Effect of Variation of Moisture in Bamboo Chips On Pulp and Papermaking Characteristics

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ABSTRACT

The storage of bamboo, the conventional raw material for papermaking in India, is necessary for continuous supply of this raw material throughout the year. It has been observed that due to storage, particularly in summer season, the moisture content reaches a very low level, which adversely affects the pulp and papermaking properties.

The present study reveals that though it is not practicable to attain higher percentage of moisture in bamboo as such by soaking in water but chips can be brought to a desired level of moisture content by soaking for a very short period in water pond. With increasing moisture content active alkali requirement, in pulping, decreases while the uniformity and pulp quality improve. The physical strength properties have also shown an increasing trend with increasing moisture content. However, it may adversely affect the black liquor characteristics, which will be obtained in less concentrated form. It has been concluded that an optimum moisture content may be maintained so as to get the uniform pulping and better quality of the pulp.

The storage of bamboo is necessary for continuous supply of raw materials throughout the year. It has been observed, that the storage, particularly in summer season, causes lowering of moisture content to minimum level. This adversely affects the pulp and papermaking characteristics such as excessive dust during chipping, higher alkali consumption in pulping, non uniformity and poor pulp quality etc.

To ensure uniform reaction during pulping, it is vital that fibers in the wood get their proper share of chemicals and heat. Deficiencies in this respect show up as a higher percentage of screening and shives in final pulp. The problem of distributing the chemicals uniformly within the wood structure in a reasonably short time is of utmost importance for good quality of chemical pulps.

The chips are generally in a state of three phase system viz. hardfiber, water and air. Even the freshly felled wood contains air in the interior parts. The penetration of chemicals in air filled wood chips involves both mass penetration by capillary rise, and penetration under gas diffusion outwards and inwards by vapour diffusion. Since, gas diffusion is the rate-limiting factor, the removal of air of the chips as completely as possible is required to achieve better penetration of cooking liquor.

It has been also reported that chip moisture and bulk density play an important role to ascertain the pulping parameters and pulp quality. The liquor to wood ratio i.e. bath ratio and percent active alkali vary considerably due to variation in chips moisture and bulk density requires a higher liquor to wood ratio to cover chips during the cook and because of extra dilution, higher percent of active alkali is required to maintain the initial chemical concentration. Similarly, it is reverse for the chips of higher bulk density.

Potdar et al reported that when moisture content in chips is varied from lower to higher, the loading in digester is increased resulting in more pulp per unit volume of digestion area used and gives more uniform pulp with lower percentage of rejects.

The impregnation of kraft cooking liquor in chips has been investigated as a function of their moisture content. The results have indicated that the rate of pulping is limited by the diffusion stage, characterized by

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mass transfer at air solution interface, diffusion transfer in the liquid and mass transfer through the boundary layer outside of the capillary upto 100°C impregnation is slowest in chips with a moisture content of 47%. Above 100°C, the initial moisture and air in the wood form a vapour mixture with impregnating liquid, leading to intense diffusive interchange which causes the impregnation rate to increase sharply.

This project was undertaken to investigate the effect of moisture variation in bamboo/chips on papermaking characteristics. The bamboo as a whole could not attain the desired range of moisture even after prolonged period of soaking in a water pond. However chips on the other hand could gain the required range of moisture within a reasonable period and were taken for this study.

EXPERIMENTAL :

SAMPLE :

Bamboo (Dendrocalamus strictus) sample was taken for the study.

MOISTURE VARIATION IN BAMBOO :

The initial moisture content of bamboo, determined on oven dry basis, was found to be 7.4%. The sample was then subjected to soaking in a waterpond to obtain varied moisture content in bamboo. At different time intervals samples were taken out, adhering water was removed, manually chopped and the moisture was determined. The results are recorded in Table 1.

TABLE – 1

SOAKING OF BAMBOO IN WATER

SL.NO.	SOAKING TIME, HR.	MOISTURE ATTAINED%
1.	0	7.4
2.	1	8.3
3.	4	10.6
4.	8	11.4
5.	24	14.2
6.	48	16 5

MOISTURE VARIATION IN CHIPS :

The same variety of bamboos were chipped in the mill chipper and moisture was determined. The chips were soaked in water for different time intervals to increase the moisture content. The results are recorded in table 2.

TABLE—2

MOISTURE VARIATION IN CHIPS BY SOAKING IN WATER

SL.NO.	SOAKING TIME, MIN.	MOISTURE ATTAINED %
1.	0	7.4
2.	5	23.4
3.	15	24.6
4.	30	26.7
5.	60	29.1

To obtain chips of moisture content below 25% it was found to be necessary to air dry the chips after soaking for five minute (Fig. 1).

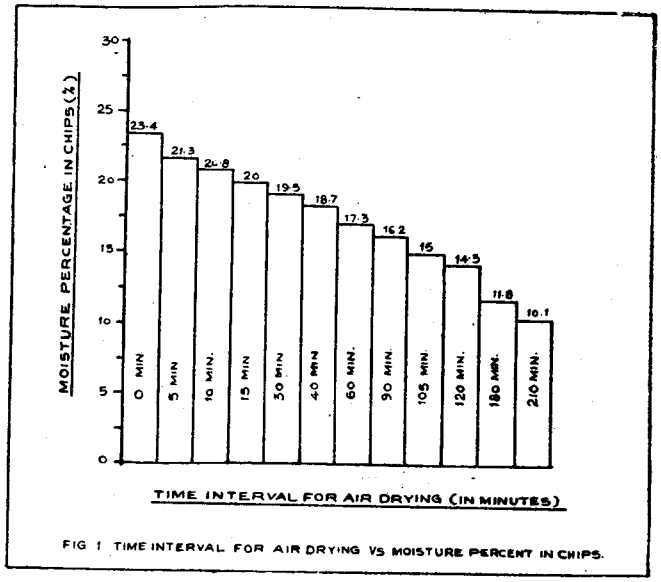

FIG 1 TIME INTERVAL FOR AIR DRYING VS MOISTURE PERCENT IN CHIPS.

For comparative study of pulping and papermaking chips containing 7, 15, 20 and 25% moisture were taken.

PULPING :

The chip samples of different moisture content were cooked separately in 15 lit. capacity electrically heated rotary digester. The active alkali was adjusted to obtain unbleached pulp of kappa number 25±1. The pulping conditions and results are recorded in Table 3.

BLEACHING :

The unbleached pulp samples obtained from all the four different chip samples were further defibrated and bleached using a CEHH sequence. In chlorination, the optimum chlorine charge, i.e. percent 1/4th of kappa number was given. Alkali charge in alkali extraction was one-fifth of the chlorine charge to obtain pH around 9.5. The hypo charges were given to obtain the bleached pulp brightness at about 78% (Elrepho). The conditions and results are recorded in Table 4.

PHYSICAL STRENGTH PROPERTIES :

The bleached pulp were beaten separately in a laboratory valley beater to four freeness levels. Handsheets of 60 g/m² were prepared on British handsheet making machine. Sheets were conditioned at 27±1°C and 65±2% RH, prior to the testing. The graphs were plotted by taking physical strength properties against the respective freeness i.e. °SR (Fig. 2–5). The strength properties at 40°SR were interpolated from respective graphs and compared in Table 5.

TABLE—3
PULPING DATA

PARTICULARS	C – 1	C – 2	C – 3	C – 4
Moisture in chips, %	7.4	15.0	20.0	25.0
Active alkali as Na_2O, % (on O.D. raw material basis)	17.5	17.0	16.5	16.5
Bath ratio	1 : 3	1 : 3	1 : 3	1 : 3
COOKING SCHEDULE :				
50–170°C, hr	2.0	2.0	2.0	2.0
At 170° C, hr	1.5	1.5	1.5	1.5
Unbleached Pulp Yield, % on O.D. raw material basis)	41.4	42.4	42.7	43.0
Rejects, %	0.90	0.55	0.24	0.20
Kappa No. No.	25 5	25.4	26.2	25.0
Black liquor, pH	11.8	12.2	12.5	12.5

TABLE—4
BLEACHING DATA

PARTTICULARS		C – 1	C – 2	C – 3	C – 4
Kappa No.	No.	25.5	25.4	26.2	25.0
Chlorination,					
Cl_2 added	%	6.5	6.5	6.5	6.5
Cl_2 consumed,	%	6.00	5.57	5.77	5.84
Final pH,	–	1.99	1.90	1.89	1.93
Alkali Extraction :					
NaOH added,	%	1.6	1.6	1.6	1.6
Final pH,	–	10.0	9.5	9.6	9.5
Hypo Stage. I					
Cl_2 added,	%	2.5	2.5	2.5	2.5
Buffer (NaOH) added,	%	0.6	0.6	0 6	0.6
Cl_2 consumed,	%	2.10	2.10	2.12	2.05
Final pH	–	8.0	7.9	8.1	8.0
Hypo Stage – II					
Cl_2 added,	%	1.0	1 0	1.0	1.0
Cl_2 consumed,	%	0.60	0.70	0.60	0.57
Final pH	–	7.8	7.6	7.5	7.6
Total Cl_2 added,	%	10.0	10.0	10.0	10.0
Total Cl_2 consumed,	%	8.70	8.37	8.49	8.46
Brightness (Elrepho)	%	78.1	78.7	78 9	78.9
P C. No		12.0	11.3	11.0	9.6

N.B. 1. Chemicals were added on O D. unbleached pulp basis.
2. Constant conditions of bleaching are given below.

PARTICULARS		CHLORINATION	ALKALI EXTRACTION	HYPO I	HYPO II
Consistency,	%	3.0	10 0	10.0	10.0
Temperature,	°C	Ambient	55±2	Ambient	Ambient
Retention Time,	Hr	0.75	2.0	4.0	2.0

TABLE—5

PHYSICAL STRENGTH PROPERTIES AT 40° SR

PARTICULARS	C – 1 (Control)	C – 2	C – 3	C – 4
Bulk, Cm^3/g	1.31	1.39	1.43	1.45
Burst factor, —	30.0	41.1	42.6	48.1
Tear factor, —	45	46	48	53
Breaking length, M	5300	7375	7550	7575
Double Folds, Nos.	64	70	73	97
Strength Index,* —	1346	1517	1562	1717

*STRENGTH INDEX — (Log. D.F. X T.F. X B.F.) $1/3 \times 100$

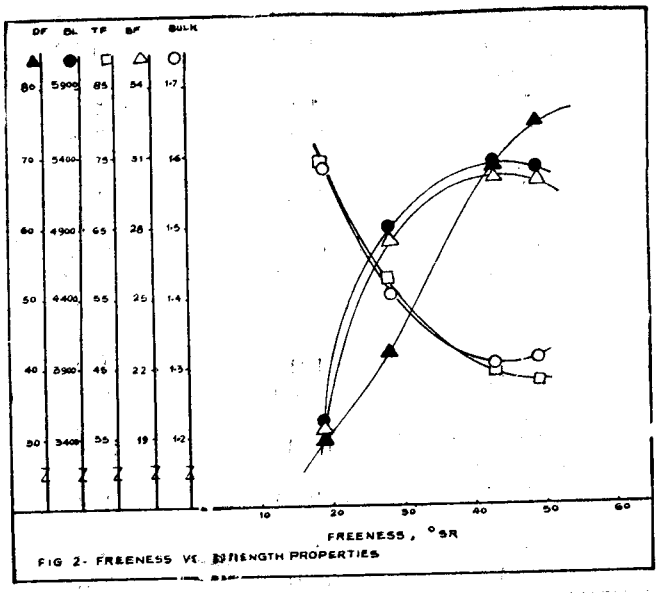

FIG 2- FREENESS VS. STRENGTH PROPERTIES

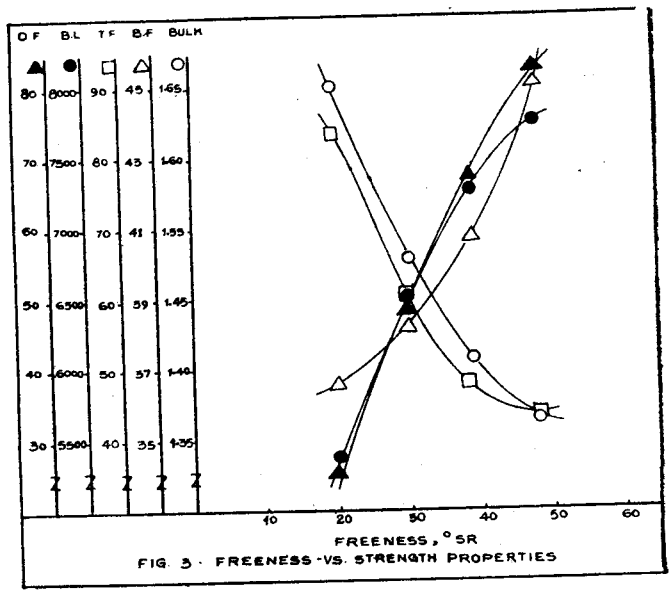

FIG. 3 - FREENESS -VS. STRENGTH PROPERTIES

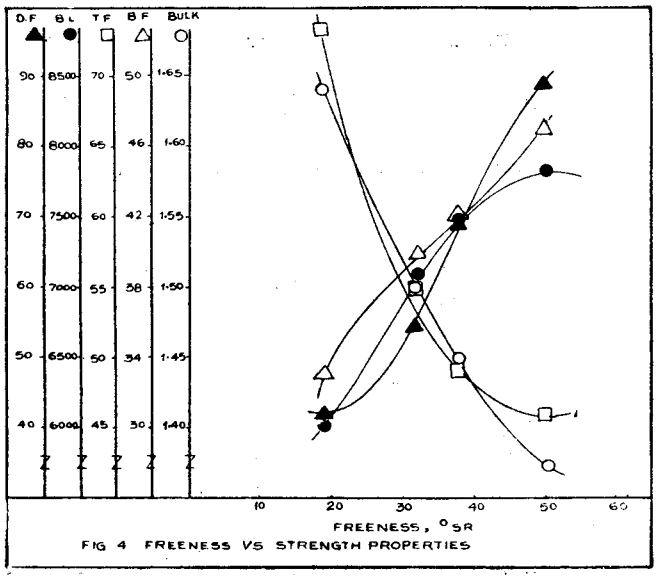

FIG 4 FREENESS VS STRENGTH PROPERTIES

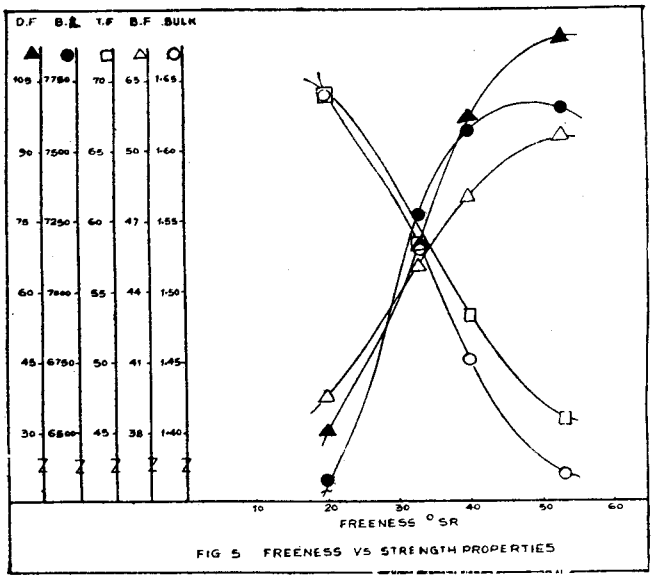

FIG 5 FREENESS VS STRENGTH PROPERTIES

OBSERVATIONS AND DISCUSSION :

1. The rate of increase in the moisture content of bamboo was very slow when bamboos were soaked in water (Table 1). It is observed that for as long as 48 hrs. of soaking, bamboo could attain only 16 5% moisture, initial being 7.4% which seems not a positive aspect for commercialization. It was because of the presence of plastic hard, type epidermis which prevented the penetration of water.

2. In case of bamboo chips, rate of penetration of water was very fast (Table 2) when soaked In water. Within short intervals of time a range of different moisture content in chips could be attainced which suited for practical application.

3. It can be observed from Table 3, that the chips of low moisture content i.e. 7.4%, required higher charge of active alkali compared to the chips of higher moisture content, to obtain a pulp of fixed kappa number of 25 ± 1. As discussed earlier, it may be due to the fact that the presence of more moisture in chips facilitated the impregnation of cooking liquor into the chips. The constant decrease in rejects established the fact that uniform cooking is resulted in case of higher moisture content chips. However, the variation in yield is not significant.'

4. The bleaching behaviour is more or less same for all the pulps. However, the colour reversion is found to be lower in case of pulps obtained from chips containing higher percentage of moisture.

5. The physical strength properties show an increasing trend (Table 5). The pulp obtained from the chips of lowest moisture content has the lowest strength properties whereas the pulps from chips of higher moisture contents have higher strength properties. The increase in tear factor, breaking length, burst factor and double folds have been observed as the moisture content in chips increases. There is an overall increase in strength index for the pulps obtained from higher moisture content chips samples.

CONCLUSION :

The rate of increase in moisture content, in as such bamboo, when soaked in water is very slow and not practicable. However, a desired level of moisture can be attained in the chips by soaking them in water. Even the chips washing system will be very effective to attain the desired level of moisture and at the same time removal of dirt and dust from chips, will also be possible.

With increasing moisture content the alkali requirement in pulping to obtain desired level of pulp kappa no. decreases. A uniform pulp with lower rejects can

be obtained when higher percentage of moisture is maintained. The initial moisture in the chips does not improve the pulp yield and bleaching characteristics. However, the strength properties have shown the increasing trend with increasing moisture. It can be finally concluded that an optimum moisture content particularly in the dry season should be maintained in the chips to get uniform pulping and better pulp quality.

ACKNOWLEDGEMENT :

Authors express their thanks to management PAPRI for giving permission to publish the work.

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