High yield pulps from bamboo

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SUMMARY

Experiments were carried out in pilot plant to prepare TMP, CTMP and cold soda pulps from bamobo *(dendrocalamus strictus)* with a view of utilizing these pulps as newsprint furinish. The details of impregnation and refining condition were presented. The strength properties of final pulps were determined and the results were discussed. Bamboo TMP could not produce good strength pulp. Cold soda pulp offers advantage over CTMP pulp. CTMP pulp required more energy and produced lower brightness pulps depending on the chemical treatment used.

It is possible to produce high yield pulps (87-91%) from bamboo with bursting tensile and tearing strength approaching th se of soft wood TMP with low energy inputs by using chemically pretreated chips.

The TMP process is based on the utilization of thermoplastic properties of ligno-cellulose raw material and thus is a thermomechanical separation of the fibres in one continuous operation. This process is largely based on the development of refiner technology.

There is a wide interest to increase the utilization of the material available in country for increasing demand of paper. To cope up with the demand, a variety of chemi-mechanical pulping techniques were introduced. These mild chemical pretreatment of the wood chips had the effect of significantly increasing the strength properties in refining. Low density hardwood chemi-mechanical pulps were practically equivalent to high quality soft wood RMP[1]. Even denser hardwoods, when treated mildly with caustic soda, yielded pulps which, upon bleaching, were suitable for a number of grades of paper. Deb[2] has shown that by a suitable chemical treatment of hardwood chips, they can be made to behave like softwood under refining.

It has been suggested that a combination of the action of chemical treatment with the unique fiberizing characteristics of TMP might result in the production of some very useful pulps. A study was undertaken, therefore to examine in a broad way, the thermomechanical refining of bamboo which had been pretreated with a variety of caustic soda solution and other chemicals. The pretreatment of chips was of greater interest, in that it allows chemical energy to assist in the subsequent fiberizing, perhaps with less fiber damage and more efficient use of energy in the mechanical steps

The objective was to obtain a general overview of these techniques by employing on bamboo chemicals and treatment conditions. No attempt was made to optimize any one specific type of treatment, and conditions were chosen to give yield in excess of 87 percent in all cases in order to retain the ultra high yield advantage of TMP.

EXPERIMENTAL PROCEDURE

Raw material

Bamboo (Dendrocalamus strictus) was received from the Forest Research Institute. Chipping was done in Pilot Plant chipper. The chips were screened to remove undersized and oversized material. The moisture content was 8.0 percent.

Treatment of chips

Bamboo chips were impregnated in sodium hydroxide solution keeping chips to liquor ratio of 1:3.5 at room temperature for overnight. The concentration of NaOH applied was varied from 10 to 50 gpl. After treatment the liquor was separated and treated chips were refined either by pressure refining CTMP or atmospheric refining cold soda pulping in two stages. After the treatment chips were removed.

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The spent liquor collected was analysed for pH, residual alkali. Results are given in Table 2.

Operation of pressure refiner in Pilot Plant

The first stage pressurized equipment consists of 200 KW, 1000 rpm ROP-20 Defibrator and RO-20 reffinator is connected to 2000 KW, 1000 rpm atmospheric refiner, Total connected refiner power is 400 KW. A schemetic diagram of pilot TMP aystem is shown in Annexure 1. The sequence of operation of a pressurized refiner is given below :—

Feeding of chips

The wood chips or treated chips are fed to a metering bin. Metering bin is having a variable speed to discharge chips to rotary feeder. The rotary feeder works between two defferent pressures.

Steaming of chips

The chips emerge from the rotary feeder into the steaming tube, expand and fall apart immediately, and are acted upon by the steam in the tube. Chips pass down the tube by gravity. The steaming time is controlled by a gamma ray level control device. This instrument is connected to the metering bin variable screw drive and speeds up or slows down the metering bin screw to maintain a set chip level in the steaming tube corresponding to the rate that the chips are fed from tube into the disc chamber. Steaming time can vary from 60 sec. to 10 minutes. The steam on giving up its heat condenses to give moisture to the chips, additional water may be added by pressure pump.

Defibration

The mechanical separation of the steam heated chips is done under pressure with grinding discs, one rotating and one stationary. The rotating disc moves axially under hydraulic pressure which positions the rotor in relation to the stator and absorbs the pressure build up. The softened chips enter the rotating disc from the vertical steaming tube by means of a variable speed inner transporting screw. As the chips enter the space between the plates, they are acted upon by a normal refiner. The height location of breaker bars, inner or outer rings, plate taper and separation, determine the fibre quality, through put and kilowatt required. As the softened chips pass from the disc centre to the outside they break down first into fibre bundles, then into individual fibres.

Discharge of pulp

The pulp is discharged from disc through a blow valve. The released pulp from blow valve goes to a cyclone. At this point the pulp goes to second stage refining. Second stage refining is carried out in atmospheric (open discharge) refiner.

Unbleabhed pulp test

Pulps were fractionated in the Bauer McNett fibre Glassifier using 28,48,100 and 150 mesh screens. The results are given in Table 3.

Pulp evaluation was carried out using PFI mill. Hand sheets of 100 g/m² were made using back water recirculation system. Wet web strength was determined. The hand sheets were dried, conditioned and tested for their strength characteristics. The method followed for testing of the hand sheets is given in Tables 4 and 5.

RESULTS AND DISCUSIONS

The operating conditions alongwith the power consumption are given in Table 1. It could be seen that the specific refining energy depends on bamboo chips, impregnation and end freeness. The consumption of 1919 KWH/t at 55 CSF (ml) level in TMP pulp while chemically treated chips have shown considerable low energy consumption ranging from 1247 to 1633 KWH/t at various NaOH concentration treatments in CTMP. Further the power consumption in cold soda pulping is much lower compared to CTMP pulp which ranges fuom 1388 to 1561 KWH/t.

Table 2 shows the effect of caustic soda pretreatment in CTMP and cold soda pulping

Pulp brightness was found reduced when chips were pretreated in 20 to 50 gpl caustic soda in CTMP Pulping. The brightness was not further improved in alkaline sulphite treatment. Brightness of pulp in cold soda pulping varied from 24.0 to 30.7 percent in the range of 50 gpl to 10 gpl.

The Bauer McNett fibre classification of bamboo pulps have been shown in Table 3. Though no trend was observed because the freeness of these pulps after second refining stage was varied in wide range the amount of fines (i.e.–150 mesh) for TMP pulp was 63.4 percent, Cold soda pulps varied 43.1 to 47.8 percent and in cold soda pulping 48.0 to 54.3 percent. This indicates that CTMP pulps produce lower fines during pressure refining.

TABLE—1 CONDITIONS USED IN THE REFINING OF BAMBOO BY TMP, CTMP AND COLD SODA

Particulars	Frst stage refining						Second stage refining					
	Pressure in preheater	Temp. in preheater	Plate clearance	Net power	Production rate	Sp. Ene. consumption	Temp.	Plate clearance	Net power	Production rate	Sp. Energy consumption	Total energy consumption
	kg/cm²	°C	mm	KW	kg/H	KWH/t	°C	mm	KW	kg/H	KWH/t	KWH/t
Bamboo												
a) **TMP** (Control)	1.2	121.0	0.35	50	48	1042	95	0.15	40	45	877	1919
b) **CTMP**												
50 gpl (17.5%) NaOH	1.2	121.0	0.35	50	73	689	95	0.20	20	55	558	1247
30 gpl (10.5%) NaOH	1.2	121.0	0.35	60	67	893	95	0.20	40	55	746	1639
20 gpl (7.0%) NaOH	1.2	123.0	0.35	50	63	794	95	0.15	45	58	859	1653
(NaOH + Na_2-) SO_3 of 10% in 80 : 20 ratio)	1.2	121.0	0.30	60	59	1016	95	0.20	30	48	625	1641
c) **Cold soda**												
50 gpl (17.5%) NaOH	—	95	0.20	20	43	462	95	0.15	30	32	926	1388
30 gpl (10 5%) NaOH	—	95	0.20	20	41	484	95	0.15	30	32	926	1410
20 gpl (7.0%) NaOH	—	95	0.20	20	41	485	95	0.15	30	31	955	1440
10 gpl (3.5%) NaOH	—	95	0.20	30	42	714	95	0 15	30	35	847	1561

TABLE—2 TREATMENT RESULTS OF BAMBOO TMP, CTMP AND COLD SODA PULPS

Particulars	Chemical applied %	Chemical consumed %	Spent liquor pH	Rejects after screening %	Unbleached pulp brightness %	Pulp freeness CSF ml
Bamboo						
a) TMP (Control)	—	—	—	1.4	25.6	65
b) **CTMP**						
with NaOH (50 gpl)	17.5	12.10	10.54	(1)	17.1	575
with NaOH (30 gpl)	10.5	8.40	11.12	(1)	22.4	350
with NaOH (20 gpl)	7.0	6 06	11.36	(1)	26.6	230
with $NaOH + Na_2So_3$ in 80 : 20 ratio	10.0	7.30	11.16	(1)	18.1	530
c) **Cold soda**						
with NaOH (50 gpl)	17.5	12.10	10.54	(1)	24.0	75
with NaOH (30 gpl)	10.5	8.40	11.12	(1)	24.7	85
with NaOH (20 gpl)	7.0	6.06	11.36	(1)	27.7	75
with NaOH (10 gpl)	3.5	3.35	10.95	7.4	30.7	115

Note : (a) Chips soaked for over night with 1:4 chips to liquor rotio.
(b) 1- Negligible amount.

TABLE—3 BAUER-McNETT FIBER CLASSIFICATION OF BAMBOO PULPS

Particulars	Chemical applied %	Bauer-McNett classification +28 %	+48 %	+100 %	+150 %	—150 %	Pulp freeness CSF ml
Bamboo							
a) **TMP** (Control)	—	2.4	18.4	12.5	3.3	63.4	65
b) **CTMP**							
with 50 gpl NaOH	17.5	35.4	13.1	6.2	1.3	44.0	575
with 30 gpl NaOH	10.5	33.4	14.2	6.6	2.4	43.1	350
with 20 gpl NaOH	7.0	29.0	13.4	6.6	3.2	47.8	230
with $NaOH + Na_2SO_3$ in 80 : 20 ratio	10.0	41.2	12.8	6.5	1.5	38.0	530
c) **Cold soda**							
with 50 gpl NaOH	17.5	27.5	13.1	7.2	4.2	48.0	75
with 30 gpl NaOH	10.5	24.2	12.8	8.6	4.4	50.0	85
with 20 gpl NaOH	7.0	19.1	14.6	8.8	3.2	54.3	75
with 10 gpl NaOH	3 5	3.8	27.0	14.1	3.8	51.3	115

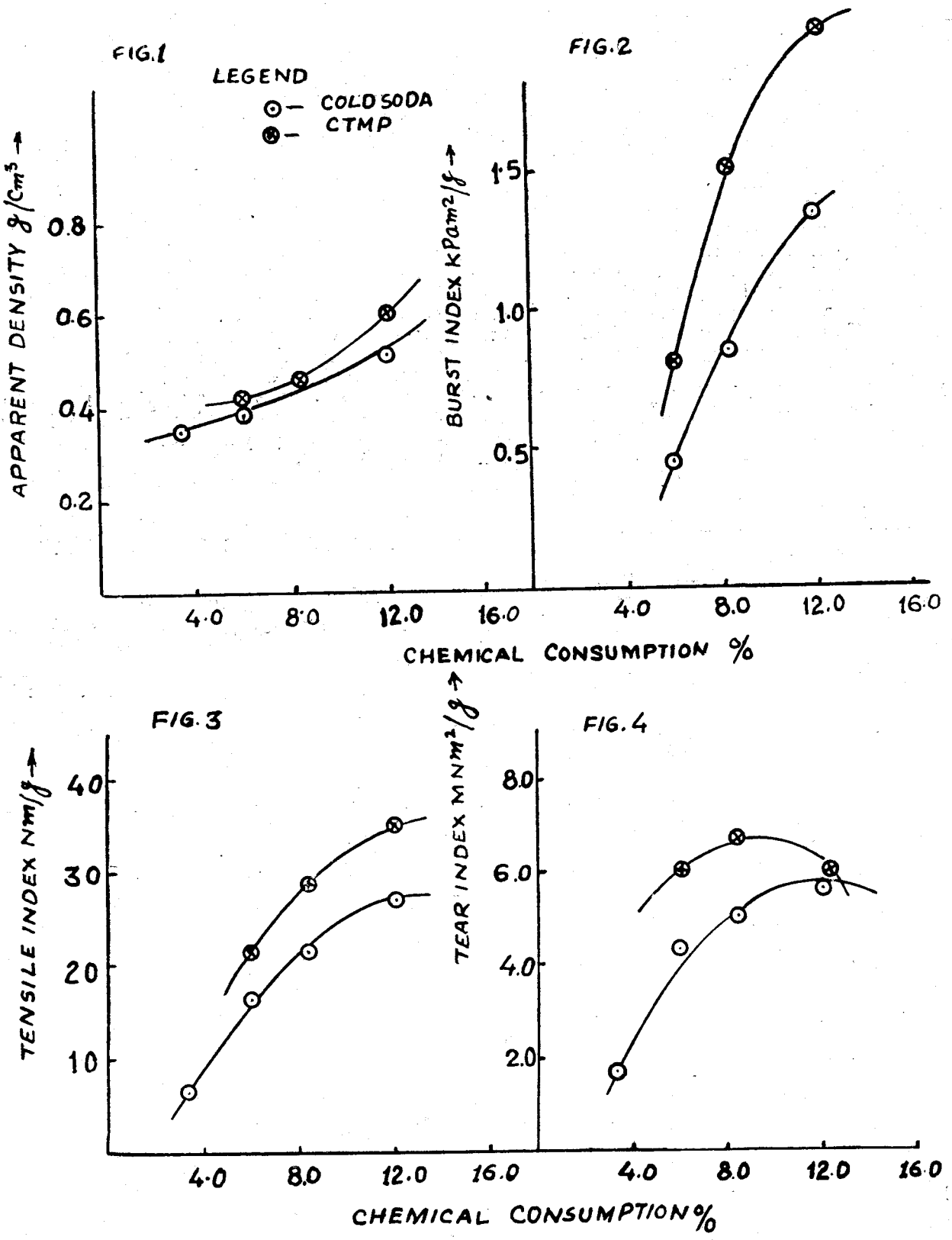
The data in Table 4 indicated that CTMP produced from different chemical treatment exhibited burst index 0.8 to 2.1, Tensile index 21.5 to 35.0 and tear index 6 to 6.7 at 100 CSF. Bamboo TMP yielded much lower strength properties. Bamboo impregnated with alkaline sulphite liquor yielded CTMP pulps with better strength properties compared to TMP pulp. It is clear that cold soda pulps have lower strength characteristics than CTMP pulps. But this minor difference in pulp strength characteristic demonstrated in Fig. 1 to 5 may compensate for the increasing energy requirement in pressure refining. This shows that pressurized refining system may not be necessary using alkali treated chips.

It is evident from Fig. 1 that when NaOH consumption varied there was not much variation in sheet density of both CTMP and cold soda pulp. Fig. 2 shows the chemical consumption on burst index. The burst index improved with NaOH cansumption Higher values of burst index were observed at high NaOH concentration in CTMP pulp than cold soda pulp. Fig. 3 illustrates the relative eflect of NaOH consumption on tensile index. It is clear that CTMP pulps gave better tensile value than cold soda pulps. There was very less variation in values at low NaOH concentration. The effect of NaOH concentration on tear index is given in Fig. 4. It indicates that there is much variation at low NaOH concentration in both cases but at high concentration there is to be no chage in tear values. Wet web properties and dynamic retention values of these pulps are given in Table 5. Fig. 5 indicates that the initial wet web strcngth of these pulps was low. Low wet web strength indicates that newsprint furnish with bamboo CTMP or cold soda will require high portion of long fibre pulp in order to attai n sufficient wet web strength.

TABLE—4 STRENGTH PROPERTIES OF BAMBOO TMP, CTMP AND COLD SODA PULPS

Particulars	Apparent density	Tensile index	Tear index	Burst index	Double folds	Sp. Scatt. coeff.	Sp. Energy consumption	Pulp freeness
	g/cm³	Nm/g	mN-m²/g	kPa-m²/g	KM	m²/kg	KWH/t	CSF ml
Bamboo								
a) **TMP** (Control)	0.38	4.50	1.20	(1)	(1)	—	1919	65
b) **CTMP**								
NaOH (50 gpl)	0.60	35.0	6.0	2.10	1.43	—	1247	100
NaOH (30 gpl)	0.46	29.0	6.7	1.50	1.15	22.4	1639	100
NaOH (20 gpl)	0.41	21.5	6.0	0.80	0.70	34.0	1653	100
$NaOH+Na_2SO_3$ (10%) of 80 :20 ratio	0.57	35.0	6.2	2.00	1.41	—	1641	100
c) **Cold soda**								
NaOH (50 gpl)	0.51	27.00	5.60	1.35	0.96	30.0	1388	75
NaOH (30 gpl)	0.46	21.5	5.00	0.85	0.78	33.9	1410	85
NaOH (20 gpl)	0.40	16.5	4.35	0.45	0.30	38.6	1440	75
NaOH (10 gpl)	0.35	6.3	1.70	(1)	(1)	40.0	1561	115

Note : (1) Too low to be measured.



BAMBOO COLD SODA & CTMP
CHEMICAL CONSUMPTION Vs STRENGTH PROS.

TABLL—5 WET WEB PROPERTIES OF BAMBOO TMP, CTMP AND COLD SODA PULPS

Particulars	Drainage time sec.	Initial wet web tensile index Nm/g	TEA index mNm/g	Dynamic retention value-200 %	Sp. Energy consumption KWH/t	Freeness CSF ml
Bamboo						
a) **CTMP** (Control	5.98	0.11	6.84	48.6	1919	65
b) **CTMP**						
NaOH (50 gpl)	18.80	0.63	28.30	43.0	1247	100
NaOH (30 gpl)	14.09	0.54	35.00	41.0	1638	100
NaOH (20 gpl)	15.70	0.47	41.50	39.1	1653	100
$NaOH + Na_2SO_3$ (10%) in 80 : 20 ratio	20.97	0.57	36.00	58.7	1641	100
c) **Cold soda**						
NaOH (50 gpl)	23.1	0.60	73.3	37.3	1388	75
NaOH (30 gpl)	16.0	0.46	47.9	40.6	1410	85
NaOH (20 gp)	15.9	0.54	39.3	35.1	1440	75
NaOH (10 gpl)	5.3	0.18	10.4	30.6	1591	115

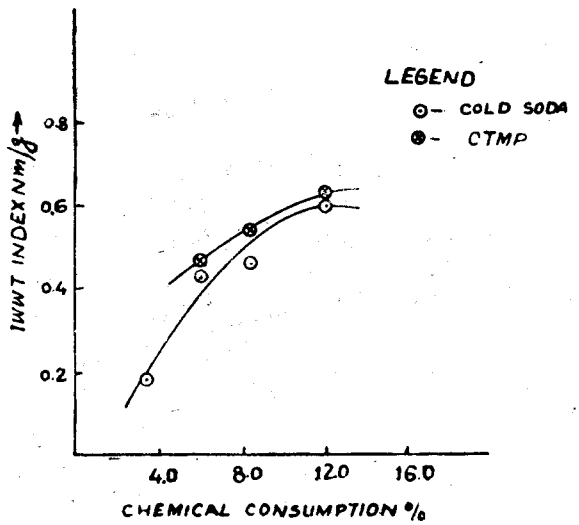


FIG. 5. BAMBOO COLD SODA AND CTMP

CONCLUSIONS

1. Bamboo TMP could not produce pulps of good strength characteristics.
2. Pressurized refining of chemically pretreated bamboo offers advantage over open discharge refining in regard to strength properties. In addition, there seems to be a tendency for the CTMP to have a larger energy requirement and lower pulp brightness depending on the chemical treatment involved.
3. Pre impregnation of bamboo with alkaline sulphite liquor results in much greater strength compared with TMP pulp but lower than alkaline CTMP pulp.
4. Cold soda pretreatment proved to be best of all the above in terms of pulp brightness, enery requirements but slightly lower strength characteristics.
5. It is possible to produce high yield pulps (87-91%) from bamboo with bursting, tensile and tearing strengths approaching those of softwood TMP with low energy inputs, by using a cold soda pretreatment.

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