Use of Whole Bagasse, Chemi Mechanical Pulp as Filler for Duplex Boards

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INTRODUCTION :

It is the constant endeavour of any industry to improve its efficiency and economic operations through well planned modernisation and expansions. The overall capacity utilisation of paper industry reached its peak in 1976 at 77.4% but since then it has drastically declined to about 60% in 1984. Of the many reasons of lower capacity utilisation scarcity of raw materials is perhaps an important factor. After bamboo, Bagasse is now emerging as an alternate raw material of very high economic value in the Indian Paper Industry.

India is one of the largest producer of sugarcane, growing around 140 million tonnes of sugarcane every year, which if utilised fully it yield around 42 million tonnes of bagasse, capable of supporting a production of 7–8 million tonnes of paper annually, an amount more than five times the present annual consumption.

In most cases bagasse is depithed and then pulped to obtain the fibres. The resultant yields are relatively lower which results in considerable loss of cellulosic material. On the contrary if whole bagasse is pulped either mechanically or chemimechanically, the resultant yields are high and the pulp, although inferior in quality can be used with advantage in many secondary applications, such as in making filler grade pulp for duplex boards, grey boards etc.

At present, pulp from low grade letter record waste paper is used as filler in duplex boards. This material is highly contaminated and the pulp obtained is of unsatisfactory quality unless intensive sorting, screening and cleaning stages are involved.

In view of these limitations an attempt was made at the Parkhe Research Institute to produce bagasse pulp to replace the filler pulp with some distinct technical and economic advantages.

EXPERIMENTAL

Preparation of whole bagasse :

Bagasse obtained from sugarmills was used as such for experiments without washing or dust removal. The proximate analysis of bagasse used, are listed in Table No. 1.

TABLE NO. 1

PROXIMATE ANALYSIS OF BAGASSE USED FOR EXPERIMENTS

1	Moisture content, %	—	8
2	Pith content, %	—	33
3	Cold water solubility, %	—	5.3
4	Hot water solubility, %	—	7.2
5	1% NaOH solubility, %	—	40.0
6	Alcohol Benzene solubility, %	—	2 5
7	Pentosans, %	—	24.7
8	Lignin, %	—	19 2
9	Ash, %	—	2 9

Tested as per TAPPI Standard Procedures.

Pulping of whole bagasse :

The scope of the experiments was ;

(1) To obtain maximum possible yield from bagasse with minimum requirements of chemicals and power consumption to economise in process.

(2) To obtain physical properties of bagasse pulp just satisfactory to replace letter record grade pulp used in fillers for duplex boards.

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Thus, chemimechanical pulping was chosen. Chemical softening pretreatment of bagasse was carried out by using sodium hydroxide impregnation at different temperatures and periods.

During this process hydrolysis of lignin and hemicellulose takes place to a limited extent yielding more flexible fibres. Partial lignin hydrolysis, converting the native lignin to more hydrophilic substances, which absorbs water, swells and aids the separation of fibres during refining.

Due to the limited softening of raw material, more fines are produced during refining and thus the pulp resembles mechanical pulp to some extent. Presence of fines in the filler grade pulp facilitates inter-fibre bonding and adhesion of layers in duplex boards.

Different sets of experiments were carried out to evaluate the pulping characteristics of whole bagasse.

Pulping at ambient temperature :

The bagasse was treated in an open vessel with thorough mixing and disintegration for two hours. The effect of chemical charge was observed with constant bath ratio and pretreatment time (Table No. 2). It is evident from the table that though unscreened pulp yields were high, the pulp obtained was very coarse, with high percentage of rejects. This pulp was unsuitable for sheet forming.

TABLE NO. 2

WHOLE BAGASSE PULPING AT AMBIENT TEMPERATURE, VARYING THE CHEMICAL CHARGE

Sr. No.	Particulars	Expt. No. 1	2	3	4
1	NaOH added, %	0	2	4	7
2	Bath ratio	1:4	1:4	1:4	1:4
3	Soaking temp. °C	26	26	26	26
4	Soaking time. hrs.	2	2	2	2
5	No. of refiner passes	6	6	6	6
	RESULTS				
1	Unscreened yield, %	97.0	80.6	76.9	74.2

* Above pulps obtained were very coarse and no hand sheets could be couched off.

Optimisation of chemical charge and pretreatment time :

The pretreatment with alkali was carried out at 90°C with a Bagasse to liquor ratio of 1 : 4. Effect of varying the chemical charge with respect to pretreatment time on pulp characteristics was evaluated. After pretreatment the pulp was processed in 12" Aspick laboratory refiner with three passes. The results are discussed in Table No. 3.

TABLE No. 3

WHOLE BAGASSE SODA PULPING AT ELEVATED TEMPERATURE BY VARYING THE CHEMICAL CHARGE AND SOAKING TIME.

Sr. No.	Particulars	Expt No. 1	2	3	4	5	6	7	8	9
1	NaOH added,%	5	5	5	6	6	6	7	7	7
2	Bath ratio,	1 : 4	1 : 4	1 : 4	1 : 4	1 : 4	1 : 4	1 : 4	1 : 4	1 : 4
3	Soaking temp., °C	90	90	90	90	90	90	90	90	90
4	Soaking time, hrs	2	3	4	2	3	4	2	3	4
5	No. of refiner passes	3	3	3	3	3	3	3	3	3
	RESULTS									
1	Unscreened pulp yield, %	72.9	72.0	69.7	70.1	69.8	68.3	67.8	67.0	65.0
2	Screened yield, %	48.2	47.2	48.9	47.0	51.0	48.0	53.3	57.0	54.0
3	Rejects, %	24.7	24.8	20.8	23.1	18.8	20.3	14.5	10.0	11.0

* Pulp obtained with 5% and 6% NaOH addition and 2 hrs soaking time were coarse due to high omount of rejects.

From data in this set, it was observed that even 5–6% alkali pretreatment produced a pulp with 18-24% reject contents; and a very coarse pulp quality. But in case of 7% alkali charge, the pulp quality dramatically improved giving very good screened yields with low percentage rejects.

Optimisation of pretreatment temperature with constant chemical charge.

Experiments were further continued to evaluate effect of temperature on pulp quality at 7% chemical charge. Same degree of refining was done after the pulping as in the preceding cases. The observations are tabulated in Table No. 4.

Pretreatment temperature of 90°C with 3 hours soaking time has given excellent pulp with minimum rejects and good pulp characteristics.

Pulping at elevated temperature, (Semi cooking)

Some experiments were studied at elevated temperature (120°C) with various chemical dosages to observe its effect on pulp characteristics. (Table No. 5). However in this set also, since the alkali concentration was low, (4—6%), the resultant pulp, even after refining was poor in quality with high reject percentage and was unsuitable.

TABLE NO 5

WHOLE BAGASSE SODA PULPING AT ELEVATED TEMPERATURE (UNDER PRESSURE) WITH VARYING CHEMICAL CHARGE

Sr. No.	Particulars	Expt. No. 1	2	3
1	NaOH added, %	4	5	6
2	Bath ratio,	1:4	1:4	1:4
3	Soaking temp. °C	120	120	120
4	Time to 120°C, min	30	30	30
5	Time at 120°C, min	90	90	90
6	No. of refiner passes	3	3	3
RESULTS				
1	Unrcreened yield, %	78.0	76.3	74.0
2	Screened yield, %	23.4	34.0	49.8
3	Rejects, %	54.6	42 3	24 2
4	Rcsidual alkali, gpl	Nil	Nil	Nil

* Residual alkali in Black liquor was nil. Hence the rejects content in pulp were high.

TABLE No. 4

WHOLE BAGASSE SODA PULPING AT CONSTANT CHEMICAL CHARGE AND VARYING THE SOAKING TEMPERATURE

Sr. No.	Particulars	Expt. No. 1	2	3	4	5	6
1	NaOH added, %	7	7	7	7	7	7
2	Bath ratio	1 : 4	1 : 4	1 : 4	1 : 4	1 : 4	1 : 4
3	Soaking temp. °C	80	80	80	90	90	90
4	Soaking time, hrs	2	3	4	2	3	4
5	No. of refiner passes	3	3	3	3	3	3
RESULTS							
1	Unscreened yield, %	72.0	71.2	69 7	67.8	67.0	65.0
2	Screened yield, %	45.8	46.2	47.3	53 3	57.0	54.0
33	Reject, %	26.2	25.0	22.4	14.5	10.0	11.0

* Pulp obtained at 80°C temperature contents high rejects.

Recommended conditions for whole bagasse chemi-mechanical pulping :

Optimum parameters for chemimechanical pulping are concluded from Tables 2—5 and are listed in Table 6. Thus a pretreatment with 7% alkali charge at 90°C for 3 hours can give a satisfactory pulp to replace lower grade letter record pulp for use in filler grade of Duplex boards.

Comparative analysis between letter record pulp and CMP bagasse pulp.

Comparative physical strength characteristics of the above pulps are listed in Table No. 7. Overall strength properties of chemimechanical bagasse pulp are better than those of letter record pulps. Especially Burst factor and Breaking length of bagasse pulp are superior than those of letter record pulps. Only the brightness of bagasse pulp is some what lower. However this aspect is secondary for fiiller grade pulps.

TABLE NO. 6

OPTIMUM SOAKING CONDITIONS SELECTED FOR WHOLE BAGASSE CHEMI-MECHANICAL PULPING

1	NaOH requirement, %	—	7
2	Batch ratio	—	1 : 4
3	Soaking temp °C	—	90
4	Soaking time, hrs	—	3
5	No. of refiner passes	—	3

(12" Aspick/disc refiner with 20 H.P. Motor)

RESULTS

1	Unscreened yield of pulp, %	—	67.0
2	Screened yield of pulp, %	—	57.0
3	Rejects, %	—	10.0
4	pH of black liquor	—	10.4
5	Alkali consumption, %	—	92
6	Total solids in black liquor, %	—	5.8
7	Kappa No.	—	74.34

TABLE No. 7

PHYSICAL STRENGTH CHARACTERISTICS OF FILLER GRADE WASTE PAPER AND WHOLE BAGASSE CHEMIMECHANICAL PULP

Sr. No.	Particulars	Filler grade waste paper	Whole bagasse chemi-mechanical pulp
1.	Freeness of pulp, CSF mL	235	205
2.	Drainage time, Sec (for 100 GSM Sheet)	19.0	12.0
3.	Bulk, Cm^3/gm	2.26	1.85
4.	Breaking length, KM	2.3	3.9
5.	Burst factor	9.1	22.4
6.	Tear factor	54.4	60.8
7.	Double folds	8	12
8.	Brightness, °PV	55	34
9.	Fiber classification		
	Mesh No.	% Fiber retained	% Fiber retained
	+ 14	1.5	2.7
	— 14+ 28	34.6	27.1
	— 28+ 50	26.7	16.2
	— 50+100	22.1	7.9
	—100	20.9	39.8

Higher strength characteristics of bagasse pulp, if used in board manufacture as a fiiller, will definitely impart better strength to the resultant board produced. Comparison between board produced from CMP bagasse and presently used record grade pulp is enlisted in Table No. 8. It is strongly felt that boards produced from bagasse high yield pulp have superior quality than that of letter grade record pulp. There are dramatic improvements in burst and breaking length, and these parameters could go a long way in quality manufacture of Boards.

TABLE NO 8

COMPARISION BETWEEN PHYSICAL STRENGTH PROPERTIES OF DUPLEX BOARDS MADE FROM RECORD GRADE WASTE PAPER AS FILLER AND WHOLE BAGASSE CHEMIMECHANICAL PULP AS FILLER

Sr. No.	Particulars	Topliner Imported bleached hardwood pulp (30% Top liner) Wastepaper pulp	Bagasse pulp
1	GSM of board	284	298
2	Bulk, ccs/gm	1.42	1.64
3	Breaking length, KM	2.4	4 8
4	Burst factor	18.6	23.5
5	Tear factor	65.2	66.7
6	Double folds	9	5
7	Brightness °PV	75	75

Other added advantages of using bagasse in place of letter records are :

1) Uniform raw materials, hence standardised processinng parameters.

2) Contraries e. g. plastics, metals etc. are absent. Hence no sorting and less wear and tear on equipments.

Bleaching studies on whole bagasse chemi-mecahnical pulp

This study was initiated with a view to obtain pulps of moderate brightness as a filler, and ultimately reduce the percentage of top layer. At present, 30-40% virgin pulp top layer is used for board making when record grade waste paper is used as filler. The brightness of bagasse chemi-mechanical pulp and filler grade waste paper pulp are mentioned in Table No. 7.

Experimental

The bleaching of whole bagasse pulp was carried out with single hypochlorite treatment with 7 5 and 10% available Chlorine on O. D. pulp basis. (Table No. 9).

TABLE NO. 9

BLEACHING OF WHOLE BAGASSE CHEMI-MECHANICAL PULP WITH SINGLE STAGE HYPOCHLORITE

Sr. No.	Particulars	Expt. No. 1	2
1	Initial brightness of pulp, °PV	35	35
2	Cl_2 used, %	7.5	10
3	Consistancy, %	5	5
4	Temperature, °C	45	45
5	pH	>9.5	>79.5
6	Final pH	6.0	6.0
7	Time, min	90	90
8	Cl_2 consumption, %	97	95
RESULTS			
1	Brightness of pulp, %	41	43
2	Shrinkage, %	1.9	2 9

However in this study the improvement of brightness is only marginal (8 limits) even with 10% Chlorine; at approx imately 3% shrinkage. The bleachability of this pulp is not so good. However, the overall brightness of boards made from Bagasse and letter record fillers are more or less comparable and, do not show any handicap with bagasse filler.

ECONOMICS IN PULPING OF WHOLE BAGASSE CHEMI-MECHANICAL PULP AND IN PROCESSING OF WASTE PAPER PULP

1. **Cost of Raw materials for chemi-mechanical pulp**

a Whole bagasse.

Price of whole bagasse–350 Rs/ton (45 % moisture)

∴ Price of O. D. bagasse–636 Rs/ton

Requirement of O. D. bagasse/ton of pulp–1754 Tones (57% screened yield)

∴ Price of whole bagasse/ton of pulp–1115 Rs.

b Chemicals

Price of NaOH — 7500 Rs/Ton

Requirement of NaOH/ton of pulp–122.78 kg.

∴ Price of NaOH/ton of pulp–920.85 say 921 Rs.

c Steam

Steam requirement/ton of pulp–0.6 ton

price of coal – 600 Rs /ton.

∴ Price of coal/ton of pulp–90 Rs.

Summing up a, b and c the cost of raw materials for chemical pulp/ton of pulp–2126 Rs.

2 Cost of raw materials for waste paper pulp

Letter record waste paper

price of letter record—1400 Rs/ton (10% moisture)

∴ price of O.D. waste paper — 1555 Rs/ton

Requirement of O D. waste paper/ton of pulp 1 250 tonnes (80% yield)

∴ price of waste paper/ton of pulp — 1945 Rs.

CONCLUSIONS AND RECOMMENDATIONS :

1 Optimum conditions for pretreatment, pulping and refining of Bagasse have been established.

These are—

a) NaOH requirement, %	—	7
b) Bath ratio	—	1 : 4
c) Soaking temperature, °C	—	90
d) Soaking time, hrs	—	3
e) No. of refiner passes	—	3
f) Yielp of pulp, %	—	67

2 The pulp obtained shows satisfactory qualities as filler grade pulp for manufacture of Duplex Boards.

3 Use of low alkali (e g. 4, 5% NaOH) and low temperature (e.g. 26—30°C) does not produce a pulp having the required characteristics to substitute record grade waste paper. These pulps are coarse and contain fines which gives problems during couching sheet. Drainage characteristics are also poor.

4 The effect of dry shredding of bagasse in order to get better penetration of alkali and to improve screened yields are also studied. But dry shredding damages the fiber structure and reduces the strength.

5 The effect of partial depithing of bagasse is also studied but this does not show any advantages in lowering the alkali requirement to get good pulp. Yields are also considerably reduced.

6 The pulp obtained with optimum soaking conditions has better strength characteristics than waste paper. Thus the overall strength characteristics of duplex board are better than conventional waste paper duplex boards.

7 The drainage time required to bagasse chemimechanical pulp is lower than filler grade waste paper. The fiber classification data also shows that pecerntage fines in bagasse chemi-mechanical pulp are lower than waste paper pulp. So this aspect may reduce the soiling of felt compared to waste paper. However high pressure water jets may be required to clean the felts as this pulp is slightly sticky in nature.

8 The bleaching of whole bagasse chemi-mechanical pulp is also studied. But the bleachability of this pulp is not good and as there is no brighness difference in top liner by using waste paper and bagasse chemi-mechanical pulp. The bleaching of this pulp is not necessary. Economics and pollution load will not permit this stage. However it may be necessary to use partially bleached Bagasse pulp as under liner to reduce the percentage of top liner virgin pulp and manufacture Duplex Boards with more than 75% Bagasse content.

9 The refining energy requirement is found to be same in processing both the pulps to get desired freeness level.

10 The consumption of alkali during optimum soaking conditions is about 92%, so the black liquor extracted from pulp requires mild acidification to reduce the pH. This black liquor also contains very low total solids. This can be further used for agricultural purposes.

11 The soaking of whole bagasse should preferably be carried out in rotary spherical digester in order to reduce the steam requirement and the losses due to radiation. This can also be carried out in hydrapulper, but due to limitations of consistency and heat losses due to radiation the steam requirement will be more (3-4 times more than spherical digester). So wherever the condensate water, flash steam or exhaust steam is available, this process can be carried out in hydrapulpers,

12 The improved bulk of the duplex board by using bagasse pulp is another additional advantage over record grade waste paper.

13 Preliminary cost estimates indicates that Bagasse chemi-mechanical pulp is costlier than letter record grade waste paper. However by reducing the

virgin pulp content in top liner, and thereby adjusting the overall Bagasse content of the Duplex Boards to 75%, the existing rebate can be obtained. This will amply compensate the increased cost of Bagasse filler grade pulp and, earn extra dividends.

14 The proccss suggested in this paper may be advantageous to paper mills situated near vicinity of sugar mills because the availability and cost of Bagasse.

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