C. T: Dathathreya
P. A. Pai
M. B. Jauhari
R. L. Bhargava

Cotton Linters For Pulp & Papermaking

Cotton linter samples obtained from various sources along with a cotton sample obtained locally were evaluated for their suitability for papermaking purposes. For the sake of convenience these samples have been designated as sample No. 1, 2, 3 (source Maharashtra) & 4 respectively. After carrying out a few preliminary experiments, it was found that it is necessary to adopt the procedure i) a first stage mechanical treatment to remove hull portions and other extraneous matter, ii) kier boiling with to 7 to 10% caustic at a material to liquid ratio of 1:7 in closed rotary pressure vessels at 140°C-150°C for about 3 hours with a small amount of soap or wetting agent (0.1%), iii) cleaning of kier boiled pulps to remove incompletely dissolved hull portions etc , iv) single stage hypochlorite bleaching with of the cleaned pulp with 1.6 to 2% available chlorine as hypochlorite NaOH buffer to maintain a final pH of not less than 8 5 and also with a small amount of sulphamic acid (0.1 to 0.15%), v) final cleaning. Mechanical cleaning losses vary between 30 to 40%, and bleach losses between 2 to 3%. The overall bleached pulp yield on original material basis were about 62 and 72% for sample 1 and 3, and 43% for sample 2. The yield for sample 4 (cotton) was 87.2%. Brightness values were 65.9, 71.5 and 81.5% and CED viscosities 36.5, 24.1 and 50.6 cP respectively for sample 1, 3 and 4.

Burst factor and Breaking lengths of linter pulps and crude cotton pulps are lower than those of bleached bamboo kraft at the same freeness level. However tear factors and stretch are very high as compared to bamboo pulp. Therefore in admixture with short fibred pulps, linters pulps have good potential to give higher wet web strength and higher tear in dried papers.

Objective

Commercial cotton seed usually consists of about 10-15% linters, 35-40% hulls and 50-55% kernals. Linters consist largely of cellulose and impurities mainly consisting of particles of plant stalks, cockleburs and cottonseed hulls and dirt. These impurities make the marketing and utilization of linters difficult.

This project was undertaken to study the possibility of *obtaining purified linters either for papermaking or for any other suitable use.*

Raw materials

Three raw cotton linter samples were obtained from two sources in the Maharashtra State. The three samples differed from each other in dirt content and other physical characteristics. Sample 2 was very dirty as compared to sample 1 and sample 3.

C. T. Dathathreya, Research Chemist,

P. A. Pai, Chemist

M. B. Jauhari, Senior Research Officer, Research Centre, West Coast Paper mills Ltd.

R. L. Bhargava–General Manager, West Coast Paper Mills Ltd., Dendeli (N.K.), Karnataka State.

Experimental

(a) A few preliminary experiments were carried out on sample 1 to find out whether these linters can be purified by bleaching only with calcium hypochlorite. Upto 7.5% available Cl_2 on pulp was used at 5% consistency, 45°C temp. with a retention time of 1 hour. Though the pulp portion was brightened, the hull portions could not be bleached.

(b) Therefore it was decided to have kier boiling stages for further work. The original material was treated with NaOH solution at 140°C for 1+ 1 hour* at a material to liquid ratio of 1:7. The results are given below :

*1 hour to raise to 140°C and 1 hour at 140°C.

Experiment No.	1	2	3
NaOH as such on linters, %	3	5	7
pH of spent liquor	8.8	9.6	10.4
Pulp yield, %	82 0	79.4	79.2

The above pulps were bleached with 5% (available chlorine). Calcium hypochlorite at 5% consistency, 45°C temp., 1 hr. retention time. However, inspite of kier boiling and bleaching, hull portions were present in oonsiderable quantity in the kier boiled as well as bleached pulp.

The above experiments lead us to decide to use the following conditions for further experiments namely :

i) a first stage mechanical treatment to remove hull portions as much as possible.

ii) kier boiling these mechanically cleaned linters with suitable amount of caustic soda.

iii) vortex cleaning of kier boiled pulps to eliminate incompletely dissolved hull portions.

iv) one stage hypochlorite bleaching of the above cleaned pulp and final cleaning to eliminate unbleached hull portions.

Using the above conditions, three experiments were carried out for all the three samples. Initial mechanical cleaning was done by slightly hammering 300 g. of samples on a 13 mm mesh. The portions remaining on the sieve was used for further experiments and those passing through were rejected (this contained major amount dirt, hull portions and a small amount of linters).

Experimental conditions and results are given in Table I.

The results clearly indicate that by using the above method of purification, good pulp could be made from Samples 1 and 3. However, for sample 2 the final brightness that could be obtained even after HEH sequence was 72.1% only. This can be ascribed to the condition of the original material which was verv dirty and solid. Also the final yield of this sample is very low as compared to the other two.

One more important point which is evident from the analysis of

Table I—Mechanical Cleaning, Kier Boiling & Bleaching

Sample No.	1	2	3
Mecchanical Cleaning :			
Accepts, %	86.3	78.1	95.1
Rejects, %	13.7	21.9	4.9
Kier boiling : (100 g. accepts were cooked in bomb digesters)			
NaOH, %	10	10	5
Time, hrs.	1+2	1+2	1+2
Temp., °C	150	150	150
Material to liquid ratio	1:7	1:7	1:7
Soap, %	0.1	0.1	0.1
Results :			
NaOH consumed, %	7.6	8.6	4.9
Yield, %	73.3	61.6	79.1
Rejects, %	2.6	2 4	2.3
Spent liquor analysis :			
pH	11.4	10.7	9.0
Total solids, g/l	45.0	53.3	30.1
Total solids, %	4.4	5.2	3.0
Colour, Pt Co. units	82,500	80,000	47,500
COD, mg/l	72,200	54.150	40,930
BOD, ,,	10,200	—	6,070
Bleaching*			
Hypochlorite, %	5	5	5
Hypochlorite consumed, %	3.2	3.5	3 5
Final pH	7.2	7.4	7.3
Bleached pulp yield, %	98.4	89.4	97 3
Rejects, %	0.4	0.2	0.6
Brightness, %	81.1	72.1**	77.2
Yield on original material, %	62.2	43.0	73.4

***Bleaching Conditions** : 5% consistency, 45°C temp., 1 hr. retention time.

**This brightness was obtained after bleaching kier boiled linters by HEH sequence (3.5% available chloride in 1st stage, 1% alkali in 2nd stage and 1.5% available Cl_2 in 3rd stage).

spent liquor is that it contributes a high colour, COD and BOD load on the stream into which it is discharged. Hence this aspect has to be kept in view while putting up a plant.

As the brightness of pulp from sample 2 was low, many alternatives such as i) 1% HCl treatment, followed by 3% hypochlorite ii) 3% hypochlorite followed by 1% HCl treatment, iii) 3% hypochlorite followed by 1.5% SO_2 treatment were given to the kier boiled sample. The hypochlorite treatments were as given earlier and HCl and SO_2 treatments were given at 5% consistency, room temp. for a retention time of 15 minutes. The brightness of these bleached pulps were 72, 68.4 and 68% respectively. This indicated that the above treatments were not beneficial. Therefore, this sample was eliminated for further work. On the basis of above work, samples 1 and 3 were selected for further work. In addition a crude variety of cotton sample obtained from the local market was also evaluated for a comparison.

The conditions of kier boiling and bleaching along with the results are given in Table II. The kier boiling and bleaching conditions were derived by carrying out many small scale experiments.

For sample 1, it was found from small scale experiments that about 4% hypochlorite was required to get about 80% brightness. On this basis pulp required for a lab. beater charge was bleached with 4% hypochlorite and strength properties of the handsheets prepared at four freeness levels were determined (Table III). It can be seen from Table III that the strength properties are very poor. The viscosity determination of the bleached pulp was highly degraded, bacause the CED viscosities of original, kier boiled and bleached pulps were respectively 181, 197, and 4.6 cP. This clearly sets a limit to the brightness attainable only by hypochlorite bleaching, i. e., degradation cannot be avoided even by maintaining proper pH and other conditions, if the higher brightness has to be obtained by single stage hypochlorite only.

To substantiate the above view,

Table II–Large Scale Kier Boiling, Cleaning & Bleaching

Sample No.	1	2	3	4* (Crude cotton)
Kier boiling**				
Amount of accepts used, equivalent to OD Wt., g.	510	486	357	600
NaOH, %	10	10	—	5
Time. hrs.	142	142	142	142
Temperature °C	150	150	150	130
Material to liquid ratio	1:7	1:7	1:7	1:7
Soap, %	0.1	0.1	0.1	0.1
Results :				
pH of spent liquor	11.1	11.1	9.6	11.2
NaOH consumed, %	7.3	7.3	6.2	3.6
Pulp yield, %	75.5	74.8	75 8	87.8
Rejects, %	2.9	3.2	—	—
Unbld. pulp yield on original material basis, %	64.0	64.4	72.0	87.8
Bleaching :				
Calcium hypochlorite, %	4.0	2.0	2.0	1.5
Consistency, %	5	5	5	5
Temperature °C	35-40	35-40	40-45	40-45
Retention time, hrs.	3	3	2.5	2.0
Sulphamic acid, %	Nil	0.125	0.125	0.125
NaOH for buffering, %	Nil	0.2	0 48	0.35
Final pH	7.5	8.5-9.5	8.5-9.5	9.5
Hypochlorite consumed, % (on pulp basis)	2.42	0.96	1.57	1.05
Bleached pulp yield, %	97.5	97.4	98.5	99.5
Bld. pulp yield on original material basis, %	62.4	62.7	71.0	87.2
Bld. pulp brightness, %	79.1	65.9	71.5	81.5
CED Viscosity, cP	4.6	36.5	24.1	50.6

* Crude variety of cotton sample obtained from the local market.

** For kier boiling after mechanical cleaning as described earlier were used except for sample 4 which was used as such.

another expt. was carried out using only 2% hypochlorite for bleaching and maintaining proper pH by buffering and also by using sulphamic acid to lessen degradation. As can be seen from the results of Table III, the strength properties of handsheets are far better than the pulp bleached with 4% hypochlorite. Hence for sample 3 and 4 lower amount of hypochlorite (2 and 1.5% respectively) were found to be suitable to preserve viscosity at a good level. These values were arrived at by a series of small scale experiments.

Table IV gives a comparative picture of the strength properties of bleached pulp handsheets for the three samples 1, 3 and 4, and also a bleached kraft pulp of bamboo.

It can be observed from the results that the burst factors and breaking lengths of linter pulps and cotton pulp are lower than that of bamboo pulp at the same °SR level. Therefore to get higher burst and breaking lengths

Table III—Strength Properties of Pulp of Sample 1

	Sample of CED Viscosity 4.6 cP, Brightness 79 7%					Sample of CED Viscosity 36.5 cP, Brightness 65.9%		
Initial slowness, °SR	8							
Final Slowness, °SR	30	45	51	61	20	28.5	42.5	50.5
Beating time, Min.	20	25	27	30	30	40	50	55
Drainage time, Sec.	5	6	7	8.5	4.5	5.5	9.3	13.2
Basis Wt , g/m²	61.6	61.0	58.6	59.2	63 3	61.7	61.6	58.5
Bulk, cm³/g	1.82	1.71	1.68	1.62	1.83	1.69	1.58	1.56
Breaking length, km	2.45	2.85	3.11	3.36	3.03	3.87	4.82	4.94
Stretch, %	3.3	3.2	3.4	3.6	3.3	3.7	3.6	3.4
Tear factor	85.6	82.5	77.5	73 4	187	174	155	149
Burst factor	17.5	20.7	20.8	22.1	23.7	29.1	34.1	36 6
Double folds (MIT)	9	13	13	17	26	43	92	101
Porosity (Bendtsen), ml/min.	1740	770	600	250	2405	685	173	101
Specific Scattering Coefficient, cm²/g	367	381	384	391	351	353	362	365
Wet web strength, Mtr.	21.3	—	21.3	—	—	44.3	55 0	—

Table IV—Strength Properties of Pulps of Samples 1. 3 & 4

Nos. Particulars	Sample 1			Sample 3			Sample 4 Crude cotton			Bleached Bamboo kraft*					
1. Final slowness, °SR	20	28 5	42.5	50.5	40	49	59	20	30	39	53	24	35	45	55
2. Beating time, Min.	30	40	50	55	35	40	45	35	45	55	65	3	7	11	14
3. Drainage time, Secs	4.5	5.5	9.8	13 2	11.0	16.0	33.0	4 0	6.5	11.5	22.0	—	—	—	—
4. Basis Wt., g/m²	63.3	61.7	61.6	58.5	60.4	56.6	60 2	59.8	60.1	61.8	60.7	58.8	59.4	59.6	59.4
5. Thickness,/um	116	104	97	91	97.4	89.1	88.8	113	111	105	97	99.6	93.9	88.6	85.1
6. Bulk, cm3/g	1.83	1.69	1.58	1.56	1.62	1.57	1.48	1.89	1.85	1.70	1.69	1.69	1.58	1.49	1.44
7. Breaking length, km	3.03	3.87	4.82	4.94	4.76	4 57	5.2	2.59	3.11	3.64	4.34	5.58	7.00	7.30	7.58
8. Streteh, %	3.3	3.7	3.6	3.4	4 5	4.9	5.0	3 7	4 3	5 4	5.6	2.2	2.7	2.7	2.7
9. Tear factor	187	174	155	149	259	221	196	408	420	347	303	93.5	77.5	74.6	70.8
10. Burst factor	23.7	29.1	34.1	36.6	39.3	40.6	41.5	27.2	30.2	33.4	38.1	33.5	40.6	42.9	43.8
11. Double folds MIT	26	43	92	101	361	445	883	103	167	452	1154	38	89	178	189
12. Porosity (Bendtsen) ml/min.	2405	685	173	101	85	45	20	560	340	93	39	–	–	–	–
13. Specific Scattering Coefficient, cm²/g	351	353	362	365	361	343	319	314	314	317	306	–	—	–	–
14. Wet web strength, Metres	—	44.3	55.0	–	72	—	71.4	–	65.1	75.0	–	–	–	–	—
15. Brightness of pulp, %		6 5. 9				71.5			8 1. 5				80.2		
16. Viscosity, CED, cP		3 6. 5				24.1			5 0. 6				16.9		

*Unbleached pulp of Kappa No. 50.5 was bleached with 14.7% A. Cl_2 by CEHH sequence.

these pulps have to be beaten to higher °SR with the added disadvantages of high drainage time.

Stretch values are higher for linter pulps and cotton pulp as compared to bamboo pulp. Tear factor is high for linter pulps as compared to bamboo pulp and it is very high for cotton pulp. This is expected because of the long fibre lengths for cotton pulps. Wet web strengths are high for linter and cotton pulps, as also folding endurance.

Hence the results indicated that linter pulps may be beneficially admixed with other short fibred pulps to improve wet web strength and also dried sheet tear and strength properties.

Conclusions :

1) Cotton linter can be used as papermaking material after suitable purification.

2) It is doubtful that 100% linter pulp will be economical for papermaking.

3) In admixture with short fiibred pulps, the linter pulps have good potential to give higher wet web strengths and higher tear in dried paper.

4) The economic evaluation as to the amount of linter pulp that can be profitably admixed or used alone can be done on the basis of cost of original material, freight, cost of caustic soda, bleaching chemicals and capital required.

5) If cotton linters have to be processed exclusively it poses a pollution problem on the stream into which it is discharged. The BOD load calculated for the Maharashtra sample in the kier boiling step (exerted by the spent liquor) will be about 71.0 Kgs/ton of the raw material processed. This can be prevented only if it is processed in a kraft mill with a recovery system which can completely use this spent liquor also.