Pulping and ECF Bleaching of Whole Jute for Higher Brightness

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ABSTRACT

Whole jute, also known as Corchorus Capsularies, is grown in many parts of the world particularly in eastern and central India, Bangladesh and south Asian countries. Due to its long fibre length, paper of considerably high tear and tensile strength could be made out of it. In this study whole jute was subjected to soda / soda-Anthraquinone pulping process. After oxygen delignification, various ECF bleaching sequences have been investigated. Conventional CEHH bleaching was also carried out for comparison. The results of bleaching were then compared and the sequence giving higher brightness and strength properties along with COD value was suggested.

Keywords: Whole Jute, Soda-AQ pulping, ECF bleaching

INTRODUCTION

Jute bast fibre, which is approximately 25 percent of whole jute has been used for packaging materials for various agricultural, food, industrial commodities and to some extent for carpet backing, hessian, decorative fabrics, etc. In pulp and paper industry it can be blended with wood pulp or bamboo pulp for the production of cigarette paper, tag paper, wrapping and bag paper, etc.[1, 2] leaving behind the jute sticks as the waste. However, the existence of jute fibre in its conventional use is challenged by the synthetic fibres and its export has gradually decreased. Therefore, it is necessary to find some new uses of jute fibre. Research [3, 4, 5] suggests that whole jute having high percentage of cellulose and long fibre is quite suitable as non-wood fibrous raw material for manufacture of different grades of paper and board. Whole jute fibers are longer and stronger than many other conventional nonwood raw materials for paper making.

Whole jute plant contains higher holocellulose and lower lignin compared to bagasse and bamboo. Like wood the whole jute contains less silica which is a positive indication for efficient working of chemical recovery unit. Fibre dimensions of whole jute were found to be comparable to other nonwood fibres [6]. In the present study whole jute pulp was made through soda and soda-AQ process and soda dose in soda-AQ process has been optimized.

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Recent trend in bleaching is, to shift to elemental chlorine free (ECF) bleaching due to its environment friendly nature. For applying ECF bleaching economically it is advisable to use 'oxygen delignification' as prebleaching stage. It reduces kappa no. of pulp significantly and thus reduces bleach chemical demand in further bleaching stages. Therefore, in the present investigation oxygen delignified soda-AQ pulp was subjected to various ECF bleaching sequences namely DEPD, ODED, ODEP, ODEPD and ODEDP. Conventional CEHH bleaching sequence was also performed prior to oxygen delignification for comparison. COD values for each sequence were calculated.

Materials and Method

Soda and Soda-AQ pulping

Whole jute plants were collected from CPPRI. The raw material was washed with water, dried under sun and chopped into small pieces. The pulping experiments were carried out in the laboratory WEVERK digester (20 l). The pulp was refined and then screened after washing. Four sets of pulping experiments were performed to optimize soda dose. The cooking conditions and the characteristics of the pulps obtained are given in Table 1. All the calculations have been done on O.D. basis.

Table 1 : Cooking conditions and results of pulping

Experiment No.	1	2	3	4
Temp., C	165	165	165	165
Time to temp., min	130	130	130	130
Time at temp., min	90	90	90	90
Bath ratio	1:5	1:5	1:5	1:5
Active alkali charge as NaOH, %	20	20	24	28
AQ charge, %	0.0	0.05	0.05	0.05
Screened pulp yield, %	41.4	44.37	46.12	44.64
Kappa No.	29.6	25.7	19.4	17.6
RAA, gpl	1.5	2.2	4.1	6.3

Table 2 : Bleaching conditions and dosing of chemicals in CEHH sequence

Chlorine demand = 5%
Concentration:
Bleach liquor = 36.93 gpl
NaOH = 88.4 gpl

Stage	C	E	H_1	H_2
Consistency, %	3	10	10	10
Temp., C	30	65	35	35
Time, min	60	60	180	180
End pH	2	10	10	10
Chlorine added, % of chlorine demand	50	-	35	15
NaOH added, %	-	1.5	-	-

Table 4 : Chemical doses in various ECF bleaching sequences

Concentration:
H_2O_2 = 74.6 gpl
ClO_2 = 21.9 gpl

Sequence	ODED	ODEDP	ODEP	ODEPD	DEPD
Cl_2 demand, %	2.9	2.9	2.9	2.9	4.85
O.D. pulp, gm	20	20	20	20	20
ClO_2 in D_1 stage, % of Cl_2 demand	70	70	100	70	70
ClO_2 in D_2 stage, % of Cl_2 demand	30	30	-	30	30
Alkali in E stage, times Cl_2 demand in D_1	0.6	0.6	0.6	0.6	0.6
Yield before P stage, %	-	90.8	90.9	91.2	92.9
Peroxide, %	-	0.3	0.3	0.3	0.3
$MgSO_4$ added, %	-	0.05	0.05	0.05	0.05
Alkali in P stage, %	-	2.0	2.0	2.0	2.0

Oxygen delignification

Pulp cooked with 24% NaOH was subjected to oxygen delignification for further ECF bleaching sequences in the same laboratory digester under following experimental conditions: consistency,10%; NaOH, 2.5%; $MgSO_4$, 0.2%; O_2 pressure, 6.5 bar; temperature,100° C; and retention time, 60 min.

Bleaching

The following six bleaching sequences were carried out on pulp cooked with 24% NaOH CEHH, DEPD, ODED, ODEDP, ODEP and ODEPD. All the bleaching experiments were performed in the laboratory using batch vessels immersed in constant temperature bath. Bleaching conditions and chemical dosing in various bleaching sequences have been recorded in Table 2 through 4.

Chlorination (C)

Bleach liquor was added to the pulp in the chlorination vessel to generate chlorine gas at pH less than 2 (1.51.8). At the end of the retention time, the pulp was washed and subjected to alkali extraction.

Extraction (E)

Table 3 : Conditions for ECF bleaching stages

Stage	D_1	D_2	E	P
Consistency, %	10	10	10	10
Temp. C	60	60	65	70
Time, min	180	180	60	180
End pH	4	4	10	10

Chlorinated lignin derivatives were extracted out by addition of alkali. NaOH added was 0.6 times Cl_2 demand in C stage. After the end of retention time the pulp was washed.

Hypochlorination (H)

The same bleach liquor as used in the C stage was used for hypochlorination with different pH (10-11). Washing of pulp was performed between each stage.

Treatment with chlorine dioxide (D)

Sodium chlorite solution was used in this stage and the pH was maintained between 4-5. This stage was used to replace both chlorination and hypochlorination stages. For the sequences with two D stages 70% of the chlorine demand was fed to the first and the rest 30% was charged in the second D stage. For ECF sequence alkali extraction was carried out in the same way as that with CEHH sequence.

Peroxide stage (P)

To increase pulp brightness without increasing the generation of chlorinated compounds in some of the ECF sequences 0.3% H_2O_2 was used in the P stage.

Determination of COD

Chemical oxygen demand (COD) of the combined effluent generated from various bleaching sequences, were estimated by open reflux method [7].

Determination of optical and strength properties of bleached pulp

Handsheets were prepared in British

Table 5 : Results of different bleaching sequences

Sequence	CEHH 1	ODED 2	ODEDP 3	ODEPD 4	ODEP 5	DEPD 6
Brightness, % ISO	77.1	86.6	90.3	88.4	87.0	80.1
Tensile index, Nm/g	78.5	83.7	82.6	82.0	80.8	79.7
Tear index, mNm^2/g	7.5	8.0	8.3	8.6	8.7	8.9
COD, kg/t	65.3	50.13	52.39	55.69	54.56	59.7

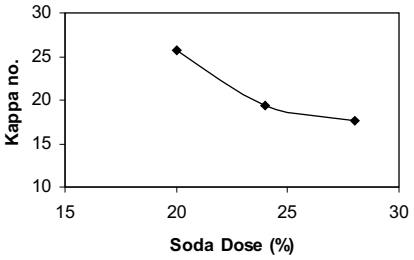

Figure 1 : Effect of soda dose on pulp kappa number (Soda-AQ pulping)

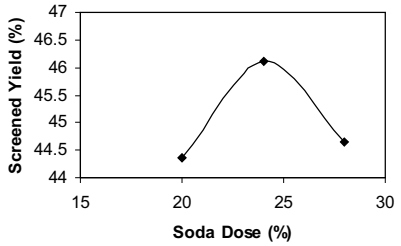

Figure 2 : Effect of soda dose on screened pulp yield (Soda-AQ pulping)

sheet former under standard pressing and drying conditions and optical and physical strength properties of all the bleached pulps were evaluated as per BIS-1848 and IS:1060 specifications (Table 5).

RESULTS AND DISCUSSION

It can be seen from Table 1 that, at the same level of soda dose, addition of 0.05% AQ in the pulping process kappa no. was decreased (11%) with increase in screened pulp yield (7%). The residual active alkali level was also higher in case of soda-AQ pulp. Experiment no.3 and 4 were performed to optimize soda dose in soda-AQ pulping without varying the AQ dose. Analysis of the data (Fig.1) shows that kappa no. was significantly reduced upon increasing soda dose from 20 to 24% while there was little decrease in kappa no. on increasing dose from 24 to 28%. Fig.2 shows that screened pulp yield was the maximum in case of soda dose of 24%. From Fig. 3 it can be seen

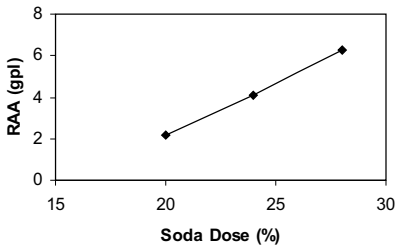

Figure 3 : Effect of soda dose on residual active alkali (Soda-AQ pulping)

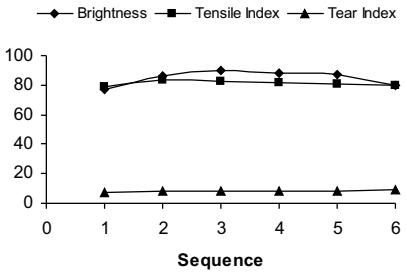

Figure 4 : Comparison of brightness and strength properties of soda-AQ pulps from different bleaching sequences

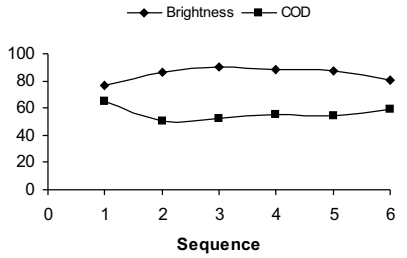

Figure 5 : Comparison of brightness and COD values of effluents from different bleaching sequences

that RAA increases with increasing soda dose. Although 28% NaOH charge resulted in lowest kappa no. pulp, but considering higher yield in case of 24% NaOH charge the later was concluded to be optimum. Therefore, pulp obtained from experiment no.3 was taken for further experimental investigation. After oxygen delignification it was found that pulp kappa no. has reduced to 11.7. This in turn will reduce the chemical requirements in the bleaching processes and thus pollution load generated will be significantly low. In the present investigation the commonly practiced CEHH sequence have been studied to compare the optical and strength properties of pulp obtained through various ECF processes (Table 5). Although conventional bleaching of whole jute pulp using chlorine is the most economic one, it is not possible to achieve higher brightness without sacrificing pulp strength and increase in the pollution load. Among the bleaching sequences studied, the ODEDP sequence was found to give highest brightness (90.3%) and tensile index (83.7) and lowest COD value. A comparison of achieved brightness levels and strength properties of the pulps obtained from different bleaching processes has been made in Fig.4. Among the sequences studied, the ODED, ODEDP, ODEPD and ODEP were found to give brightness above 86%. The CEHH and DEPD sequences could not reach the target brightness of 85%. Fig.5 compares the brightness level achieved in various bleaching sequences investigated with the measured values of COD generated. The COD value for the CEHH sequence was found maximum. It can be observed that inclusion of P stage in the ECF processes increases the pulp brightness with significant increase in the COD level.

CONCLUSIONS

For whole jute Soda-AQ pulping process is more suitable than Soda pulping as the former results in lower kappa no. and increase in the screened pulp yield. Soda dose of 24% was found to be optimum in Soda-AQ pulping of whole jute, as screened yield was the maximum in this case. Though oxygen delignification prior to bleaching is capital intensive, higher brightness pulp (above 86%) with reduced COD load may be achieved through only three stage bleaching process after oxygen delignification (ODEP and ODED). Higher values of tensile index and tear index were achieved in all the ECF bleaching sequences. In ODEDP sequence brightness was significantly higher than CEHH and other ECF sequences. Tensile strength in ODEDP was higher than most of the other

bleaching sequences but slightly less than ODED. There is little variation in tear strength amongst the ECF bleaching sequences. Among the bleaching sequences studied ODEDP was found most suitable in terms of brightness, physical strength properties and pollution parameter.

REFERENCES

1. Hurter, R. W. , Nonwood plant fiber uses in paper making, agricultural residue, *TAPPI Short course notes*, 53-61 (2001).

2. Kerr, A. J., Whole jute semichemical pulp as a reinforcing pulp for unbleached kraft paper, *APPITA Jl*., Vol.24(3), 180-188 (1970).

3. Gupta, H. K., Shivharc, P. and Mohindru, V. K.,, Suitability of whole jute plants over other conventionally used non-woody raw materials for paper and newsprint, *IPPTA Jl*., Vol.10 (3), 112-143 (1998).

4. Bhowmic, K., Dissolving pulp from jute stem (Chorchorus Capsularies) by water prehydrolysis kraft process, *IPPTA Jl.*, Vol.11 (1), 51-63 (1999).

5. Kleinert, T. N., Suitability of whole jute CMP for newsprint, *TAPPI Jl*., Vol.49 (2), 53-57 (1966).

6. Shah, A. M., Morphological characteristics of different non-wood fibers, *IPPTA Jl*., Vol.3 (2), 62-68 (1991).

7. Standard methods for the examination of water and wastewater, *Published jointly by APHA, AWWA and WPCF,* 16th Edn., (1985) 533-535.