ECF Bleaching of Assam Bamboo Pulp

Priti S. Lal, Sandeep Tripathi, Arvind Sharma, S.V. Subrahmanyam and A.G. Kulkarni
Central Pulp and Paper Research Institute, Saharanpur.

Abstract

The ECF/TCF bleaching is today's most concerned area in large paper mills of India. The demand of TCF and ECF bleached pulp has been growing rapidly during the last years, which is indicative of people's awareness towards cleanliness of environment. ECF and TCF bleaching sequences help in minimizing the bleach plant effluent load by minimizing the pollution parameters such as BOD, COD, AOX and colour that can eventuallly lead to totally effluent free production. Successful implementation of ECF and TCF sequence in a system demands low kappa number of unbleached pulp, as chlorine free bleaching agents are less efficient than elemental chlorine. ECF bleaching studies are reported for different Indian forest based raw materials. Response of bamboo pulp in conventional bleaching sequences is very poor that has induced us to take up a study where-in the pulp could be bleached to reasonably higher brightness levels with out sacrificing the strength properties. A study on oxygen treatment of bamboo pulp of two different kappa numbers followed by ECF bleaching is conducted. The merits of ECF bleaching process are compared with conventional sequence and impact on stength viz viscosity and liquid discharge quality.

INTRODUCTION

ECF bleaching, the substitution of chlorine bleaching stage with chlorine dioxide has become the most attractive method to bleach chemical pulp. It allows the maintenance of high pulp quality and acceptable yield, while at the same time producing only a low level of halongenated compounds (OX). ECF bleaching normally follows in oxygen delignification stage, therefore the demand for active chlorine can be low compared to conventional bleaching, however the total cost of bleaching is higher compared with conventional chlorine bleaching. This is mainly due to the higher cost of chlorine dioxide compared with chlorine (1,2).

The use of bamboo as papermaking raw material has long history. Many of large paper mills in India with ≃300 TPD production capacity are using bamboo with different percentage. Bamboo has it's own papermaking potential, which can hardly be substituted by other raw materials. Direct bleaching of bamboo pulp of kappa ranging from 15-25 is difficult using ECF sequence to high brightness. It is possible with conventional sequence but effluent load generation is proportionally high and use of high bleach chemical leads to yield and strength loss during bleaching. The studies in the present communications are focused on oxygen treatment and ECF feasibility of bamboo (3,4).

The concept of ECF is to produce bleached pulp with significantly high brightness. It is possible when kappa number of oxygen treated pulp is lowered to ≃8to10. Unbleached pulp with high kappa≃25 cannot be bleached to high brightness. Hence, we have tried to assess the impact of unbleached kappa number on the yield and quality of bleached pulp obtained through Oxygen delignification followed by various conventional and ECF sequences. The bleach sequences tried in the current study include conventional (CEH) bleaching, partial substantiation of chlorine with chlorine dioxide (C/DEH and C/DED) and ECF sequence (DED). All parameters such as kappa after oxygen treatment, viscosity, brightness etc. are studied (4-5).

EXPERIMENTAL

Collection of raw material

Bamboo chips were collected from Cachar Paper Mills, a unit of Hindustan Paper Corporation Ltd. The sample was kept in a polythene bag to attain a uniform moisture level. The moisture was determined before cooking of the bamboo chips, following standard TAPPI method.

Pulping of Assam Bamboo

Optimization of pulping chemical requirement

Optimisation of kraft pulping chemical requirement to obtain different kappa numbers was carried out with an H factor of ≃1400. Application of 14% and 16% kraft liquor (as Na_2O) with a sulphidity of 20% yielded the pulp of desired kappa numbers i.e. 16 and 23. Experiments were performed in series digester consisting of six bombs each of 2.5-liter capacity, rotating in an electrically heated polyethylene glycol bath. At the end of the cooking time. the bombs were removed and quenched in the water tank to cool down and the cooked mass from each bomb was taken for washing. Washing was carried out with hot water till the cooked mass was free from spent liquor. After thorough washing, the unscreened pulp yield was determined and the pulp was screened in laboratory 'Serla' screen by using mesh of 0.25 mm slot width. Kappa number of the screen pulp was determined as per the Tappi standard procedure T-236-OS-76. The cooking conditions are given below:

Cooking Conditions:

Raw materials in each bomb	:	200 g
Bath ratio	:	1:4
Cooking temperature °C	:	168
Cooking time, min.	:	120

Determination of pulp kappa number, brightness and viscosity

Pulp in as such were analyzed for yield, kappa number (Tappi T:236 OM 99), brightness (ISO 2470) and intrinsic viscosity (Scan C:3)

Oxygen pre-treatment of pulp

Oxygen delignification of unbleached pulp samples was carried out in Quantum mixer. Pulp weighing 250g was taken for each oxygen treatment in reactor vessel. After mixing the sodium hydroxide to the pulp, the pulp was pre-heated in the microwave oven to 95°C and pH of the pulp was determined. Volume of the reactor vessel is 3.5 liters and it is electrically heated. The temperature of the reactor vessel was maintained 95°C prior starting the experiment. The preheated pulp was placed in reactor vessel. The oxygen gas was injected in to the reactor vessel through the cylinder. Mix time/heat transfer time was given after every 15 minutes for 12 seconds. The oxygen treatment was given using following conditions.

Oxygen treatment conditions

Pulp consistency	:	10%
Sodium hydroxide charged	:	2.0%
Oxygen pressure	:	0.6Mpa
Treatment temp.	:	95°C
Treatment time	:	60 minutes

pH of pulp was determined after oxygen treatment,. Kappa number, brightness, viscosity and yield of the oxygen treated pulps were determined after thorough washing of the pulp. The procedure of oxygen treatment is as described in manual of oxygen reactor supplied by Quantum Inc, Ohio, USA.

Bleaching Experiments

Bleaching experiments were carried out on unbleached pulps having initial kappa numbers 16.1 and 23.2, which were reduced to 6.8 and 11.2 in Oxygen delignification process. These pulps were bleached using conventional CEH, modified with dioxide substitution C/DEH and ECF, DED sequences. Bleaching conditions used for different stages of bleaching are recoded in Table 1.

RESULTS AND DISCUSSION

Proximate chemical analysis of Assam bamboo

Detailed chemical analysis of Assam bamboo is recorded in Table 2. It is shown that lignin content is Assam bamboo is 23.4%, holocellulose

Table 1. Bleaching conditions

	Unit	Cl_2 stage	Extraction stage (Ep)	Hypo stage	Dioxide-D stage
Consistency	%	3.0	8.0	8.0	10
Reaction time	min	30	60	120	180
Reaction temperature	°C	Amb	60	40	75

73.2%, out of which α,β and γcelluloses are 44.9%, 19.7% and 8.6% respectively.

Pulping experiment of Assam bamboo

Bamboo was cooked use 14% and 16% of cooking chemical dose (as Na_2O) to get kappa in the range of 22-23 and 16-17. Yield with 14% chemical was 49.15% with 16% chemical it was 46.4%. The viscosity of low(16) kappa pulp was 1057 cm^3/g and high kappa(23.2) pulp was 1161 cm^3/g Table 3.

Oxygen treatment of Assam bamboo pulp

The results of oxygen treatment of Assam bamboo pulp are shown in Table-3. Low kappa (16.1) pulp after oxygen treatment is reduced to 6.8 and high kappa (23.2) reduced to 11.2. The drop is 57.7 and 51.7% respectively for low and high kappa pulp. Brightness increases from 23.2% ISO to 39.1% ISO and 18.5% ISO to 34.5% ISO respectively for low and high kappa pulp.

Bleaching of bamboo pulp

Lot of studies have been carried out on bleaching of bamboo. In general the bleaching of bamboo is not fairly good and it is difficult to bleach bamboo pulp beyond 80-81% ISO brightness level for a middle range kappa pulp i.e. 15-20.(5,6). Studies have been carried out on ECF bleaching of bamboo earlier (4,5) also show that it is hard to get brightness more than 81% ISO. Moreover, if we go for high bleach chemical dose to get high brightness, the bleach pulp yield as well as strength both will be affected negatively.

To get high brightness pulp from bamboo it is necessary to reduce pulp kappa before entering

Table-2 Proximate chamical analysis of Assam bamboo

Properties	Unit	Quantity
Ash	%	2.7
Cold water solubility	%	4.0
Hot water solubility	%	4.8
N/10 NaOH solubility	%	25.1
Alcohol benzene solubility	%	2.6
Acid insoluble lignin	%	23.4
Acid soluble lignin	%	0.53
Pentosans	%	16.5
Holocellulose	%	73.2
α cellulose	%	44.9
β cellulose	%	19.7
γ cellulose	%	8.6

Table-3 Results of pulping experiment of Assam bamboo

Parameters	Unit	Experiment 1	Experiment 2
Cooking Chemical as Na_2O	%	16	14
Sulphidity	%	20	20
Unscreened Yield	%	46.4	49.2
Rejects	%	0.03	0.17
Unbleached pulp Kappa	no.	16.1	23.2
Black Liquor properties			
pH		11.1	10.7
TS	%	19.0	18.0
RAA	gpl	11.8	6.8

Table-4 Oxygen treatment of Assam bamboo pulp

Parameters	Unit	Pulp A	Pulp B
Initial kappa number	no.	16.1	23.2
Initial pulp brightness	%	23.5	18.5
Initial pulp viscosity	cm^3/g	1057	1161
Oxygen treatment			
NaOH added	%	2.0	2.0
Initial pH		12.0	12.1
Final pH, at 35°C		10.5	10.4
Kappa number	no.	6.8	11.2
Pulp brightness	%ISO	39.1	34.5
Intrinsic Viscosity	cm^3/g	865	846
Yield	%	97.5	98.0

to bleach plant. Oxygen pretreatment is best option in this case. Bleaching experiments are planned for both oxygen treated and untreated bamboo pulp. The results are separately shown below for low and high kappa pulp.

Bleaching of bamboo low kappa oxygen untreated and treated pulp

Bleaching result of low kappa oxygen treated and untreated pulp are shown in Table5. Direct CEH bleaching of 10-kappa pulp could be bleached to 79.6 ISO brightness level and a partial substitution of C with D in C/DEH sequence has brightness level of 82.2% ISO. Kappa reduced to 6.8 after oxygen treatment and pulp after CEH bleaching has 86% ISO brightness. OC/DEH

Table-4 Bleaching of bamboo pulp with low kappa no.

Parameters	Unit	Pulping with 16% Alkali (as Na_2O, 20.6% as NaOH) with sulphidity ~ 20%					
Unbleached pulp							
Kappa No.		16.1					
Brightness	%ISO	23.5					
Viscosity	cm^3/g	1057					
Treatment of pulp		Control		Oxygen delignified			
NaOH applied %		NA		2.0			
Kappa No.		16.1		6.8			
Brightness		23.5		39.1			
Viscosity	cm^3/g	1057		865			
C-Stage (.25 factor)							
Bleaching sequence		CEH	C/DEH	OCEH	OC/DEH	OC/DED	ODED
C-Stage(.25 factor)							
Chlorine added	%	4.3	3.44	1.7	1.36	1.36	--
ClO_2 app% as avl Cl_2	%	--	0.86	--	0.34	0.34	1.7
E-stage							
Alkali applied, & as NaOH	%	2	2	2	2	2	2
H-Stage							
Hypo applied	%	2	2	2	2	--	--
D-Stage							
ClO_2 applied, % as Cl_2	%	--	--	--	--	2	2
Brightness	%ISO	79.6	82.2	86.0	86.2	86.3	83.7
Post Color Number		5.5	4.1	2.6	3.1	1.3	1.2
Intrinsic Viscosity	cm^3/g	464	552	480	576	683	695
AOX generated	Kg/t	5.3	4.61	3.7	2.42	1.82	0.74

sequence resulted to brightness 86.2% ISO and OC/DED to 86.3% ISO and ECF sequence of ODED has a brightness level of 83.7% ISO.

Bleaching of bamboo high kappa oxygen untreated and treated pulp

The high kappa(23.2) CEH bleached pulp could be bleached to 76.2% brightness level. Even partial substitutions of chlorine with chlorine dioxide also have not much affected on bright level i.e. 80.2% ISO. While after O_2 treatment. The kappa reduced to 11.2 and OCEH bleaching could bleach pulp to 86.7% ISO brightness level and OC/DED sequence resulted in 86.3% ISO brightness level and OC/DED sequence has resulted in 88.6% ISO brightness, ECF sequence applied after O_2 treatment ODED resulted in 83.7% ISO brightness.

Table-5 Bleaching of bamboo pulp with high kappa

Parameters	Unit	Pulping with 14% Alkali (as Na_2O, 18% as NaOH) with sulphidity ~ 20%					
Unbleached pulp							
Kappa No.		23.2					
Brightness	%ISO	18.5					
Viscosity	cm^3/g	1161					
Treatment of pulp		Control		Oxygen delignified			
NaOH applied %		NA		2.0			
Kappa No.		18.5		11.2			
Brightness		18.5		34.5			
Viscosity	cm^3/g	1161		846			
C-Stage (.25 factor)							
Bleaching sequence		CEH	C/DEH	OCEH	OC/DEH	OC/DEH	ODED
C-Stage(.25 factor)							
Chlorine added	%	6.2	4.96	2.8	2.24	2.24	--
ClO_2 app% as avl Cl_2	%	--	1.24	--	0.56	0.56	2.8
E-stage							
Alkali applied, & as NaOH	%	2	2	2	2	2	2
H-Stage							
Hypo applied	%	2	2	2	2	--	--
D-Stage							
ClO_2 applied, % as Cl_2	%	--	--	--	--	2	2
Brightness	%ISO	76.2	80.2	86.7	86.3	88.6	83.7
Post Color Number		5.4	4.0	2.3	2.53	1.0	0.89
Intrinsic Viscosity	cm^3/g	608	670	526	590	677	740
AOX generated	Kg/t	7.2	6.2	3.8	3.4	2.8	1.0

CONCLUSION

Bleaching of bamboo with conventional CEH sequence is difficult to bleach above 80% ISO Oxygen treatment of bamboo pulp reduced unbleached pulp kappa substantially thereby the bleach chemical demand.Partial substitution of chlorine with chlorine dioxide and its use in replacement of hypo in final stage results in substantial gain in brightness>85% ISO.Effluent load also reduced with reduction in chlorine and hypo during bleaching.

REFERENCES

1. Tendulkar S.K. and shinde T.K. IPPTA J. 13, p.51 (2001).
2. Ahmed W. and C.T. Dathathreya, IPPTA, J. Con. Issue, 109 (1991).
3. Suss H.U., Kurt S., M.D. Grosso and M. Mahagaonkar, A PPITA J. 53, 116.(2000).
4. Shibahare P.K. and Patel M., IPPTA J. 19, (2002).
5. Suss. H.U. and Fillho C.L.ABTCP conf., Sao Paulo, Brazil, May 1998.
6. Report on energy audit, conducted by CPPRI for Hindustan Paper Corporation Cachar and Nagaon units.