Sugar - cane 'rind' fibre for pulping & paper making

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ABSTRACT : Fractionation of sugar-cane for optimal use is the new technology. "Rind Fibre" obtained by such fractionation was tested for its pulp and paper making ability.

"Rind Fibre" is low in pith content, lends itself to satisfactory soda chemical pulping and conventional three stage bleaching. The physical strength characteristics of both the unbleached & bleached pulp are higher compared to those normally reported/obtained for pulps from depithed bagasse including an imported commercial bleached bagasse pulp.

The unrefined unbleached & bleached pulp of "Rind Fibre" are more free/easy draining as measured by freeness test. The material passing through 100 mesh screen is also less compared to that normally given for pulps from depithed bagasse. After due consideration of some additional factors like greater removal of sugar, cuticular wax etc from 'Rind Fibre' it appears storage & black liquor properties will not pose much of the problem.

In general "Rind Fibre" appears a superior material to depithed bagasse for pulp & paper making.

INTRODUCTION—

India is one of the major producers of sugar-cane in the world. About 100 yrs ago India had started growing sugar cane and till few years back India was worlds largest producer of sugar cane of the order of nearly 190 million tonnes per annum. Sugar-cane is grown in almost all the States and Union Territories of India, Out of the total sugar cane one third is crushed in sugar industries to produce sugar as much as 55% is used for manufacture of Gur/Khandsari and the balance is used for seed and chewing.

Crushing of sugar cane for extracting sugar containing juice is invariably practiced by the Sugar Industry leaving a residue commonly referred to as 'Bagasse'. Bagasse as discharged from a Sugar Mill contains about 45% crude fibre and 4 to 5% water solubles. The balance is moisture. The crude fibre consists of about 30% pith, 5% epidermal material, 5% dirt and other foreign material and 60% sound fibre. Thus the composition of bagasse discharged from a typical sugar mill on a moist weight basis is in general as foilows—

— Water	50%
— Water solubles	5%
— Pith & epidermal material	15,5%
— Dirt	2.5%
— Sound fibre	27%

— OR on a bone dry/moisture free basis, the composition of bagasse is in general—

— Water solubles	10%
— Pith & epidermal material	31%
— Dirt	5%
— Sound fibre	54%

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From the above it would be clear that water solubles, pith-mostly thin walled non-fibrous parenchyma cells and epidermal material and dirt are not beneficial to pulp and paper making and their removal should be preferred prior to pulping. It is the fibre fraction that is of value for the production of pulp & paper and various methods are practiced to enrich the fibre content in bagasse before pulping and paper making.

An Alternative to above was conceived more than 30 yrs. ago comprising of separating the outer skin (rind) of the sugar cane stalk from the interior storage area (pith). The outer skin-rind is rich in long, strong fibres and can be used directly for production of high quality chemical pulp. Approximately 50% of the dry weight of the stalk consists of high quality fibre bundles concentrated in the hard, dense rind of the stalk. The fibre bundles located in this rind layer are all oriented parallel to the axis of the stalk, except for those at the nodes and they give rigidity to the slalk. The pith or centre portion constitutes approx. 30% of the oven dry weight of the cane stalk. (excluding the sugar content of the sugar juice). The epidermis or extreme outer layer which is rich in wax is another main part of the sugar-cane stalk. The cane separation process for which specialized machinery is being developed aims at separating the sugar cane stalk into Rind, Pith and Epidermis for varied uses/applications. It is believed that for production of pulp, paper and paper board 'Rind fibre' is superior to best quality depithed bagasse. The troublesome epidermis and pith fractions have already been removed from the rind fibre. The bagasse fibre after passing through the sugar milling operation has been repeatedly cut and shortened in average length from about 1-5- 1.7 mm as it exists in the cane down to a maximum average length of about 1. mm. By contrast the fibre in the rind fraction resulting from the separation process retains its full original fibre length which results in improved strength properties as compared to bagasse. The present study has aimed at to confirm the above observations already recorded elsewhere in the literature.

An interesting paper titled Cane Separation-its integration into the conventional sugar industry by Bourzutschky, Wittwer and Badiuk (1) describe in detail both the concept & working principle of Cane Separation. It is further reported that a full scale operating Plant of 25 MT/hour cane capacity is operating in Ecuador, South America.

Experimental

(i) **Raw Material :** Sugar cane 'Rind' fibre was received from Walchandnagar Industries, Pune. On receipt the material was air dryed to about 16% moisture in order to avoid deterioration. length was about 70-120 mm, width 10-20 mm and thickness 0.4 to 1.0 mm.

(ii) **Proximate Analysis :** 'Rind' was cut in to small pieces and then grinded. The -40+60 mesh fraction was utilised for chemical analysis. The analysis was carried out as per Tappi standard methods. The results are given in Table I.

TABLE—I

PROXIMATE ANALYSIS

(All values on 100 gm O.D. material)

Sl. No.	Characteristics	
1.	Ash	2.81
2.	Cold water solubility	8.9
3.	Hot water solubility	10.53
4.	1% NaOH solubility	21.08
5.	Alcohal Benzene solubility (1 : 2)	5.42
6.	Ether solubility	1.33
7.	Acid Insoluble Lignin (uncorrected for Ash)	21.3
8.	Chlorite Holo Cellulose „ „	79.9
9.	Pentosans	31.0
10.	Silica	1.14
11.	Sugar	0.47
12.	Pith	15.8

Pith content was determined as per the procedure laid down in Tappi useful method No 3. For determining the sugar content following procedure was adopted :—

"15 gm of 'Rind' was cut into small pieces & then refluxed in 500 ml of distilled water for 4 hrs. The process was repeated with new change of 250 ml of distilled water. The 'Rind' after collecting both the changes of water was washed with about

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200 ml of hot distilled water. The three treated solutions are transferred in a measuring flask and then made up to 1 litre at 20°C. Sugar content in this prepared solution was determined by adopting the method from "Standard Method of Chemical Analysis" by Welcher.

Pulping: Soda pulping was carried out on the material received-after air drying using a rotary electrically heated digester. It was desired to obtain a pulp of about 12.0 permanganate number with maximum screened pulp yield. Both the Alkali charge & 'H' factor were changed for obtaining a satisfactory pulp. The data is given in Table II.

TABLE—II Pulping Data

S. No.	Particulars		COOK NO. 1	2	3	4
1.	% Caustic as NaOH		16	18	19	20
2.	Rind : liquor ratio		1:4	1:4	1:4	1:4
3.	Temperature Schedule Time in minutes at					
	ambient to 110°C		15	15	15	15
	Venting		15	15	15	15
	Approx100 to 140°C	Minutes	30	30	30	30
	at 140°C	„	30	30	30	30
	140°C to 160°C	„	30	—	—	—
	At 160°C	„	60	—	—	—
	140°C to 162.5°C	„	—	45	45	45
	At 162.5°C	„	—	60	85	90
4.	H Factor	„	563.8	752.6	959.7	999.1
5.	Permanganate Number		17.6	15.9	14.0	11.8
6.	% Screened yield (O.15mm screen)		40	45.6	50.7	51.0
7.	% Reject on 0,15 mm slot screen		13.8	8.9	2.9	1.46
8.	Viscosity cps (O,5% CED solution)		37	29.9	25.4	22.9
9	Free Alkali in black liquor gms/litre as NaOH		3.8	6 5	9.7	10.5

At the end of the cooking, the digester was relieved to atmospheric pressure and the contents transferred to a centrifuge for first collecting the black liquor & finally washing the material free of dissolved solids. Pulp was defibrated in a mechanical disintegrator before screening through Somerville screen using 0.15 mm slot width. Both the rejects and screened pulp quanti y was determind on the O.D rind used Black liquor was also tested for free alkali e'c.

Bleaching : A three stage conventional bleaching sequence comprising of chlorination, caustic-extraction and calcium hypochlorite was followed:

Results & Discussion : The chemical analysis shows that in the cane separation process followed, the cuticular wax has not been removed resulting in high alcoholbenzene solubility. Both the pith and sugar contents are low, but there is need for further reduction in sugar content to avoid fermentation.

The material is rich in pentosans with low lignin content and high holocellulose content. The pulping data shows that probably because of the presence of epidermal layer, the material is resistant to pulping. In the cane separation process using various stages of splitting, pressing and separation, the epidermal layer may get removed and ease of pulping improve as measured by the reduction in the amount of screenings in the permanganate number range of 12 to 16.

For bleaching pulp of permanganate number 11-8 (Cook No. 4) was used. Using C.E H sequence a pulp of 80% brightness could be obtained (Table III). The consumption of bleaching chemicals was normal. Pulp evaluation results of both the unbleached & bleached pulp (Table IV) show that the strength characteristics are close to many tropical hardwood pulps and superior to commercial bleached bagasse pulp from depithed bagasse. The main improvement in the "Rind Fibre' pulp is Tearing strength and Folding Endurance. With gentle treatment the pulps develop maximum strength properties and the results obtained at 400 csf are not very different from those at 300 csf.

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TABLE-III

Bleaching Data for Pulp of Permangana'e Number 11.8:

Particulars	Chlorination	Extraction	Hypochlorite
% Chemical added on O.D Pulp	4.75 as Cl_2	2.0 as NaOH	2.75 av.Cl_2 + 1.0NaOH (Buffer) +O.1Sulphamic Acid
Temperature °C	Ambient	65	40
% consistency	3.0	10.0	6 0
Retention time in mts	45	90	120
% Chemical consumed on added basis	99.4	—	98.4
pH at the start	1.8	11 9	9 6
pH in the end	2 2	11.0	8.2
Pulp Brightness% (Photovolt)	41	42	79
Viscosity Cps (0.5% CED solution)	15.6	14.4	10.5
Reverted Brightness % (105°C -4 hour)	—	—	75.5
Post colour No.			1 2

The fibre classification data (Table V) for both the unbleached and bleached 'Rind Fibre' pulp show less amount of material passing through 100 mesh screen. This may reflect in improved runnability of the stock on the paper machine including possibility of increased fillIng to improve the opacity of the paper.

Test results in black liquor obtained at the end of the cook from the Digester are given in Table VI and VII. The liquor has a good organic to inorganic ratio, and normal silica content. The viscosity of the black liquor is higher than normally obtained for Bamboo sulphate black liquor.

Conclusion—

'Rind Fibre' is superior to depithed bagasse for pulp and paper making as measured by cleanliness drainability and physical strength characteristics of the pulp stock. There is need for more extensive work to be undertaken on storage, wet web strength of the pulp optical properties including black liquor properties.

TABLE—IV

PHYSICAL STRENGTH PROPERTIES OF STANDARD HAND SHEETS OF 60 GSM

Characteristics	Unbleached pulp			Bleached Pulp			Commercial Bleached Pulp					
Beating Tackle	PFI MILL			PFI MILL			Valley Beater			PFI MILL		
REVOLUTION Number/Beating time minutes.	0	600	800	0	600	800	0	7	15	0	250	550
°CSF	580	400	300	610	400	310	460	390	280	470	400	300
Bulk CC/Gm	1 43	1.31	1 23	1.38	1.25	1.22	1.47	1.34	1.32	1.25	1.21	1.18
Breaking length km	5.39	7.05	7.37	4.28	6.45	6 83	4.00	4.44	5.04	4.81	6.62	6.7
Burst Factor	27	42	48	29	39	40	21	27	32	30	38	42
Tear Factor	63	60	57	55	52	50	39	41	35	44	42	39
Double Fold Number (Kohler-Molin)	62	256	378	29	159	225	11	26	28	50	85	170
Brightness Photovolt %	—	—	—	78	74	73	81	80	79	77	76	74
Tappi Opacity%	—	—	—	72	—	—	—	—	—	72	—	—

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TABLE-V

FIBRE CLASSIFICATION DATA-COOK NO 4

Particulars	Unbleached	Bleached	Commercial Bagasse 1	Bleached Pulp 2
Initial CSF	580	610	460	470
% retained on				
30 mesh	9.7	8 5	13 6	Nil
—30+50	29 4	29.1	26 6	41.0
—50+80	18.2	17.2	5.7	4.0
—80+100	12 4	14 0	7 0	3 4
Passing through 100 mesh	30.3	31.2	47.1	51.6

TABLE-VI

BLACK ,LIQUOR DATA FOR COOK NO. 4

Sl. No.	Characteristics	Results
1.	pH	12.05
2.	% Total Solids	15.32
3.	Total titrable alkali as Na_2O gm/litre	39.72
4.	Residual alkali as NaOH gm/litre	10 5
5.	Total organics—% W/W	61.6
6.	Total inorganic (100—organics) % W/W	38.4
7.	Org : Inog Ratio	1: .62
8.	Silica as SiO_2—% W/W	0.92
9.	Surface Tension—Dyne/cm	33.16

TABLE—VII

BROOKFIELD VISCOSITY OF BLACK LIQUOR CENTIPOISES

Sl. No.	Total solids	Spindle No. 1 — RPM 10 At Temp °C			Spindle No. 1 — RPM 20 At Temp °C		
	% W/W	90	60	30	90	60	30
1.	15.32	1.25	2.0	3.75	6.25	8.75	12.5
2.	36 5	10	15	20	20	30	45

Viscometer Model R V F.

Literature Cited

1. Bourzutschky, H. C. C., Wittwer, E., Badiuk, J., Paper presented at the 6th SATCA (Sociedad Argentina de technicos de la cane de Azucar) Conference in Tucuman/Argentina in April 1989.

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