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High Alpha Pulp From Bagasse

The possibilities of production of High Alpha pulp from Bagasse by acid prehydrolysis followed by Kraft cooking have been studied. A five stage bleaching sequence CEHH SO_2/HCl of the Kraft pulp was followed. The acid prehydrolysed yield and the kraft pulp yield on oven dry partially depithed bagasse was found to be 70% and 30.5% respectively. The bleached pulp yield was 27.1%. The brightness of bleached pulp was 93% Ecl and the cupramonium viscosity was 10.7 Cps. which satisfies the requirement but the overall low yield is detrimental for commercial production of dissolving grade pulp from bagasse under the conditions followed in the study. It is visualised that the proper dipithing of the bagasse will lower the chemical requirements for pulping and bleaching and improve the quality and yield of the pulp.

1. Introduction

The production of Rayon Grade pulp in the country during 1976 is reported to be 1.26 Lacs tonnes. This is likely to increase to about 6.0 lacs tonnes per year by the end of Sixth Five Year Plan[1].

The bamboo was the main raw material for the manufacture of paper and rayon grade pulp in the country. However due to short supply of bamboo intensive investigation was carried on the suitability of hardwoods for the manufacture of paper and rayon grade pulp. Lot of success was achieved in this direction. It was thought that it would be desirable to utilise long fibred bamboo in paper furnish and suitable hardwoods for dissolving grade pulp as fibre length is not so important a factor for such pulps. It is visualised that sufficient hard woods both from natural and man made forests would not be available for the manufacture of paper and rayon grade pulp, for meeting the future requirements. Therefore, it was considered worth-while to explore the possibilities of making high alpha pulp required by various cellulosic based industries, viz. rayon, explosives, plastics etc. from agricultural residues such as bagassse.

India is one of the large sugar producing countries in the world. The production of whole bagasse in the country from sugar mills is estimated around 6.64 million tonnes annually. However, the bagasse available for the manufacture of pulp, paper and allied products is only about 2.0% of the total bagasse produced and the rest is burnt as a fuel by sugar factories[2]. Bagasse could be made available from the sugar factories either as surplus or by using alternative fuel like coal or oil, as substituted bagasse.

2. Technical Aspects of the Utilisation of Bagasse

The average calorific value of bagasse with 48% moisture is 2222 K. Cal./Kg. as compared to 6112 K. Cal./Kg. of average grade of coal. The furnace oil has a calorific value of about 10,000 K. Cal./Kg. Based on calorific value, a tonne of average grade of coal can replace about 3.2 tonnes of 50% moist or about 2.0 tonnes air dry bagasse. A tonne of furnace oil can replace about 6 tonnes of 50% moist or about 4.0 tonnes air dry bagasse[2]. As compared to bagasse, coal or oil is more convenient to use but the cost of substition can not be equated on the basis of calorific values of coal or oil. The reason being the sugar factory furnaces are designed to burn moist bagasse and changes are necessary for using coal or oil as a fuel. Thus, the availability of bagasse will depend upon the economics of

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the changes. Besides this the difficulty of transportation, handling and storage of baggasse are also to be considered. Moreover the paper manufacture is carried out about 330 days in a year where-as the sugar is a seasonal industry. Thus, the use of surplus bagasse is possible only for small size pulp and paper mills of about 20 TPD preferably as a sister concern of a sugar mill, so that the other factors may not come in the way.

Bagasse consists of about the same amount of hollocellulose as in hard woods and bamboo but alpha cellulose in bagasse is little less. On the other hand, the bagasse consists of more hemicelluloses than wood and bamboo. For rayon grade pulp the use of such cellulosic raw material is desirable which has got high alpha cellulose, less pentosans, ash and silica content. Therefore, for the manufacture of rayon grade pulp from bagasse, a somewhat drastic treatment is required at the first stage.

During recent years various attempts have been made for manufacture of rayon grade pulp from bagasse. Thus, Locus[3], Hamaguti-*et al*[4], Jayme[5]. Mishra[6], and others have worked on the feasibility of manufacturing disolving grade pulp from bagasse by prehydrolysis sulphate process, using various prehydrolysing agents.

In India, Guha[7], Basu[8], and Yadav[9] have also studied the use of bagasse for the production of high alpha pulp. It is now recognised that rayon grade pulp can be manufactured from bagasse by using sulphuric acid as prehydrolysing agent followed by conventional kraft process for pulping. The characteristics of alpha pulps obtained from bagasse was very much similar to the pulps obtained from hardwoods and bamboo.

3.0 Experimental

3.1 Raw Material Preparation

For the present investigation bagasse was procured from M/s. Shree Gopal Paper Mills, Yamunanagar (Haryana). It was partially depithed in hammer mill in order to remove pith. But due to lack of suitable depithing equipment, the bagasse could not be entirely depithed. The partially depithed bagasse was used for experimental work.

The proximate analysis of the bagasse was carried out as per *Tappi* standards and the results are given in Table No. 1 alongwith the proximate analysis of bamboo and Eucalyptus tereticornis for comparison.

3.2 Prehydrolysis of Bagasse

The prehydrolysis kraft pulping of bagasse was carried out in an electrically heated stainless steel (WEVERK) rotary digester of 15 litres capacity The partially depithed bagasse was prehydrolysed with water and sulphuric acid at different concentrations varying from 0.125% to 1.25% calculated on oven dry weight of bagasse and at different prehydrolysing temperatures varying from 140°C to 170°C. The other conditions maintained were:

(1) Bath ratio. = 1:5

(2) Time to Maximum temp. = 90 minutes

(3) Time at Maximum temp. = 90 minutes

After the completion of prehydrolysis, the whole mass was thoroughly washed and subsequently air dried. The prehydrolysed bagasse

TABLE 1.

Proximate Analysis of Bagasse Bamboo and Eucalyptus Hybrid.

(All percentages are expressed on O.D. Basis)

Sl. No.	Particulars.		Bagasse (used in investigation)	Eucalyptus Hybrid (10) (Grown in U.P.)	Bamboo (11) Dendrocalamus Strictus)
1.	Ash.	%	1.70	0.64	4.9
2.	Silica.	%	0.45	0.02	3.3
3.	Solubilities in				
	(a) Hot water	%	3.9	13.8	3.8
	(b 1% NaOH	%	37.6	16.4	17.8
	(c) Alcohol-Benzene	%	4.2	1.1	1.6
4.	Pentosans Content.	%	25.2	15.7	17.2
5.	Lignin (Ash free).	%	18.5	28.3	25.6
6.	Alpha cellulose.	%	42.4	45.2	45.9
7.	Holocellulose.	%	64.5	67.2	64.5

yield, pentosans and alpha cellulose content were determined. The results are given in Table No. 2.

3. (3) **Kraft Pulping of Prehydrolysed Bagasse**

After optimising the prehydrolysis conditions on the basis of maximum pentosan's removal and alpha cellulose retained in the prehydrolysed bagasse, the Kraft pulping was carried out, using sodium hydroxide and sodium sulphide cooking chemicals expressed as Na_2O and calculated on ovendry weight of prehydrolysed bagasse. The cooking chemicals were varied from 15 to 18%. The constant conditions maintained in Kraft pulping were :

(1) Bath ratio. = 1 : 3.5
(2) Maximum cooking temp. = 165°C
(3) Time to Max. Temperature = 90 mins.
(4) Time at Max. Temperature = 90 mins.
(5) Sulphidity. = 21 to 22%

After the completion of Kraft cook, the pulp was washed and the yield was determined. The permanganate number and pentosans content of kraft pulp were also determined. The results are given in table No. 3.

3. (4) **Prehydrolysis and Kraft Pulping of Bagasse at optimum conditions**

Based on permanganate number, pentosans content and yield of unbleached pulp, the percentage of cooking chemicals to be used for pulping of water and acid prehydrolysed bagasse were optimised. The fresh samples of bagasse were prehydrolysed with water and 0.5% sulphuric acid at 170°C and 160°C respectively, while other conditions were kept constannt as described in 3.2. Both prehydrolysed bagasse were cooked with 15.5% active alkali expressed as Na_2O separately at 165°C. The other cooking conditions

TABLE 2

Prehydrolysis of Bagasse Using Different Hydrolysing Agent at Different Temperatures

Prehydrolysing Agents used on Ovendry Weight of Bagasse

Particulars	Unit	Water				0.125% H_2SO_4			0.250% H_2SO_4			
		1.	2.	3.	4.	1.	2.	3.	1	2.	3.	4.
1. Prehydrolysing Temperature.	°C	140	150	160	170	140	150	170	140	150	160	170
2. Bath Ratio.		1:5	1:5	1:5	1:5	1:5	1:5	1:5	1:5	1:5	1:5	1:5
3. Time to Maximum Temperature.	Min.	90	90	90	90	90	90	90	90	90	90	90
4. Time at Maximum Temperature.	Min.	90	90	90	90	90	90	90	90	90	90	90
5. Prehydrolysed bagasse yield	%	95	91.5	88.5	76.5	91.9	89.5	71.3	90.4	83.4	77.0	65.0
6. Pentosans content.	%	25.1	24.7	20.8	14.6	24.5	24.1	14.0	23.9	23.7	17.0	12.7
7. Pentosans removed (based on (whole bagasse)	%	0.5	2.0	17.5	42.0	3.0	4.5	44.5	5.5	6.0	32.5	49.5

Particulars	Unit.	0.375% H_2SO_4			0.500% H_2SO_4				0.750% H_2SO_4			1.00% H_2SO_4		1.250% H_2SO_4	
		1.	2.	3.	1.	2.	3.	4.	1	2.	3.	1.	2.	1.	2.
1. Prehydrolysing Temp.	°C	140	150	170	140	150	160	170	140	150	160	140	150	140	150
2. Bath Ratio.		1:5	1:5	1:5	1:5	1:5	1:5	1:5	1:5	1:5	1:5	1:5	1:5	1:5	1:5
3. Time to Max. Temp.	Min.	90	90	90	90	90	90	90	90	90	90	90	90	90	90
4. Time at Max. Temp.	Min.	90	90	90	90	90	90	90	90	90	90	90	90	90	90
5. Prehydrolysed bagasse yield.	%	88 6	79.5	61.5	87.4	76.5	70.2	59.8	82.8	73.5	63.2	76.4	69.5	68.4	65.0
6. Pentosans content.	%	23.6	23.5	10.7	21.7	16.7	13.0	9.0	19.4	14.4	9.6	16.5	12.1	12.2	8.8
7. Pentosans removed (based on whole bagasse).	%	6.5	70.	57.5	14.0	33.5	48.5	64 5	23.0	43.0	62.0	34.5	52.0	51.5	65.0

were maintained as described in 3.3. The unbleached pulps obtained in each experiment were thoroughly washed and their yields were determined. These pulps were also analysed for permaganate number, pentosans content and viscosity. All the results are given in table No. 4.

3. (5) Bleaching of Prehydrolysed Kraft Bagasse Pulp

The pulps were bleached in four stages, consisting of chlorination, hot alkaline extraction, and hypochlorite treatment. After bleaching, the pulps were treated with 2.0% HCl at 3% consistency for 30 minutes and washed. At hypochlorite stages the calcium hypochlorite bleached liquor was used. The bleaching conditions are given in Table No. 5.

The yield of bleached pulp samples were determined, and these bleached pulps were analysed for Alpha Cellulose, pentosans content, ash and brightness. The viscosity was also determined. All results are included in Table No. 6.

4.0 Discussion of the Results

The results given in Table No. 1 show that bagasse consists of more pentosans and about the same less holocellulose as compared to eucalyptus and bamboo. Therefore, two sets of experi-

TABLE 3

Kraft Pulping of Prehydrolysed Bagasse at Various Cooking Chemicals Charge

1. Prehydrolysis : (a) Bath Ratio. =1:5
(b) Time to Max. Temp. =90 min.
(c) Time at Max. Temp. =90 min.

2. Kraft Cooking : (a) Bath Ratio =1:3.5
(b) Max. cooking Tem. =165°C
(c) Time to Max. Temp. =90 min.
(d) Time at Max. Temp. =90 min.
(e) Sulphidity % =20-21%

Sl. No.	Particulars	Unit.	COOK NUMBERS							
			1.	2.	3.	4.	5.	6.	7.	8.
A.	Prehydrolysis									
1.	Prehydrolysing Agent.	—	Water	Water	Water	Water	0.5% H_2SO_4	0.5% H_2SO_4	0.5% H_2SO_4	0.5% H_2SO_4
2.	Prehydrolysing Max. Temperature.	°C	170	170	170	170	160	160	160	160
3.	Pentosans content.		14.6	14.6	14.6	14.6	13.0	13.0	13.0	13.0
B.	Kraft Cooking :									
1.	Cooking chemicals used ($NaOH+Na_2S$) expressed as Na_2O based on O.D. wt. of P.P. bagasse.	%	15	16	17	18	15	16	17	18
2.	Suphidity of cooking liquor.	%	20–21	20–21	20–21	20–21	20–21	20–21	20–21	20–21
3.	Unbleached Kraft Pulp Yield.	%	41.7	41.0	39.4	39.0	41.1	40.4	39.0	38.1
4.	Pentosans content.	%	8.9	8.5	8.3	8.3	7.9	7.3	6.3	3.0
5.	Permanganate No. of pulp.	No.	13.4	9.4	8.4	7.2	11.7	9.4	8.2	6.7
6.	Overall pentosans removed based on original bagasse.	%	65.0	66.5	67.0	67.5	68.5	71.0	75.0	76.2
7.	Overall unbleached prehydrolysed Kraft pulp yield based on original bagasse.	%	32.1	31.6	30.3	30.0	28.3	28.0	27.2	26.9

TABLE 4

Prehydrolysis and Kraft Pulping of Bagasse at Optimum Conditions

Particulars.	Prehydrolysing Agents	
	Water	0.5% H_2SO_4
A. Prehydrolysis		
1. Bath Ratio.	1:5	1:5
2. Maximum cooking Temperature °C	170	160
3. Time to Maximum Temperature Mins.	90	90
4. Time at Maximum Temperature Mins.	90	90
5. Prehydrolysed Bagasse yield. %	76.5	70
6. Pentosans Content in prehydrolysed bagasse. %	14.7	10.0
7. Pentosans removed based on Original bagasse. %	41.5	60.0
B. Kraft Pulping of Prehydrolysed Bagasse :		
1. Cooking chemicals used ($NaOH+Na_2S$) expressed as Na_2O.	15.5	15.5
2. Sulphidity of cooking liquor. %	21.6	21.6
3. Maximum cooking Temperature °C	165	165
4. Time to Maximum Temperature Mins.	90	90
5. Time at Maximum Temperature Mins.	90	90
6. Bath Ratio.	1:3.5	1:3.5
7. Unbleached pulp yield (based on prehydrolysed bagasse). %	43.7	43.1
8. Permaganate Number.	9.3	7.6
9. Pentosans Content. %	8.3	3.7
10. Overall pentosans removed based on original bagasse. %	67.0	85.5
11. Viscosity of pulp Cps.	43.5	39.6
12. Overall yield of pulp based on original bagasse. %	33.9	30.5
13. Alpha cellulose content. %	83.7	86.8

ments on prehydrolysis of bagasse using water and different concentrations of sulphuric acid at temperatures varying from 140°C to 170°C were conducted. From the results given in Table No. 2, it may be observed that by using water as prehydrolysing agent, even at 170°C pentosans could be removed only to the extent of 42%, while using sulphuric acid as prehydrolysing agent, pentosans decreased with increase in the concentration of sulphuric acid and prehydrolysing temperature. Based on maximum pulp yield and pentosans removed, the optimum prehydrolysis conditions were obtained at 0.5% sulphuric acid and 160°C.

From the results given in Table No. 3, it may be observed that pentosans content of bagasse prehydrolysed with 0.5% sulphuric acid and water (cooked with 15% active alkali as Na_2O at 165°C for 90 minutes at the maximum temperature) decreased from 14.6% and 13.0% to 8.9% and 7.9% respectively.

The optimum conditions used for Kraft cooking of water/H_2SO_4 prehydrolysed bagasse are given below :

(a) Cooking chemicals ($NaOH+Na_2S$) expressed as Na_2O = 15.5%
(b) Maximum cooking temperature = 165°C
(c) Cooking time to max. temperature = 90minutes
(d) Cooking time at max. temperature = 90minutes
(e) Bath Ratio = 1 : 3.5
(f) Sulphidity = 21–22%

Table No. 5
Bleaching of Prehydrolysed Kraft Bagasse Pulp

Particulars		Water P.H. Kraft Pulp	Acid P.H. Kraft Pulp
A. Chlorination Stage			
1. Chlorine used based on O.D. pulp.	%	4.0	3.0
2. pH		2.0	2.0
3. Consistency	%	3 0	3.0
4. Bleaching Time	Min.	30	30
5. Bleaching Temperature	°C	21	21
6. Consumption of Cl_2 based on O.D. pulp.	%	3.3	2.4
B. Alkali Extraction Stage			
1. NaOH used on O D. pulp	%	4.0	4.0
2. pH		10.5	10.5
3. Consistency	%	10.0	10.0
4. Extraction Time	Min.	120	120
5. Extraction Temperature	°C	78-80	78 80
6. Consumption of NaOH based on O.D. pulp	%	3.5	3.0
C. First Hypochlorite Stage			
1. $Ca(OCl)_2$ used as available Chlorine based on O.D. pulp	%	2.0	1.5
2. pH		9.5	9.5,
3. Consistency	%	7.0	7.0
4. Bleaching Time	Min.	90	90
5. Bleaching Temperature	°C	40	40
6. Bleach liquor consumption available Chlorine based on O.D. pulp	%	1.6	1.2
D. Second Hypochlorite Stage			
1. $Ca(OCl)_2$ used as available Chlorine based on O.D. pulp	%	1.0	0.5
2. pH		9.5	9.5
3. Consistency	%	7.0	7.0
4. Bleaching Time	Min.	120	120
5. Bleaching Temperature	°C	40.0	40.0
6. $Ca(OCl)_2$ consumption as available Chlorine based on O.D.	%	0.67	0.40
E. Acid Treatment			
1. HCl used on O.D. pulp	%	2.0	2 0
2. Consistency	%	3 0	3.0
3. Temperature	°C	22.0	22.0
4. Time	Min.	30.0	30.0
F. Bleached Pulp Yield on O.D.			
Weight of Prehydrolysed Kraft Pulp	%	90.0	89.0
G. Brightness of bleached pulp			
(Elrepho).	%	91.0	93.0

The pentosan content in acid prehydrolysed kraft bagasse pulp was 3.7% as compared to 8.3% in water prehydrolysed kraft bagasse pulp. The viscosity and alpha cellulose content were satisfactory in both the kraft pulps.

The two kraft pulps obtained from water and acid prehydrolysed bagasse were bleached separately using C–E–H–H bleaching sequence. At the hypochlorite stages, calcium hypochlorite bleach liquor was used. The bleaching conditions are given in Table No. 5. The overall yield of bleached pulp and its brightness obtained were 30.5% and 91.0% respectively by water prehydrolysis kraft process, whereas these values were 27.1% and 93% in the case of bagasse prehydrolysed with 0.5% sulphuric acid.

The results of chemical charactristic of bleached bagasse pulp are given in Table No. 6. These results indicate that alpha cellulose and brightness of both the bleached pulps are satisfactory. The bleached pulps obtained from acid prehydrolysed bagasse is better than bleached pulp obtained from water prehydrolysed bagasse as regards to pentosans content and ash content are concerned. It may be mentioned in this connection that the ash content in bleached pulp may be further reduced by using sodium hypochlorite as bleach liquor.

5. Conclusion

1. The characteristics of bleached pulp obtained from bagasse by water and acid prehydrolysis kraft

Table No. 6
Bleached Pulp Characteristics

Sl. No.	Particulars		Water P.H. Kraft bagasse pulp.	Acid P.H. Kraft bagasse pulp.
1.	Bleaching sequence used.		CEHH	CEHH
2.	Bleached pulp yield on ovendry weight of original raw material.	%	30.5	27.1
3.	Alpha cellulose in (Ash free) bleached pulp.	%	90.5	94.4
4.	Pentosans content.	%	7.6	3.5
5.	Viscosity of pulp in (Cuprammonium) Cps.		14.5	10.7
6.	Brightness.	%	91.0	93.0
7.	Ash content.	%	0.45	0.22
8.	Silica content.	%	0.08	0.07

process are given in Table No. 6.

2. Rayon grade bleached pulp can be prepared from properly depithed bagasse by acid prehydrolysis and kraft pulping process followed by multistage bleaching in five stages C E H H SO_2/HCl with an yield of 27.1% on ovendry bagasse. The over all low yield is detrimental for commercial production of dissolving grade pulp from bagasse under the conditions of the study. It is visualised that the proper depithing of the bagasse will lower the chemical requirements for pulping and bleaching and improve the quality and the yield of pulp.

References

1. Planning Com. Report., Govt. of India.
2. Manohar Rao, P.J., Co-operative Sugar Vol. 7 (4) Dec, 1960.
3. Locus, A.H., *Tappi* Vol. 43 (1), Jan. 1960.
4. Hemaguti E. *etal.* J. Soc. Trop. Agr. Taihoku, IMP Univ. Vol. 12 pp 9-16 (1940) (CA 34, 71365).
5. Jayme G. *Etal.* Das Papier Vol. 11 PP 7-14, 1957.
6. Mishra D.N. *Tappi* 42, No. 1, Jan. 1957.
7. Guha S.R.D. *Etal,* IPP Vol. 16 Nov., October, 1961.
8. Basu S., IPP Vol. 23 No. 8, Feb. 1969, IPPTA Vol. II CN, 1970.
9. Yadav R. P. *Etal* IPP Vol. XXVII No. 3 and 4 PP 47 1972.
10. Guha S.R.D. Indian Forester Vol, 95 No. 8, 1969.
11. Jauhari *Etal* IPPTA, Vol. 7 No. 4, 1970.
12. Guha S.R.D. IPPTA Vol. 5. No. 3 T-169 Sept.,1968.