Effect of Process Variables in the Oxygen Bleaching of Poplar Deltoides

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Oxygen delignification is a proven approach in the pulp and paper industry to reduce the residual lignin that is the lignin resident in the pulp following the kraft pulping process[1-2] Conventional kraft pulping was performed at different active alkali charge (16% to 22% AA). The pulps at the optimum condition (20% AA, sulfidity 25%, and kappa number 24.8). was bleached with different variables like oxygen pressure (kept constant), alkali charge, temperature, and consistency. The effect of sodium hydroxide charge on the kappa number reduction comparatively smaller. An increased temperature accelerate considerably the oxygen delignification process. Brightness of oxygen treated pulp sheets inceased with decrease in kappa number. Partially bleached pulps made with oxygen at different conditions were treated with DEH bleaching sequence and other were fully bleached with CEH sequence. Both pulps were comparable in strength properties, whereas the brightness significantly increased in ODEH bleaching.

INTRODUCTION

Environmental concerns in the paper industry have led to a need to reduce the kappa number, about 50% in the oxygen stage, of the pulps entering the bleaching stage in order to reduce the BOD and AOX of the effluent discharge. In addition to minimizing additional recovery load and reducing environmental impact, other issues of concern with this approach to extended delignification are pulp quality (strength properties). Therefore, studies were taken for the following objectives:

1. To evaluate the effect of oxygen delignification of the pulps in the 5-12 kappa number range.
2. To estimate the kappa number reduction and subsequently the decrease in pulp yield in the oxygen stages.
3. To compare the strength properties and brightness of such pulps with conventional kraft pulps after final bleaching.

EXPERIMENTAL

Pulping Optimization

The purpose of the series of the experiments was to identify the conditions necessary to reach the kappa number which is best suited for the oxygen bleaching. Pulping of poplar kraft chips was carried out in laboratory digester at four different alkali charges, keeping sulfidity constant at 25%. Active alkali charges used were 16, 18,20,22 percent at the temperaturel 65°C and 3.5hrs of cooking time. Kappa number, yield percentage were measured in each case. The cooking was carried out in the laboratory digester. For each experiment 250gm (o.d.) wood chips were taken. The cooking temperature was ketp at 165°C. The time of the cooking was two hours excluding one and half hours required to reach the maximum temperature of the content from room temperature. The bath ratio was kept 1 :4 in all experiments. Then pulps were washed and screened on a laboratory lambert screen fitted with an appropriate screen plate.

Oxygen Delignigication

The objective of this part of the study was to optimize oxygen delignification and examine the effect of alkali charge and temperature change. Oxygen delignification of the poplar deltoides pulps was carried out in the laboratory series digester in which six bombs each of 2.5 litres capacity can be made simultaneously at 8 kg/ cm^3 (constant), 90°C, 100°C and 110°C, 15% consistency and 1% magnesium sulphate, for one hour at different alkali charge .

Bleaching

An elemental chlorine free sequence(DEH) and chlorine containing sequence(CEH) were used for bleaching. The test specimens were taken from brown stock poplar kraft pulp as well as from the partially and fully bleached pulps under the following different bleaching sequences:

1. Partially bleached pulp through oxygen/alkali and then bleached with DEH sequence.
2. Fully bleached pulp through CEH sequence. The bleaching conditions were as follows in the Table1.

RESULTS AND DISCUSSION

Pulping

Kraft Pulping were carried out at different alkali charge. kappa number and yield percentage decreased with the increased alkali charge. Pulp with kappa number 24.8 and yield 44.6% was selected for further study. Table-2 shows yield and pulping conditions.

Oxygen-Delignification

In this study, oxygen pressure had been kept constant at 8.0 kg/cm^3, the level already found optimum. It was seen that as we go through the temperature 90°C to 100°C, kappa number and the yield % were reduced simultaneously but at high temperature I 10°C the kappa number decreased sharply as compared to yield. It is due to the higher temperature and longer exposure of the pulp to oxygen[3]. Fig. (2-4) shows the percentage delignification at different alkali charges during an oxygen stage. As the kappa number decreased with alkali charge, yield percentage also decreased simultaneously. There was a gradual decrease in pulp yield with the decrease in kappa number as the alkali charge was increased from 1.5% to 2.5%. At 2.5% alkali charge, a rapid drop in kappa number was observed whereas the yield was not appreciably decreased so fast[4,5].

Bleaching

Pulps delignified with oxygen/alkali with 2.5% alkali charge at 110°C for 90 minute having kappa number 5.4 was subjected to DEH(D=chlorine dioxide, E=extraction and H= hypochlorite) bleaching. The kraft pulp at kappa number 24.8 was bleached through CEH sequence and then both the pulp were beaten with the same freeness 350 CSF in the PFI mill and compared the quality (strength properties) of both of the pulp. results are recorded in Table-6 and 7

In the partially bleached pulp through alkali - oxygen treatment it is observed that there is marginal improvement in the tensile index property with the change in alkali concentration.

The tensile index remaining almost unchanged when the temperature is raised from 90°C to 100°C, but when it is raised to 110°C, the index decreased appreciably. Brightness of oxygen treated pulp sheets increased with the decrease in kappa number.

Table 1 : Bleaching Conditions

Bleaching sequence	Stages	Consistency (%)	Temp (°C)	Time (Min)	Charges (%)
CEH	Cl_2	3%	20	60	7%
	E	5%	70	60	3%
	H	3%	30	60	5%
DEB	D	3%	20	60	1%-1.5%
	E	5%	70	60	2%
	H	3%	30	60	0.5%-1.5%

CONCLUSION

For the oxygen bleaching, brown stock pulp was selected on the basis of kappa number and pulp yield. Alkali charge was adjusted according to bleaching results desired. There seems to be a quite uniform relationship between NaOH charge and kappa number.

Table 2

Active Alkali %	Sulfidity %	Bath Ratio	Temp. °C	Time hrs	Total Yield %	Kappa Number
16	25	1:4	165	3.5	46.4	31.2
18	25	1:4	165	3.5	45.9	27.8
20	25	1:4	165	3.5	44.6	24.8
22	25	1:4	165	3.5	42.8	21.8

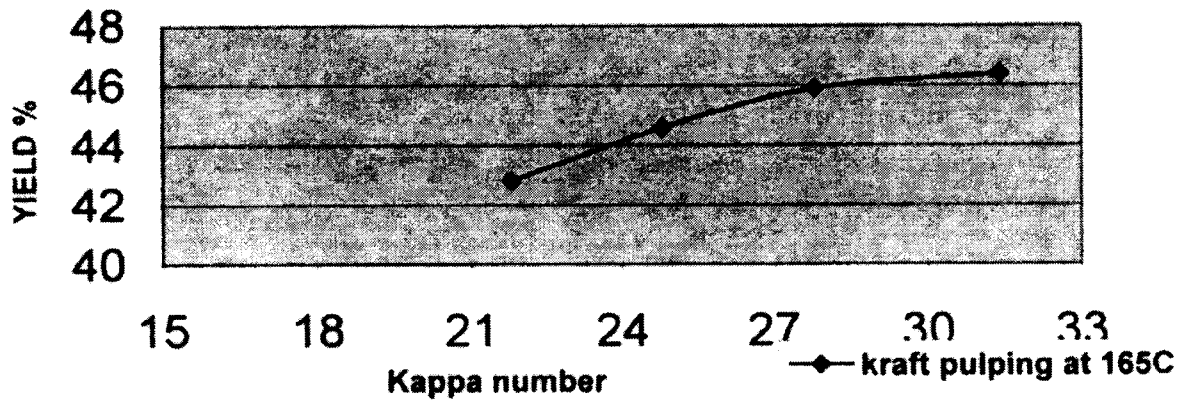

Fig. 1 : Kraft Pulping of Poplar Deltoides at Different Alkali Charge

Delignification of P. deltoides kraft oulo with oxygen at 90 °C:

Conditions of delignification:on o.d. pulp basis

Oxygen pressure : 8 kg/cm^3

Pulp consistency: 15%

Alkali concentration: 1.5%, 2.0%, 2.5% NaOH

Table 3

Alkali Conc. On O.D. pulp %	Time at 90°C	Pulp Yield %	Kappa Number	Lignin % on O.D. pulp.
1.5	30min.	44.2	12.25	1.80
1.5	60min.	42.8	11.30	1.66
1.5	90min.	42.5	11.10	1.63
2.0	30min.	44.0	11.90	1.75
2.0	60min.	42.4	10.81	1.59
2.0	90min.	42.1	10.21	1.50
2.5	30min.	43.9	11.40	1.68
2.5	60min.	41.1	10.00	1.47
2.5	90min.	41.0	9.80	1.44
Unbleached pulp		44.6	24.8	3.55

Delignification of P. deltoides kraft pulp with Oxygen at 100 °C

Conditions of delignification :

Alkali concentration : 1.5%, 2.0%, 2.5% NaOH

Oxygen pressure : 8 kg/cm^3 on o.d. pulp basis

Pulp consistency : 15%

Table 4

Alkali Conc. On O.D. pulp %	Time at 100°C	Pulp Yield %	Kappa Number	Lignin % on O.D. pulp.
1.5	30min.	44.0	10.00	1.47
1.5	60min.	42.5	9.30	1.37
1.5	90min.	42.4	9.20	1.35
2.0	30min.	43.9	10.05	1.48
2.0	60min.	41.9	9.20	1.35
2.0	90min.	41.2	9.05	1.33
2.5	30min.	43.7	10.00	1.47
2.5	60min.	41.7	9.10	1.38
2.5	90min.	41.1	8.90	1.30
Unbleached pulp		44.6	24.8	3.55

Delignification of p. deltoides kraft pulp with oxygen at 110 °C:

Conditions of delignification :

Alkali concentration : 1.5%, 2.0%, 2.5% NaOH

Oxygen pressure : 8 kg/cm^3 on o.d. pulp basis

Pulp consistency : 15%

Table 5

Alkali Conc. On O.D. pulp %	Time at 110°C	Pulp Yield %	Kappa Number	Lignin % on O.D. pulp.
1.5	30min.	43.80	10.05	1.48
1.5	60min.	40.65	8.80	1.30
1.5	90min.	40.60	7.20	1.07
2.0	30min.	43.75	10.00	1.47
2.0	60min.	40.60	8.20	1.21
2.0	90min.	40.55	6.00	1.08
2.5	30min.	43.7	8.40	1.25
2.5	60min.	40.55	6.80	1.01
2.5	90min.	40.50	5.40	0.82
Unbleached pulp .		44.6	24.8	3.55

Table 6 : Pulp Bleached Through ODEH Sequence

Bleaching Sequence	Tensile Index (Nm/g)	Tear Index (mNm^2/g)	Burst Index ($kpa.m^2/g$)	Brightness (ISO)
D-1.0% E-2.0% H-1.0%	69.92	1.88	5.70	79.00
D-1.5% E-2.0% H-1.0%	73.90	1.68	6.10	81.00
D-1.0% E-2.0% H-0.5%	81.92	3.82	7.88	74.00

Table 7 : Pulp Bleached Through CEH Sequence

Chlorination phase	Time	Tensile index Nm/g	Tear index mNm^2/g	Burst index $kpa.m^2/g$	Brightness ISO
Chlorine stage : Cl_2 -7% Temp. -20 °C Consistency-3%	60 min.	80.17	1.10	5.60	
Alkali stage : NaOH -3% Consistency 5% Temp -70°C	60 min.	81.12	1.12	5.62	
Hypochlorite stage : Available chlorine -5% consistency- 3% Temp- 30 °C at PH-10	60 min.	82.00	2.32	4.61	68.0

Results from bleaching of poplar deltoides show no serious degradation. The brightness of the oxygen-bleached pulp will accordingly be quite high. A very short bleaching sequence for fully bleached pulp, ODEH with comparably low consumption chemicals is thus attainable.

It can be seen that Poplar deltoides pulps were easily delignified during oxygen bleaching. An unbleached kappa number 24.8 and DEH bleaching sequence was normally sufficient for a Fully oxygen bleached poplar kraft pulp. The pulp was easily oxygen bleached below kappa number six, could be achieved without much loss in strength properties. Which was comparable to other hard wood (Eucalyptus and Birch)[6-7]. The strength properties of oxygen bleached and conventionally bleached pulps were equivalent if the degree of delignification in the oxygen stage does not exceed above 50%. However, by producing fully bleached pulp, the potential gain is decreased. It was established that effluent load was less for final bleaching in case of oxygen - bleached pulp due to less residual substances to be dissolved in the bleach plant during the final bleaching.

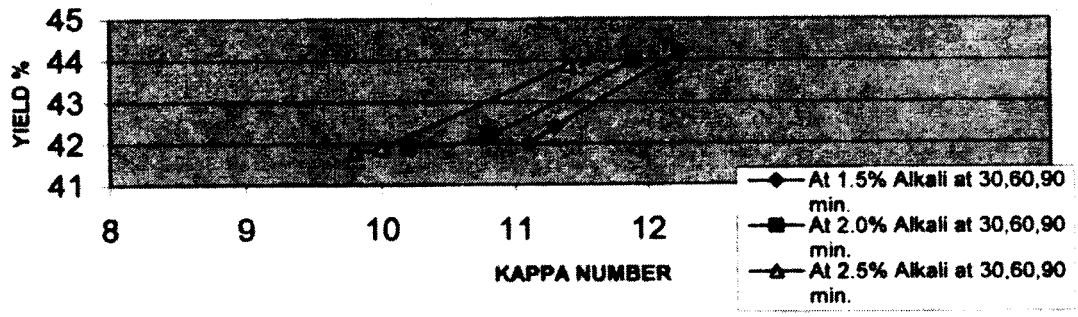

Fig. 2 : Oxygen delignification of P.deltoides kraft pulp at 90°C

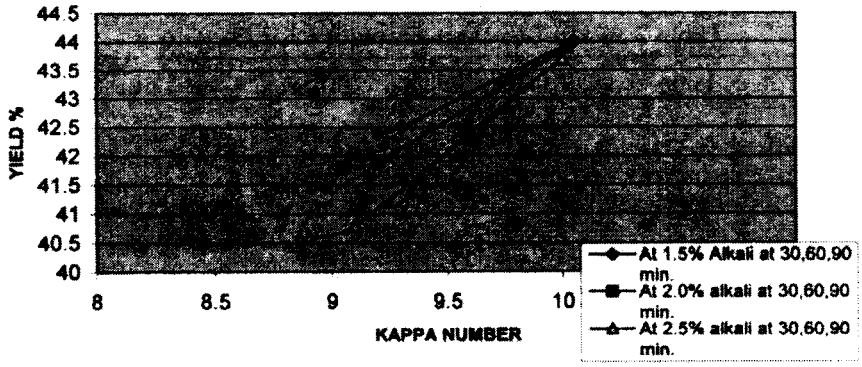

Fig. 3 : Oxygen delignification of P. deltoides kraft pulp at 100°C

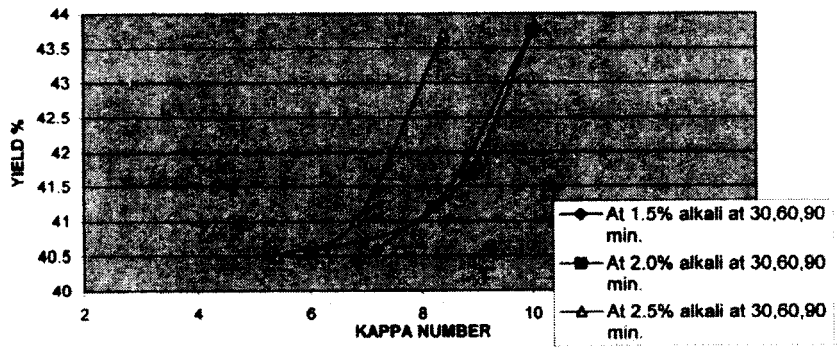

Fig. 4 : Oxygen delignification of P. deltoides kraft pulp at 110°C

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