Pak. j. sci. ind. res., vol. 36, no. 9, September 1993

STUDIES ON SODA-SULPHUR PULPING
Part- VI. Pulping of Muli-Bamboo *(Bambusa baccifera)* by Soda-Sulphur Process

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(Received June 11, 1990; revised May 20, 1993)

Unbleached pulps from muli-bamboo were obtained by using optimum pulping conditions of 1.5% elemental sulphur in 22% NaOH solution in the rotary digestor of 20L capacity at a temperature of 165° for 3 hrs with a material-liquor ratio of 1:4 at pressure 6.5 kg/cm². The unbleached yield was 46.09%. The unbleached pulp was then subjected to 3 and 5 stage bleaching systems. The paper properties and brightness of unbleached and bleached pulps were determined. The highest tear factors, most important one considered for paper-making, were obtained 160.83 and 150.07 respectively for 3 and 5 stage bleached pulps. The highest yield (42.87%) and higher brightness value (83.4%) were obtained in case of 3 stage bleached pulp. From the studies in details, it has been found that a stronger pulp with higher yield in less cooking time is obtained by use of soda-sulphur process on muli-bamboo for making good quality writing and printing paper.

Key words: Soda-sulphur, Muli-bamboo, Pulping.

Introduction

Bamboo is a potential raw material for cellulose. In 1956 the Karnafuli paper Mills of Bangladesh started its production of making Pulp and paper using muli-bamboo *(Bambusa baccifera)* [1] with high consumption of total chemicals of 28% sodium hydroxide and sodium sulfide in a ratio of 3:1 for 5 hrs. But the bleached yield was slightly above 30% and the brightness found below 75%. Other paper-properties were found at the minimum level of the international specification. More or less similar results were obtained by others [2-5] with other varieties of bamboo like South Bengal *(Bambusa tulda)*, mitinga *(Bambusa vulgaris)*, etc. for making pulp and paper. Even the studies made by them on different varieties of bamboos by soda and sulphate process were incomplete in the sense that their studies could not include the determination of physical properties of the unbleached pulp-sheets obtained from the pulps of different digestions required for establishment of optimum cooking conditions. In addition, the laboratory evaluation of the unbleached pulps were not done. Considering the low pulp-yields, with the use of higher amount of chemicals for longer cooking time and pulp-sheets of low tear factor and low brightness value obtained by others as mentioned above, present studies were made on muli-bamboo with a view to obtaining higher yields of better grade pulps in less cooking time for writing and printing paper.

Materials and Methods

Chemical composition of muli-bamboo was determined by TAPPI Standard procedures [6-9] and the results are given below:

Alpha cellulose	46.70%
Lignin	26.38%
Pentosan	18.83%
Ash	3.69%

Preparation of raw material. A muli-bamboo was cut into smaller ones and these were cut into pieces of 1" in length and then sun dried. The moisture content of the material was determined in an electric oven at 105° by keeping the samples for 18 hrs.

Cooking. The cooking liquor for soda-sulphur process was prepared by adding elemental sulphur to the caustic soda solution in a rotary digestor of stainless steel of 20L capacity. Before use both caustic soda and sulphur were analysed by conventional methods [10,11]. Series of digestions were given for establishment of optimum pulping conditions and the results along with permanganate number [12] are given in Table 1. Bamboo-pulps for laboratory evaluation of unbleached pulps and those for 3 and 5 stage bleaching were made by using the following optimum conditions, NaOH 22.0%, sulphur 1.5%, temperature 165°, time 3 hrs., material-liquor ratio (1:4), pressure 6.5 kg/cm² (Tables 2-4).

Handsheets and testing. Handsheets each weighing 60 g/M² were made from unbleached and bleached pulps in Rapid Kothen sheet forming machine and conditioned according to TAPPI Standard [13,14]. The sheets were tested for physical properties like breaking length [15], tear factor [16], burst factor [17] and brightness [18].

Yield. The unbleached yield was found as 46.09%.

Bleaching. In 3 stage bleaching, 60% chlorine was supplied as 3.5% consistency, pH 1-2, 25-30° for 60 mins and the

TABLE 1. EFFECT OF CAUSTIC SODA, ELEMENTAL SULPHUR, TEMPERATURE, TIME, MATERIAL-LIQUOR RATIO ON PULP-YIELD, PERMANGANATE NUMBER OF UNBLEACHED PULP AND PHYSICAL PROPERTIES OF THE UNBLEACHED PULP-SHEETS OF SODA-SULPHUR PULP OF MULI-BAMBOO.

Expt. No.	NaOH ((%)	Unbleached yield(%)	Permanganate number	Breaking length (meter)	Tear factor	Burst factor	Brightness (%)
1	20	Partly	Remained	Undigested			
2	22	43.78	13.12	2796	100.12	43.14	41.7
3.	24	42.60	11.10	2944	90.04	49.35	43.9
	Sulphur(%)						
4	0.0	Remained	Undigested	–	–	–	–
5	0.5	42.21	14.28	2477	95.50	40.50	40.9
6	1.0	43.78	13.12	2796	100.12	43.14	41.7
7	1.5	46.09	11.49	3018	106.60	53.28	44.0
8	2.0	46.25	11.51	3051	107.47	53.49	43.5
	Temp. (°C)						
9	155	48.48	14.95	2793	100.52	49.30	38.5
10	165	46.09	11.49	3018	106.60	53.28	44.0
11	175	43.00	9.58	3400	98.63	59.89	51.3
	Time (hours)						
12	2	Remained	Undigested	–	–	–	–
13	3	46.09	11.49	3018	106.60	53.28	44.0
14	4	42.96	9.06	3617	97.04	62.00	53.7
	Material liquor ratio						
15	1:3	46.22	11.77	3001	105.18	53.00	43.2
16	1:4	46.09	11.49	3018	106.06	53.28	44.0
17	1:5	45.90	11.36	3030	105.00	53.59	44.7

Material used in each experiment in the autoclave (digestor) was 1000g o.d. basis bamboo-chips.

TABLE 2. YIELD AND BRIGHTNESS OF THE UNBLEACHED SODA-SULPHUR PULP OF MULI-BAMBOO.

Type of pulp	Bleached yield (%)	Brightness(%)
3 stage	42.87	83.4
5 stage	41.53	86.7

TABLE 3. FIBRE-DIMENSIONS OF SODA-SULPHUR MULI-BAMBOO PULP.

Type of pulp	Length (mm)		Diameter (mm)		Average (mm)
	Maximum	Minimum	Maximum	Minimum	
3stages	4.36	0.88	0.026	013	0.020
5 stages	4.00	0.48	0.026	0.012	0.020

TABLE 4. FIBRE-FRACTION OF SODA-SULPHUR MULI-BAMBOO PULP.

Type of pulp	Fibre		Fraction (%)	
	0.50 – 0.99 (mm)	1.00 – 1.49 (mm)	1.50 – 1.99 (mm)	2.00 – 2.49 (mm)
3 stages	3.40	9.60	24.05	41.95
5 stages	6.03	20.05	19.95	20.32
Type of pulp	2.50 – 2.99 (mm)	3.00 – 3.49 (mm)	3.50 – 3.99 (mm)	4.00 – 4.49 (mm)
3 stages	10.50	5.50	2.96	2.04
5 stages	9.68	15.55	1.45	6.97

remaining 30% chlorine was supplied as NaOC1 during sodium hydochlorite treatment at 3.5% consistency, pH 9-11, 25-30° for 60 mins. The intermediate step was 2% caustic extraction against o.d. basis pulp at 13.5% consistency, 75-80° for 60 mins. In Ist stage of 5 stage system, 60% chlorine was supplied as Cl_2 and in each of the 3rd and 5th stage, 15% chlorine supplied as NaOCl. The intermediate 2nd and 4th stages were 2% caustic extraction. Conditions for chlorination, caustic extraction and hypochlorine treatment were same as those in 3 stage.

Laboratory evaluation of pulps. One kilogram of each of the unbleached and bleached pulps was disintegrated and beaten according to TAPPI Standards [19] in pilot plant Hollander beater for a period of 60 mins. Samples of pulp-slurry at 0 min. beating time and after each 10 mins. interval of time were collected. Standard pulp-sheets were made from collected samples and tested as usual. The results are expressed graphically in Figs. 1-3.

Results and Discussion

The unbleached, 3 stage bleached and 5 stage bleached yields for soda-sulphur pulp from muli-bamboo were 46.09, 42.87 and 41.53% respectively. In case of muli-bamboo pulp these values are higher than those obtained by previous work-

ers [1-5]. Muli-bamboo contains 46.70% alpha cellulose. The different pulp yields and alpha cellulose originally present in muli-bamboo indicate that optimum conditions for pulping did not give rise to abnormal loss in cellulose and the degree of loss was minimum with soda sulphur process.

Elemental sulphur has been known to have beneficial effect in alkaline pulping. The highest yield 46.09% in Table1 for unbleached pulp was obtained with the addition of 1.5% elemental sulphur to the cooking liquor. Attempts were made for higher pulp yields with more addition of sulphur but with little success (Table 1). So the amount 46.09% was considered as the highest pulp-yield for the present studies.

The most widely accepted reaction mechanism for the addition of elemental sulphur to the cooking liquor is as follows:

$$6NaOH + 4\,S \longrightarrow 2\,Na_2S + Na_2S_2O_3 + 3H_2O$$
$$Na_2S + H_2O \longrightarrow NaOH + NaHS$$

Thus sodium sulphide increases the sodium hydroxide content of the cooking liquor. In addition, it produces hydrosulphide which acts as a buffer and tends to reduce the degrading or injurious effects of the more active sodium hydroxide on cellulose and hemicellulose giving rise to higher pulp yields and stronger pulps. The hydro-sulphide also reacts with lignin to produce thiolignin which in turn makes lignin

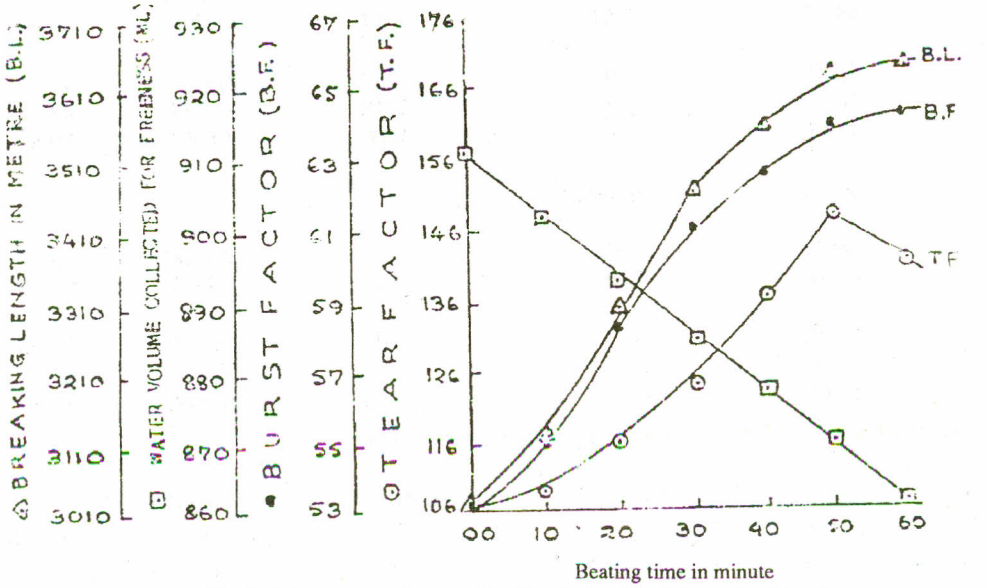

Fig. 1. Laboratory evaluation of unbleached soda-sulphur pulp of bamboo.

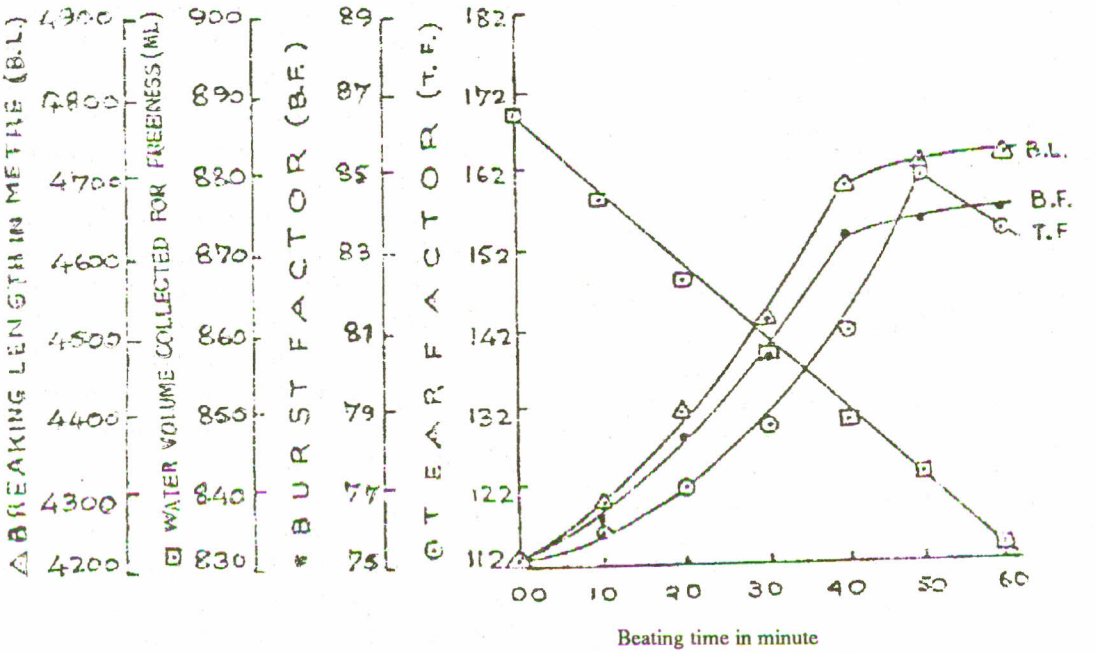

Fig. 2. Laboratory evaluation of CEH bleached soda-sulphur pulp of bamboo.

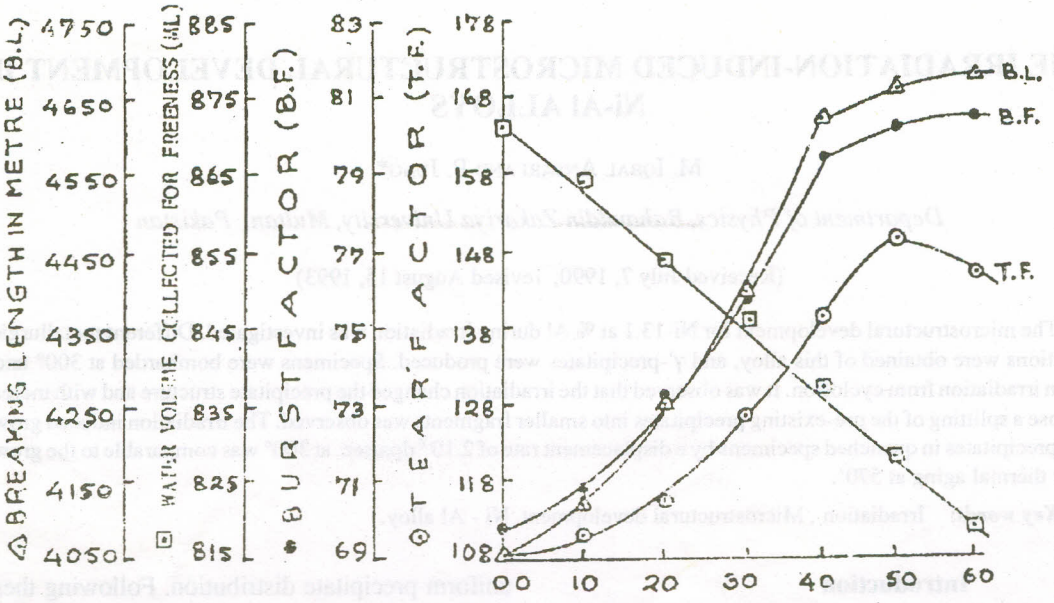

Fig. 3. Laboratory evaluation of CEHEH bleached soda-sulphur pulp of bamboo.

more readily solubie in alkali and thus reduces cooking time 5 hrs. for soda or sulphate process [1-5] to 3 hrs for soda-sulphur process in case of muli-bamboo.

The permanganate number 11.49 (Table 1) which is lower than those obtained by others [1-5] shows that the pulp-yields obtained were not at the cost of pulp-purity indicating that optimum pulping conditions were rightly selected and adequate for good delignification.

For 5 stage soda-sulphur pulps, the brightness was 86.7% which is also higher than those obtained by previous workers [1-5].

The fibre-lengths 2.31 and 2.23 mm given by 3 and 5 stage bleached pulps respectively indicate that pulps of muli-bamboo have long fibres and least degraded among soda, sulphate [1-5] and soda-sulphur pulps of muli-bamboo during pulping and their subsequent stages of bleaching.

It is seen from the Figs. 1-3 that the breaking length and burst factor of the unbleached, 3 stage and 5 stage bleached pulps increased from 0 to 60 mins. beating time due to increase in area of fibres in optical contact. But there was rise in tear factor of all the pulps from 0 to 50 min beating time (as is seen from the Figs.) after which it decreased probably due to decrease in fibre-length of the pulps. The tear factor (160.85) given by 3 stage soda-sulphur pulps at 50 mins beating time (Fig.2) with freeness 841 was the highest of all the bleached pulps so far obtained from muli-bamboo [1-5].

It is also evident from the Figs. 1-3 that there was normal fall in freeness throughout the progress of beating time with bleached as well as unbleached pulps.

The above results obtained from the present studies are in very good agreement with the international specification for making good quality writing and printing paper.

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