may not be any need therefore to eliminate the fines during paper manufacturing even though they possess inferior optical properties compared to the fibrous fraction.

INTRODUCTION

Though role of fines in high productivity as well as product quality in paper manufacturing is recognized since long, it is only recently that a rational classification of the various fines with mechanisms for access into the fiber network was given (1). The fines were divided into four categories:

a) White water fines

b) Simulated fines

c) Filler fines

c) Fiber fines.

The fiber fines occupy the void spaces occuring in the wet web during paper manufacturing. The turbulence created by shearing forces in the system, converage the fines towards the voids increasing thus the fiber-fiber interactions. The fiber fines were found to enhance the strength properties of paper as the short fibers possess composite bonding characteristic. The present paper is intended to further establish this conception specially with respect to localization, bonding characteristic and consequently the brightness property of the paper made from the 'whole'.

The fiber fines are known to be different (2) from those of the fiber fractions in morphology, physicochemical properties, swelling behaviour, crystallinity, water vapour sorption and pore size distribution.

The fines produced by cutting of fiber bundles are undesirable as they lack in bonding property which can cause linting and dusting problems in the sheet. Only fines obtained from individual fibers and segments are desirable (3) in paper manufacturing. These fines are also generated from the fiber cell walls. It is often rich in non-fiber cells including parenchyma cells, mineral matter, low molecular carbohydrates like xylan, arabinose (pentosans) and notably the lignin (4, 5, 6). The fines have been considered to be deleterious to the final brightness property and even fractionation of the fines has been

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suggested (7, 8). The present work advocates against need of such fractionation. In fact, separation of fines in the unbleached pulp is rarely practised as the yield will be reduced significantly and the economic viability can be questioned. Thus, the present work is of commercial significance also.

EXPERIMENTAL

Dendro calamus strictus variety of bamboo has taken in the present study which was chipped manually and the accepted portion (-30, +3 mm) has been cooked in a Rotary digester with following conditions:

Active alkali dose	= 17.5%
Sulfidity	= 18%
Bath ratio	= 1 : 2.7
Time to temperature	= 2 hr, and
Time at temperature	= 1.5 hr.

The bleaching has been carried out in CEHH sequence with

(a) similar conditions (same amounts of Cl_2 (6.6%) and hypo (3.5%) were added;

(b) Optimum condition (Cl_2 and hypo were varied in the 3 samples based on kappa no.).

The unbleached pulp has been taken for proximate chemical analysis and bleaching studies. The fines consist of -200 mesh fraction (separated in the Britt dynamic jar) fibers, +200 mesh and the 'whole' is the pulp as such without fractionation.

Tappi standard methods (9) have been adopted for the chemical analysis and bleaching conditions maintained, are as in the mill. Brightness, P.C. no., viscosity and copper no. have also been determined as per standard Tappi procedures (10). The brightness was measured in the Brightness tester (Elrepho) at wave length of 457 nm with MgO standard.

RESULTS AND DISCUSSION

The proximate chemical analysis in Table 1 shows that excepting the pentosan content, the fine fraction is inferior to the fibrous fraction and whole in Alcohol-Benzene extractive, lignin and ash content. The higher amount of lignin in the fines is due to the primary layer of cell wall (11), present in the fine fraction. The fine fraction has 2.66% of ash which is 0.59% in the fibrous part; lignin is 3.5% in the former while it is 1.1% in the fibrous part; the corresponding Alcohol-Benzene extractive are 2.3 and 0.51%. The 'whole' has average composition of extractive values as well as lignin but its ash content is as high as the fine fraction (2.63%)

The bleaching conditions are given in Table 2 and 3. The bleaching characteristics (Table 3) show that the Cl_2 consumed is comparatively higher (6) in the fines fraction (6.6% instead of 5.57% in the fibrous fraction). In the extraction stage, the final pH in the fine fraction is 10.1 which is 11.1-11.2 in the other two, showing higher consumption of NaOH.

Table-1

Proximate chemical analysis

Property		Whole	Fibrous fraction	Fines fraction
Alcohol-Benzene extractive	%	1.25	0.51	2.30
Klason lignin,	%	2.00	1.10	3.50
Pentosan,	%	14.80	13.70	16.70
Ash,	%	2.63	0.59	2.66

Table-2

Bleaching conditions

Particulars		Chlorination	Extraction	Hypo
Temperature,	°C	Ambient	55	40
Retention time,	hr	0.75	1.5	2.5
Consistency,	%	3	10	10

Table-3

Bleaching characteristics

Particulars		Whole	Fibrous fraction	Fines fraction
Kappa no.		26.3	17.7	30.4
CHLORINATION				
Chlorine added,	%	6.6	6.6	6.6
Chlorine consumed,	%	6.14	5.57	6.6
Final pH		1.8	1.5	1.8
EXTRACTION				
Alkali added,	%	1.8	1.8	1.8
Final pH,		11.2	11.1	10.1
HYPO				
Hypo added (as Cl_2),	%	3.5	3.5	3.5
Buffer added (alkali),	%	0.8	0.8	0.8
Final pH		8.3	8.6	7.6
Chlorine consumed,	%	3.2	3.2	3.5

In the hypo-stage, the final pH in the fine fraction is 7.6 instead of 8.6 in the fibrous fraction and 8.3 in the 'whole'. Correspondingly, Cl_2 consumed is 3.5% in the fines (3.2% in the other two).

The kappa no. (Fig. 1) of the fine fraction is very high (30.4) compared to the fibrous fraction (17.7) and the 'whole' (26.3). The higher kappa no. is due to higher lignin content (4) and Alcohol-Benzene extractive (Table 1).

The viscosity value of the fine fraction is also poor (5.7 cP); it is 7.8 cP in the fibrous fraction and 7.3 cP in the 'whole' (Fig. 2). This can be explained on examining the results (Table 4) of α-cellulose which is 87.6% in fibrous fraction and 57% in the fine fraction. The lower strength cellulose namely β

FIG.1 : KAPPA NO. OF PULP

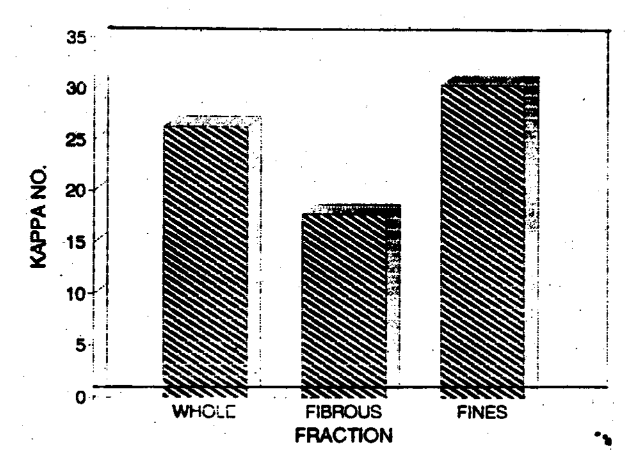


FIG. 2 : VISCOSITY OF PULP

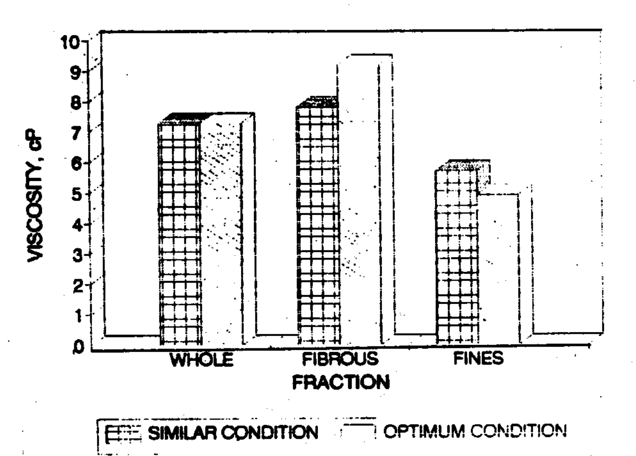


Table-4

Bleached pulp properties

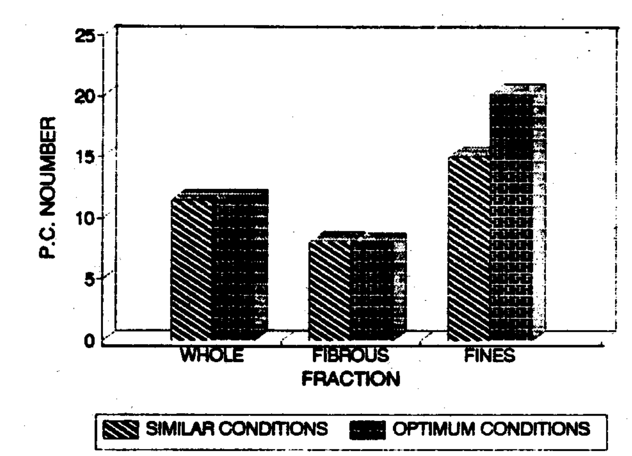
Property		Whole	Fibrous fraction	Fines fraction
α-cellulose,	%	86.4	87.6	57
β-cellulose,	%	4.3	2.8	11.3
γ-cellulose,	%	9.3	9.6	31.7

and γ-cellulose are also more in the fines than on the fibrous fraction and the 'whole'. The γ-cellulose is as high as 31.7% in the fine fraction.

The viscosity values of fines, fibrous fraction and 'whole', are shown in Fig. 2, for pulp samples bleached in similar as well as optimum conditions. Though the fines possess very low viscosity 4.9 cP compared to the fibrous fraction (7.8 and 9.2 cP), the viscosity of 'whole' is 7.3 cP in both the pulps. It can be seen that the deterioration in strength property due to the fines is not significant, specially in the pulp bleached for 'whole' at similar condition.

The P.C. nos. of the 3 pulp samples studied, are also shown in the histograms (Fig. 3). The fine fractions have very high P.C. no. of 15 and 20.2 respectively in the pulp at similar and optimum bleaching conditions. In the fibrous fractions it is 8.1 and 8 in the two conditions while in the 'whole', it is 11.5 for both the pulp samples. The fine fraction in the 'whole' being ~30%, the effect of fines in the 'whole' pulp should have been more severe but probably because of the fines remaining partially shielded by the long fibers.

FIG. 3 : P.C. NUMBER OF PULP



The copper no. of the 3 pulp samples are given in Fig. 5, showing colour reversion to be comparatively higher in the fines than in the other two samples (2.4 in fines; 0.7 in fibrous part and 0.87 in the 'whole').

The bleaching characteristics at optimum doses of chemicals are given in Table 5. It can be seen that the Cl_2 consumption is quite high in the fines; 7.88% in stead of 4.61 and 6.33% in the fibrous part and 'whole' respectively. Because of higher Cl_2 content, the pH is also slightly less in the fines fraction. Similar to the results in Table 3, the NaOH requirement of the fines is more than the other two pulp samples. The corresponding Cl_2 consumed in the hypo stage is also quite high for the fines compared to the other pulp samples. Because of high lignin, Alcohol-Benzene extractive and short fibers (β and γ-cellulose), the fines consume more of chemical than the other two pulp samples. Naturally, if the fine portion is reduced, there will be reduction in chemical consumption with improvement in the optical properties. Therefore, even fractionation of the fines, has also been suggested (7). However, this will reduce the yield, apart from the cost to be involved in the fractionation.

FIG. 4 : BRIGHTNESS OF PULP

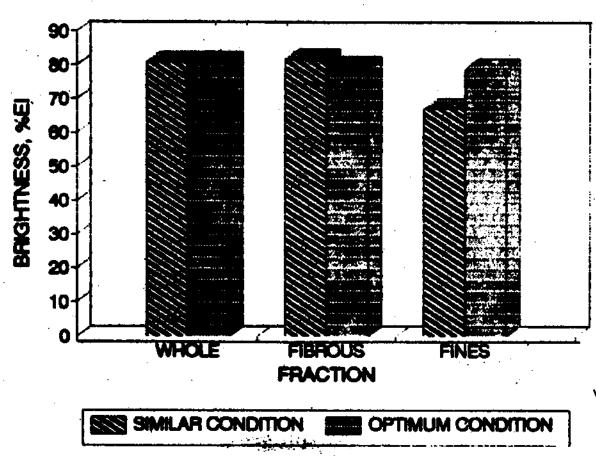
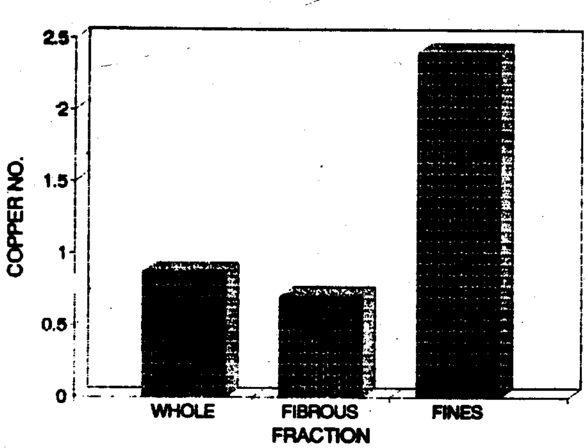


FIG. 5 : COPPER NUMBER OF PULP



The analysis results of α, β and γ-cellulose in the 3 pulp samples are given in Table 6. The γ-cellulose in fines is 43% only compared to 92% in the fibrous fraction and 86.3% in the 'whole' part. These values have bearing on the viscosity values (Fig. 2)

The brightness values (Fig. 4) of the fine fraction is 79% El which is 79.8% El in the fibrous fraction and 80.9 in the 'whole'. as the 'whole' contains also the fines, one would expect the brightness value to have come down further but because of localization of the fines in the void spaces, the effect does not become dominant on the overall pulp

Table-5

Bleaching characteristics at optimum doses of chemicals

Particulars		Whole	Fibrous fraction	Fines fraction
CHLORINATION				
Chlorine added,	%	6.6	4.75	8.0
Chlorine consumed,	%	6.33	4.61	7.88
Final pH		1.9	1.8	1.7
EXTRACTION				
Alkali added,	%	1.8	1.5	2.0
Final pH,		10.6	10.1	9.5
HYPO				
Chlorine added,	%	3.50	2.75	4.80
Chlorine consumed,	%	3.22	2.75	4.46
Final pH		8.6	9.5	7.9

Table-6

Bleached pulp properties at optimum conditions

Property		Whole	Fibrous fraction	Fines fraction
Brightness,	% El	80.9	79.8	79
Viscosity	cP	7.3	9.2	4.9
α-cellulose,	%	86.3	92	43
β-cellulose,	%	9.3	6.3	40.9
γ-cellulose,	%	4.4	1.7	16.2

brightness. This is more pronounced in Table 4 where the brightness of the 'whole' has been raised to 80.9% El in spite of the poor brightness of the fines which is 67% El.

The fiber fines being fairly flexible, packing of the void spaces becomes easy specially in presence of the turbulence created by shearing forces during hand sheet making. The opposing negative changes of the void surface and fiber fines become less important in front of the shearing force, resulting on a better packing system (1).

CONCLUSIONS

Bamboo fines (-200 mesh) possess higher lignin, Alcohol-Benzene extractive and ash than the fibers (+20 mesh) which result in lower viscosity and high chemical consumption values in the fines compared to the fibrous fraction.

The P.C. no. and copper no. of the fine fraction are also high indicating intense colour reversion property compared to the fibrous fraction. The fines fraction has also poor brightness property but in the 'whole' portion, it is not reflected.

Based on the optical properties, the localization of fines in the void spaces of the sheet, has been established.

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