High yield alkaline sulphite-anthraquinone pulping of bamboo

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SUMMARY

An improved approach to producing high yield bleached chemical pulps is described. Alkaline Sulphite solution with and without anthraquinone (AQ) under high temperature and pressure produced pulp of 25 and 32 Kappa number with unbleached screened yield of 61 and 60 percent respectively. Addition of 0.1% AQ on chips offered the advantage of producing pulp of low Kappa number with high pulp yield and also enabled to carry out the cooking at a much lower maximum temperature compared to where no AQ was added. The pulps could be easily bleached in 3 stages of calcium hypochlorite bleaching to brightness of 78 and 76 percent with bleached pulp yield of 59.4 and 57.4 percent respectively. The physical strength properties and opecity were matching with those of sulpate pulp In comparison to sulphate pulp the Alkaline Sulphite-AQ pulp is obtained in about 7.7% greater pulp yield both in the unbleached and bleached state.

The process offers advantage of higher unbleached/bleached pulp yield, higher unbleached pulp brightness and greater ease of bleaching, an alternative of interest over Sulphate process for bamboo pulping.

Alkaline Sulphite pulping of bamboo as an improved process for conversion of bamboo to pulp was earlier reported (1) by one of the present authors. Advantage of 8–10% higher unbleached, bleached pulp yield and greater ease of bleaching over Sulphate with comparable physical and optical properties were indicated. However, the unbleached pulps were obtained in 58–62 Kappa number not low enough to be considered, in the present day thinking, for bleaching of pulp by conventional multistage bleaching sequence in view of the concern for bleach plant effluents. Interest in the process was revived for mainly two reasons ;

(i) Bamboo (Bambusa arundinacea/balcooa) was available and used here mainly in the green from.

ii) Anthraquinone as a proven catalyst in Soda/Sulphate pulping offered scope for investigating its suitability for extended delignification when using Alkaline Sulphite solutions.

and accordingly investigations were initiated. Another variety of bamboo viz. Dendrocalamus strictus which is mostly used stored and dry was also included for study. The overall objetive of the study was to investigate the suitability of the Alkaline- Sulphite process for producing bleachable grade pulps in high yields both with and without anthraquinone in a manner that the consumption of bleaching chemicals is kept quite low and comparable or even lower to chemical sulphate pulp. This is in contrast to the general thinking that though Neutral/Alkaline Sulphite pulps can be obtained in high pulp yield, but only at the expense of high consumption of bleaching chemicals in conventional multistage bleaching. In other words the utility of the process was to be measured by its ability to retain the paper making constituents/components of the bamboo as much as possible even if the delignification is carried out too far off, and further the pulp to bleach easily so that good quality writing and printing papers can be made. The process should also not necessitate the use of exotic materials of construction to counter corrosion and spent liquor obtained can be either processed by cross-recovery, evaporation and marketing for use as emulsion stabiliser, dyestuff dispersant, cement processing additive etc. Alternatively after evaporation and burning, the

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regeneration of cooking chemicals can be also considered depending upon the economics, using well established technologies.

EXPERIMENTAL : Green bamboo chips mostly of Bambusa arundinacea and Bambusa balcooa with about 50% moisture were collected from the chipper house. The chips were allowed to condition and a uumber of charges equivalent to about 1.6 Kg. of O.D. chips were weighed out. Pulping was carried out in an electrically heated rotary digester of 10 litre capacity. At the end of the cooking period the digester was relieved to atmospheric pressure and contents transferred to bucket for disintegration using a high speed stirrer. The disintegrated pulp was washed free of chemicals and dissolved impurities in a hydra-extractor, granulated and weighed. During the process of granulation, uncooked pieces were removed, dried and weighed separately and calculated as rejects. Tne O.D.w eight of the well cooked pulp was found out from the moisture content and pulp yield calculated as a percentage of the original weight of the chips. The unbleached pulp was tested for brightness and Kappa number as per TAPPI standard. Bleaching was carried out using 3 stage calcium hypochlorite bleaching and both the unbleached and bleached pulps were evaluated for physical strength properties after refining to varying degrees in laboratory valley beater and standard handsheets forming. Similar test was conducted on stored Dandro calamus strictus variety of Bamboo.

RESULTS & DISCUSSION : The results in Table–I shows that addition of small amount of anthraquinone enables to delignify the material to very low lignin content as measured by the Kappa number of pulp, without losing pulp yield.

TABLE—I.

Alkaline Suplbite and Sulphate pulping of Bamboo chips (Bambusa arundinacea/balcooa)
Pulping data and results

Cook No.	Moisture in chips % 8.9 1	2	3	4
Na_2SO_3 on Chips %	18	18	18	18
NOH on Chips%	2.5	2.5	2.5	2.5
Bath ratio	3.5:1	3.5:1	3.5:1	3.5:1
Anthraquinone on Chips %	0.1	Nil	Nil	Nil
Initial pH of the cookin ; liquor	13.3	13.3	13.3	13 3
Finnal pH ofthe spent liquor	9.6	9.4	9.3	9 4
Temperature schedule:				
30 - 120°C min.	60	60	60	60
At —120°C min.	45	45	45	45
120–140°C min.	45	45	45	45
At 140°C min.	45	45	45	45
140–Max. temp. min.	45	45	45	45
At max. tem. min.	150	150	150	150
Max. temp. °C	162	162	170	170
Screened Pulp yield %	61.0	62.8	60.0	59.7
Rejects %	0.9	0.6	0.8	0.7
Kappa Number of Pulp	25	40	32	32
Unbleached pulp brightness %	45	—	42	—

Sulphate Pulping : (Cook No. 5) NaOH + Na_2S on chips % 18, Bath ratio 3:1, Sulphidity % 12.0. Temperature schedule—30—120C° 60 min., At 120°C 60 min., 120—162°C min., At 162°C 120 min. Screened Pulp yield % 53.4, Reject % Nil, Kappa Number of Pulp 30, Unbleached Pulp brightness % 25.

Anthraquinone addition also enabled to complete the cooking at much lower maximum temperature than where no anthraquinone was added. Even the use of higher cooking temperature alone or both higher cooking temperature and cooking time did not produce a pulp with as low a Kappa number as obtained by addition of anthraquinone to the cooking chemicals. This establishes the advantage of obtaining higher pulp yield and possible reduction in either the cooking time or cooking temperature, the latter having the advantage of reduction in energy consumption. The sodium sulphite consumption during cooking ranged between 15-16%.

Both the unbleached pulp yield and unbleached pulp brightness were higher compared to sulphate pulp at comparable Kappa number. Alkaline Sulphite pulp response to bleaching was quite good and hypochlorite bleaching alone produced pulp of 76-78% brightness, for the chlorine consumption of 6.2–6.4%. As the bleaching of pulp to satisfactory brightness level could be performed in few stages, the expected benefits will be in reduction in water consumption and net energy (Electrical and steam) consumption per tonne of product. As the bleaching could be ferformed by hypochlorite stages alone, the colour formation in the waste water at various bleaching stages was very low. The maximum bleached pulp yield that could be obtained was 59.4%, about 7.7% higher than Sulphate pulp (Table–II)

TABLE–II.

BLEACHING DATA & RESULTS

Cook No.	Alkaline Sulphite Anthraquinone AS—AQ 1	Alkaline Sulphite AS 3	Sulphaye. 5
Kappa Number of Ub Pulp	25	32	30
Hypo I			
Av. Cl_2 added on pulp %	5	5	7.6
Residual chlorine %	Nil	Nil	Nil
Retention time, mniutes	150	90	60
Sulphamic acid on pulp %	0.02	0.02	0.02
NaOH on pulp %	0.12	0.2	0.12
End pH	7.2	7.1	7.3
Hopo II			
Av. Cl_2 on pulp %	1.0	1.2	2.0
Residual Cl_2 on pulp %	0.08	0.1	0 3
NaOH as buffer %	0.9	0.8	0.9
End pH	8.0	8.0	8.5
Retention time miuutes	75	120	120
Hypo III			
Av. Cl_2 on pulp %	0.2	0.3	0.3
Time min.	30	15	15
NaOH on pulp %	0.3	0.3	0.3
pH	8.0	8.1	8.2
Shrinkage during bleaching %	2.6	4.6	3.2
Bleached pulp yield on chips %	59.4	57.2	51.7
Brightness %	78	76	73
Total Cl_2 consumed %	6.2	6.4	9:6

CONSTANT CONDITIONS:

Hypo I Consistency % 5	Tamp. °C 30
Hypo II Consistency % 5	Temp. °C 45 ± 2
Hypo III Consistency % 5	Temp. °C 45 ± 2

The interesting aspect of the process is that the end pH of the spent liquor is about 9.4 and is not expected to necessitate use of expensive metallurgy to counter corrosion. The process, if followed with a full chemical recovery system, does not generate problems of disposal of any kind of solid waste also.

The physical strength properties of the unbleached (Table-III) and bleached pulp were quite compareable to sulphate pulp and actually little higher for the bleached sulphite pulp as will be evident from figure 1.

TABLE—III.

Valley Beater Evaluation of Unbleached Pulp Standard Handsheet of 60 g/m²

Cook No.	AS—AQ 1			AS 3			Sulphate 5		
Final Slowness °SR	25	35	45	25	35	45	25	35	45
Beating time minutes	24	31	36	23	32	40	19	32	43
Bulk cc/g	2.13	1.98	1.80	2.25	2.08	1.90	2.0	1.78	1.70
Breaking length KM	5.65	7.00	7.25	5.20	6.30	7.30	5.20	6.80	7.70
Burst factor	36	45	49	31	42	49	28	42	48
Tear Factor	135	127	124	165	136	123	159	144	127

The opacity of the bleached handsheets of 50 g/m² was 70% both for Sulphite and Sulphate pulp.

The process was equal y applicable on stored and dry bamboo chips of Dendrocalamus strictus as will be evident from Table-IV, expect that the pulps obtained have somewhat higher Kappa number compared to what was obtained when using green conditioned bamboo chips of Bambus arundinacea/balcooa. The pulp yield was high and the strength properties comparable to Sulphate pulp. Bleaching with hypochlorite alone though resorted to (Table-V), is not the ideal approach at this Kappa number of unbleached pulp as the brightness of pulp could not be raised above 72%. Also the bleaching conditions were probably harsh for the Sulphate pulp due to marked reduction in the Tear factor (Table VI & VII). It is interesting to note that the total bleach consumption in both the cases i.e. Alkaline Sulphite and Sulphate pulp have not differed much. This is contrary to what was observed earlier where alkaline Sulphite pulp consumed about 3% less available chlorine in comparison to Sulphate pulp even though the initial Kappa number of both the pulps was nearly same. No hypothesis is proposed for this observed difference but it is obvious that not all varieties of bamboo behave similarly to alkaline sulphite pulping and bleaching. Nevertheless conditions could be standardised both of Alkaline Sulphite pulping and bleaching to achieve the desired result. Pulping with Anthraquinone to be preferred to bring down the Kappa number to bleachable grade.

CONCLUSION

1. Alkaline Sulphite-Anthraquinone pulping of bamboo is in alternative of interest over Sulphate process.

TABLE—IV

ALKALINE-SULPHITE AND SULPHATE PULPING OF BAMBOO CHIPS (DENDROCALAMUS STRICTUS)-PULPING DATA & RESULTS.

	Moisture in Chips % 10	
Cook No.	6	7
Na_2SO_3 on chips %	18	18
NaOH on chips %	2.5	2.5
Bath Ratio	3 5:1	3.5:1
Anthraquinone on Chips %	0.1	Nil
Initial pH of the cooking liquor	13.2	13.2
Final pH of the spent liquor	9.4	9.3
TEMPERATURE SCHEDULE		
30–120°C min.	60	60
At 120°C min.	45	45
120–140°C min.	45	45
At 140°C min.	45	45
140–Max. Temp. min.	45	45
At max. temp. min.	150	150
Max. temp. °C	162	162
Screened Pulp Yield %	58.0	61.0
Rejects %	1.5	1.8
Kappa Number	37	52

Sulpbate Pulping : (Cook No. 8) NaOH+ Na_2S on chips % 18, Bath ratio 1:3, Sulphidity % 12.5, Temperature schedule : 30-120°C 60 min., At 120°C 45 min., 120-140°C 45 min., At 140°C min., 140–160°C 45 min., At 162°C 120 min., Screened pulp yield % 50 2, Rejects % negligible, Kappa Number of pulp 38.

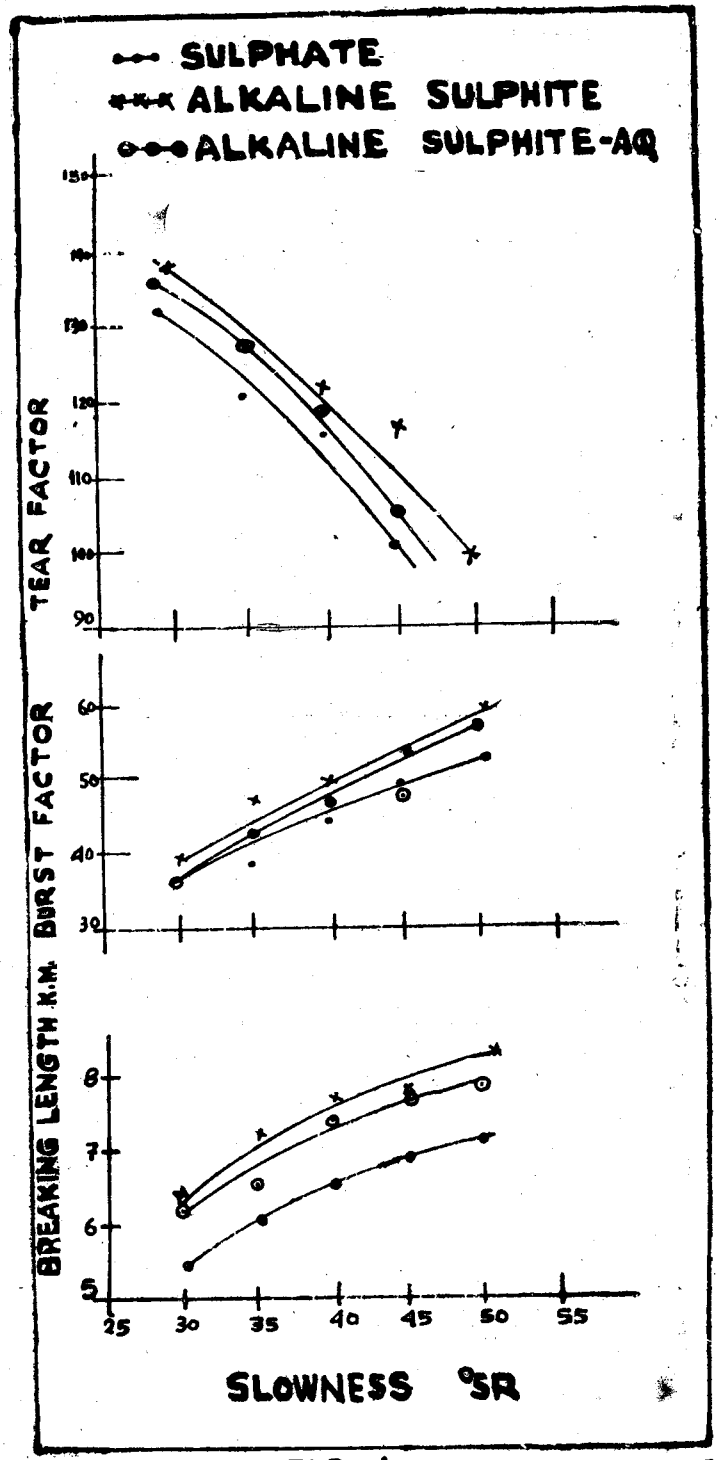

FIG-1

Fig. 1. Slowness (°SR) versus Breaking length, Burst factor and Tear factor for sulphate, Alkaline Sulphite and Alkaline Sulphite-Anthraquinone pulps.

TABLE—V

BLEACHING DATA AND RESULTS
(DENDROCALAMUS STRICTUS)

Cook No.	6 AS—AQ	8 Sulphate
Kappa Number	37	38
Hypo I		
Av. Cl_2 added %	8.0	8.0
Av. Cl_2 consumed %	7.6	7.7
Sulphamic acid on av. Cl_2%	4.0	4.0
End pH	6 5	6.5
Time, minutes	90	90
Hypo II		
Av. Cl_2 added %	4.0	4.0
Av. Cl_2 consumed %	3.6	3 9
End pH	9.5	9.5
Time, minutes	90	75
Hypo III		
Av. Cl_2 added %	1.0	1.0
Av. Cl_2 consumed	0.6	0.8
End pH	9.0	9.0
Time minutes	60	60
Total Cl_2 added %	13.0	13.0
Total Cl_2 consumed %	11.8	12.4
Brightness %	72	72
Shrinkage %	4.5	4.3
Yield of bleached pulp on chips %	55.3	48.0

	Hypo I	II (Buffered)	III (Buffered)
Consistency %	5	5	5
Temp. °C	30	48	48

TABLE—VI VALLEY BEATER EVALUATION OF UNBLEACHED PULPS (DENDROCALAMUS STRICTUS)—STANDARD HANDSHEETS of 60 g/m².

Cook No.		6			8	
Initial Slowness °SR		13			13	
Final Slowness °SR	30	40	50	30	40	50
Beating time minutes	34	47	58	31	42	52
Bulk cc/g	1.90	1.70	1.60	1.70	1.60	1.50
Breaking length KM	4.40	6.00	6.60	5.40	6.15	6.70
Burst factor	27	33	40	29	34	40
Tear factor	135	127	117	138	130	124

TABLE—VII VALLEY BEATER EVALUATION OF BLEACHED PULPS (DENDROCALAMUS STRICTUS)—STANDARD HANDSHEETS OF 60 g/m².

Cook No.		6			8	
Initial Slowness °SR		15			15	
Final Slowness °SR	30	40	50	30	40	50
Beating time, minutes	27	38	48	25	36	45
Bulk cc/g	1.85	1.60	1.55	1.60	1.40	1.30
Breaking length KM	4.85	5.55	6.30	5.35	6.30	6.80
Burst Factor	30	33	40	29	33	40
Tear Factor	106	98	87	92	76	72

2. Unbleached and bleached pulp yield are higher by 7.8% when compared to that obtained by Sulphate process and physical strength properties comparable to Sulphate.
3. Alkaline Sulphite-Anthraquinone process enables to obtain unbleached pulps in Kappa number range of 25-35 for easier bleaching.
4. There is need for investigating the suitability of the process on various varieties of bamboo available in different parts of the country. Also pulping tests need be carried out both with fresh and stored bamboo. On chips size there cannot be any compromise, and a major fraction must lie near to or below 25mm with chip thickness control.

LITERATURE CITED

1. Jauhari, M. B.; Pai, N. M.; Jaspal, N. S., Bhargava, Roshan L., Tappi C. A. Report No. 40-175-207 (1971).

Acknowledgement

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