ECF Bleaching Sequence for Straw Chemical Pulp A Practical Eco-Friendly Approach Recommended at ABIL

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Surging environmental awareness and concern, with the stringent environmental norms from Government has forced the Pulp and Paper Industry to look into alternative ECF/TCF bleaching sequences to reduce the pollutants loads in general and Chloro-organic compounds in particular. Several Eco-Friendly bleaching sequences were tried with Straw Chemical pulp and present experiments were focused on ECF bleaching with and without Oxygen delignification. The end results are quite encouraging with less pollutant loads and also elimination of Elemental Chlorine usage in bleaching sequence. The final bleached pulp obtained from ECF bleaching was around 87 %ISO with reasonably good strength for quality Papermaking. This paper deals with the combination of different bleaching sequences and recommendation of the best ECF sequence for Wheat Straw Chemical pulp. It is first time in India, ABIL has embarked ECF bleaching sequence for Wheat Straw chemical pulp i.e. $OD_{I}E_{op}D_2$ Fiber Line from world leader Metso Sundsval AB., Sweden.

ABOUT THE MILL

M/s Abhishek Industries Ltd., (ABIL) is an integrated pulp and paper mill situated at Dhaula, District Sangrur, Punjab. It is a part of Trident group of companies. The mill produces Eco-friendly paper varieties using wheat straw, an agro based residue. The mill is a success story following the path of sustainable development and continuous improvement.

The paper division of ABIL was established at Dhaula, Punjab in the year 1993. The mill was initially established as a 75 tpd Writing and Printing grade paper mill, based primarily on Wheat Straw. The mill installed a new fourdrinier paper machine, a captive pulp mill with rotary batch digesters, brown stock washing, screening and cleaning, four stage bleach plant (C-E(P)-H-H) and supporting utilities. ABIL has upgraded its paper mill to expand the capacity and make the operations more environmentally friendly. Presently the mill produces 117 tpd of Printing and Writing paper grades, which are widely accepted in the national and also international markets. Presently ABIL has embarked on massive expansion to go for 392 tpd with latest Eco-friendly technologies. The mill also is going for a new Fibre line supplied by the world leader Metso Sundsval AB., Sweden, with an ECF bleaching sequence of $OD_1E(OP)D_2$ to get bleached Wheat Straw pulp Brightness of 87+ %ISO.

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INTRODUCTION

Total global papermaking fibre consumption is projected to increase from about 300 millions tones for 1998 to about 425 million tones by Jaakko Poyry Consultants (1). The new fibre requirement will come from Recovered fibre, Non-wood fibre and fast growing wood plants. Atchison (2) estimates that the global supply of Agricultural residues which could be used for paper making is in the order of 2.45 billion bone dry metric tones. Of this, about half is Straw which, in fact, the most widely used Non-wood plant fibrous raw material in the Pulp and Paper Industry. As per Robert W.Hurter (3), China 73.5%, India 6.3%, Pakistan 2.0%, Mexico 1.6% and Peru amounts to 1.4% of the total global Non-wood pulping capacity.

With ever increasing awareness towards pollution abatement and with the implementation of stricter environmental regulations, the pulp and paper industry is forced to look for alternatives to meet the stringent effluent regulations and ever growing competition. IFC Environmental Review Report (4) has recommended M/s Packages Limited, Punjab Province, Pakistan to go for ECF bleaching of $D_1E(OP)D_2$ sequence for their new 2005-2008 Wheat Straw Sulphite pulp project, to reduce the AOX emissions.

Generally free radical present in Chlorine Dioxide is very sensitive and also highly reactive as an oxidizing agent in ECF bleaching sequence of Chemical pulps. It is specific in reacting with pulp constituent component getting oxidized (5). This results in preserving strength while giving high brightness, less colour reversion of bleached pulp and low AOX discharge level when compared to that of conventional CEHH

Table 1
Constant Conditions of ECF Bleaching of $OD_0E_pD_1$ Sequence

Parameters	O	D_1	E_p	D_2
Consistency, %	10	8	10	8
Temperature, °C	120	70	65	70
Retention Time, Mt	60	180	60	180
pH	10.5	4.5	9.5	4.5
O_2 Pressure, Kg/cm^2	5	-	-	-

bleaching sequence. This paper discusses about the optimization of Oxygen Delignification and ClO_2 bleaching conditions. It also focuses on the benefits of using $OD_0E_pD_2$ bleaching sequence to produce paper grade 87+ %ISO brightness pulp from Soda Wheat Straw chemical pulp.

EXPERIMENTAL

The different Kappa No. pulps were obtained from our Soda chemical pulping process of Wheat Straw were used during these experiments in Laboratory. All the experiments were performed in triplicate and the average results of the three trials have been presented. The standard ECF bleaching conditions maintained during laboratory scale trials are given in Table-1

Oxygen Delignification of Straw chemical pulp was carried out in laboratory digester. The Sodium Hydroxide Chemical dosage was varied in Oxygen Delignification stage with different Kappa No. pulps. The conditions of Oxygen Delignification

Table 2
Oxygen Delignification of Unbleached Straw Pulp

Case	1	2	3
UNBLEACHED PULP			
Unbld.Pulp Kappa No	21.0	16.1	19.8
Viscosity of Unbld. pulp	7.8	7.2	7.5
Brightness %	37.0	39.1	38.0
OXYGEN- DELIGNIFICATION			
NaOH, %	2.0	2.0	1.0
$MgCO_3$, %	0.5	0.5	0.5
Kappa No	13.5	11.0	15.0
Brightness of Pulp, % (ISO)	48.0	49.0	42.0
Pulp Yield, %	94.4	94.0	95.5
Viscosity of O_2 Bleached pulp	7.2	6.8	7.1
Kappa No. Reduction %	35.7	31.7	24.2
Freeness, °SR	19	21	20

Table 3
Chlorine Dioxide Bleaching of Oxygen Delignified Straw Pulp

Kappa No	13.5	13.5	13.5	13.5
Viscosity of O_2 Bleached pulp	7.2	7.2	7.2	7.2
Experiment No	**I**	**II**	**III**	**IV**
D_1- STAGE				
ClO_2 as Active Cl_2, %	5.0	6.0	7.0	8.0
Brightness, % (ISO)	76.6	79.7	80.0	80.5
E_p-STAGE				
NaOH, %	1.0	1.0	1.0	1.0
H_2O_2, kg/t	5.0	5.0	5.0	5.0
Initial pH	10.5	10.6	10.5	10.5
Brightness, % (ISO)	79.5	81.5	82.5	82.8
D_2-STAGE				
ClO_2 as Active Cl_2, %	2.5	2.0	2.0	2.0
Brightness, % (ISO)	83.7	84.5	85.0	86.0
Viscosity of Bleached pulp	6.8	6.6	6.5	6.2
Tear Factor of pulp	54.4	54.1	53.5	53.0
Breaking Length, meters	4310	4330	4350	4380

Table 4

Chlorine Dioxide Bleaching of Oxygen Delignified Straw Pulp

Kappa No	11.0	11.0	11.0	11.0
Viscosity of O_2 Bleached pulp	6.8	6.8	6.8	6.8
Experiment No	**I**	**II**	**III**	**IV**
D_1- STAGE				
ClO_2 as Active Cl_2, %	5.0	6.0	7.0	8.0
Brightness, % (ISO)	77.0	80.0	80.5	80.8
E_p-STAGE				
NaOH, %	1.0	1.0	1.0	1.0
H_2O_2, kg/t	5.0	5.0	5.0	5.0
Initial pH	10.7	10.6	10.5	10.5
Brightness, % (ISO)	79.7	81.7	82.8	82.9
D_2-STAGE				
ClO_2 as Active Cl_2, %	2.5.	2.0	2.0	2.0
Brightness, % (ISO)	83.8	84.6	85.3	86.3
Viscosity of Bleached pulp	6.6	6.5	6.3	6.2
Tear Factor of pulp	53.9	53.7	53.6	53.5
Breaking Length, meters	4320	4340	4370	4390

along with the testing details of the pulps are given in table-2. The Kappa reduction with 2% NaOH is between 32 -36% where as with 1 % NaOH it was 24% only. Hence Case-1 conditions were selected for further ECF bleaching.

Chlorine Dioxide was prepared in the laboratory using Sodium Chlorite, Glacial Acetic Acid,Sodium Acetate and water. The ClO_2 strength as active chlorine of corresponding mixture was determined fresh every time before carrying out the bleaching experiments. ClO_2 was varied in D_1 stage from 5 to 8% as active Chlorine and then added 2 to 3.5 % as active Chlorine in D_2 stage.

The details of $D_1E_pD_2$ bleaching conditions along with the results carried on the pulp of Kappa No 13.5 are given in Table-3.

The similar details of $D_1E_pD_2$ bleaching

Table 5

Chlorine Dioxide Bleaching of Oxygen Delignified Straw Pulp

Kappa No	15.0	15.0	15.0	15.0
Viscosity of O_2 Bleached pulp	7.1	7.1	7.1	7.1
Experiment No	**I**	**II**	**III**	**IV**
D_1- STAGE				
ClO_2 as Active Cl_2, %	5.0	6.0	7.0	8.0
Brightness, % (ISO)	73.6	74.8	74.7	77.5
E_p-STAGE				
NaOH, %	1.0	1.0	1.0	1.0
H_2O_2, kg/t	5.0	5.0	5.0	5.0
Initial pH	10.7	10.6	10.6	10.6
Brightness, % (ISO)	75.8	76.9	78.5	80.4
D_2-STAGE				
ClO_2 as Active Cl_2, %	3.0	2.5	2.5	2.5
Brightness, % (ISO)	82.5	82.9	83.6	84.7
Viscosity of Bleached pulp	6.6	6.5	6.3	6.2
Tear Factor of pulp	53.9	53.9	53.7	53.6
Breaking Length, meters	4350	4390	4400	4440

Table 6

Chlorine Dioxide Bleaching of Unbleached Straw Soda Pulp

UNBLEACHED PULP					
Viscosity of Unbleached pulp	7.2	7.2	7.2	7.2	7.2
Brightness, %(ISO)	40	40	40	40	40
Kappa No	16	16	16	16	16
BLEACHING DATA					
Experiment No	**I**	**II**	**III**	**IV**	**V**
CHLORINE DIOXIDE STAGE-1(D_1)					
ClO_2 as Active Cl_2, %	5.0	6.0	7.0	8.0	8.0
Retention Time, hrs	2.5	2.5	2.5	2.5	3.0
Pulp Brightness, % (ISO)	54.0	64.8	74.0	77.2	77.9
EXTRACTION WITH PEROXIDE (E_P)					
NaOH, %	1.5	1.5	1.5	1.5	1.0
H_2O_2, kg/t	5.0	5.0	5.0	5.0	5.0
Brightness, % (ISO)	65.6	72.2	78.6	81.5	82.0
CHLORINE DIOXIDE STAGE-II (D_2)					
ClO_2 as Active Cl_2, %	5.0	4.0	3.0	2.5	2.5
Retention Time, hrs	2.5 .	2.5	2.5	2.5	3.0
Brightness, % (ISO)	81.4	81.6	84.2	85.6	87.0
Pulp Yield, % (On O.D.Unbld Pulp)	92.4	92.6	92.8	93.0	93.2
BLEACHED PULP PROPERTIES					
Freeness, °SR	23	24	24	23	24
Viscosity of Bleached pulp	5.4	5.7	5.8	6.4	6.6
Tear Factor of pulp	48.5	50.2	51.2	53.0	52.2
Breaking Length, meters	4310	4280	4250	4220	4400

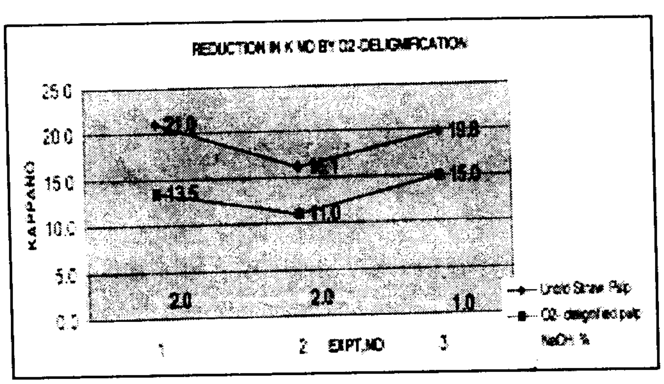
conditions along with the results carried on the pulp of Kappa No 11.0 are given in Table-4

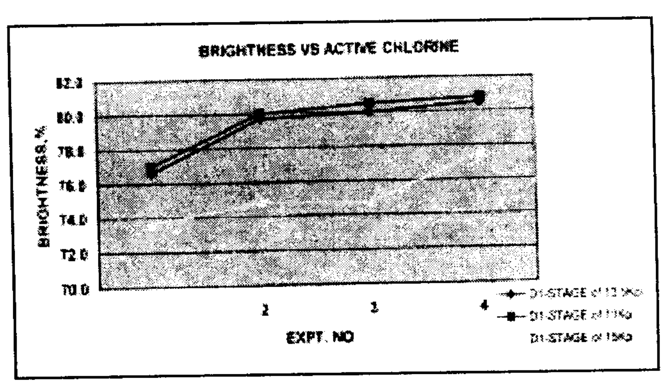
The similar details of $D_1E_PD_2$ bleaching conditions along with the results carried on the pulp of Kappa No 15.0 are given in Table-5

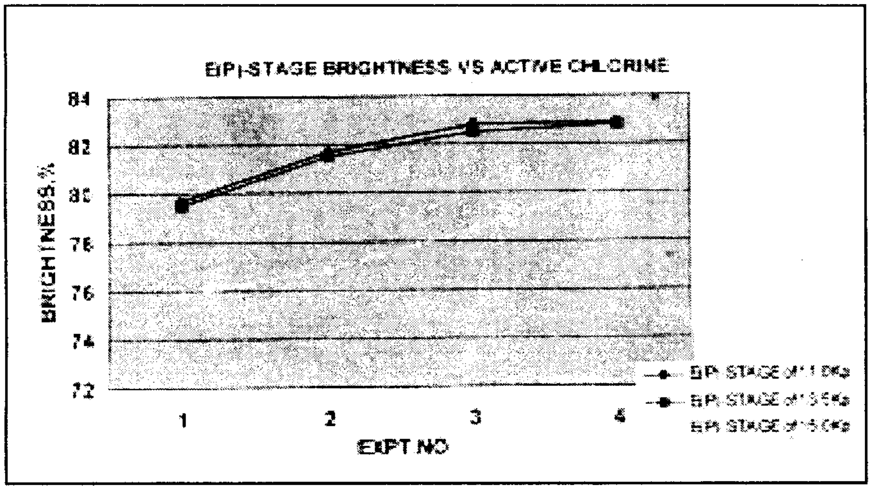
The above results obtained after Oxygen delignification followed by D1 EpD2 were compared with ECF bleaching of Unbleached Straw Soda chemical pulp without Oxygen delignification. These experiments are carried out to study the effect of Oxygen delignification in subsequent stages of ECF bleaching. The Kappa No. of unbleached pulp selected for these experiments is 16.0 so that like to comparison is obtained. The standard conditions and also the results are given in Table-VI for reference.

RESULTS & DISCUSSIONS

In ECF bleaching the stability of the pulp's brightness is affected by small residuals of oxidized Lignin. Quinoid compounds, generated during Chlorine Dioxide bleaching are an important source for Chromophores producing







brightness losses (6). Lower Kappa numbers achieved from Extraction stage after D_1 stage will produce a much stable, high bright, high strength pulp with less colour reversion.

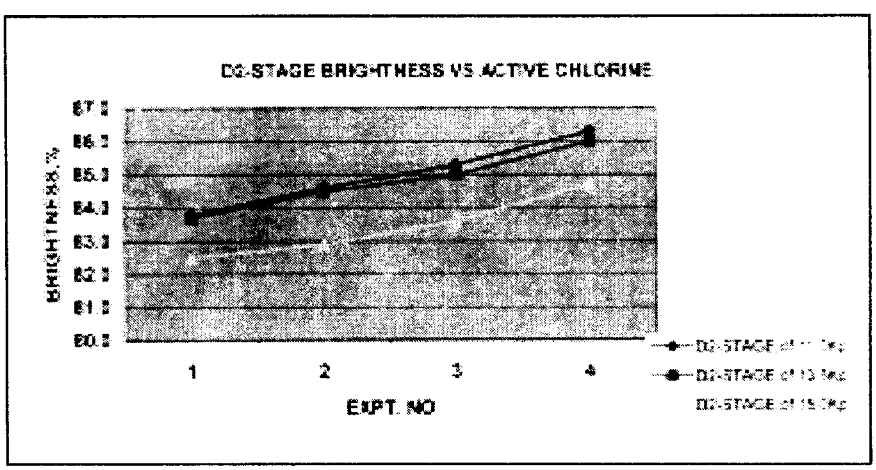
The Kappa No. reduction in Oxygen delignification stage was around 32 to 35% and the similar conditions are preferred in all our experiments because of very less reduction of Viscosity of the pulp after Oxygen stage. Oxygen delignification with 2.0% Caustic resulted in increase in brightness with decrease in Kappa no of the unbleached pulp. The higher Kappa No unbleached pulp resulted in better tearing strength after Oxygen delignification. The shrinkage for all set of pulps after Oxygen delignification were about six percent. The Oxygen delignification with 2% Caustic was preferred over that of 1.0% Caustic.

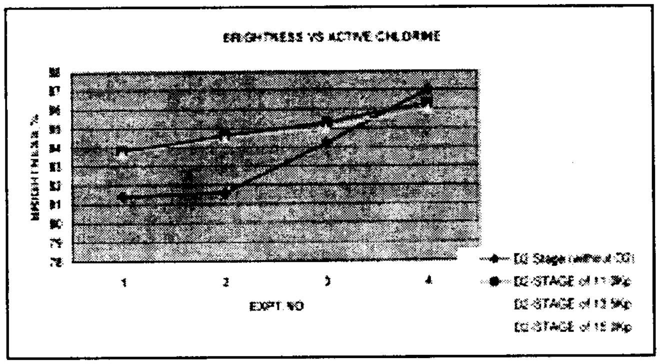
After D_1 stage, 5 Kg/t of Hydrogen Peroxide was used during Alkali Extraction stage in all the cases. The higher ClO_2 requirement in D_1 stage found to be favorable than in D_2 stage in order to achieve comparatively higher brightness in pulp because of lower CEK No. of pulps obtained with higher dosages of ClO_2. The strength properties of the final bleached pulps also are much preserved with the pulp given higher dosages of ClO_2 during D_1 stage respectively. Comparatively lower Kappa unbleached pulp with higher dosages of ClO_2 in D_1 and constant dosages in D_2 stages resulted higher brightness in pulp with better strength properties. Similar experiments were carried out with the pulps having Kappa No. 13.5, 11.0 and 15.0 separately. The trends of the results were similar, but the Brightness development is better with the lower Kappa no. used in the experiments. It is possible to get final pulp upto 86% ISO brightness without loosing much strength with 10% Chlorine Dioxide as active Chlorine. Higher dosages of ClO_2 can give higher brightness pulps upto 88% ISO, but economic viability has to be studied to each variety of pulp used. From the experiments, 87% ISO brightness for final pulp can be obtained.

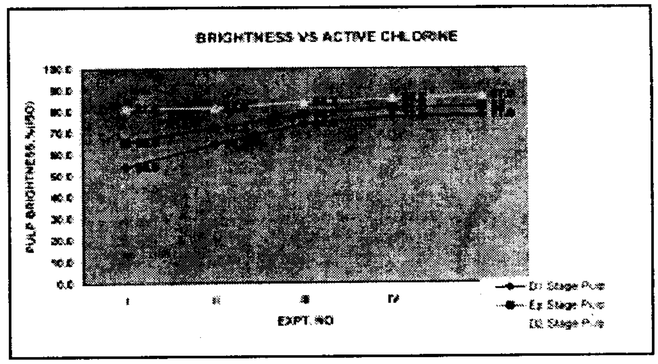
The Unbleached Straw pulp of 16 Kappa was taken for $D_1E_pD_2$ sequence of bleaching without Oxygen stage and we could achieve brightness of 85.5-87.0 %ISO, having Viscosity range of 6.4 to 6.6 cps. The final bleached pulp shrinkage is 7-8% with $D_1E_pD_2$ sequence, which is similar and the strength of the pulp was slightly lower than those of pulp with Oxygen delignification. Hence Oxygen stage before Chlorine Dioxide stage is desirable.

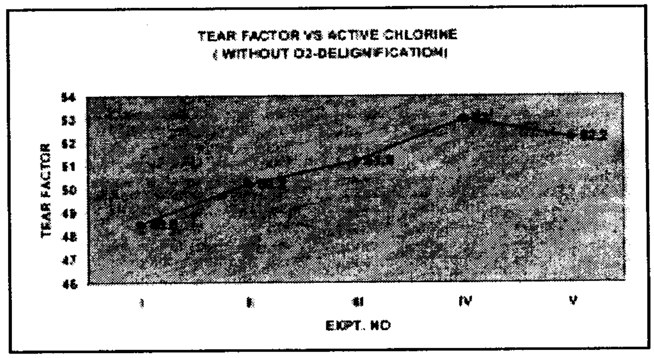
OBSERVATAION AND CONCLUSIONS

- The Kappa No. reduction in Oxygen delignification stage was around 32 to 35%.
- The shrinkage for all the pulps after Oxygen delignification was around 6% and 2% NaOH dosage is desirable in O_2 stage.
- Higher dosages of ClO_2 in D_1 to get lower Kappa number pulps from Extraction stage will produce a much stable, high bright, high strength pulp with less colour reversion.
- The higher ClO_2 requirement in D_1 stage found to be favorable than in D_2 stage in order to achieve comparatively higher brightness in pulp.
- It is possible to get final pulp upto 87% ISO brightness without loosing much strength with 10%Chlorine Dioxide as active Chlorine.









- Lower Kappa unbleached pulp with higher dosages of ClO_2 in D_1 and constant dosages in D_2 stages resulted higher brightness and clean pulp with better strength properties.
- Higher dosages of ClO_2 can give higher brightness pulps upto 88% ISO, but economic viability has to be studied.
- The Unbleached Straw pulp of 16 Kappa with $D_1E_pD_2$ sequence of bleaching, without Oxygen stage also can give brightness of final pulp with 87.0 %ISO, but with slightly lower strength and requires slightly higher dosages of ClO_2.
- Oxygen stage before Chlorine Dioxide stage is desirable.

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