Oxygen Treatment Parameters of *Anthocephalus Indicus* Kraft Pulps

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Abstract

Anthocephalus indicus was subjected to kraft pulping using 10,12,14, 16 and 18 % active alkali as Na_2O at 23.0 % sulphidity level. It yielded 55.58, 58.98, 49.49, 47.17 and 47.06 % screened pulp, corresponding to kappa number 60.04, 36.49, 24.76, 19.02 and 16.25 respectively. These pulps were evaluated for strength properties. The pulps corresponding to kappa number 36.49 and 24.76 possessing optimum strength properties were chosen for oxygen treatment at 6,8,10 kg/cm^2 oxygen pressure and 90,100 and 110^{o}C temperature for 60 minutes. 0.00,1.00, 2.00, 3.00 and 4.00 % alkali as NaOH was charged in oxygen treatment stage, in each case. Pulp yield, kappa number, klason lignin and brightness of pulps were determined. It was observed that at 2.00 and 1.00 % alkali charge for corresponding to kappa number 36.49 and 24.76, respectively, the kappa numbers were decreased to 18.04 $\pm$ 1.29 and 13.29 $\pm$ 0.75 at 8 kg/cm^2 oxygen pressure in 60 minutes reaction time and 90, 100 and 110^{o}C reaction temperature. Similar was the trend for klason lignin content, thus considered to be sufficient to achieve about 50 % (about 50 % drop in kappa numbers) delignification. The pulps produced under optimize conditions were evaluated for strength properties. On the basis of data obtained, 8 kg/cm^2 Oxygen pressure at 100^{o}C treatment temperature and 60 minutes reaction time were considered to be optimum for oxygen treatment using 2.00 and 1.00 % alkali charge for pulps corresponding to kappa number 36.49 and 24.76 respectively. Results are discussed at adequate length in the paper.

Keywords: Kappa Number, Klason Lignin, Delignification, Oxygen Pressure, Oxygen Treatment.

Introduction

Today every industry emphasizes on three “E” Energy, Environment and economics. Paper industry has always been associated with all the three E”. However in the recent past sticker environmental regulations forced the industry to pay more emphasis on effluent discharge/ pollution control. Discharge of chlorinated organic matter from bleach plant, particularly from chlorination and alkali extraction stage makes the problem more acute as these chlorinated compounds are slow biodegradable and contribute for Suspended Solid (SS), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Absorbable Organic Halides (AOX), toxicity and colour of the effluent. A portion is even bioaccumulable andgenotoxic[1,2]. The amount of chlorine used for the bleaching of pulp is directly proportional to the residual lignin in pulp, consequently determine the effluent quality and quantity [3]. Thus complete or even partial replacement of chlorine by an environmental friendly bleaching compound could improve the effluent quality and reduces its quantity in recipient water.

Aim of the Study

In the recent years there has been a rapid increase in the prices of conventional delignification chemicals. So oxygen is an inexpensive in comparison to conventional chemicals. Besides this oxygen treatment of pulps lead to the considerable amount of reduction in BOD, COD, colour toxicity, mutagenicity, carcinogenicity and other biological effect, consequently improves the effluent quality and finally reduces the water pollution.

Review of Literature

A world wide drive to reduce pollution caused by bleaching of pulp has resulted into application of oxygen prior to conventional bleaching using chlorine and or chlorinated compounds. Oxygen delignification is extensively used for lignin removal before bleaching. Oxygen delignification are chemical costsaving, yield retention and improved environmental performance4. Even partial replacement of chlorine by oxygen improves the effluent quality and reduces the effluent load in terms of TSS, BOD, COD, AOX, toxicity and colour etc of the effluent, considerably. Effluent generated from the oxygen stage could be recycled in chemical recovery section 5. The main disadvantage of oxygen delignification is low lignin selectivity compared to chlorine. The low lignin selectivity has limited delignification to about 50 % lignin removal.It may be possible to extend the delignification by improved selectivity and optimization of experimental parameter. The selectivity is improved by better knowing about mechanism of delignification. Researchers like Backa et al. [6] and Lawoko et al. [7] have suggested that the residual lignin is covalently bound to the hemicelluloses through lignin carbohydrate complexes (LCC) linkages. Oxygen delignification is initiated by generation of phenolate radical and a superoxide anion radical from the attack of oxygen on thephenolate anion formed from phenolic lignin at alkaline conditions[8,9]. The resonance stabilized phenoxy radical from the attack of then undergo reaction with themselves or with oxygen species such as hydroxyl($HO^{\cdot}$), hydroperoxy ($HOO^{\cdot}$) and superoxide($O2^{\cdot}$-) radicals to from organic acids, carbon dioxide and other small molecular weight organic products via side chain elimination, ring opening and demethoxylation reactions. During oxygen delignification, the number of phenolic hydroxyl groups in the pulp decrease and the number of carboxylic acid groups increase, which is expected since the degradation products from oxygen delignification are predominately organic acids and carbon dioxide[10].

Therefore studies were initiated to optimize the oxygen treatment parameters for *Anthocephalusindicus*kraft pulps with an aim to achieve the pulp possessing optimum properties.

1. Oxygen Delignification of Acid Sulfite and Bisulfite Softwood Pulps discusses alternatives for the production of sulfite pulps cooked to high kappa numbers, and a subsequent oxygen treatment by using the same cation in the cooking and in the oxygen stages.
2. Various biodegradable anionic polymers has potential in purifying the effluent water and to reduce the dose of COD and biological oxygen demand (BOD).

Experimental

Pulping

Anthocephalusindicus logs were debarked, chipped and chips were screened. Screened chips (15-30 x 10-20 x 2-3 mm) were taken for pulping experiments. Pulping experiments were carried out in a air pulping bath unit consisting of six bombs of 2.5 litre capacity using 10, 12, 14, 16 and 18 % active alkali as Na_2O at 23.0 % sulphidity level. Bath ratio 1 : 4 maximum temperature, 170^{o}C were kept constant in all the cases. Room temperature to 100^{o}C temperature was raised in 90 minutes followed by 10^{o}C rise in 15 minutes to 170^{o}C and kept at maximum temperature for 60 minutes. Pulping schedule corresponds to H-factor, 1110. Cooked material was washed with hot water, fiberized in laboratory disintegrater and screened over flat laboratory screen having 0.25 mm slots. Pulp yield and kappa number were determined in each case.

Beating, Sheet Making and Physical Strength Properties of Pulps

Unbleached pulps were beaten in PFI mill at different revolutions. Hand sheets of 65$\pm$2 gsm of each pulp were made on standard British sheet making machine, air dried, conditioned at 27$\pm$1 ^{o}C and 65$\pm$2 % relative humidity and tested for various strength properties. Results were interpolated at freeness 250(ml) csf.

Oxygen Treatment of Kraft Pulps

Unbleached kraft pulps using 12 % and 14 % active alkali in pulping corresponding to kappa number 36.49 and 24.76 were treated with oxygen at 6, 8, 10 kg/cm^2 oxygen pressure. At each pressure, treatment was given 90^{o}C, 100^{o}C and 110^{o}C temperature for 60 minutes using 0.00, 1.00, 2.00, 3.00 and 4.00 % alkali charge, in each case 1:12 bath ratio was maintained. 0.25 % magnesium sulphate was added in oxygen treatment stage. The pulps, thus obtained, were subjected to pulp yield, holocellulose, kappa number, klason lignin and brightness determination.

Based on the results obtained for pulp yield, holocellulose, kappa number, klason lignin and brightness, pulps of kappa number 36.49 and 24.76 using 2.0 and 1.0 alkali, respectively and treated at 8 kg/cm^{2}oxygen pressure and 90,100 and 110^{o}C treatment temperature in each case were chosen for strength properties evaluation. Pulps were beaten, hand sheets were made, air dried, conditioned, as earlier. These sheets were tested for physical strength properties and result were interpolated at freeness 250(ml) csf.

Results and Discussion

Effect of Alkali Chargeon Pulp Yield, Kappa Number and Strength Properties of Unbleached Pulps

It was observed that under the identical conditions of pulping, pulp yield and kappa number decreased with the increase in alkali charge, as expected. Total pulp yield was 70.94, 63.69, 53.62, 48.30 and 47.64 % while screened pulp yield was 55.58, 58.98, 49.49, 47.17 and 47.06 % at 10, 12, 14, 16 and 18% alkali charge corresponding to 60.04, 36.49, 24.76, 19.02 and 16.25 kappa number, respectively (Table 1). Slightly lower screened pulp at 10 % alkali charge as compared to 12 % alkali charge is due to the higher amount of rejects.

Table -1 Pulping Conditions, Pulp Yield and Kappa Number of *A. Indicus* Kraft Pulps

S.No	Particulars	Alkali charge, pulp yield and kappa number				
01	Active Alkali as Na_2O* , %	10.00	12.00	14.00	16.00	18.00
02	Total pulp yield*, %	70.69	63.69	53.62	48.30	47.64
03	Screened pulp yield*, %	55.58	58.98	49.49	47.17	47.06
04	Kappa Number	60.04	36.49	24.76	19.02	16.25

*percentage based on o.d raw material

Strength properties of the pulp produced using 10 % active alkali was lowest. Strength properties were improved with the increase of alkali charge up to 14 % active alkali followed by marginal drop in properties, in general or almost comparable (Table 02). Burst index (kPam^2/g) 5.86$\pm$0.12; tensile index (Nm/g) 95.00 $\pm$ 0.50; tear index (mNm^2/g) 5.59 $\pm$ 0.05 at freeness 250(ml) csf for the pulp produced using 12 % and 14 % alkali in pulping suggested that though the pulp yield and kappa number were slightly higher for the pulp produced using

12 % alkali as compared to pulp produced using 14 % alkali during pulping, but the strength properties were more or less comparable and better than pulps produced using 10,16 and18 % active alkali under identical conditions of pulping. Therefore, these pulps were chosen for oxygen treatment to observe the effect of oxygen treatment on pulp yield, holocelloluse, kappa number, klason lignin and brightness of the pulps in order to optimize the oxygen treatment parameters for *A.indicus*kraft pulps with an aim to achieve the pulps possessing optimum properties.

Table- 2 : Physical Strength Properties of Unbleached Kraft Pulps of *A. Indicus* at Freeness 250 (ml) csf

S.No	Active Alkali as Na_2O, %*	Apparent Density, g/cm^3	Tensile Index, Nm/g	Tear Index, mNm^2/g	Burst Index, $kPam^2/g$
1	10	0.75	80.5	5.18	4.41
2	12	0.79	94.5	5.54	5.54
3	14	0.81	95.5	5.64	6.00
4	16	0.80	94.0	5.60	5.50
5	18	0.79	87.5	5.38	5.00

*percentage based on o.d raw material

Effect of Oxygen Treatment on Pulp Yield and Holocelloluse

Pulp yield was decreased with the increase in temperature and oxygen pressure even without alkali charge 58.98 % yield for pulp produced using 12 % active alkali was decreased to 56.98, 56.06 and 55.78 % at 6 kg/cm^2 oxygen pressure, 55.76, 54.98 and 54.86 % at 8 $kg/cm^2$and 55.16, 54.76 and 54.46 % at 10 kg/cm^2 oxygen pressure at 90, 100 and 110^oC, respectively (Table -3) Similar was the trend for the pulps produced using 14 % active alkali (Table -3). The decrease in pulp yield for the pulps produced using 14 % alkali was marginally lower as compared to pulp produced using 12 % alkali due to inherent lower amount of residual lignin in pulp to be dissolved out during oxygen treatment. These valves correspond to an average of 55.67 ± 1.03 % and 46.71 ± 0.65 % for 12 % and 14 % alkali charge, respectively as against 58.98 % and 49.49 % for the control pulps sample. (Table -3)

Data recorded for holocellulose for pulps produced using 12 and 14 % active alkali during pulping also revealed that there was a drop in holocellulose content on oxygen treatment even without alkali charge (Table 4). It was dropped to an average 88.92 ± 0.78 % and 91.84 ± 1.02 %, respectively, at different level of oxygen pressure and treatment temperature, studied as against 91.79 and 94.04 % for control samples of pulp produced using 12 and 14 % active alkali during pulping (Table 4).

Careful perusal of these data indicated that considerable drop in pulp yield and holocellulose was observed even without alkali charge in oxygen treatment. While the kappa numbers 36.49 and 24.76 for pulps produced using 12 and 14 % active alkali was decreased to only 35.15 ± 0.85% and 24.10 ± 0.50 % (Table 5). Similarly, klason lignin content 6.65 and 4.85 % was decreased to only 6.29 ± 0.27% and 4.03 ± 0.31 % (Table 5). These data suggested that the kappa number and klason lignin content of these pulps were almost comparable to that of control pulp samples. Thus, the decrease in kappa number and klason lignin content was insignificant as compare to decrease in pulp yield and holocellulose content. This may be attributed to the fact that in the absence of alkali,oxygen treatment was more selective to polysaccharides degradation rather than lignin [11,12,13,14]. Presence of oxygen without alkali might have caused the formation of carboxylic acid and various polysaccharides degrading species leading to their degradation [15,16, 17].

Marginal, but consistent drop in pulp yield was observed with the increase in temperature at different level of oxygen pressure and alkali charge (Table 3). The average pulp yield was 55.24 ± 1.32%, 54.61 ± 1.15%, 54.11 ± 0.95% and 53.76 ± 1.00% at 1.0 %, 2.0%, 3.0% and 4.0% alkali charge, respectively, as against 58.98 % for pulps produced using 12 % active alkali in pulping. Similarly for pulps produced using 14 % active alkali, the average pulp yield was 46.52 ± 0.66%, 45.75 ± 0.89%, 46.52 ± 0.66% and 45.97 ± 0.89% as against 49.49 % for control pulp sample, at any level of oxygen pressure and temperature, studied (Table 3). A marginal drop in pulp yield was observed with the increase in oxygen pressure at a particular level of temperature and alkali charge (Table 3).

Table 3 : Effect of Oxygen Treatment on Pulp Yield of *A. Indicus*kraft Pulps Produced Using 12 % And 14 % Active Alkali

S.No	Alkali Charge %*	Pulp Yield % at different oxygen pressure, Kg/cm^2								
		6			8			10		
		Temperature °C			Temperature °C			Temperature °C		
		90	100	110	90	100	110	90	100	110
Pulps produced using 12 % active alkali, yield 58.98%										
1	0.00	56.98	56.06	55.78	55.76	54.98	54.86	55.16	54.46	54.36
2	1.00	56.56	55.26	55.02	55.26	54.46	54.14	54.98	53.24	53.92
3	2.00	55.76	54.86	54.46	55.12	54.09	53.84	54.30	53.78	53.46
4	3.00	55.06	54.28	54.03	54.23	53.73	53.33	53.86	53.42	53.16
5	4.00	54.76	53.92	53.64	53.64	53.15	53.08	53.54	53.24	53.02
Pulps produced using 14 % active alkali, yield 49.49%										
1	0.00	47.36	47.07	46.62	47.26	46.96	46.08	47.06	46.86	46.06
2	1.00	47.28	46.73	46.28	46.89	46.80	45.77	46.70	46.64	45.92
3	2.00	47.18	46.43	46.10	46.72	46.08	45.57	46.64	46.32	45.86
4	3.00	46.99	45.92	45.53	46.49	45.56	45.32	46.32	45.88	45.00
5	4.00	46.86	45.06	45.01	46.16	45.22	45.12	46.06	45.18	45.08

*percentage based on o.d raw material

Average valve for holocellulose was 88.77 ± 0.51%, 88.88 ± 0.42%, 89.98 ± 0.62% and 89.97 ± 0.60% for pulps produced using 12 % active alkali and 92.08 ± 1.03%, 92.65 ± 0.97%, 92.90 ± 0.92 % and 93.03 ± 0.85% for pulps produced using 14 % active alkali in pulping at 1.0%, 2.0%, 3.0% and 4.0% alkali charge in oxygen treatment stage. The consistent increase in holocellulose with increase alkali charge may be attributed to consistent improvement in delignification of pulps. This is also in agreement with the decrease in kappa number (Table 5). The increase in holocellulose content and decrease in kappa number and klason lignin with the addition of alkali during oxygen treatment suggested that in alkaline media oxygen attacked lignin macro molecule preferentially.

Table 4 : Effect of Oxygen Treatment on Holocellulose of *A. Indicus*kraft Pulps Produced Using 12 % And 14 % Active Alkali

S. No	Alkali Charge %*	Holocellulose %** at different oxygen pressure, Kg/cm^2								
		6			8			10		
		Temperature ^oC			Temperature ^oC			Temperature ^oC		
		90	100	110	90	100	110	90	100	110
Pulps produced using 12 % active alkali, holocellulose, 91.79%										
1	0.00	87.51	87.60	87.98	87.62	87.78	88.12	88.09	88.84	89.08
2	1.00	88.26	88.37	88.48	88.68	88.69	88.74	88.78	88.98	89.28
3	2.00	88.46	88.68	88.96	88.72	88.82	89.06	89.13	89.26	89.30
4	3.00	88.86	88.98	89.34	89.06	89.17	89.24	89.76	90.08	90.10
5	4.00	89.19	89.29	90.02	89.72	89.95	90.25	90.27	90.36	90.38
Pulps produced using 14 % active alkali, holocellulose 94.04%										
1	0.00	90.87	91.32	91.76	91.76	91.97	92.56	91.96	92.06	92.86
2	1.00	91.05	91.48	91.91	91.96	92.06	92.86	92.65	92.78	93.11
3	2.00	91.68	92.16	92.51	92.15	92.36	93.22	92.86	93.16	93.61
4	3.00	91.98	92.38	92.80	92.86	93.14	93.34	93.26	93.76	93.81
5	4.00	92.28	92.64	93.65	92.98	93.22	93.36	93.36	93.85	93.98

* and**percentage based on o.d raw material and pulp, respectively

Effect of Oxygen Treatment on Kappa Number And Klasonlignin

Drop in kappa number without alkali charge was insignificant. It was dropped to only 35.51 ± 0.49, 35.51 ± 1.10 and 34.78 ± 0.48 at 6, 8 and 10 k/cm^2 oxygen pressure, respectively at 90, 100 and 110^oC treatment temperature as against kappa number 36.49 for control pulp sample produced using 12 % alkali in pulping. The kappa number 24.76 for control pulp sample using 14 % alkali in pulping was dropped to 24.33 ± 0.26, 24.16 ± 0.31 and 23.99 ± 0.39 at 6, 8 and 10 k/cm^2 oxygen pressure, respectively at 90, 100 and 110^oC reaction temperature (Table 5). In general, there was a marginal but insignificant drop in kappa number without alkali charge at any level of oxygen pressure and reaction temperature. Similarly the drop in klason lignin was also insignificant. It was dropped to 6.29± 0.27% and 4.03 ± 0.13 % as against 6.65 % and 4.58 % for control pulp sample produced using 12 and 14 % alkali, respectively at different level of oxygen pressure and treatment temperature was studied.

Kappa number was marginally decreased with the increase in oxygen pressure and treatment temperature at a particular level of alkali charge. The average value of kappa number was 24.52 ± 3.47, 18.35 ± 3.29, 14.26 ± 3.0 and 11.63 ± 1.83 as against 36.49 for control pulp produced using 12 % alkali and 15.50 ± 3.14, 12.60 ± 2.56, 10.41 ± 2.56 and 8.80 ± 1.09 as against 24.76 for control pulp produced using 14 % alkali in pulping at different level of oxygen pressure and treatment temperature using 1.0% , 2.0 %, 3.0 % and 4.0 % alkali in oxygen treatment stage. Perusal of these data indicated that the drop in kappa number was more significant with the increase in alkali charge rather than the increase in oxygen pressure or reaction temperature.

Drop in kappa number and klason lignin content was more pronounced up to 2.0 % and 1.0% alkali charge during oxygen treatment stage for pulp produced using a 12 % and 14 % alkali, respectively, in pulping. At 2.0 % and 1.0% of alkali charge, at any level oxygen pressure more or less 50 % delignification (based on kappa number and residual lignin in pulps) was achieved (Table 5 and 6). However, lower oxygen pressure required higher temperature which may result into more degradation to the pulp produced. Thus, 8kg/cm^2 oxygen pressure was chosen for further studies.

Table 5 : Effect of Oxygen Treatment on Kappa Number of *A. Indicus*kraft Pulps Produced using 12 % and 14 % Active Alkali

S. No	Alkali Charge %*	Kappa number at different oxygen pressure, Kg/cm^2								
		6			8			10		
		Temperature ^oC			Temperature ^oC			Temperature ^oC		
		90	100	110	90	100	110	90	100	110
Pulps produced using 12 % active alkali, kappa number, 36.19										
1	0.00	36.00	35.85	35.02	35.80	35.60	35.30	35.25	34.72	34.30
2	1.00	27.98	23.82	22.32	26.42	22.82	21.52	22.90	22.16	21.05
3	2.00	21.64	19.92	18.32	19.32	17.56	16.75	17.10	15.46	15.06

4	3.00	17.36	15.36	11.16	14.92	12.45	12.02	13.52	12.45	11.26
5	4.00	13.46	12.05	10.92	11.58	10.85	9.85	10.82	9.82	9.80
Pulps produced using 14 % active alkali, kappa number, 24.76										
1	0.00	24.59	24.38	24.07	24.47	24.15	23.85	24.38	24.05	23.60
2	1.00	18.64	15.46	14.80	14.04	13.12	12.54	12.95	12.87	12.76
3	2.00	15.16	12.48	11.40	12.96	11.33	10.14	10.78	10.28	10.04
4	3.00	12.96	11.38	11.30	9.97	9.13	8.05	9.80	8.55	7.85
5	4.00	9.89	8.15	8.02	7.79	7.77	7.72	7.79	7.76	7.71

* percentage based on o.d pulp

Table 6 : Effect of Oxygen Treatment on Klason Lignin of A. Indicuskraft Pulps Produced Using 12 % and 14 % Active Alkali

S.No.	Alkali Charge %*	klason lignin %* at different oxygen pressure, Kg/cm^2								
		6			8			10		
		Temperature ^oC			Temperature ^oC			Temperature ^oC		
		90	100	110	90	100	110	90	100	110
Pulps produced using 12 % active alkali, klason lignin, 6.65%										
1	0.00	6.55	6.28	6.08	6.32	6.22	6.05	6.10	6.06	6.02
2	1.00	5.10	5.02	4.96	4.98	4.52	4.52	4.48	4.36	4.26
3	2.00	4.80	4.42	4.12	4.03	3.39	3.39	3.50	3.12	3.06
4	3.00	4.03	3.38	2.60	3.24	2.67	2.67	2.71	2.46	2.40
5	4.00	3.16	2.66	2.43	2.58	2.39	2.36	2.38	2.26	2.19
Pulps produced using 14 % active alkali, klason lignin, 4.58%										
1	0.00	4.15	4.09	4.01	4.05	3.94	3.87	4.01	3.82	3.70
2	1.00	3.88	2.96	2.91	2.95	2.94	2.85	2.92	2.89	2.82
3	2.00	3.05	2.86	2.85	2.29	2.20	2.18	2.28	2.22	2.16
4	3.00	2.94	2.42	2.28	2.15	2.05	1.92	2.05	1.97	1.85
5	4.00	2.13	1.77	1.75	1.84	1.72	1.68	1.83	1.67	1.62

* percentage based on o.d pulp

Effect of Oxygen Treatment on Brightness of Pulps

Result recorded for brightness improvement (Table 7) hold the reverse trend to that of decrease kappa number because the brown colour of the pulp originates from the chromophoric groups present in the residual lignin in pulp. Oxygen treatment removes the lignin as well as modifies the chromophoric groups consequently, improves the brightness of pulp [18]. The brightness of pulps treated with oxygen without alkali was almost comparable to that of control pulps sample i.e 24.31 ± 0.66 and 27.72 ± 0.27 % ISO at different treatment temperature and oxygen pressure, studied, as compared to 23.35 % ISO and 27.39 % ISO for control pulp samples produced using 12 and 14 % alkali in pulping. The brightness of the pulp in general, improved with the increase in alkali charge and treatment temperature at any level of oxygen pressure. As an average the brightness at different level of temperature and pressure was 31.07 ± 0.92, 40.23 ± 5.47, 47.86 ± 5.34 and 54.76 ± 4.33 % ISO as against 23.34 % ISO for pulp produced using 12 % alkali and 38.52 ± 8.90, 46.50 ± 6.18 , 52.99 ± 5.07 and 55.78 ± 4.49 % ISO as against 27.39 % ISO for pulp produced using 14 % alkali charge, when oxygen treatment was given using1.00, 2.00, 3.00 and 4.00 % alkali charge at 6, 8 and 10 kg/cm^2 oxygen pressure and 90, 100 and 110^{o}C treatment temperature. It was observed that the brightness gain was more pronounced with the increase in alkali charge rather than the reaction temperature or oxygen pressure which is in agreement with the trend observed in decrease in kappa number and klason lignin.

Table 7 : Effect of Oxygen Treatment on Brightness , % (ISO) of *A. Indicus*kraft Pulps Produced Using 12 % And 14 % Active Alkali

S.No.	Alkali Charge %*	Brightness %(ISO) at different oxygen pressure, Kg/cm^2								
		6			8			10		
		Temperature ^oC			Temperature ^oC			Temperature ^oC		
		90	100	110	90	100	110	90	100	110
Pulps produced using 12 % active alkali, Brightness %(ISO), 23.35%										
1	0.00	23.65	23.85	23.95	23.86	24.45	24.46	23.91	24.86	24.97
2	1.00	25.15	29.56	36.84	30.66	32.51	35.14	30.46	31.56	33.98
3	2.00	34.76	36.54	38.65	40.36	41.46	44.02	41.24	42.71	45.69
4	3.00	45.52	44.63	47.32	45.25	46.33	48.02	49.54	50.27	53.20
5	4.00	50.46	54.54	56.56	52.60	56.29	57.93	58.19	58.19	59.12
Pulps produced using 14 % active alkali, Brightness %(ISO), 27.39%										
1	0.00	27.45	27.62	27.82	27.70	27.82	27.93	27.83	27.92	27.98
2	1.00	29.62	32.63	35.62	35.32	39.40	45.10	38.64	42.63	47.42
3	2.00	40.32	43.03	47.54	47.06	48.92	50.62	48.66	50.29	52.68
4	3.00	47.92	49.76	50.61	52.75	53.89	54.06	54.62	55.78	58.06
5	4.00	51.29	52.62	53.92	55.76	58.09	59.74	58.62	60.02	60.26

* percentage based on o.d raw material

Strength Properties of Oxygen Treated Pulps

Pulp produced using 12% alkali corresponding to original kappa number 36.46 after oxygen treatment at 8k/cm^2 oxygen pressure for 60 minute using 2.0% alkali in oxygen treatment stage exhibited, burst index 4.80, 5.40 and 4.92; tensile index 85.60, 86.20 and 85.15 and tear index 5.48, 5.86 and 5.79 respectively at 90,100 and 110^{o}C oxygen treatment temperature. Similarly,Pulp produced using 14 % alkali corresponding to original kappa number 24.76 exhibited burst index 5.20, 5.23 and 5.08; tensile index 85.40, 85.85 and 85.05 and tear index 5.17, 5.40 and 4.95, respectivelyat 90,100 and 110^{o}C oxygen treatment temperature under the above conditions except the alkali charge was 1.0% instead of 2.0 % (Table 8). These results indicated that, 100^{o}C treatment temperature using 2.00 and 1.00 % alkali during oxygen treatment for the pulp having original kappa number 36.49 and 24.76 possessed superior physical properties at adequate level of pulp brightness. Thus consider to be optimum.

Table 8 : Physical Strength Properties of Oxygen Treated *A. Indicus*pulps Atfreeness 250 (ml) csf

S.No	Original kappa number	Treatment temp ^{o}C	kappa number after Oxygen stage	Pulp Yield %	App. Density, g/cm^3	Tensile index, Nm/g	Tear index, mNm^2/g	Burst index, Kpam^2/g	Brightness, % ISO
1	36.49	90 100 110	19.32 17.56 16.75	55.12 54.09 53.84	0.79 0.81 0.80	85.60 86.20 85.15	5.48 5.86 5.79	4.80 5.40 4.92	40.36 41.46 44.02
2	24.76	90 100 110	14.04 13.12 12.54	46.89 46.80 45.77	0.80 0.81 0.80	85.40 85.85 85.05	5.17 5.40 5.08	5.20 5.23 4.95	35.32 39.40 45.10

Conclusions

On the basis of analysis of data for pulp yield, holocellulose, kappa number and klason lignin, it was concluded that oxygen treatment at 8kg/cm^2 pressure, for 60 minutes and 2.0 % and 1.0 % alkali in oxygen treatment stage, for pulp produced using 12 % and 14 % alkali in pulping, corresponding to kappa number 36.49 and 24.76, was sufficient to achieve about 50 % delignification. On evaluation of the pulps produced under optimized conditions of oxygen pressure and alkali charge at different temperature, it was also concluded that the 100^{o}C reaction temperature is optimum to produce the pulps possessing optimum strength properties.

End Notes

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