Comparison of ECF Bleaching Sequences of Bagasse Pulp

A.K.Ray, Vivek Kumar, Dharm Dutt, K.C.Mittal and J.S. Upadhyaya
Department of Paper Technology, Indian Institute of Technology, Roorkee, Saharanpur campus, Saharanpur-247001

Experiments were conducted on bleaching of bagasse pulp using two prospective sequences namely, DED and DEpD. Studies were also made with CEH bleaching sequence for merely comparison purpose. Partially depithed bagasse obtained from a mill were subjected to combination depithing and then separately soda and soda- oxygen pulping were carried out in the laboratory 15 liter Weverk rotating digester. The conditions for soda-oxygen pulp were selected based on earlier findings. The resulting soda pulps were treated with the traditional bleaching sequence to be used as a base. The soda- oxygen pulps were treated with the short sequence ECF bleaching sequences DED and DEpD- the most economically viable sequences in ECF bleaching process. On the basis of pulp quality in terms of kappa number, the chemical doses were fixed in all the cases. EDTA was added to stabilize peroxide in peroxide reinforced extraction stage of DEpD sequence. Total twenty-six experiments were conducted including two tests with CEH sequences and the rest twelve each on DED and DEpD. The quality of bleached pulp in terms of brightness, yield and tensile index from all the sequences were compared. Finally COD values of the combined effluent were measured to assess the amount of pollutants generated.

INTRODUCTION

Soda, soda - oxygen and soda - oxygen - anthraquinone pulping of bagasse and other non-wood fibres followed by conventional bleaching process has been studied extensively by many authors (1-9).

Recent trends in bleaching is to shift to Elemental Chlorine Free (ECF) bleaching, i.e replacing elemental chorine with chlorine di-oxide.Chlorine dioxide is an unusual chemical compound, since ClO_2 has 19 valence electrons. Thus, it has unpaired electron and is really a free radical. This probably accounts for its relative instability. It may explode at lower concentrations with less violence if heated, exposed to light or subjected to electric spark. It is stable in liquid form at its melting point (-61°C), in aqueous solution. It is highly toxic to almost all forms of life.

The sensitivity of this free radical probably also accounts for its high reactivity as an oxidizing agent used for pulp bleaching. It is specific in reacting with pulp constituent component getting oxidized. This results in preserving strength while giving high brightness & less reversion and discharging relatively lesser toxic effluent in comparison to conventional CEH bleaching sequence.

Large volume of experimental data of bleaching of bagasse pulp with single stage bleaching and with CEH sequence are available (8). However bleaching based on Chlorine- di-Oxide in single and with multi-stage is very scanty in literature(10).

An attempt is being made in this investigation to compare the bleached pulp characteristics in terms of strength and brightness values with respective COD load generation.

EXPERIMENTAL

Raw Material Characteristics

The composition of mill-depithed bagasse, used for the experiments, is given below:

Composition of mill-depithed bagasse

(i) Fibre 40 - 45%
(ii) Pith 8-10%
(iii) Moisture - 45- 50%

Proximate analysis of bagasse (on OD basis)

(i)	Alcohol benzene solubility	- 1.9 %
(ii)	Holocellulose	- 67.8 %
(iii)	Lignin	- 17.4 %
(iv)	1% NaOH solubility	- 25.4 %
(v)	Pentosan	- 19.6 %

Pulping of bagasse

The bagasse was pulped, by two processes namely, soda pulping and soda oxygen pulping process. The pulping was done in the laboratory WEVERK digester of 20-liter capacity. In case of soda oxygen pulping, oxygen was fed when cooking temperature had reached. The pulp obtained was refined and then screened after washing. The condition of cooking is given in the following table.

Bleaching Operation

The bleaching experiments were carried out in the laboratory-using batch vessels immersed in a constant temperature bath. The sequences employed are C E H, D E D and DE_pD. C E H sequence was used for soda pulp only as usually done in mill. D E D and DEpD sequences were used for soda oxygen pulp. The liquors were collected for tests. The steps are as follows:

Chlorination

Bleach liquor was used to generate chlorine gas inside the container in which pulp was added. The gas was generated due to lowering of pH. pH was kept around 1.5. After certain retention time this pulp was washed.

Extraction

Chlorinated lignin derivatives are to be extracted out of the pulp by addition of alkali. The alkali charge was 2.5%. After giving a certain amount of retention time the pulp was washed.

Hypo chlorination

The extracted pulp is mixed with bleach liquor and pH was maintained above 9.

Treatment with Chlorine dioxide

Sodium chlorite was used for this bleaching stage. This solution was added to pulp and pH at the end was maintained less than 6. This stage was used to replace both chlorination and hypochlorite stages in case of Soda-oxygen pulp. During the experiments percentage of active chlorine was varied in both the stages of chlorine dioxide treatment. In both the sequences i.e., DED and DEpD three different doses of active chlorine varying from 3.5 % to 4.5 % were taken. In the second stage, in case of DED sequence two chlorine doses, 2.5% & 3.5 % were used and in the case of DEpD sequence two chlorine doses, 1.5% & 2.5 % were used. Thus, six different bleaching experiments for each bleaching sequence were carried out. All the condition except chlorine dose for the above mentioned experiments were kept constant.

Extraction and reinforcement with peroxide

In DED sequence the alkali extraction was carried out in the same way as that of C E H. In DEpD sequence the extraction stage was little different. In this case 0.3% of peroxide (H_2O_2) was also added along with the alkali. EDTA was also added to stabilize the peroxide to avoid decomposition by metal ions.

Estimation of COD

The chemical oxygen demand of the combined effluent was estimated using COD reactor available in Central Pulp and Paper Research Institute (CPPRI). The method used was titration method. Three sets of readings were noted for each sample and average reading was taken. 2 ml of effluent was used in each test. Finally the COD load was calculated per unit per unit weight of bleached pulp.

RESULTS AND DISCUSSION

The main aim of this investigation was to find out a bleaching sequence, which would reduce the pollution load on the environment. The results of bleaching with CEH sequence are shown in Table-1. The same for other sequences, namely, DED, and DEpD are shown in table-2.

Table 1 : Cooking conditions for soda pulping

Particular	Conditions	
	Soda Pulping	Soda Oxygen
Cooking Chemical charge as NaOH%	15	14
Bath ratio	1:5	1:5
Maximum cooking temperature, °C	170	140
Time at temperature, min,	90	50
Time to temperature, min.	45	60
Mixed unbleached pulp Kappa No.	22.25	26.8
Screened pulp yield, %	46.15	50.1
Unbleaching pulp brightness, % ISO	30.2	31.4
Oxygen Pressure, kg/cm^2		5

Table 2: Experimental Conditions and results with CEH sequence

Particular	C	E	H
Chemical charge % (Active Chlorine)	3.5	2.5	3
Consistency %	3.5	8	8
pH	1.5-1.8	11	>9
Temperature °C	Ambient	60°	35°
Reaction time, hrs	1	1	2.5
Brightness % ISO		78.6	
Yield %		87.4%	
Tensile index $kN/m/g/m^2$		0.0135	
COD kg/t of bleached pulp		47.4	

Note: Lower charge of chemicals as usually employed in industry is used in case of CEH sequence in order to get higher strength properties for comparison purposes.

Table 3: Experimental Conditions for DEpD sequence

Particular	A	B	C	D	E	F
Chlorine dioxide:						
Chemical charge %. (Active Chlorine)	3.5	4	4.5	3.5	4	4.5
Consistency %	8	8	8	8	8	8
Temperature °C	60	60	60	60	60	60
pH	4.5	4.5	4.5	4.5	4.5	4.5
Time, hrs	2	2	2	2	2	2
Extraction with 0.3 % peroxide						
Alkali charge %	2.5	2.5	2.5	2.5	2.5	2.5
Consistency %	8	8	8	8	8	8
Temperature °C	60	60	60	60	60	60
Reaction time, hrs	1	1	1	1	1	1
PH	11	11	11	11	11	11
Chlorine dioxide:						
Chemical charge	1.5	1.5	1.5	2.5	2.5	2.5
Consistency	8	8	8	8	8	8
Temperature	60	60	60	60	60	60
pH 4.5	4.5	4.5	4.5	4.5	4.5	
Reaction time, hrs	3	3	3	3	3	3
Brightness % ISO	76.3	79.2	80.1	78.2	80.5	82.1
Yield %	98.4	97.6	95.8	96.9	96.1	94.3
Tensile Index (kN/m/g/m2) x 10^{-3}	16.4	16.1	15.0	15.6	14.8	13.9
COD kg/t of bleached pulp	25.24	31.10	33.13	28.48	33.02	37.317

Table 4: Experimental Conditions for DED sequence

Particulars	A	B	C	D	E	F
Chlorine dioxide :						
Chemical charge %. (Active Chlorine)	3.5	4.0	4.5	3.5	4.0	4.5
Consistency %	8	8	8	8	8	8
Temperature °C	60	60	60	60	60	60
pH	4.5	4.5	4.5	4.5	4.5	4.5
Reaction time, hrs	2	2	2	2	2	2
Extraction :						
Chemical charge %	2.5	2.5	2.5	2.5	2.5	2.5
Consistency %	8	8	8	8	8	8
Temperature °C	60	60	60	60	60	60
Reaction time, hrs	1	1	1	1	1	1
pH	11	11	11	11	11	11
Chlorine dioxide:						
Charge % (AC)	2.5	2.5	2.5	3	3	3
Consistency	8	8	8	8	8	8
Temperature °C	60	60	60	60	60	60
pH	4.5	4.5	4.5	4.5	4.5	4.5
Reaction time, hrs	3	3	3	3	3	3
Brightness % ISO	72	76.3	76.7	78.3	82.1	83.2
Yield %	97.2	96.8	95.4	96.9	94.8	93.8
Tensile Index ($kN/m/g/m^2$) x 10^{-3}	16.3	15.8	14.5	15.4	15.0	14.0
COD g/kg of bleached pulp	25.55	31.36	34.71	28.48	32.02	37.51

The results for the DED, and DEpD bleaching sequences were plotted from figure 1 to figure 8. Bar charts are drawn from figure 9 to figure 12 for comparing all the three sequences. COD load of the combined effluent per kg of unbleached as well bleached pulp was considered one of the main parameter for selection of the sequence.

Fig. 1 and Fig. 2 shows the effect of active chlorine dose (from chlorine di-oxide) on brightness of pulp from DED and DEpD sequence. It was observed that DEpD sequence gives better brightness level with less chlorine consumption. For the same charge DEpD sequence gave higher brightness than DED may be due to presence of ferric ions in water. The Result also shows that brightness level increases with increase of percentage active chlorine in both first and second stage. But in case of DED sequence, rate of increase in brightness is higher in the beginning then becomes almost constant but in case of DEpD sequence a steady rate in increase of brightness is observed. Highest % of brightness was observed in case of DEpD sequence with 2.5 % active chlorine in first stage and 4.5 % the active chlorine in second stage. Fig 9 shows that CEH sequence even with higher consumption of chemical could produce less brightness in comparison to the chlorine dioxide bleaching.

Fig. 3 and Fig. 4 show the effect active chlorine (from chlorine di-oxide) dose on yield of pulp from DED and DEpD sequence. It was observed that DEpD sequence gives higher yield in comparison to DED sequence. Result shows that yield decreases with increase of percentage active chlorine in both the first and second stage for both DED & DEpD sequence. Fig 10 show that yield is much less in CEH sequence in comparison to the chlorine dioxide bleaching.

Fig. 5 and Figure 6 show the effect of active chlorine (from chlorine di-oxide) dose on COD load of effluent from DED and DEpD sequence. It was observed that COD load per tonne of bleached pulp increases with use of active chlorine dose, which is incoherent with other results like decreasing yield and increasing brightness. Although the COD load from DED and DEpD sequences are almost same but if the results are seen interms of brightness level achieved, DEpD shows better results. From fig 11 It was also observed that COD load

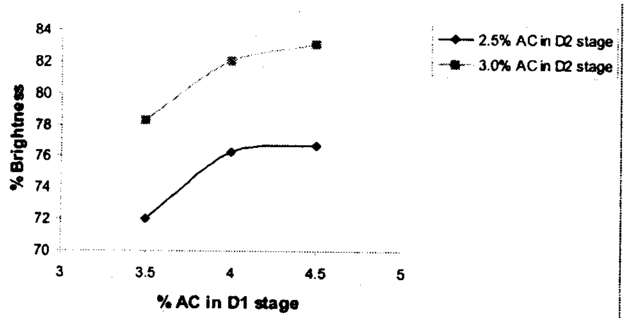

Fig. 1 : Effect of % Active Chlorine in D1 stage in DED bleaching sequence on brightness

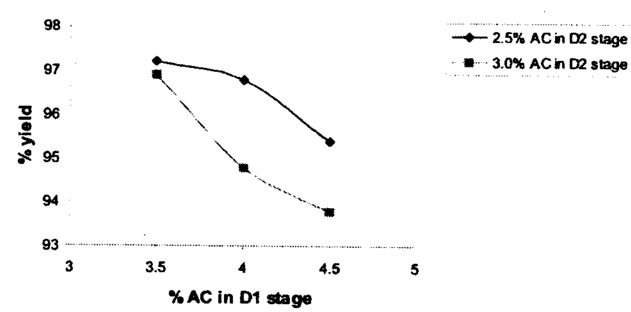

Fig. 3 : Effect of % Active Chlorine in D1 Stage in DED bleaching sequence on yield

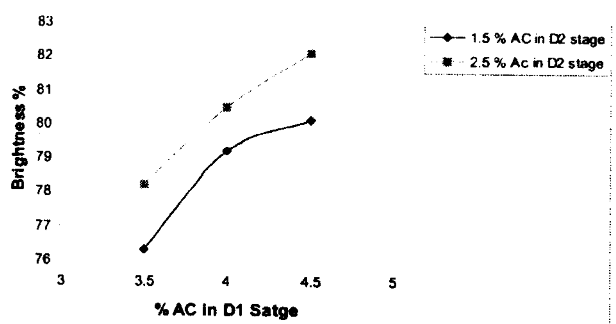

Fig. 2 : Effect of % Active Chlorine in D1 Stage in DEpD bleaching sequence on brightness

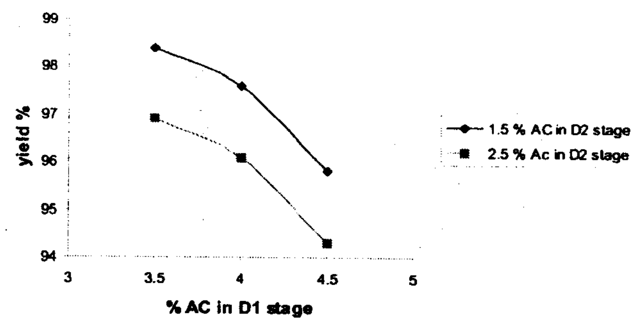

Fig. 4 : Effect of % Active Chlorine in D1 Stage in DEpD bleaching sequence on yield

per kg of bleached pulp in case of DEpD sequence is reduced by approximately 45% in comparison to the COD load per tonne of bleached pulp in case of CEH sequence attaining the same level of brightness.

Figure 7, Figure 8 shows the effect active chlorine (from chlorine di-oxide) dose on tensile index of pulp from DED and DEpD sequence and figure 12 compares the tensile index of pulp from DED, DEpD and CEH. The results were on expected line as tensile index reduces the high dose of active chlorine. Also it was found that pulp from DED and DEpD sequence have better tensile index in comparison of the pulp from CEH sequence.

CONCLUSION

The DED and DEpD sequence were compared with CEH sequence for nearly same brightness and lower COD value. Yield is not important because both DED and DEpD gave higher yield. The strengths of DED and DEpD bleached pulps were also found better than CEH bleached pulp. Bleaching by chlorine dioxide gives lower pollution load. There is a drastic decrease in COD value of the effluent from DED and DEPD stages compared to CEH sequence. The shrinkage due to bleaching also decreased by bleaching with chlorine dioxide.

REFERENCES

1. Fiala,W.,Danielson,O., and Ryrberg, K.G., Nardi,F., and Nardi, S.- TAPPI Non-wood Plant Fibre Progress Report: No. 14,77(1983)

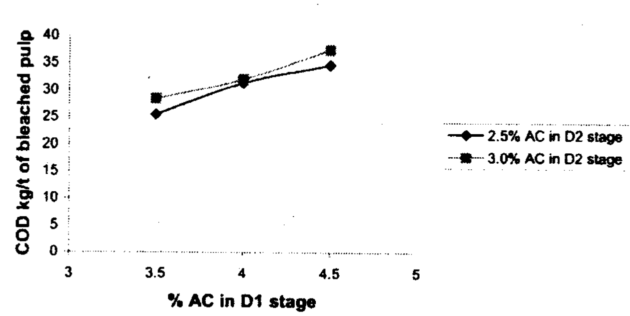

Fig. 5 : Effect of % Active Chlorine in D1 Stage in DED bleaching sequence on COD load

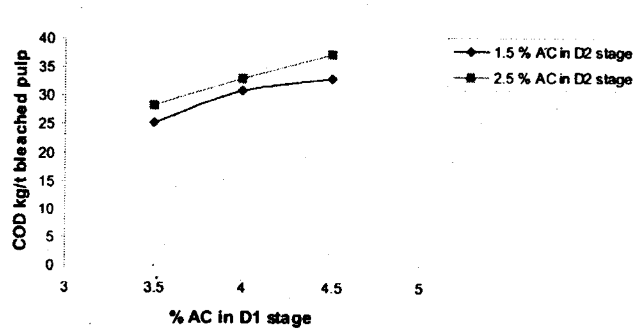

Fig. 6 : Effect of % Active Chlorine in D1 Stage in DEpD bleaching sequence on COD load

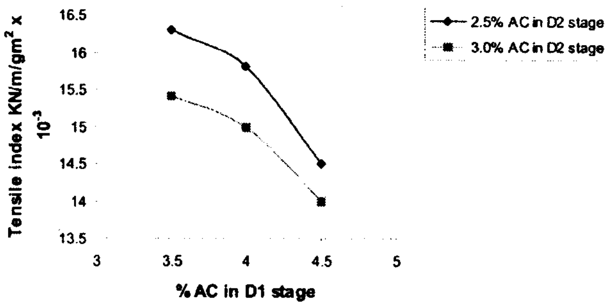

Fig. 7 : Effect of % Active Chlorine in D1 stage in DED bleaching sequence on Tensile index

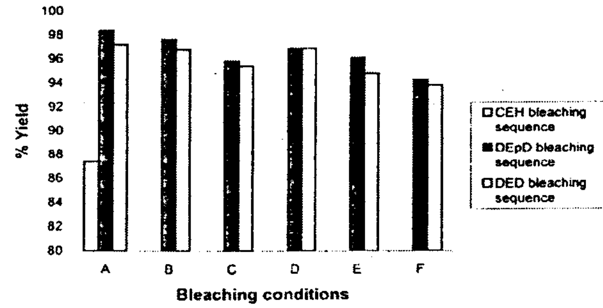

Fig. 10 : Comparision of % yeild from different bleaching sequence and different conditions

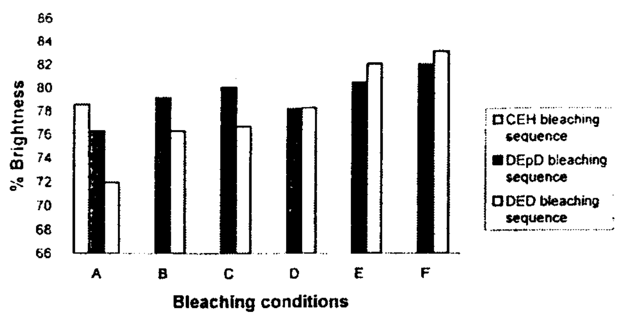

Fig. 9 : Comparision of % brightness from different bleaching sequence and different conditions

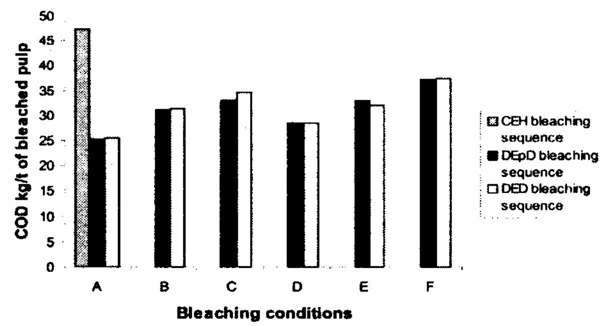

Fig. 11 : Comparision of COD from different bleaching sequence and different conditions

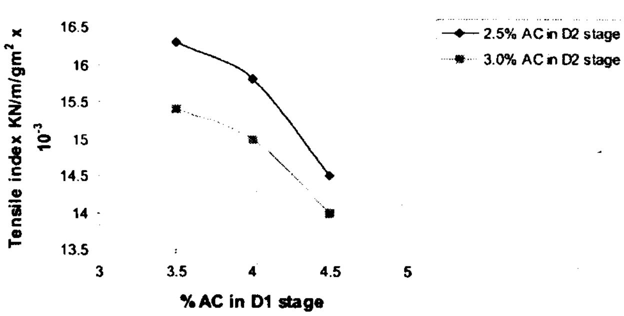

Fig. 7 : Effect of % Active Chlorine in D1 stage in DED bleaching sequence on Tensile Index

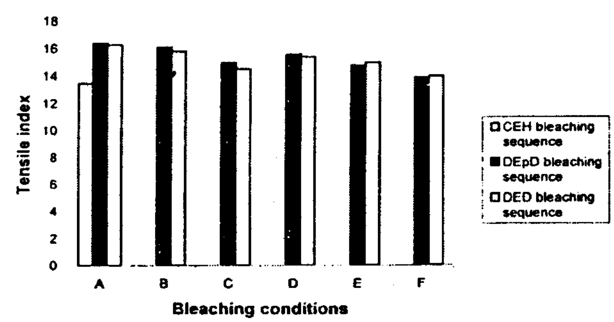

Fig. 12 : Comparision of Tensile index from different bleaching sequence and different conditions

2. El-Ashmawy, A.E., Fadl,M.H.Saleh,T.M., and El-Meadawy,S.A.- TAPPI J. 60(6),109(1977)

3. Singh, R.,Kumar, K. Kumar,V.,Dutt,D.- IPPTA, J. 4(4):1(1992)

4. Mohta, D.C., Upadhyaya, J.S.,Kapoor, S.K.,Ray, A.K., and Roy, D.N. TAPPI J. 81(6), 184(1998)

5. Ravi Mohan, Prasad, R., Yadav, R.,Ray, A.K. and Rao, N.J.-Proc. Inter. Non-Wood Fibre Pulping and Papermaking Conf. Beijing , The Peoples' Republic of China, July 11-14, 339 (1988)

6. Udaychandran, R. , Rao, N.R.K.,Ray A.K., and Rao, N.J.- ibid,393

7. A.K.Ray ,N.J.Rao, B.B.Dash, C.S.Babu and P. Sridhar- 55th Ann. Conv., The Sugar Technologists's Asso. of India, G-61-G-67 (1993)

8. Sriram,S., V.Kannan, A.K.ray and B. Mohanty- Joint Conv. of STAI and DSTA, G 615-G 626 (1992)

9. A.K.Ray, N.J.Rao, M.C.Bansal and B.Mohanty, Proc. of TAPPI Pulping Conference held at Orlando,USA,pp 441-453 1991.

10. Mohta, D.C., Upadhyaya, J.S., ,Kapoor, S.K., Roy, D.N. and, Ray, A.K.:TAPPI Pulping Conference,1,(1998)

ACKNOWLEDGEMENT

The experimental works carried out in the laboratory of Department of Paper Technology by B.Sriram and Mudit Chandra are gratefully acknowledged.