Delignification of bagasse pulps using oxygen and alkali

TRIVEDI, M. K. AND MURTHY, T. S.

SUMMARY

Delignification of pulps involves treatment with costly chemicals and the effluents from the process streams may cause pollution of water streams. Newer processes are being designed to solve these problems. Oxygen alkali treatment of pulps is an approach of this kind. The data presented here shows the feasibility of using this process on bagasse pulps which results in higher yields, effective utilisation of chemicals and effluents with reduced pollution load. Some studies on the bleaching of such Pulps have also been included.

The global raw material shortage, growing demand for pulp products, increasing concern with environmental pollution and effective use of costly chemicals are the major factors to have a fresh look at the conventional pulping processes which leave a large portion of the lignin in pulps to be removed by chlorine based chemicals. The effluents of these stages may cause pollution of water streams if not treated. Many investigators have reported that if oxygen and alkali are used to delignify wood, better pulps with a scope to reduce the pollution load are obtained[1-6]. However, the factors such as the difficulty in penetration of oxygen into wood chips, reduced strength properties of pulps and low calorific value of spent liquors had prevented its wide spread use[4].

Knowledge of the fact that the degradation of cellulose is diminished in presence of small amounts of alkali earth carbonates, phosphates, silicates and oxides, brought a big support to this process. Magnesium carbonate 1-5% based on pulp offers maximum protection to cellulose but if Magnesium-complexes are used, it is claimed that very low addition (0.03-0.05%) as Magnesium ions based on pulp can give sufficient protection to cellulose[2]. With pine and other wood enough work has been done to make it a commercially feasible process. Work on Indian hard woods and bamboo has also been reported and need for extensive work has been felt before adopting this process to indigeneous raw materials[7,8]. Single stage alkali oxygen pulping of bagasse has been reported in which yields were high but the strength properties of pulps were poorer than soda pulps[9]. The work presented here is on a process in which the alkali cooked bagasse pulp can be further delignified in presence of oxygen and alkali to get pulps in high yield and low kappa number, and thus facilitate further bleaching steps.

EXPERIMENTAL

BAGASSE PULP—Bagasse ground and sieved (−12+44 mesh) was pre-soaked in water and boiled with 1% aqueous sodium hydroxide for 1 hour to obtain pulps according to method established in this laboratory[10,11]. The analysis of bagasse and pulp is given in Table 4 (Column 1, 2).

OXYGEN TREATMENT OF PULPS

About 20 g of pulp exactly weighed was taken in a stainless steel autoclave of 1 litre capacity to which predetermined quantities of alkali water and Magnesium carbonate were added. The reactor was equipped to measure inside temperature and pressure. Oxygen was introduced to a certain gauge pressure when the temperature was 10°C below the reaction temperature. The time to reach the reaction temperature was 20 min. In all the runs, Oxygen pressure was released after the specified time and the contents were quantitatively transferred to a beaker, the pulp was washed and analysed.

*Chemical Engg. Dept., Indian Institute of Technology, Bombay 400 076.

The variables studied were oxygen pressure, time, temperature, alkali charge and liquor to solid ratio. The analyses were done according to Tappi standards. All reported results are average of three consistent observations.

The bleaching of pulps was done under the conditions described in Table 3. Brightness was measured on universal photometer Model ⌀ M-56.

DISCUSSIONS

Sugarcane bagasse belongs to grass family and has an open and less developed structure as compared to woods. It is expected that problems such as penetration of oxygen into chips and nonuniformity arising due to that will be minimum with bagasse and milder conditions for treatment than for woods used.

The results in Table 1 indicate that an oxygen gauge pressure of 2 kg/cm^2 is sufficient to bring down the kappa number (K number) by 3 units using 5% alkali and a temperature of 90°C for 30 minutes. Application of higher pressures do reduce the K number by as much as 6 units but the pulp yield also decreases. Though the high oxygen pressure is known to increase the rate of delignification, the use of high pressures may severely degrade the pulp. Increasing the temperature of treatment from 80 to 120°C results in a quick loss of yield and K number. A temperature of 100°C seems to have advantage of minimum loss in yield coupled with a 5 point decrease in K number.

The next set of experiments done at 100°C for varying time from 20 to 90 min. show that increasing the time of treatment reduces both the pulp yield and K number, though the effect is less severe than that observed with the increasing temperature. Increasing the time by 10 minutes enhances the pulp loss by about 1% and a corresponding fall in K number. A time period of 50 min. was found most suitable under these conditions. The fall in K number here suggests that it is mainly lignin which is degraded by increasing the severity of the treatment.

The amount of alkali and its concentration during the oxygen treatment both have significant effect as seen from the results in Table 2. The increasing amount of alkali causes increased loss in yield without a proportionate decrease in K number. It may be so due to the carbohydrate degradation. A charge of 5% alkali on pulp appears to give the maximum fall in K number. But if the concentration of alkali is more during the treatment, it almost exclusively affects the extent of delignification because the fall in yield corresponds with the fall in K number of the pulp. This fact has also been noticed in studies on woods where a high consistency during the oxygen treatment results in decreased requirement of alkali to obtain a selected K number[2]. However, a very high concentration of alkali may adversely affect the pulp quality.

When results of varying liquor to solid ratio were examined, it was found that the fall in K number was not adversely affected by decreasing this parameter. The soluability of these pulps in 7.14% sodium hydroxide was estimated. It has been claimed to give the best indication of the undegraded cellulose[12]. The results indicate that a liquor to solid ratio of 5:1 gives pulp with low K number and high yields of pulp with minimum effect on the cellulose.

The optimum conditions so established were successfully tried on 150 g batches. Pulp from these were bleached under conditions shown in Table 3. It was found that considerably lesser quantities of chlorine is required to bleach an oxygen treated pulp as compared to an untreated pulp to a desired brightness values[10].

The analysis of the final pulp (Table 4, column 4) indicates that pulp in about 52%, yield is obtained with a high alpha cellulose content, low ash and lignin. A slight increase in the alpha cellulose content of the pulp after the oxygen treatment may be due to the dissolution of some trapped hemicelluloses during the treatment. The loss in yield after the oxygen treatment is about 11% whereas the K number is reduced by 50 percent The brightness of the pulp shows a sharp rise only after bleaching.

It is known that the use of an alkali oxygen stage reduces the pollution load of the effluents, as the effluents from this stage can be processed to recover heat and chemicals in a recovery system. This leaves very little lignin to be removed in subsequent bleaching stages thus reducing water pollution due to discharge from them. The treatment also results in overall economy of chemicals and improvement in the quality of the pulp. However, a detailed study of the process and spent liquors is necessary to adopt the process on indigenous raw materials like bagasse.

CONCLUSIONS

Bagasse pulps can be delignified by an oxygen-alkali treatment under the following conditions :—

Oxygen pressure	—2 kg/cm^2
% Alkali on pulp	—5
Temperature °C	—100
Time-minutes	—50
Liquor : solid ratio	—5 : 1
Inhibitor $MgCO_3$ on pulp	– 1%

TABLE—1 OXYGEN TREATMENT OF BAGASSE PULP UNDER VARYING CONDITIONS

% Alkali on pulp —5
Liquor to solid ratio —8:1
$MgCO_3$ added, % on pulp —1

Oxygen gauge pressure kg/cm²	Temperature °C	Time min.	Yield % on pulp	Kappa number
Nil	90	30	87.7	24.2
1.0	90	30	86.8	22.8
2.0	90	30	85.2	21.2
2.5	90	30	83.8	20.8
3.0	90	30	81.5	18.8
4.0	90	30	81.4	18.0
2.0	80	30	86.1	22.6
2.0	100	30	84.3	16.6
2.0	110	30	71.4	17.0
2.0	120	30	69.3	16.0
2.0	100	20	87.6	22.4
2.0	100	40	84.0	16.5
2.0	100	50	83.8	15.0
2.0	100	60	82.8	15.2
2.0	100	70	81.0	14.9
2.0	100	90	79.5	14.8

TABLE—2 EFFECT OF ALKALI CHARGE AND LIQUOR TO SOLID RATIO ON OXYGEN TREATMENT

Oxygen pressure – kg/cm² —2
Time min. —50
Temperature —100 °C
$MgCO_3$ % on pulp —1

Alkali charged % on pulp	Liquor to solid ratio	Yield % on pulp	Kappa number	7.14 % NaOH in solubles
1	8	95.0	18.0	—
2	8	93.8	17.1	—
3	8	90.2	16.1	—
4	8	88.0	15.8	—
5	8	83.8	15.0	—
6	8	83.0	15.2	—
5	7	82.5	14.8	81.0
5	6	82.4	14.4	80.4
5	5	82.0	13.6	82.5
5	4	80.0	13.6	80.0
5	3	79.1	13.0	79.5

TABLE—3 BLEACHING OF PULPS

Weight of pulp—20 g

	Chlorination	Alkali extraction	Hypochloride
% Chlorine on pulp	3.0	—	1.0
% alkali on pulp	3	5	5
Time-min	30	60	120
Temperature °C	30	80	40
pH	3.0	—	11.0
Residual chlorine gpl	.01	—	.01

TABLE—4 ANALYSIS OF BAGASSE AND PULPS

(% given on o.d. bagasse)

	Bagasse	Pulp	Oxygen treated pulp	Bleached pulp
Hot water solubles	3.8	—	—	—
Alcohol : benzene solubles	5.2	—	—	—
Ash	2.0	0.8	0.4	0.3
Lignin	21.0	4.8	2.2	1.6
Pentosans	22.0	16.1	9.1	9.0
'α' cellulose	41.0	38.6	38.9	38.9
'β'+'γ' cellulose	6.3	3.9	1.6	1.5
Yields	100	64.3	52.7	51.7
Kappa number	—	26.5	13.6	5.0
% Brightness	—	40.0	48.0	84.0

These pulps are easily bleached to a brightness value of 84%. The final pulps in about 52 percent yields are obtained with a high alpha cellulose, low ash and lignin contents.

ACKNOWLEDGEMENT

The authors are thankful to Director, I.I.T. Bombay for providing financial assistance and a scholarship to T. S. Murthy during the project.

REFERENCES

1. Nikitin, V.M. and Akim, G.L., Bumazh. Prom **35**, 5 (1960).
2. Croon, I and Andrews, D.H., *Tappi*, **54** (11), 1893 (1971).
3. Engstrom, H.E., Ivans, L. and Pettersson, B., ibid, 1899 (1971).
4. Cox, L. A. and Worster, H.E., ibid, 1890 (1971).
5. Kleppe, P. J., Eckert, R. C. and Hou. Min chang, Pulp, Paper Mag. Can. **73** (12), 102 (1972).
6. Worster, H.E. and Pudek, M. F., Pulp, Paper Mag. Can. **75** (1), 126 (1974).
7. Mokhari, S. G., Fernades, J. D. and Saraf, V. P., *Ippta* **15** (3) 90 (1978).
8. Sadawarte, N. S. and Prasad, A. K., *Ippta* **14** (1) 29 (1977).
9. El-Ashmawy, A.E. *et al. Tappi*, **60** (6) 109 (1977).
10. Kamath, N. R. and Sidhanty, A. R., Ind. Pulp, Paper **23** (4), 1 (1968).
11. Trivedi, M. K , *Ippta* **12** (4) 308 (1975).
12. Ritcher, G.A. *Tappi*, **38** (2) 29 (1955).