Low pollution bleaching of Indian bagasse soda-oxygen pulps

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ABSTRACT

Soda and Single stage soda oxygen pulps were prepared from partially depithed bagasse procured from Saharanpur, India. The unbleached pulps of Kappa Nos. 21 and 21.5 were bleached in CEH, CEOH and CEOD bleaching sequences.

Compared to control pulp (Bagasse Soda pulp), the yield and brightness of unbleached soda-oxygen pulps are higher at almost the same Kappa Nos. (21, 21.5) and pH (10-11) of residual spent liquor.

Also both the pulps were bleached in a conventional and modified bleaching sequences such as CEH, CEOH and CEOD. The yield and brightness of bleached pulps increased at very much reduced post color no.

Therefore it may be concluded that soda-oxygen pulping technique followed with CEOH or CEOD sequence may result good pulps having lower color reversion and higher productivity. It is also expected that the effluent from soda-O_2-CEOH/CEOD sequences will also have much lower pollution loads such as COD, TOCl AND color.

The Bagasse pulps produced from soda–oxygen CEOH/CEOD sequences have better strength properties compared to soda/soda oxygen-CEH pulps.

Therefore, it is suggested that the small paper mills in India may use single stage soda oxygen pulping technique followed with hypochlorite bleaching process while for medium and large paper mills, soda/sulphate pulping followed with CEOH or CEOD bleaching techniques shall be much economical in terms of chemical and physical energy inputs and paper quality.

Key Words : Bleaching, oxygen, bagasse, chlorine dioxide, chlorine, pollution, soda pulp.

Introduction :

While India is doubtless famished in forestry, it is largest sugarcane growing country in the world. On less than 2.5% of land under cultivation. India grows and harvests about 190 million tonnes of cane every year. Only 45% of the cane presently produced reaches the sugar mills, where after saving 10% for seed etc. 35% of cane produced is crushed Due to variation of fibre content in sugar cane from 13% to 16% of cane in Northern and Southern regions of our country, the production of wet bagasse varies form 26% to 36% based on sugar cane crushed, OR 33% of the cane crushed. The balance 55% of the cane produced is used by Gur and Khandsari units from where bagasse is not available as it is used as fuel. Therefore

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oabut 22 0 million tonnes of Bagasse at about 50% moisture content is being produced annually from the Sugar mills in India. Assuming 100% availability and six tonnes wet bagasse would yield one tonne pulp, the country has already raw material adequate to produce mo·e than 36.6 lakh tonnes pulp which may be used for pulp and paper manufacture. The availability of bagasse at the end of centuary is estimated to be 40 million tonnes (wet basis) which can produce 60 lakh tonnes of pulp.

In India, bagasse is used mostly as fuel in sugar mills in order to produce energy for their use and hardly 2 5% of the total bagasse produced is used for the production of paper, paperboard and newsprint. The average calorific value of wet bagasse is about 1800 KCals/kg as compared to 5000 KCals/kg. of average grade coal and 8000 KCals/kg. of furnace oil. It means that one tonne average grade coal may substitute about 2.8 tonnes wet Bagasse (50% moisture) or 1.5 tonnes air dry bagasse. Therefore the use of bagasse for pulp/paper manufacture has to be increased by developing new technologies, such as :—

1. Incrceasing the over all thermal efficiency of the sugar mills by adopting modern technology for extraction and concentration of sugar juice and
2. Generating steam and power at much higher levels of pressure and temperature.
3. Utilisation of coal or gas in the existing or new boilers of the sugar mills.
4. Drying of bagasse or pith and pelletisation of pith for using as fuel in the sugar mills.

It is estimated that by bringing fuel economy in the sugar mills, atleast 30% of the total bagasse produced can be made available for pulp/paper industries which in turn will depend upon :-

1. Economic cost of bagasse which will depend on cost and availability of coal at the sugar mills site and
2. Firm assurance for timely supply of coal both to the sugar and paper mills

As sugarcane gives many biproducts such as Sugar, molasses and Bagasse, an integrated complex containing paper mill, sugar mill and a distillery can be quite successful. Further paper units require large powder while sugar mills need higher steam. Hence if paper and sugar mills are combined in to one integerated industrial complex, both the industries can work complementary to each other and economic viability of both the units will be much higher. Therefore, the entire bagasse from the suger mills can be used for paper manufacture and the excess power that could be generated out of the process steam requirement, can be used in paper unit.

Till to-date, Bagasse has been cooked by soda/sulphate process in which energy consumption is as 6.2 G. cals/T paper. Earlier (1) attempt has been made to conserve energy by using oxygen for cooking of wheat straw as such, and the results have been found quite encouraging. The bleaching charactaristics (2) of bagasse soda pulps have also been studied using conventional CEH process. The conventional bleaching is a source of acute pollution while the brightness of bleached pulp is hardly 75% with a reasonable pulp strength. Since the demand of present market in India is also for high quality pulp with +80% brightness, oxygen has been used at extraction stage followed with hypochlorite or chlorinedioxide which has also been used in short bleaching sequence since 1980 (3).

Results & Discussions

Studies on pulping and bleaching have been carried out in the presence of molecular oxygen and has been planned as :-

(i) Effect of molecular oxygen on degree of delignification and pulp strength.

(ii) Effect of molecular oxygen at extraction stage of a conventional bleaching sequence.

(iii) Effect of chlorine dioxide on quality of bleached pulp.

Effect of molecular oxygen on degree of delgnification

In order to study the effect of oxygen, bagasse was cooked with 14% NaOH as Na_2o alone and also in the presence of oxygen at 160° c and 120°c respectively. The results are given in Table II. The data given in the Table-II indicate that under otherwise equivalent cooking conditions except cooking temperature) oxygen has a considerable effect on degree of delignification. Soda oxygen cooking at 120°c results in unbleached pulp of almost the same quality but hig-

her yield as compared to conventional soda pulp obtained at 160° C. Unbleached pulp yield is increased by about 8% and alongwith increase in degree of brightness by 4%. The residual alkali in the black liquor was on an average 6 gpl as NaOH which is quite satisfactory in order to check precipitation of lignin and degree of corrosion, which is anticipated in the presence of oxygen. The higher yield is due to selected delignification of bagasse.

Effect of Molecular Oxygen at extraction stage of bleachitg sequences

Unbleached pulps were bleached in CEH and CEOD sequences under the conditions given at 4 (E). The results are given in Table (iii). The results indicate that brightness of soda bleached pulp increases with the use of molecular oxygen at extraction stage from 78-81.0% and the brightness of soda-oxygen bleached pulp increased from 80-83%. Simultaneously bleached pulp yield increased by about 2% while post colour No. decreased by 1.0. These results confirm that use of oxygen at extraction stage stablises the hemicelluloses and reduces degradation of cellulose Also color of effluent of alkali oxygen extraction stage was very much lighter than the effluent of alkali extraction stage.

Effect of Chlorine-di-oxide on quality of bleached pulp

In order to produce bleached pulp of very high brightness (+ 80%), the hypochlorite was replaced with chlorinedioxide which has been established to produce pulp of high brightness without degradation of cellulose. Therefore, both the unbleached pulp were bleached in CEOD sequence, under the conditions given in 4 (E). The results given in Table-(iii) indicate that the bleached pulp yield increases to 38.2% and 45.0% respectively, as compared to the pulps obtained in CEH and CEOH sequences Also the Brightness increases to 82% and 89% that is about 8% in each case while post colour no decreases drastically from 3.2-0 6. The results confirm that di-oxide is further helpful to check degradation of cellulose and to enhance brightness of pulp.

Effect of Molecular oxygen on pulp Properties

The Table -IV confirms that the paper properties of bleached pulps do not decrease on oxygen pulping. Hence degradation of carbohydrate can be avoided under controlled conditions.

TABLE-II

SODA AND SODA OXYGEN SINGLE STAGE PULPING OF BAGASSE

Sl. No.	Particulars	Unit		
1.	Chemicals used.	—	NaOH	$NaOH-O_2$
2.	Amount of chemicals used as Na_2O	%	14.0	14.0
3.	Maximum cooking temperature °C	°C	160	120
4.	Oxygen pressure at max.cooking temperature.	kgs/cm²	—	5.0
5.	Bath ratio	—	1:5	1:5
6.	$MgCo_3$ used	%	—	0.5
7.	Time to maximum temperature	Min.	60	60
8.	Time at maximum temperature	Min.	60	60
9.	Unscreened pulp yield	%	43.1%	51.0
10.	Screened yield	%	41.9	50.4
11.	Kappa No.	—	21.0	21.5
12.	Brightness	% Ecl	34	38.0
13.	Residue cutive alkali of spent liquor.	gpl	5.6	6.0
14.	pH of spent liquor. (as such)	—	10 8	11.0

TABLE–III

Bleaching Characteristics of Soda and Soda-Oxygen Unbleached Pulps

S No.	Particulars	Unit	Soda Pulps			Soda oxygen pulps		
			CEH	CEOH	CEOD	CEH	CEOH	CEOD
1.	Unbleached pulp yield.	%	41.9	41.9	41.9	50.4	50.4	50.4
2.	Kappa No.	—	21.0	21.0	21.0	21.5	21.5	21.5
3.	Brightness of unbleached pulps	%ECI	34	34	34	38	38	38
4.	Chlorine consumption at (C) stage	%	3.5	3.5	3.5	3.5	3.5	3.5
5.	Caustic consumption at (E) stage	%	1.5	1.5	1.5	1.5	1.5	1.5
6.	Chlorine consumption at (H) stage	%	3.0	3.0	—	3.0	3.0	—
7.	Chlorine consumption at (D) stage	%	—	—	3.0	—	—	3.0
8.	Bleached pulp yield	%	35.7	37.4	38.2	42.1	43.8	45.0
9.	Brightness of bleached pulps	%Ec	74	78.0	82.0	80.0	84 0	89.0
10.	Post color No.	—	3.2	2.1	1.2	2 4	1.8	0 6

TABLE – IV

Strength Properties of Bleached Pulps of Bagasse.

Sl. No.	Particulars	Soda Pulp			Single Stage Soda-Oxygen Pulp		
		CEH	CEOH	CEOD	CEH	CEOH	CEOD
1.	Double folds	86	105	120	88	110	120
2.	Burst factor	37	40	45	40	45	48
3.	Tear factor	40	50	70	45	60	75
4.	Breaking Length (M)	5770	6400	6500	6000	6500	6600

CONCLUSIONS :

From results, the following conclusions can be drawn :—

(i) The bagasse and other agro fibres can be cooked in a single stage soda-oxygen process because the lignin of agro fibres is more sensitive to the selected action of oxygen and they do not need either a pretreatment or high temperature and long cooking time.

(ii) Presence of oxygen increases the productivity and hence alkali oxygen process will save enormous paper making raw materials and also will reduce pollution load while maintaining a quality of pulp.

(iii) The modification of conventional bleaching process i.e. by introducing alkali-oxygen extraction stage, a better quality of bleached pulp is obtained to meet the demand of present paper market. Alkali oxygene extraction stage will also reduce the color of effluent which may be recirculated in the system and also can be used at other places in the pulp mill. This will finally save the water consumption and reduce the generation of bleach plant effluent.

(iv) Further modification of a bleaching process by using chlorine-dioxide at the last stage, the bleached pulps of + 80% brightness alongwith better quality in respect of high strength properties lower color reversion can be obtained

— Finally, the conventional soda-hypo process, can be modified to soda oxygen hypo process. This

process will be highly economical for small paper mills.

- Conventional sulphate CEHH process be upgraded to sulphate CEOD process which will produce the pulp of super brightness and better strength properties. The process will be quite economical and beneficial for large paper mills.
- Use of peroxide at extraction and/or last stage of bleaching sequence shall be quite economical also.
- Suggested to extend the studies on use of peroxide at extraction and last stages of bleaching sequence and characteristics and recycling of bleach plant effluents.

EXPERIMENTAL PROCEDURE :

(A) PREPARATION OF BAGASSE :

The bagasse bails were obtained from local sugar mills which were broken and depithed by manual hammering process. The pith was removed by screening through 20 mesh screen. The dry partially depithed bagasse was used for the investigation. The wet depithing of bagasse was also carried out in a Mechano chemical digester (Hydra pulper) under the following conditions.

Wetting agent	—	Water
Consistency	—	Ambient
Time	—	5 min.

After depithing the slurry was screened through 10 mesh screen. The material retained on the screen was squeered, pressed & dried in air. The results are given below.

Table—(A)

			Dry depithed
1.	Fibrous material	—	84.4%
2.	Pith and water soluble	—	15.6%

The useful fiber content in the original dry depithed bagasse and the wet depithed bagasse was determined as per TAPPI UM—3. The results are given below :—

Table— (B)

		Dry depithed bagasse	Wet Depithed bagasse
Water soluble including sugar, dirt and epidermic cell.	—	18.5%	8.5%
Pith	—	23.0%	12.5%
Fibrous Material	—	58.5%	79.0%

(B) PROXIMATE ANALYSIS OF WHOLE BAGASSE :

The Dry depithed bagasse was grounded and screened through 80 mesh screen. The material retained on 80 mesh was taken for analysis, which has been carried out as per TAPPI Standard Methods. The results are given below :

Table—(C)

1.	Solubility in cold water %	=	1.2
2.	Solubility in hot water %	=	4.2
3.	Solubility in alcohol benzene %	=	1.6
4.	Solubility in 1.0% hot NaOH %	=	37.5
5.	Ash %	=	2.7
6.	Silica %	=	1.70
7.	Lignin %	=	17.5
8.	Pentosans %	=	24.3
9.	Holocellulose %	=	68.0
10.	Alpha Cellulose %	=	42.4

(C) SODA PULPING OF BAGASSE :

Soda pulping of Dry depithed bagasse was carried out using 14% alkali as Na_2O under following cooking conditions.

S.No.	Particulars	Unit	
1.	Maximum temperature	°C	160
2.	Bath ratio	—	1 : 5
3.	Time to maximum temperature.	min.	60
4.	Time at temperature	min.	60

The cook was carried out in an electrically heated rotary digester. The cooked material was defibrated in a disc refiner. The refined pulps was washed and screened and analysed for Kappa No. Pulp yield. Results are tabulated in Table-II.

(D) SODA OXYGEN SINGLE STAGE PULPING :

The process used consists of soda cook in the presence of oxygen under pressure in the digester.

Oxygen was passed through a nonreturn valve connected to the vent valve of the digester at ambient temperature and then temperature was raised. Alkali-oxygen cooking of bagasse was carried out using 14% NaOH as Na_2O. Under the following cooking conditions.

Sl.No.	Particulars	Unit	
1.	Chemical applied as Na_2O	%	14
2.	Bath ratio	—	1:5
3.	Maximum cooking temperature	°C	120
4.	Time at maximum temperature	min	60
5.	Time at maximum temp.	min	60
6.	$MgCO_3$ added	%	0.5
7.	Oxygen pressure	Kg/cm^2	5.0

After cooking, pressure was reduced to atmospheric pressure. The pulp was discharged, and refined in the Defibrater make disc refiner. The refined pulp was washed, screened and analysed for Kappa Number and Pulp yield. Results are tabulated in Table-II.

(E) BLEACHING :

Both Soda and Soda Oxygen pulps were bleached in CEH, CEOH and CEOD sequences and the amount of chlorine was added based on Kappa Number of unbleached pulps. The conditions of each stage are given below.

(1) CEOH, CEOD and CEH Bleaching of Pulp :

(i) Chlorination State

Amount of chlorine	=	50% of T C. D. (Total chlorine demand)
Consistency	=	3.0%
Reaction Temp.	=	Ambient
pH	=	Below 2.0
Reaction Time	=	40 min.

(ii) Alkali Oxygen Extraction (CEOH/CEOD sequence)

Sl No.	Particulars	Unit	
1.	Consistency of the pulp.	%	7.0
2.	Caustic applied	%	1.5
3.	Maximum temperature.	°C	120
4.	Time at ,,	min.	60
5.	Oxygen pressure	Kg/cm^2	1.5
6.	pH		11.0

(iii) Caustic Extraction (CEH sequence)

Amount of alkali added.	=	1.5%
Consistency of pulp	=	10%
pH	=	11.0
Temperature	=	60°C
Reaction time	=	120 min.

(iv) Hypo chlorite stage (CEH & CEOH sequence)

Amount of chlorine added	=	50% of TCD
Buffer (NaOH)	=	as required
pH	=	8.5 – 9.0
Temperature	=	40 °C
Reaction time	=	120 min.
Consistency	=	10%

(v) Chlorine Dioxide Stage (CEOH sequence)

1.	Amount of chlorine dioxide added.	=	50% of TCD
2.	pH	=	3—4 0
3.	Temperature	=	80 °C
4.	Retention Time	=	180 min.
5.	Consistency	=	10%

After completion of CEOH, CEH, and CEOD bleaching sequence, the pulp was analysed for yield, brightness and post colour number. Results are tabulated in Table-III.

(F) Evaluation of bleached pulps :

The bleached bagasse pulps were beaten in a valley beater under standard conditions upto 40°SR, handsheets were made and their strength properties were determined. Results are give in Table-IV.

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