

Pulping studies of cotton linters

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SUMMARY

Laboratory experiments on the pulping of cotton linters are described. It is observed that unbleached yield of 80% can be obtained when it is pulped with 6% chemicals for 5 hours in the laboratory. The pulp is easier to bleach. The pulp yield in the Pilot Plant is lower than the laboratory trials as expected due to the fact that 36/40 wire mesh screen is used for washing of both unbleached and bleached pulp in the Pilot Plant instead of 60 mesh screen used in the laboratory. The strength properties of the blended pulp with the mill pulp are also satisfactory.

India has the largest area in the World under cotton cultivation which is more than one fourth of the World hectareage and the production is about 8.4% of the world production. The total area under production is over 7.7 million hectares¹. Cultivated cotton fall under 4 species of *Gossypium* L. viz *G. arboreum* L, *G. barbadense* L, *G. herbaceum*, L, and *G. hirsutum*. L. Each of these species comprises a large number of races based on geographical distribution and associated genetical features. Although India grows a number of cotton types belonging to all the above species except *G. barbadense* which is only to be found as a home yard plant in many states, commercially the cotton belonging to *G. herbaceum* constitute a large percentage of medium staple cotton grown in the country.

Sowing is done in the northern parts in June and in August-October in southern parts. The duration of the crop season in India is a 6 to 8 months¹.

Cotton linter for the present investigation was received from M/s Gujarat State Corporation, Gujarat. It was of good quality and the presence of kernel was negligible. Laboratory pulping studies were carried out and based on these pulping trials Pilot Plant studies were conducted.

EXPERIMENTAL

Cotton linter pulping trials were carried out in an electrically heated indirect forced circulation

digester of 30 litres capacity. The cooking conditions and results are recorded in table-1. Cotton linter unbleached pulp was bleached with different Calcium hypochlorite dosages in a single stage blea-

Table—1
LABORATORY DIGESTION OF
COTTON LINTER

S. No.	Particulars	EXPERIMENT		
		1	2	3
1.	Active alkali as Na ₂ O (%)	6.0	6.0	7.0
2.	Sulphidity (%)	9.67	15.5	9.67
3.	Bath ratio	1:3.5	1:3.5	1:3.5
4.	Temperature raised(°C)	140	150	150
5.	Cooking schedule			
	(i) Time required to raise temp. (mts)	60	60	60
	(ii) Hold time (mts) at maximum temp	240	240	240
	(iii) Total cooking time (mts)	300	300	300
6.	Yield unbleached (%) on O.D. Basis	82.75	79.5	78.25
7.	Black Liquor Analysis			
	(i) °TW at 60°C	6.0	6.5	8.5
	(ii) R.A.A. as Na ₂ O (gpl)	7.75	10.85	11.5
	(iii) Total solids (%)	7.75	8.5	10.5

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ching to optimise the hypochlorite stage. The bleaching conditions and results are given in table-2. Unbleached and bleached cotton linter pulps (under optimum beaching condition experiment No. 5, table-2) were beaten in a laboratory valley beater at different °SR freeness. Standard sheets were made and tested as Tappi Standard. The physical strength properties of unbleached and bleached cotton linter pulps are tabulated in table-3 and 4 respectively.

Bleached cotton linter pulp and mill pulp were beaten to 40°SR in a laboratory valley beater and blended in different proportions. The physical strength properties of the various blends are given in table-5.

PILOT PLANT TRIALS

Pilot Plant pulping trials were conducted under the same laboratory conditions in a 25 M³ capacity rotary digester. Washing and bleaching of cotton linter pulp were carried out in a Hollender beater of 11 M³ capacity.

During washing the stock consistency of the pulp was kept 5.0-6%. The unbleached and bleached cotton linter pulps of the Pilot Plant were beaten to different °SR freeness, in a laboratory valley beater. Standard sheets were made and tested as per Tappi Standards. The physical strength properties of unbleached and bleached cotton linter pulps are recorded in table-6 and 7. Bleached cotton

TABLE—2 OPTIMIZATION OF HYPOCHLORITE BLEACHING CONDITION OF COTTON LINTER, PULP

Sl. No.	Particulars	Experiment Number				
		1	2	3	4	5
1.	Pulp (g) (OD)	50	50	50	50	50
2.	Hypochlorite applied as chlorine on (OD) pulp (%)	1.0	1.5	2.0	2.5	3.0
3.	Consistency (%)	5.0	5.0	5.0	5.0	5.0
4.	Temp.°C	40±1	40±1	40±1	40±1	40±1
5.	Retention time (mts)	120	120	120	120	120
6.	pH during bleaching	9.10	9.10	9.10	9.10	9.10
RESULTS :						
1.	End pH	8.0	8.1	8.1	7.8	7.9
2.	Chlorine consumption (%)	68.05	60.00	54.00	36.08	31.3
3.	Brightness % (P.V.)	74.5	75.5	77.0	78.0	79.5
4.	Viscosity (0.5%) CED Cps	4.47	4.22	4.09	3.97	3.72
5.	Copper No.	1.08	1.14	1.21	1.27	1.40

*Pulp chosen from experiment No. 1

TABLE—3 PHYSICAL STENGTH PROPERTIES OF UNBLEACHED COTTON LINTER PULP (LABORATORY)

Sl. No.	Experiment No. I				Experiment No. II				Experiment No. III			
	20	30	40	50	20	30	40	50	20	30	40	50
1.	Pulp beaten (°SR)	100	96	87	90	94	90	92	92	88	87	87
2.	Calipers (micrones)	1.68	1.66	1.57	1.58	1.57	1.52	1.50	1.45	1.54	1.46	1.44
3.	Bulk cc/gm											
4.	Tensile Index (N.m/g)	32.84	37.53	43.8	48.0	27.58	33.06	41.65	46.56	33.24	37.89	41.37
5.	Tear index (mNM ² /g)	15.93	14.24	10.64	11.78	16.42	15.86	14.08	13.31	17.19	15.67	13.19
6.	Bursting Index (KPam ² /g)	2.15	2.51	3.09	3.31	1.98	2.12	2.56	2.98	1.63	1.84	2.22
7.	Double fold	125	210	460	500	65	105	305	330	45	95	250

Table—4
PHYSICAL STRENGTH PROPERTIES OF BLEACHED COTTON LINTER PULP (LABORATORY)

S.No.	Particulars	Results			
1.	Beaten freeness° SR	20	30	40	50
2.	Calipers (microns)	116	112	115	90
3.	Bulk cc/gm	1.96	1.85	1.77	1.66
4.	Tensile index(N.m/g)	19.3	25.47	32.17	34.9
5.	Tear index(mN.m ² /g)	10.62	9.42	8.27	7.98
6.	Burst index (KPa m ² /g)	10.62	9.42	8.27	7.98
7.	Double fold	15	25	45	50

linter pulp beaten at 40°SR was blended in different proportions of mill pulp (beaten at 4°SR). The pulp evaluation data is given in table-8.

DISCUSSION

Cotton linter digested with 6.0% and 7.0% active alkali as Na₂O at temperature 140°C, 150°C respectively, resulted in unbleached pulp yield 82.75%, 79.5% and 78.25% respectively. Bath ratio kept 1:3.5 in all the above experiments was found satisfactory as per literature³. The black liquor analysis (table-1) shows that the chemical applied for cooking was sufficient.

Unbleached cotton linter pulp (experiment No. 2, table-1) bleached with 1.0%, 1.5%, 2.0%,

TABLE 5 PHYSICAL STRENGTH PROPERTIES OF BLENDED COTTON LINTER PULP WITH BLEACHED BAMBOO PULP (AT 40°SR)- (LABORATORY RESULTS)

Sl. No.	Particulars	Cotton Linter				Bamboo Pulp			
		100:0	90:10	80:20	50:50	30:70	20:80	10:90	0:100
1.	Calipers (microns)	115	94	99	95	95	92	94	92
2.	Bulk (cc/g)	1.77	1.64	1.65	1.60	1.57	1.54	1.54	1.56
3.	Tensile index (N.m/g)	22.17	32.50	35.57	44.25	46.29	51.79	52.79	54.83
4.	Tear index (m.Nm ² /g)	8.27	6.83	5.91	5.31	4.41	3.96	3.32	4.18
5.	Burst index (Kpa m ² /g)	1.96	2.04	2.46	2.82	3.01	3.15	3.30	3.40
6.	Double fold	45	40	40	40	30	25	25	25

Table—6
PHYSICAL STRENGTH PROPERTIES OF UNBLEACHED COTTON LINTER PULP. (PILOT PLANT)

S. No.	Particulars	Results			
1.	Pulp beaten (°SR)	20	30	40	50
2.	Calipers (microns)	105	98	86	88
3.	Bulk (cc/g)	2.31	1.97	1.76	1.76
4.	Tensile index(N.m/g)	11.99	18.71	27.09	28.69
5.	Tear index(mN m ² /g)	6.47	5.61	4.90	4.62
6.	Burst index (KPa m ² /g)	1.43	1.84	2.10	2.23
7.	Double fold	4	7	14	16

Table—7
PHYSICAL STRENGTH PROPERTIES OF BLEACHED COTTON LINTER PULP. (PILOT PLANT)

S. No.	Particulars	Results			
1.	Beaten freeness °SR	20	30	40	50
2.	Calipers (microns)	127	125	117	110
3.	Bulk (cc/g)	2.24	2.15	1.91	1.88
4.	Tensile index(N.m/g)	11.76	16.93	21.35	22.98
5.	Tear index(m.Nm ² /g)	6.58	5.75	5.52	5.37
6.	Burst index (KPa m ² /g)	1.12	1.43	1.64	1.76
7.	Double fold	3	7	10	11

2.5% and 3.0% Calcium hypochlorite in a single stage bleaching shows that 3.0% Calcium hypochlorite was optimum for attaining a pulp brightness around 80% P. V. Copper No. and P. C. No. of bleached pulps show that these pulps have not degraded during bleaching table—2.

The pulp evaluation data of unbleached and bleached pulps of cotton linter recorded in table 3 and 4 and represented in Figs 1 and 2. (Tensile Index, Burst Index and Tear Index versus freeness° SR) shows that the pulps have satisfactory physical strength properties.

Bleached cotton linter pulp (Experiment no. 5, table—3) was beaten to 40° SR blended with mill pulp beaten at 40° SR in 90:10, 80:20, 50:50, 30:70, 20:80, 10:90 and 100% proportions. The physical strength properties of blended pulps are recorded in Table—5. Physical strength properties (Tensile Index, Burst Index and Tear Index versus freeness° SR depicted in Fig. 3 showst hat Tensile Index, Burst Index increases with increase in the mill pulp. Proportion and reverse trend was observed with tear index. It can be concluded that mill pulp can be easily blended in 50:50 proportion to produce good quality of paper.

Pulping trials of cotton linter were carried out in the Pilot Plant using identical optimum cooking conditions as followed in the laboratory.

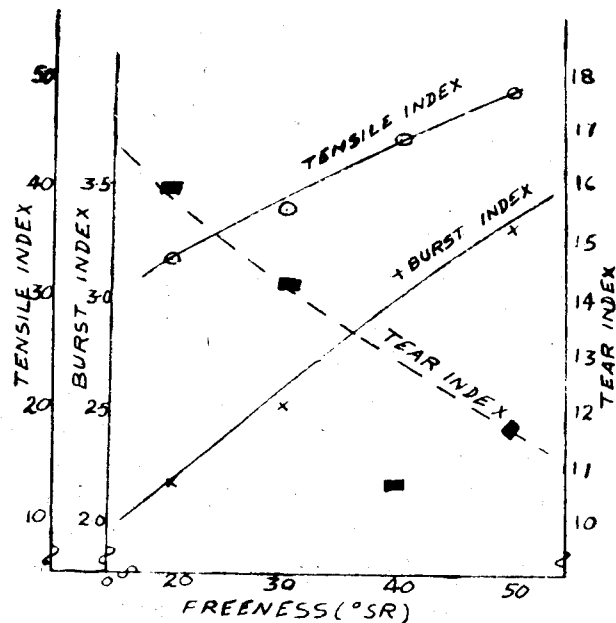


Fig. 1—Strength Properties of Unbleached Cotton Linter Pulp (LAB)

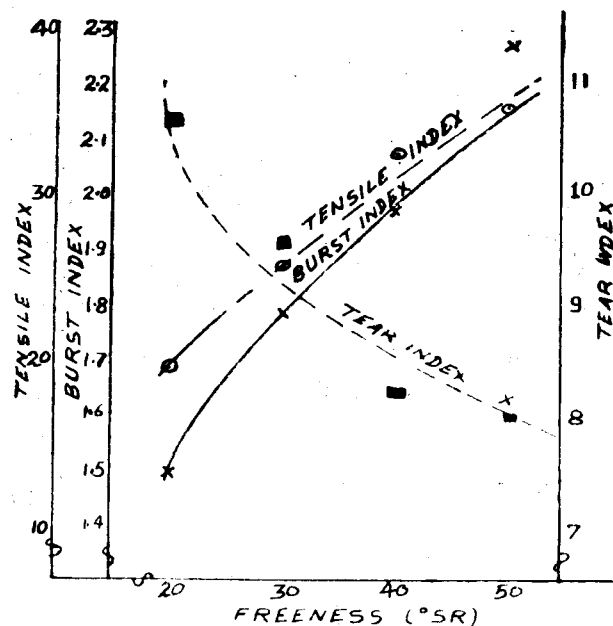


Fig. 2—Strength Properties of Bleached Cotton Linter Pulp (LAB)

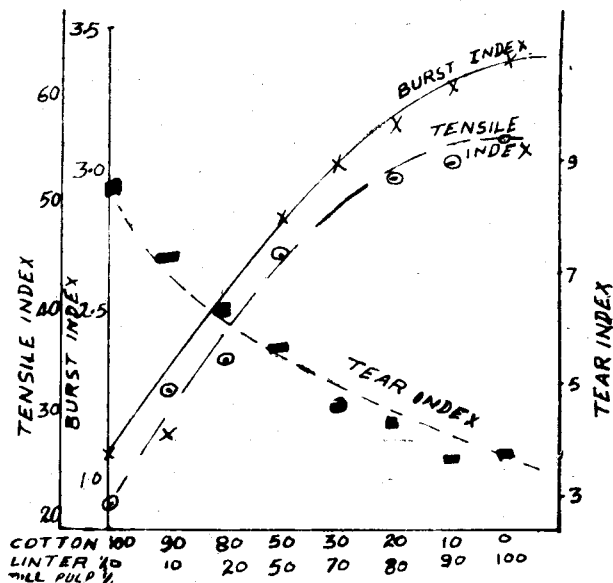


Fig. 3—Physical Strength Properties of cotton Linter (BLD) Pulp & Mill Pulp (BLD) Beaten & Blended Inlab.

The physical strength properties of Pilot Plant cotton linter pulp beaten at different freeness^o SR in the Laboratory are recorded in table—6. Physical strength properties, Tensile Index, Burst Index and Tear Index depicted in Fig.4 against freeness shows that the strength properties are satisfactory. Cotton linter unbleached pulp (produced in the Pilot Plant) was bleached in a Hollender beater under the identical conditions as followed in the Laboratory. The bleached pulp yield was 70% in the Pilot Plant. This lower yield is due to the fact that washing in the Hollender beater was carried out using 36×40 mesh. Screen and the

decker had also 36×40 mesh screen.

Bleached cotton linterpulp beaten at 40°SR and blended with mill pulp in 90:10, 80:20, 50:50, 30:70, 20:80, 10:90 and 100% shows that the physical strength of the blends are inferior to the blends of laboratory pulps table—8. The physical strength properties viz Tensile Index, Burst Index, Tear Index of various blends projected in Fig. 6 against freeness^oSR shows that Tensile Index, Burst Index in the blends increases in millpulp proportions.

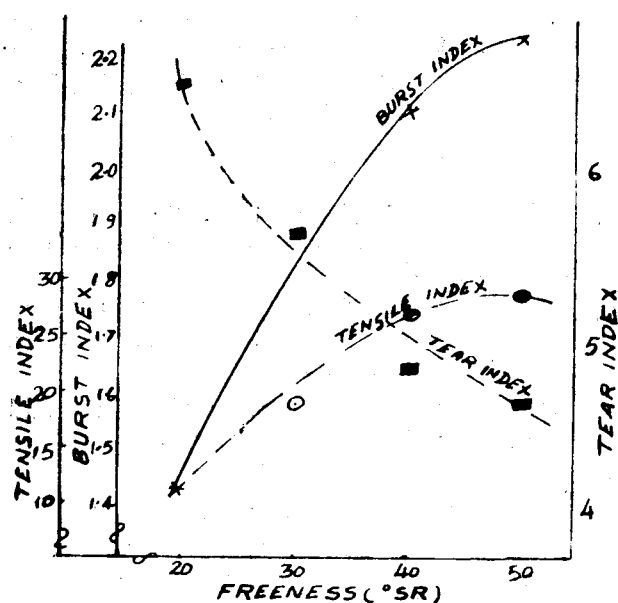


Fig. 4—Physical Strength Properties of Unbleached Cotton Linter Pulp (Pilot Plant)

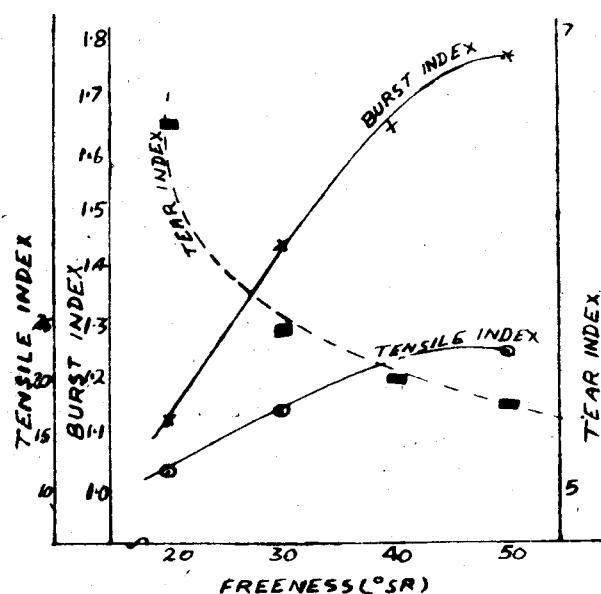


Fig. 5—Physical Strength Properties of Bleached Cotton Linter Pulp (Pilot Plant)

TABLE—8 PHYSICAL STRENGTH PROPERTIES OF BLENDED COTTON LINTER PULP WITH BLEACHED BAMBOO PULP (40°SR) (PILOT PLANT RESULTS)

Sl. No.	Particulars	Cotton Linter Pulp					Bamboo Pulp		
		100:0	90:10	80:20	50:50	30:70	20:80	10:90	0.100
1.	Calipers (microns)	117	108	105	101	99	94	94	95
2.	Bulk (cc/g)	1.91	1.84	1.78	1.69	1.65	1.66	1.60	1.58
3.	Tensile index (N.m/g)	21.35	23.52	24.48	32.89	37.15	44.01	44.53	53.37
4.	Tear index (mN m ² /g)	5.52	4.85	4.98	5.25	5.24	5.73	6.00	6.53
5.	Burst Index (KPa m ² /g)	1.64	1.50	1.65	1.97	2.37	2.52	2.58	2.85
6.	Double fold	10	10	12	15	30	60	90	100

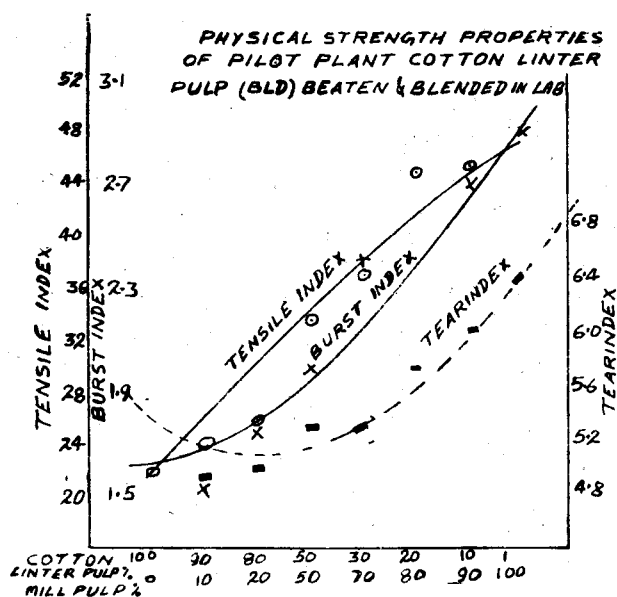


Fig. 6

CONCLUSION :

1. Cotton linter can be used as paper making material after suitable purification.
2. In admixture with short fibred pulps the linter pulps have good potential to give higher wet web strength and higher tear in dried paper.

3. It has been proved that the cotton linter can easily be cooled by 6-7% chemicals keeping bath ratio 1:3.5.
4. The cotton linter bleached pulp may be blended upto 50% with bleached bamboo pulp to obtain desired satisfactory strength properties.

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