Comparative Pulping Studies of Eucalyptus Hybrid by Kraft Soda and Soda-Anthraquinone Processes

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ABSTRACT: *Comparative pulping studies of Eucalyptus Hybrid by kraft, Soda and Soda-Anthtraquinone processes were carried out on a Laboratory scale for attaining nearly same kappa No. There was difference in cooking and bleaching chemicals in all the processes under identical cooking and bleaching conditions.*
Anthraquinone (0.1%) dosage in Soda-Anthraquinone pulping reduces cooking chemical and improves unbleached pulp yield as compared to kraft and Soda cook. Soda-Anthraquinone black liquor has higher organics percentage and calorific value than Soda and kraft black liquors. There was 1.3% and 3.1% gain in bleached pulp yield against Sulphate and Soda processes respectively. The physical strength properties of Soda-Anthraquinone bleached pulps were little inferior to Sulphate pulp but were superior to Soda bleached pulp. Soda-Anthraquinone process could be used as a substitute of Sulphate process in Eucalyptus Hybrid pulping.

INTRODUCTION

The use of anthraquinone (AQ) as an additive in Soda and kraft pulping [1-5] continues to offer considerable promise as means of improving yield and productivity and it appears likely these improvements can be translated into economic benefits. Anthraquinone enhances the rate of delignification stabilizes carbohydrates and results in increased pulp yield. It has been shown small amount (0.05-0.1%) of anthraquinone on wood is very effective in enhancing the rate of delignification and in achieving yield stabilisation. Anthraquinone and its derivates are potentially most beneficial in Soda pulping, where rate and selectivity of delignification can be increased equal to that of kraft pulping[6].

It has also been confirmed[7-9] anthraquinone addition during digestion increased pulp yield and reduced chemical consumption. Further it has been found Soda anthraquinone pulping offers definite advantage over Soda and kraft process having superior mobility and combustion characteristics of black liquor and lower chemical requirement in pulping and bleaching[10].

To ascertain the advantages of anthraquinone as pulping additive kraft, Soda and Soda-anthraquinone pulping processes were investigated on Laboratory scale with Eucalyptus Hybrid the promising raw material for the paper industry.

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LABORATORY PULPING STUDIES

Digestion

Eucalyptus chips passing through 22 m.m. screen and retained on 10 m.m. screen were digested with white liquor, Sodium hydroxide and Sodium hydroxide anthraquinone under similar pulping conditions as reported in Table-1. Physico chemical properties of pulp and black liquor were also studied and the results are given in Table-1.

Table-1.

Laboratory pulping trials of Eucalyptus Hybrid with kraft, Soda and Soda-anthraquinone processes

S.No.	Particulars	Kraft cook	Soda cook	Soda Anthraquinone cook
1.	Active alkali as Na_2O on O.D. chips.	18.0	19.9	17.05
2.	NaOH % on O.D. chips	23.2	25.7	22.0
3.	Anthraquinone added % on O.D. chips.	--	--	0.1
4.	Sulphidity %	16.5	--	--
5.	Bath ratio	1:3	1:3	1:3
6.	Cooking shedule Mts			
	(i) Upto 100°C	60	60	60
	(ii) 100°C to 135°C	60	60	60
	(iii) 135°C to 165°C	60	60	60
	(iv) At 165°C	60	60	60
7.	Total unbleached pulp yield%	46.14	44.6	48.0
8.	Screen rejects%	0.62	0.49	0.40
9.	Kappa No.	21.5	23.5	21.5
10.	Unbleached pulp Viscosity (0.5% CED) Cps	19.3	17.5	19.7
A.	Black liquor analysis.			
11.	°TW at 60C	20	21.5	19
12.	Residual active alkali as Na_2O GPL	17.05	18.0	16.5
13.	Inorganics O.D.%	35.9	36.6	34.2
14.	Organics O.D.%	64.1	63.4	65.8
15.	Calorific Value, Cal/gram (O.D. basis)	3242	2887	3360
16.	(a) Black liquor solid concentration %	21.4	23.5	20.8
	(b) Viscosity of Black liquor (Cps) Ostwald at 80°C	2.10	3.15	2.37
B.	Black liquor generated per ton of O.D. pulp (m^3/ton)	2.92	2.62	2.71

Fibre dimension

Fibre length and diameter of kraft, Soda and Soda-anthraquinone pulps are measured under a Projectina Projection microscope and the results are given in Table-2.

Table-2.

Fibre dimensions of eucalyptus hybrid, Soda and Soda-Anthraquinone pulps

S.No.	Fibre dimensions	kraft pulp	Soda pulp	Soda anthraquinone pulp
1.	Fibre length, m.m.			
	Minimum	0.7	0.7	0.7
	Maximum	1.8	1.9	2.0
	Average	1.14	1.09	1.15
2.	Fibre diameter m.m.			
	Minimum	0.01	0.01	0.01
	Maximum	0.025	0.024	0.025
	Average	0.016	0.015	0.016
3.	Slenderness ratio	71.25	72.66	71.87

Fibre Classification

Fibre classification of kraft, Soda and Soda-anthraquinone unbleached pulps was done in a Bauer Mcnett classifixer and the results are tabulated in Table-3.

Table-3.

Bauer Mcnett fibre classification of kraft, Soda and Soda-Anthraquinone unbleached eucalyptus pulps

		% Retention		
S.No.	Mesh size	kraft pulp	Soda pulp	Soda anthraquinone pulp
1.	+ 40	52.54	52.34	51.23
2.	- 40 + 70	29.60	29.33	31.67
3.	-70 + 100	6.64	6.12	6.02
4.	-100 + 140	1.67	1.29	1.53
5.	- 140	9.55	10.92	9.55

Physical strength properties

Unbleached kraft, Soda and Soda-anthraquinone pulps were beaten to 45 °SR freeness. Standard sheets

were prepared and tested for physical strength properties, which are reported in Table-4.

Table-4.

Physical strength properties of kraft, Soda and Soda-Anthraquinone unbleached pulps

S.No.	Particulars	kraft pulp	Soda pulp	Soda anthraquinone pulp
1.	Beating revolution P.F.I. mill	14,000	12,000	13,500
2.	Final freeness ^{0}SR	45	45	45
3.	Bulk cc/gram	1.40	1.42	1.41
4.	Breaking length (meters)	7070	6444	7107
5.	Burst factor	53.5	48.6	52.4
6.	Tear factor	73.3	68.3	70.3
7.	Double fold	Above 800	Above800	Above 800
8.	Tensile Index N.m/g	69.30	63.17	69.67
9.	Burst Index K.Pa.m^2/g	7.18	6.69	6.89
10.	Tear Index, mN	5.24	4.76	5.13

Bleaching of pulps

Karft, Soda, and Soda-anthraquinone pulps of nearly same kappa No. were bleached under C/E/H Sequence under similar bleaching conditions to attain around 78% P.V. brightness. The bleached pulps were analysed for P.C.No. Copper No. and Viscosity and the results are given in Table-5.

Table-5.

Bleaching condition and pulp characteristics

S.No.	Particulars	Kraft pulp	Soda pulp	Soda Anthraquinone pulp
Bleached condition Ist stage (Chlorination)				
1.	Chemical as available chlorine %	3.5	3.5	3.5
2.	Consistency %	3.0	3.0	3.0
3.	Temperature ^{0}C	Room	Room	Room
4.	Time Mts	60	60	60
5.	End pH	2.0	1.8	2.0
6.	Chlorine consumed %	3.32	3.40	3.31
Second stage Alkali Extraction				
1.	Chemicals as NaOH %	2.5	2.5	2.5
2.	Consistency %	5.0	5.0	5.0
3.	Temperature ^{0}C	55	55	55
4.	Time Mts	60	60	60
5.	End pH	10.4	10.5	10.4
Third stage Calcium Hypochlorite				
1.	Chemical as available chlorine %	2.5	3.0	2.5
2.	Consistency %	5.0	5.0	5.0
3.	Temperature ^{0}C	40	40	40
4.	Time Mts	120	120	120
5.	End pH	8.1	8.2	8.0
6.	Chlorine consumed %	2.21	2.68	2.15
Final Results				
1.	Total chlorine applied %	6.0	6.5	6.0
2.	Total chlorine consumed %	5.53	5.08	5.46
3.	Brightness of pulp %	78.5	78.0	77.5
4.	Viscosity (0.5% CED) Cps	10.5	9.5	10.3
5.	Copper No.	1.2	1.25	1.1
6.	P.C.No.	3.98	3.95	3.56
7.	Bleached pulp yield %	41.5	39.7	42.8
8.	Pulp shrinkage % on O.D. unbleached pulp precent	4.64	4.9	5.2

Fibre Classification of bleached pulps

Fibre classification of kraft, Soda and Soda anthraquinone bleached pulps was also carried out in a Bauer Mcnett classifier and results are mentioned in Table-6.

Table-6.

Bauer Mcnett fibre classification of kraft, Soda and Soda-Anthraquinone bleached pulps

S.No.	Mesh size	% Retention kraft pulp	Soda pulp	Soda anthraquinone pulp
1.	+ 40	49.80	48.32	49.62
2.	- 40 + 70	35.21	34.15	34.58
3.	-70 + 100	4.26	6.50	5.11
4.	-100 + 140	1.32	1.95	1.45
5.	- 140	9.41	9.08	9.24

Physical strength properties of bleached pulps

Kraft, Soda and Soda-anthraquinone bleached pulps were beaten at 45 ^{0}SR freeness and evaluated for physical strength properties which are recorded in Table-7.

Table-7.

Physical strength properties of kraft, Soda and Soda-Anthraquinone bleached pulps

S.No.	Particulars	kraft pulp	Soda pulp	Soda anthraquinone pulp
1.	Beating revolution P.F.I. mill	8,500	7,500	8,000
2.	Final freeness °SR	45	45	45
3.	Bulk cc/gram	1.36	1.38	1.35
4.	Breaking length (meters)	7666	6666	7231
5.	Burst factor	56.9	53.3	55.0
6.	Tear factor	66.0	58.3	61.0
7.	Double fold	Above 800	Above800	Above 800
8.	Tensile Index N.m/g	75.15	63.35	70.89
9.	Burst Index K.Pa.m^2/g	5.57	5.22	5.39
10.	Tear Index, mN.m^2/g	6.47	5.73	5.98

DISCUSSION

Digestion of Eucalyptus chips

Kraft, Soda and Soda-anthraquinone pulping of Eucalyptus chips need 18%, 19.9% and 17.05% alkali as Na_2O respectively to achieve nearly same kappa No. i.e. 21.5, 23.5 and 21.5 respectively under similar pulping conditions (Table-1). The unbleached pulp yield in Soda-anthraquinone pulping of Eucalyptus shows around 2% gain against kraft pulping and 3.4% gain against Soda pulping. Unbleached kraft and Soda-anthraquinone has higher viscosity than Soda pulp indicating superior pulp quality produced by these two process.

Black liquor characteristics reported in Table-1 shows organics % and Calorific value in Soda-anthraquinone black liquor was higher as compared to Soda and kraft black liquor. The viscosity of kraft black liquor is lower than Soda and Soda-anthraquinone black liquor which is a different observation reported in the literature[10].

Fibre Morphology and Fibre Classification

Kraft, Soda and Soda-anthraquinone pulps did not show significant difference in fibre length, fibre diameter and slenderness ratio (Table-2).

Fibre classification results reported in Table-3 indicate over 80% fibres were retained upto +70 mesh.

Physical strength properties

Physical strength properties of unbleached kraft, Soda and Soda-anthraquinone pulps beaten in a P.F.I. mill and reported in Table-4 shows Soda pulp has lower strength properties than both kraft and Soda-anthraquinone pulp. Kraft and Soda anthraquinone pulps have equivalent physical strength properties.

Bleaching of pulps

Eucalyptus kraft, Soda and Soda-anthraquinone unbleached pulps bleached under C/E/H Sequence shows that bleach consumption was higher in Soda pulp as compared to kraft and Soda-anthraquinone pulps (Table-5) to attain around 78% brightness. Colour reversion in Soda-anthraquinone bleached pulp was lower than kraft and Soda bleached pulps. The pulp viscosity of kraft and Soda-anthraquinone pulps was nearly the same. The shrinkage in Soda-anthraquinone (5.2%) is little on higher side than kraft (4.64%) and Soda (4.9%) bleached pulps as compared to their unbleached pulps.

Fibre Classification of bleached pulps

Fibre classification results of kraft, Soda and Soda-anthraquinone bleached pulps reported in Table-6 indicates fibre retention on +40 mesh is lower than their corresponding unbleached pulps but retention % was higher on + 70 mesh.

Physical strength properties

The Physical strength properties of bleached pulps are better in kraft followed by Soda-anthraquinone and Soda bleached pulps (Table-7). The physical strength properties of kraft Soda and Soda anthraquinone bleached pulps were better than their unbleached pulps. The bulk in all the three bleached pulps was on higher side.

CONCLUSION

It has been found 0.1% anthraquinone dosage in Soda-anthraquinone pulping of Eucalyptus reduces cooking chemical and improves in unbleached pulp yield for obtaining nearly same kappa No. by kraft and Soda processes employed for Eucalyptus digestion.

Anthraquinone addition in cooking operation gives black liquor of higher organics percentage and higher calorific value as compared to Soda and Sulphate black liquor. There was 1.3% and 3.1% gain in bleached pulp yield against Sulphate and Soda processes respectively using Soda-anthraquinone process. The physical strength properties of Soda-anthraquinone bleached pulps were little inferior to Sulphate pulp but were superior to Soda bleached pulp. Soda-anthraquinone process could be used as substitute of Sulphate process in Eucalyptus Hybrid pulping.

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