the influence of sulphidity on alkaline pulping of bamboo chips

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SUMMARY.

Pulping studies on bamboo chips (*Bambusa arundinacea*) were carried out in order to determine the optimum sulphidity which will produce high strength properties in the pulp. The conditions of cooking such as temperature, time of cooking, bamboo to liquor ratio and Active Alkali charges were kept constant while sulphidity was varied over a wide range of 7 to 31 percent.

This Laboratory investigation presents data to show the influence of sulphide on the cooking reaction and on the properties of resulting pulps. The data revealed that the breaking length, burst factor, tear factor and double folds were significantly changed when the sulphidity was raised from 7 to 21 percent.

The difference between strength properties of unbleached pulps were, however, insignificant between sulphidities of 7 and 18 percent. The differences were marked only when the sulphidity of 21% and above (24%) was reached.

At a high sulphidity (31%) the strength properties again have the tendency of getting reduced, a plausible reason for which may be the reduction of effective alkali, which adversely affects the pulping.

If sulphidity is lowered below 20% pulp strength decrease and pulp bleach demand is increased.

INTRODUCTION :

During the last 2-3 years the cooking conditions at the West Coast Paper Mills Limited have undergone radical change. This necessitated a thorough investigation of cooking variables such as active alkali, time, temperature and sulphidity. The first three variables are fairly within limits in the Pulp Mill, whereas sulphidity was found to vary. It was felt that it would be worth-while to make a study of this last variable on the cooking reaction, pulp yield, strength characteristics and hardness of pulps, with the quality of Bamboo presently used.

The role of sulphide in alkaline pulping of woods is fairly well established. Considerable work had been done to study the effect of this variable on cooking of both soft-woods and hard-woods. Investigations in the range of 0-20% sulphidity were made by Hart and Strapp on spruce[1] and Bray and Martin on Sweet gum[2]. These investigations showed that when a constant amount of active alkali was employed, increasing sulphidity from 0-20% resulted increased pulp strength and decrease in pulp bleach demand. Hagglund[3] observed while pulping spruce that increased amounts of sodium sulphide improved its ability to dissolve lignin. Precisely, it may be stated that by increasing the sulphidity, a number of advantages such as improved yield for a given lignin content, better strength properties and easy bleachable pulps could be obtained.

However, it is always better to determine the optimum sulphidity, which to a large extent depends on the nature of raw material, the pulping conditions and the properties required in the final product. The optimum operating sulphidity will be influenced by economic conditions also. At the West Coast Paper Mills Limited, the last point is weighing more as the prices of salt cake are shooting up. Therefore, it was felt necessary to study the effect of this important variable in pulping, to determine the optimum operating level of sulphidity for the Pulp Mill.

OBJECTIVE

The objective of the investigation was to determine the adequate sulphidity which would give the

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highest quality of unbleached pulp and will bleach easily to give a pulp of highest strength characteristics.

EXPERIMENTAL

Flowered Dowga (*Bambusa arundinacea*) chips were collected from Chip Silo. Hand sorting of the chips was done to ensure chip uniformity. Chips were then mixed thoroughly, analysed for moisture content and then a number of charges were weighed out to contain 1 kg. of chips (o.d. basis).

The white liquor samples were prepared from sodium hydroxide, sodium sulphide and sodium carbonate. The desired sulphidity was adjusted in each case by varying the amount of sodium hydroxide and sodium sulphide. The white liquor causticity was maintained between 82-84 percent.

In the present study the sulphidity has been expressed, as the amount of sodium sulphide, as a percentage of active alkali, both expressed as Na_2O

$$\text{Sulphidity}\% = \frac{Na_2S}{NaOH + Na_2S} \times 100$$ (All expressed as Na_2O).

The pulping experiments were carried out in an electrically heated Rotary Autoclave of 15 litre capacity. The required liquor volume was made up by the addition of water only. Black liquor was not used as diluent. The conditions of cooking are recorded in Table—I.

After the cooking period was over, the chips were fiberised in a Laboratory Disintegrator. The so obtained pulp was finally thickened in a Hydro-Extractor, where hot water washing was used to remove the spent liquor efficiently. The thickened pulp was separated of knots, which were weighed separately after drying, to calculate the percentage of rejects. The thickened pulp free of knots was weighed separately and a portion from which was used for consistency determination to calculate the yield. Besides the yield, the physical characteristics and Kappa number of pulps, was also determined; strength properties were determined using Valley Beater according to TAPPI procedure.

DISCUSSION OF RESULTS

It can be seen from Table-I that by increasing the sulphidity from 7% to 24.6% the Kappa number of pulps is continuously decreasing, whereas the unbleached yield is relatively unchanged. The figures in col. 1 shows the variation in Kappa number with sulphidity. At a sulphidity of 31.2% the Kappa number has the tendency of going up. The rejects percentage also started increasing. A plausible reason for this may be the lowering of effective alkali ($NaOH + 1/2\ Na_2S$). In the present study the effective alkali was reduced from 13.8% to 12.2%, when the sulphidity was increased from 7% to 31 percent.

A comparison of the strength properties of unbleached pulps (Table-II) show that best results were obtained between sulphidity of 21-24 percent. The improvement in strength properties could be ascribed also to lower lignin contents in pulp which is, however, the advantage of using sulphide, when active alkali, cooking time and cooking temperature are fixed.

It is well known that oxygen in presence of alkali has a degrading influence on carbohydrates. It is believed that sodium sulphide because of its reducing properties may reduce this reactivity towards carbohydrates. For this reason it was felt necessary to determine the viscosity of unbleached pulps. The pulps were delignified using a single stage chlorite bleach, buffered with acetic acid, sodium acetate at room temperature. The results of determination of cupramonium viscosity are recorded below:

Sulphidity, % ...	7.6	11.4	17.9	21.0	24.6	31.2
Cuprammonium Viscosity of delignified pulp. Centipoises ...	215	230	232	228	263	286

The results indicate that Viscosity values were relatively unchanged when the sulphidity was increased from 7.6 to 17.9 percent. Only at a sulphidity of 24.6 and 31.2% some increase in viscosity was obtained. Because of this difference in viscosity of unbleached pulps at higher sulphidity, it was deci-

ded to make bleaching studies also. It is interesting to see that these pulps have lower Permanganate Number, but higher viscosity indicating selectivity of removal of lignin.

BLEACHING

Bleaching of pulps was carried out using a three-stage bleach sequence with a final SO_2 wash. The amount of chemicals used in chlorination and hypochlorite stages were adjusted according to Permanganate Number of unbleached pulps. It was intended to bleach all the pulps to nearly the same brightness and then determine the viscosity and strength properties of bleached pulps.

The bleaching data is recorded in Table-III.

It can be seen from the results that the total bleach consumption is continuously decreasing (from 15.2% to 12.5%), when the sulphidity was increased from 7 to 21%, a saving of about 2.7% chlorine. This advantage will be gained without sacrificing the bleached yield. It is interesting to see that the viscosity of bleached pulps was unaffected when the sulphidity was increased from 7 to 17.9 percent. The difference become noticeable at 21% and above. Somewhat similar sudies have been made by Zebbs(4).

A comparison of the strength properties of bleached pulps indicate that a sulphidity of about 24% would be required to get a pulp of good strength characteristics.

CONCLUSIONS

(1) With the quality of bamboo presently used and other variables such as time, temperature, and active alkali fixed, a sulphidity of 21-24% would improve the cooking reaction, bleachability of pulps and the strength characteristics of unbleached and bleached bamboo pulps.

(2) It may be stated that difference in pulps because of different sulphidity used in cooking, can be partly offset by greater uniformity of cooking, refining techniques and paper machine conditions.

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(1) Hart, J. S., and Strapp, R. K., Pulp Paper Mag. Canada. 49 No. 3 : 151—165 (1945).

(2) Bray, M. W., and Martin, J. S., Paper Trade Journal. 113, No. 25 : 35 – 46 (1941).

(3) Hagglund, Erik. Tappi 32, No. 6 : 241—245 (June 1949).

(4) Zebbs, L. Francis, Tappi 39, No. 4 : 180A—181A. (April 1956).

TABLE I

Cooking Data :

Constant Conditions : Liquor : Chips ... 3·1
Chemicals % (NaOH + Na2S) ... 18·5
Max. Temperature, °C ... 150
Time to Raise to Max. Temperature, Mts ... 120
Time of cooking at Max. Temperature, Mts. ... 60

COOK NO.	1	2	3	4	5	6
Sulphidity, % ...	7·6	11·4	17·9	21·0	24·6	31·2
NaOH added, % on chips ...	17·15	16·44	15·40	14·70	14·00	12·82
Na2S added on Chips, % ...	1·37	2·05	3·09	3·80	4·44	5·67
Effective alkali ; NaOH + ½/Na2S expresed as Na2O...	13·81	13·55	13·15	12·90	12·61	12·18
Total Yie ld, % ..	55·5	55·1	55·0	54·8	55·7	55·6
Rejects, % ...	5·9	5·5	5·4	5·4	6·6	7·2
Unbleached Yield %	49·6	49·6	49·6	49·4	49·1	48·4
Kappa Number ...	47·5	44·0	41·0	38·9	38·1	39·8
Equivalent KMn04 Number (40 ml) ...	26	24·9	24·0	23·3	23·0	23·6

TABLE—II *Strength Peroperties of Unbleached Pulps*

COOK NO.	1		2		3		4		5		6	
Initial Freeness, °SR ...	8.5		9.0		8.0		10.0		9.0		10.0	
Final Freeness, °SR ...	30	45	26	39	33	41	29	44	29	43	35	44
Beating time, Mts. ...	23	29	21	27.5	20.5	26.0	23	30	25	32.5	19	24
Basis Weight, G/m2 ...	58.5	58 3	58.5	61.5	56.7	59.5	60	60.7	57.6	60	60.2	57.0
Thickness, Microns ...	130	120	130	125	120	110	120	110	120	110	125	115
Bulk, cc/G. ...	2.22	2.06	2.22	2.03	2.12	1.85	2.00	1.81	2.08	1.83	2.08	2.02
Tensile Strength, Kg/cm.	2.44	2.75	2.46	2.73	2.38	2 64	2.63	2.93	2.71	2.91	2.50	2.52
Breaking Length, Metres.	4000	4720	4205	4440	4200	4440	4383	4830	4705	4850	4150	4420
Stretch, % ...	3 00	3.25	3 00	3.5	3.00	3.5	3.5	4.0	3.0	3.5	3.7	4.2
Bursting Strength, Kg/cm2.	1.30	1.96	1.60	1.91	1.54	1.83	1.90	2.20	1.84	2.17	1.81	1.96
Burst Factor ...	22.2	33.6	27.3	31.0	27.1	31.0	31.6	36.2	32.0	36.2	30.0	34.4
Internal Tearing Resistance Grams. ...	64	62	68	68	68	64	76	68	68	66	76	68
Tear Factor ...	109.4	106.4	116.2	110.6	120	107.2	126.6	112	118	110	126	119.5
Double Folds ...	57	54	59	95	100	114	98	220	70	94	144	230

TABLE—III *Bleaching of Pulps*

Kappa Number of Unbleached Pulp ...	47·5	44·0	41·0	38·9	38·1	39·8
Chlorination						
Consistency %, 3						
C12 added, % ...	12·0	11·0	11·0	10·0	10·0	10·0
Temp. °C 30±1						
Time Mts. 60						
C12 consumed, % ...	11·95	10·88	10·70	9·90	9·92	9·98
Alkali Extraction						
Consistency %, 5						
NaoOH added ...	3	3	3	3	3	3
Temp. °C 50±1						
Time Mts. 60						
Final pH ...	9·5	9·8	9·8	9·9	10·0	9·9
Hypochlorite						
Consistency %, 5						
Temp. °C 40±1						
Time Mts. 135						
C12 added, % ...	4·0	3·5	3·5	3·0	3·0	3·0
C12 consumed, % ...	3·28	2·87	2·63	2·62	2·60	2·65
NaOH added, % ...	0·80	0·70	0·60	0·60	0·60	0·60
Final pH ...	8·2	8·1	8·1	8·2	8·0	8·1
SO2 Wash						
Consistency %, 2						
SO2 added %, 0·8						
Final pH 4						
Time Mts. 15						
Viscosity, cP ...	46·0	46·5	46·0	49·0	53·0	56·5
Brightness,% ...	78·0	78·0	78·0	78·0	78·5	80·0
Total C12 consumed, % ...	15·23	13·75	13·33	12·52	12·52	12·63

TABLE—IV *Lampen Mill Evaluation of Bleaches Pulps*

Consistency, % : 3

Temperature, °C : 30

Time, Mts. : 60

Number of Revolution : 13,020

COOK NO.	1	2	3	4	5	6
Final freeness, °SR	46	40	40	44	41	48
Basis Weight, Gm./m2 ...	60	58	59 7	58	59	60
Thickness, Microns	76	76	77	74	75	76
Bulk, cc/g. ...	1.27	1.31	1.29	1.27	1.27	1.26
Tensile Strength, Kg./cm. ...	3.43	3.35	3.35	3.40	3.86	3.95
Breaking Length, m.	5720	5775	5610	5860	6540	6580
Stretch, % ...	3.0	3 0	3.7	3.7	3.75	3.75
Bursting Strength, Kg./cm2. ...	2.08	2.18	2.14	2.23	2.40	2.60
Burst Factor ...	34.6	37.6	35.8	38.0	40.6	43.3
Internal Tearing Resistance, g.	36	35.6	36	36	36	41
Tear Factor ...	60	61.3	60	62	61	68.5
Double Folds ...	22	15	19	17	17	23