Pulping and papermaking characteristics of bamboo twigs

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SUMMARY

Bamboo twigs and branches have been examined for their pulping and papermaking characteristics, singly and in mixture with sound bamboo (Dendrocalamus strictus). The study reveals that bamboo and its twigs differ considerably in their chemical constituents, yet their pulping and bleaching characteristics are more or less similar. Bacause of lower length of rhe twigs, their physical strength properties are some what lower than bamboo. However, a mixture of twigs and bamboo in the ratio of 1:6 has comparable pulping, bleaching and strength properties with those of bamboo. Hence, twigs can be utilized as a substitute raw material for papermaking, provided proper arrangements are made for their collection, transportation and chipping.

The continuously growing scarcity of bamboo has already forced the paper industries in India, to use various hardwoods, grasses etc. as substitute material. Many hardwood varieties behave differently from bamboo and so it is very difficult to process them together. Bamboo twigs which constitute about 10 percent of total bamboo culm are left in the fields at the time of felling and subsequently burnt. This forest waste can be utilized for making pulp and paper. The twigs can be baled for easy transportation. The collection of twigs can be done first by bundling them at felling site and then these bundles are to be brought to a place where baling facilities are provided. The bales of twigs then can be easily transported to the mills. However the economic aspects of packing and transportation are to be carefully weighed. In this project the potentiality of bamboo twigs as a raw material for paper industries has been investigated and the technical merits and demerits of using this raw material are discussed.

EXPERIMENTAL

Bamboo (Dendrocalamus strictus) samples with twigs and leaves were collected from a local nursery. The twigs were detached from culm and leaves were separated after drying. The twigs were chipped manually to 10-15 mm length. Bamaboo samples were also chipped in a conventional paper mill chipper.

Chips size classification was carried out on William's chips classifier and results are recorded in Table—1. Chips —32 + 3 mm fractions were taken for study.

TABLE—1
CHIPS SIZE CLASSIFICATION

	Bamboo	Twigs
+32	4.2	Twigs were manually Chipped.
—32+25	26.2	
—25+22	15.9	
—22+19	11.0	
—19+16	11.2	
—16+13	14.4	
—13+ 6	15.3	
— 6+ 3	1.8	

PROXIMATE CHEMICAL ANALYSIS

Bamboo and bamboo twigs were powdered separately in laboratory grinder and powdered samples were analysed. The analysis was carried out as per TAPPI standard methods except holocellulose

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which was determined by sodium chlorite method. The results are recorded in Table—2.

TABLE—2

PROXIMATE CHEMICAL ANALYSIS

PARTICULARS		BAMBOO	TWIGS
Moisture	%	6.0	6.0
Cold water solubility	%	6.0	8.5
Hot water solubility	%	7.6	11.0
1%NaOH solubility	%	22.0	26.6
Alcohol/Benzene solubility	%	6.9	7.7
Pentosons,	%	17.1	18.3
Klason lignin,	%	27.6	24.4
Holocellulose	%	70.9	69.0
Ash	%	4.60	4.05

PULPING

As twigs constitutes about 10% of bamboo culm, the pulping of the following samples were studied for relative evaluation :

A — Bamboo 100%

B — Twigs 100%

C — Mixture of twigs and bamboo (10% : 90%)

The optimum conditions of pulping ie chemicals and 'H' factor were determined to get unbleached pulp of Kappa No. 26 ± 2 The pulping of individual samples (A, B, C) was carried out by taking 2 Kg OD chips in an electrically heated rotary digester under the optimum conditions of pulping. The conditions of pulping and results are recorded in Table -3.

TABLE—3

PULPING DATA

PARTICULARS		BAMBOO	TWIGS	BAMBOO+TWIGS (90%+10%)
Moisture in chips	%	10	10	10.0
Active alkali on OD chips, as Na_2O	%	17.5	18.0	17.5
Bath ratio (Chips : Liquor)	%	1:3	1:3	1:3
Diluent		Water	Water	Water
White liquor Sulfidity ±1	%	19	19	19
Cooking schedule		50 to 170°C=2 hr At+170°C=1 hr	50 to 170°C=2 hr At+170°C=1.25 hr	50 to 170°C=2 hr At+170°C=1.0 hr
'H' Factor		1120	1260	1120
Screened pulp yield	%	45.2	40.5	45.0
Rejects	%	1.6	3.0	1.8
Total yield	%	46.8	43.5	46.5
Kappa No.		26.5	28.0	27.9
Black Liquor				
pH		11.6	12.2	12.2
Active alkali as Na_2O at+200 gpl T.S.		8.4	9.1	8.3

BLEACHING

CEHH sequence was used for bleaching the pulps, 500 g OD pulp for each set was taken and disintegrated to open the fiber bundles and excess water was removed, for chlorination, an optimum chlorine doze of 1/4 of Kappa No. was used[1]. After chlorination the filtrate was collected and residual chlorine and pH were determined and pulp was washed thoroughly. Alkali extraction was carried out at a pH of 9.5 using optimum conditions of temperature and alkali concentration[2], as given in Table—4. Hypo I & II stages were also carried out in hot water bath and using calcium hypochlorite of 24-25 gpl. available chlorine. The pulps were washed thoroughly after every stage of bleaching. These data are shown in Table—4.

BAUER McNETT CLASSIFICATION AND FIBER MORPHOLOGY

Bauer McNett classification of the bleached pulps were carried out as per TAPPI T-233 standard procedure. The results are recorded in Table—5-A. Average fiber length and diameter of individual bleached pulps (100% bamboo and 100% twigs) were determined microscopically and recorded in Table - 5 B.

PHYSICAL STRENGTH PROPERTIES OF PULPS

The bleached pulps were beaten separately in a laboratory valley beater to four different slowness

TABLE—4
BLEACHING WITH CEHH SEQUENCE

		BAMBOO	TWIGS	BAMBOO+TWIGS
unbleached pulp Kappa No.		26.5	28.0	27.9
CHLORINATION				
Cl_2 added	%	6.50	7.00	6.50
Cl_2 Consumed	%	6.45	6.65	6.40
Final pH		1.7	1.7	1.7
ALKALI EXTRACTION				
NaOH added	%	1.7	1.7	1.7
Final pH		9.2	9.7	9.3
HYPO I STAGE				
Cl_2 added	%	2.50	3.00	2.50
NaOH added	%	0.6	0.6	0.6
Cl_2 consumed	%	2.38	2.56	2.37
Final pH		8.6	8.7	8.4
HYPO II STAGE				
Cl_2 added	%	1.C0	0.50	1.00
Cl_2 consumed	%	0.60	0.23	0.68
Final pH		7.6	7.9	7.7
Total Cl_2 added	%	10.00	10.50	10.00
Total Cl_2 consumed	%	9.43	9.42	9.45
Brightness (Elrepho.)	%	80.0	79.6	78.5
Viscosity Cp (CED)		10.6	7.4	9.60
Post colour No. 95% RH, 95°C for 1 hr		7.8	79.6	8.9

N.B. (1) Chemicals were added on the basis of O.D. unbleached pulp.

(2) Constant conditions

		C	E	H_1	H_2
Consistency	%	3.0	10.0	10.0	10:0
Temperature	°C	Ambiant (28-30)	55	40	40
Retention time hr		0.75	1.0	1.0	1.5

TABLE—5A

BAUER McNETT CLASSIFICATION OF FIBERS

Mesh No.	Mesh Opening mm.	BAMBOO	TWIGS
		% Retained	
+16	1.19	58.9	12.28
—16+30	0 595	14.3	30.35
—30+50	0.297	8.5	17.20
—50+200	0.074	5.5	13.6
- 200	—	12 9	28.6

TABLE 5—B

FIBER MORPHOLOGY

PARTICULARS	BAMBOO	TWIGS
Av. fiber length, mm	2.1	0.90
Av. fiber Diameter Micron.	16	11.3

levels and standard handsheets (60 gsm) were made on British Hand Sheet making machine. After conditioning, the sheets were tested for various strength properties at different slowness levels as shown in figs. 1, 2 & 3 and strength properties at 30°SR are recorded in Table—6.

OBSERVATIONS AND DISCUSSIONS

1) Chips of bamboo twigs, manually cut, were cylindrical, shorter in length and non-uniform.

2) Proximate chemical analysis (Table—2) shows that cold and hot water. 1% NaOH, Alcohol-benezene solublities and pentosan contents are more and lignin, holocellulose and ash contents are lower in case of twigs compared to bamboo.

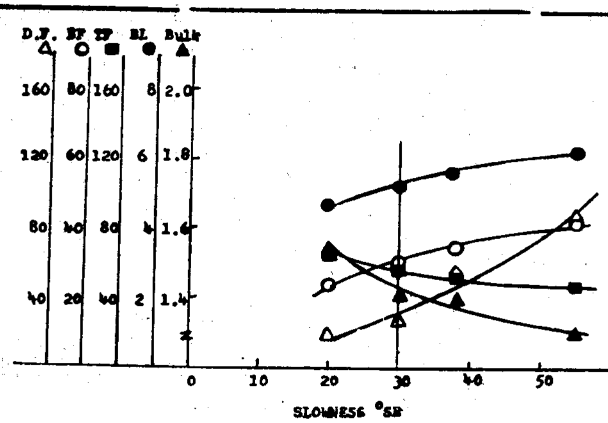

Fig. 2—Slowness Vs Physical strength properties (Twigs Pulp)

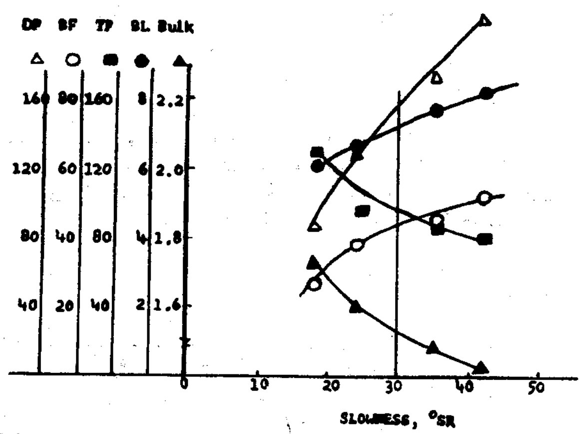

Fig. 1– Slowness Vs Physical strength properties (Bamboo Pulp)

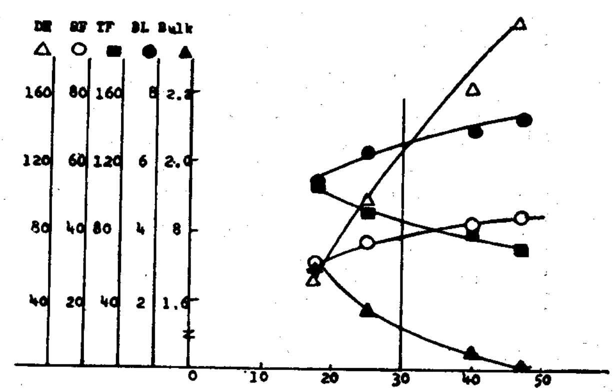

Fig. 3—Slowness Vs Physical strength properties (Bamboo + Twigs Pulp)

TABLE—6

PHYSICAL STRENGTH PROPERTIES OF HANDSHEET AT 30°SR

Particulars	Bamboo	Tw gs	Bamboo + Twigs
Slowness °SR	30	30	30
Basis wt, gsm ±1	60	60	60
Bulk $Cm^3/9$	1.54	1.46	1.52
Burst factor	45	31	39
Tear factor	98	56	86
Breaking length, Km	7.30	5.40	6.60
Double folds No.	1С0	32	128
Strength index	2140	1377	1920

Strength index. $(\text{Log D. F} \times \text{T. F} \times \text{B. F})^{1/3} \times 100$

3) It can be observed from Table-3 that bamboo (A) twigs (B) and their mixture[8] required nearly the same chemical (active alkali) charge to obtain pulps of Kappa No. 26±2. Percentage rejects was higher in case of twigs due to non uniformity of chips size. Total pulp yield in case of twigs[8] was lower compared to bamboo (a). However, yield was comparable for A &C.

4) Bleaching results indicate (Table-4) that all the pulps (A,B,C) behaved in a similar way i.e. nearly same amount of chlorine was required to obtain the desired brightness, viscosity of the pulps of twigs was lower compare to A and C., which (A & C) were nearly the same.

5) Bauer McNett classification data indicate that pulp of twigs has comparatively very low fiber (in length) as shown by retention values at 16 and 30 mesh. This finding is further confirmed by microscopic determination of fiber length. Average fiber length of bleached pulps of twigs is 0.9mm. while of bamboo pulp 2.1 mm as shown in Table 5-6.

6) Comparing the data of strength properties at 30°SR by interpolation of fig. 1,2 & 3 and shown in Table-6, it is seen that all the properties i.e. double folds, breaking length, tear factor and burst factor are lower in case of twigs (B) than bamboo (A.) In case of sample (C) (90% bamboo and 10% twigs) also all those properties are slightly reduced as compared to those of sample (A).

CONCLUSION

It is observed that twigs are rather non uniform in their phys ical characteristics and hence the chips after pulping give more rejects. But this problem can be solved by using mechanical chippers suitable for the twigs.

Bamboo (A) and twigs (B) are having difference in their chemical constituents as shown by proximate chemical analysis data but their behaviour during pulping and bleaching is nearly the same except lower yield. In case of twigs the strength properties of twigs are also lower as confirmed by results of Bauer McNett classification of fibers. However, when bamboo and twigs are mixed in the ratio of 90:10, the results of pulping, bleaching and even the strength properties are quite comparable with bamboo.

So, it can be finally said that bamboo twigs can be utilized with sound bamboo for making pulp and paper without affecting the various processing parameters, provided collection and appropriate chipping arrangements of twigs are possible.

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