Preliminary studies on the preparation of refiner-mechanical pulp, simulated thermo-mechanical pulp and cold soda pulp from boswellia serrata (salai chips)

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SUMMARY

Laboratory experiments on the preparation of refiner mechanical pulp from Salai chips were carried out and for comparison refiner mechanical pulps were also prepared from Sal and Bamboo. The pulp was bleached by hypochlorite followed by hydrogen peroxide. The brightness of salai bleached pulp was high i.e. 50%. This pulp was blended with the mill chemical pulp and the strength properties were determined and it is observed that for having satisfactory strength properties and brightness for cheap grade of writing and printing paper, Salai refiner chemical pulp can be blended upto 30%. Other high yield pulping processes were tried such as cold soda and simulated thermomechanical pulping. It was observed that the power consumption in simulated thermo-mechanical refining of Salai chips is lower as compared to refiner mechanical pulping. Simulated thermo-mechanical Salai pulp was also bleached and the brightness achieved was 48%. Blends of mill pulp with 20% Thermo-mechanical pulp also gave satisfactory strength properties. Cold caustic soda pulp from salai chips was produced and bleached with Hypochlorite followed by hydrogen peroxide. The brightness of the cold caustic soda pulp from salai chips was high (52% P.V.). The power consumption was considerably reduced and the strength properties of the blended pulps were better. It was also observed that for obtaining Satisfactory strength properties we could blend 30-44% of this material with fhe conventional mill pulp.

On the whole, it can be concluded that depending on the availability of the caustic, steam and power, suitable method for preparing high yield pulp can be adopted. This pulp can be blended with the mill pulp upto 30–40% for cheap grade of paper.

It is well known that our conventional raw materials such as bamboo and mixed hard woods are the major raw materials, besides non-conventional raw material for the Indian Paper Industry. Bamboo forests are depleting alarmingly, and the availability of hard woods from future point of view does not seem to be optimistic. We cannot afford for a longer time to depend upon old pulping processes such as Kraft, Sulfite and caustic pulping. These processes give pulp in lower yield. We will have to find out ways and means to improve pulp yield either by modification of these processes or going in for high yield pulping processes to compensate price inflation of raw materials, equipments and labour cost.

At Orient Paper Mills, Amlai we are consuming 70-75% Bamboo and 25-30% mixed hardwoods to produce about 200 tonnes of writing, printing and other grades of paper using sulfate process. *Shorea Robusta* (Sal) and *Boswellia Serrata* (Salai) are the main hardwoods used in major quantity with other hardwoods. It was planned to carry out a systematic study to produce refiner mechanical pulp from these two hardwood species along with Bamboo. Other high yield pulping processes such as simulated thermo-mechanical pulping and cold soda pulping were also studied.

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Refiner mechanical pulp produced from hardwoods[1] is of inferior quality due to presence of vessels, short fiber length, thinner wall, over and above peculiar ultra structure. Other high yield pulping process is simulated thermo-mechanical pulping process[2]. The main advantages of thermmechanical pulping process[2] are appreciably lower shieve content, more stable and steadier operation with a narrow range of power swings, and some what higer strength at the same power consumption. The pretreatment of hardwoods[3] was of greater interest in that it allows chemical energy to assist in subsequent fiberizing perhaps with less fiber damage more efficient use of energy in the mechanical pulps. Indeed cold soda proved to be superior to all the above in terms of pulp strength development and energy requirement.

Experimental and Results

Refiner Mechanical Pulp : One kg each of Sal, Salai and bamboo chips were soaked overnight in water and passed through 12" Sprout Waldron disc refiner having a disc no. D-2A-501. The clearance between the plates was kept at 2540, 508 & 0 microns successively. The power consumption of Salai wood was 800.87 K.wh/Tonne and unbleached yield 80%. Salai pulp was bleached with hypochlorite followed by hydrogen peroxide and the brightness of the pulp obtained was 50%. The conditions of refining of Salai chips are recorded in Table-1. Bleaching conditions of this pulp are mentioned in Table-2. Fibre classification of these refiner mechanical pulp was carried out in Bauer Mcnett classifier. The results obtained are tabulated in Table-3. Further Salai bleached pulp was blended with mill pulp in 20%, 40%, 60% and 80% proportions. The strength properties of the blended pulps, brightness and bulk are recorded in Table-4. Refiner mechanical pulps from bamboo and Sal for comparison were bleached and, fiber classification was carried out. The results are given in Table-1, 2 & 3.

Simulated Thermo-Mechanical Pulp

For studying the suitability of other high yield pulping processes Salai wood was pulped by simulated T.M.P. process. Two kg. of Salai chips was steamed in 30 litre electrically heated autoclave having a forced circulation system. The bath ratio was kept 1:4.5. The material was steam heated at 130°C for five minutes and passed through 12" Sprout-Waldron Disc refiner having Disc No. D2A-501. The refining conditions, power consumption, brightness and pulp yield are recorded in Table-5. This pulp was bleached in multi stage bleaching using hypochlorite and hydrogen peroxide. The conditions of bleaching are recorded in Table-6.

TABLE—1. REFINING CONDITIONS FOR SAL, SALAI AND BAMBOO CHIPS.

Sl. No.	Particulars	Shorea Robusta (Sal)	Boswellia Serrata (Salai)	Dendro Calmus Strictus (Bamboo)
1.	Weight of chips taken (gms) on O.D. Basis.	1000.0	1000.0	1000.0
2.	Clearance kept between the refiner plates (microns)	2540 508 0 0	2540 508 0 0	2540 508 0 0
3.	Power consumption Kwh/Tonne of chips	938.93	800.87	696.90
4.	Yield (%)	80.17	78.72	79.90
5.	Pulp brightness (% P.V.)	—	27.0	21.0

TABLE—2. BLEACHING OF SAL, SALAI AND BAMBOO REFINER MECHANICAL PULPS.

Sl. No.	Particulars	Shorea Robusta (Sal)	Boswellia Serrata (Salai)	Dendro Caimus Strictus Bamboo)
1.	**Hypochlorite Stage—1**			
	(i) Pulp taken in (gms) O.D. basis	50.0	50.0	50.0
	(ii) Hypo applied (%) as available chlorine	10.0	10.0	10 0
	(iii) Consistency of pulp (%)	5.0	5 0	5 0
	(iv) Reaction temperature°C	40±1	40±1	40±1
	(v) Retention time (mts)	120	120	120
	(vi) pH during reaction	9—10	9—10	9—10
	(vii) Hypo consumed (%)	99.9	100.0	99.86
	(viii) Caustic used (%)	2.0	2.0	2.0
2.	**Hypochlorite Stage—2**			
	(i) Bleaching condition as mentioned above			
	(ii) Hypochlorite applied (%)	5 0	—	—
	(iii) Hypo consumed (%)	99.72	—	—
3.	**Hydrogen Peroxide Stage—3**			
	(i) Hydrogen peroxide applied (%)	2.0	2.0	2.0
	(ii) Sodium silicate (%)	5.0	5.0	5.0
	(iii) Magnesium sulphate (%)	0.5	0.5	0.5
	(iv) Caustic (%)	0.6	0.6	0.6
	(v) Consistency of pulp (%)	10.0	10.0	10.0
	(vi) Reaction temp. °C	50±1	50±1	50±1
	(vii) Retention time (mts)	120	120	120
	(viii) pH during bleaching	10—11	10—11	10—11
	(ix) H_2O_2 consumed (%)	75.58	85.72	52.06
4	**Results**			
	(i) Shrinkage of pulp (%)	5.14	5.64	6.02
	(ii) Brightness of pulp (%) P.V.	21.0	50.0	48.0

TABLE—3. FIBRE CLASSIFICATION OF BLEACHED REFINER MECHANICAL PULP FROM SAL, SALAI AND BAMBOO.

Sl. No.	Mesh size	Shorea Robusta (Sal)	Boswellia Serrata (Salai)	Dendrocalamus Strictus (Bamboo)
1.	+20	48.77	41.83	41.10
2.	—20+40	22.19	22.41	20.37
3.	—40+70	12.35	13.59	14.71
4.	—70+100	8.83	9.29	9.29
5.	—100+140	4.04	5.41	3.43
6.	—140	3.82	7.47	11.10
7.	Total	100.00	100.0	100.0

Fibre classification of the bleached pulp in Bauer Mcnett classifier was carried out and the results are tabulated in Table-7 Further, bleached pulp was blended with mill pulp in 20%, 40%, 60% and 80% ratio. The strength properties of various blends are recorded in Table-8.

Cold-Soda Pulp

Cold soda pulp from salai Wood was prepared for comparison with other high yield pulps. One kg of chips was refined in 12" Sprout-Waldron Disc refiner using plate no. D-2A-501, keeping clearance between the plates 2540 microns. These refined chips were further soaked in 60 g/l caustic soda solution for three hours. These soaked splints were further refined keeping the clearance between the plates at 762,127 and 0 microns successively. The refining conditions, power consumption, brightness,

TABLE—4. PHYSICAL STRENGTH PROPERTIES OF R.M.P. SALAI BLEACHED PULP BLENDED WITH MILL BLEACHED PULP.

Sl. No.	Particulars	Mill bleached pulp (100%)	Mill bleached pulp + Refiner Bleached pulp (80%+20%)	Mill bleached pulp + Refiner bleached pulp (60%+40%)	Mill bleached pulp + Refiner bleached pulp (40%+60%)	Mill bleached pulp + Refiner bleached pulp (20%+80%)
1.	Final freeness of beaten pulp (°SR)	45	44	46	45	45
2.	Caliper (microns)	85	88	93	125	130
3.	Bulk (c c./g)	1 36	1·69	2.0	2.51	2.58
4.	Brightness of sheet (% P.V.)	78.5	70 0	64.0	61.5	58.5
5.	Tensile Index (N.m/g)	58.86	38.67	25 30	17.05	9 05
6.	Tear Index (m.N.m²/g	4.54	3.19	2 94	2.35	1.60
7.	Burst Index (K.pa m	2.046	1.800	1.264	0.686	0.294
8.	Double fold	25	5	3	2	1

TABLE—5 REFINING CONDITIONS FOR SALAI (PRE-STEAMED AT 130 C) CHIPS.

Sl. No.	Particulars	Boswellia Serrata (Salai chips)
1.	Weight of chips taken (gms) O.D. basis	2000,0
2.	Bath Ratio	1:4.5
3.	Steaming temperature°C	130
4.	Steaming time (mts)	5.0
5.	Refining conditions	
	Clearance kept between the refiner plates (microns)	2540 508 0 0
6.	Power consumption Kwh/Tonne of chips	696.0
7.	Yield (%)	79.42
8.	Pulp brightness (% P.V)	25.0

TABLE—6 BLEACHING OF SALAI SIMULATED THERMO-MECHANICAL PULP

Sl. No.	Particulars	Salai simulated thermo-mechanical pulp
1.	Hypochlorite Stage	
	i) Pulp taken (gms) on O.D. basis	500.0
	ii) Hypochlorite applied (%) as available chlorine	10.0
	iii) Consistency of pulp (%)	5.0
	iv) Reaction temperature°C	40±1
	v) Retention time (mts)	120
	vi) pH during reaction	9-10
	vii) Hypo consumed (%)	100 0%
2.	Hydrogen Peroxide Stage	
	i) H_2O_2 applied (%)	2.0
	ii) Sodium silicate (%)	5.0
	iii) Magnesium sulphate (%)	0.5
	iv) Caustic (%)	0.6
	v) Consistency of pulp (%)	10.0
	vi) Reaction temperature°C	50±1
	vii) Retention time (mts)	120
	viii) pH during bleaching	10-11
	ix) H_2O_2 consumed (%)	85.5
3.	Result	
	i) Shrinkage of pulp (%)	4.2
	ii) Brightness of pulp (%) P.V	48 0

TABLE—7 FIBRE CLASSIFICATION OF BLEACHED SALAI SIMULATED THERMO-MECHANICAL PULP

Sl. No.	Mesh Size	Salai Pulp (% Retention)
1.	+ 20	39.25
2.	— 20+ 40	24.36
3.	— 40+ 70	15.45
4.	— 70+100	9.94
5.	—100+140	5.54
6.	—140	5.46
7.	Total (%)	100

pulp yield are recorded in Table-9. This pulp was bleached by multi-stage bleaching using hypochlorite and hydrogen peroxide. The bleaching conditions and results are given in Table-10. The results of fibre classification of bleached pulp are recorded in Table-11. Salai cold soda bleached pulp was blended in different proportion with mill bleached pulp and the physical strength properties of various blends are given in Table-12.

Results & Discussions

A perusal of Table-14 shows that Salai chips has lower density than Sal chips and has nearly the same specific gravity and bulk density as that of Bamboo

TABLE—8 PHYSICAL STRENGTH PROPERTIES OF BLEACHED SALAI SIMULATED THERMO-MECHANICAL PULP BLENDED WITH MILL BLEACHED PULP

Sl. No.	Particulars	Mill bleached pulp 100 %	Mill bld. pulp + TMP bld. pulp from Salai (80% + 20%)	Mill bld. pulp + TMP bld pulp from Salai (60% + 40%)	Mill bld. pulp + TMP bld pulp from Salai (40% + 60%)	Mill bld. pulp + TMP bld pulp from Salai (20% + 80%)	Thermo-mechanical bld. pulp from Salai
1.	Final freeness of beaten pulp (SR°)	48	47	47	46	45	44
2.	Caliper (microns)	84	102	115	135	152	165
3.	Bulk (c. c/g)	1.42	1.75	1.97	2.26	2.53	2.64
4.	Brightness of pulp (%) PV	79.0	70.5	65.0	60.0	54.0	48.0
5.	Tensile Index (N.m/g)	59.81	42.59	28.06	21.42	10.90	20.13
6.	Burst index ($K.Pa.m^2/g$)	2.73	2.17	1.18	0.82	0.41	0.118
7.	Tear Index ($mN.m^2/g$)	4.83	3.69	3.19	2.79	2.12	0.95
8.	Double fold	77	15	4	2	1	Nil

TABLE—9. REFINING CONDITION FOR COLD CAUSTIC SALAI CHIPS.

Sl. No.	Particulars	Boswellia Serrata (Salai chips)
1.	Weight of Salai chips (gms) on O.D. basis	1000.0
2.	Bath Ratio	1:4.5
3.	Caustic (%) applied for soaking splints of salai chips	6.0
4.	Soaking time (mts)	180
5.	**Refining Condi tions**	
	(i) Water soaked chips passed through refiner p'ates (microns)	2540
	(ii) Clearance kept between plates for caustic soaked splints (microns)	762 127 0
6.	Power consumption K. wh/Tonne of chips	556.0
7.	Yield (%)	67.84
8.	Brightness of pulp (%) P.V.	27.0
9.	Chemical consumed (%) on O.D. chips basis	4.6%

chips[5]. Because of high density of sal wood and dense structure, the power consumption is higher in mechanical refining of this wood as compared to salai and bamboo (Table-1). The percent RMP yield in Sal, Salai and Bamboo were found nearly the same i e. about 80%. Sal, Salai and Bamboo refiner mechanical pulps bleached with hypochlorite (10%) and H_2O_2 (2%) in multi-stage bleaching does not give significant improvement in brightness for Sal and Bamboo pulp but the brightness of Salai was improved 50% P.V. (Table-2). The proximate chemical analysis (Table-13) shows that Sal wood has higher lignin content than salai wood[4] which appears to be possible reason for the brightness improvement after bleaching of salai RMP.

Fibre classification of these bleached pulps shows that fines percent development was not significant (Table-3) but shieves and longer fiber percent retention on 20 mesh was over 40%. Salai bleached RMP (45°SR) was blended in different proportion upto 80% mill bleached pulp (45°SR) shows that 20-30% bleached refiner salai mechanical pulp can be blended with mill pulp for cheap grade papers

TABLE—10. BLEACHING OF SALAI COLD SODA REFINER MECHANICAL PULP

S. No.	Particulars	Cold Soda Salai Refiner Pulp
1.	**Hypochlorite Stage**	
	i) Pulp taken (gms) on OD basis	400.0
	ii) Hypochlorite applied (%) as available chlorine	10.0
	iii) Consistency of pulp (%)	5.0
	iv) Reaction temp. °C	40±1
	v) Retention time (mts)	120
	vi) pH during reaction	9-10
	vii) Hypo consumed (%)	100.0
2.	**Hydrogen Peroxide Stage**	
	i) H_2O_2 applied (%)	2.0
	ii) Sodium silicate (%)	5.0
	iii) Magnesium sulphate (%)	0.5
	iv) Caustic (%)	0.6
	v) Consistency of pulp (%)	10.0
	vi) Reaction temp. °C	50±1
	vii) Retention time (mts)	120.0
	viii) pH during bleaching	10-11
	ix) H_2O_2 consumed (%)	84 0
3.	**Results**	
	i) Shrinkage of pulp	4.85
	ii) Brightness of pulp (%) P.V.	52.5

TABLE-11. FIBRE CLASSIFICATION OF BLEACHED SALAI COLD SODA REFINER MECHANICAL PULP

S. No.	Mesh size	Salai Cold Soda retention
1.	+20	40.18
2.	—20 + 40	23.41
3.	—40 + 70	15.68
4.	—70 + 100	10.56
5.	—100 + 140	5.51
6.	—140	4.66
7.	Total	100

with satisfactory strength properties (Table-4).

Further simulated thermo-mechanical pulping trials of salai was carried out. The power consumption of salai chips was 696 K.wh/Tonne, pulp yield 79.42% and brightness 27% P.V. The brightness was reduced by 2 points as compared to RMP of salai pulp (Table-5), simulated TMP from salai was bleached under the same conditions as followed in refiner mechanical pulping (Table 6). The brightness of this bleached pulp was 48% PV and was lower than RMP bleached pulp.

The bleached simulated thermo-mechanical salai pulp has nearly the same fibre percent retention on different mesh as in RMP bleached pulp (Table-7). The bleached thermo-mechanical pulp was blended with mill pulp in different proportions (pulps freeness 45°SR). There was improvement in physical strength properties of the blended sheets (Table-8). Even 100% bleached thermo mechanical pulp sheet could be prepared which was not possible in Salai RMP. Evaluation of strength properties of blended sheets shows that 20 30% bleached simulated thermomechanical salai pulp could be mixed with mill bleached pulp for better strength properties than RMP for cheap grade papers.

In continuation of high yield pulping process followed earlier for Salai wood it was planned to try cold caustic refiner mechanical pulping for cheap grade paper. The soaking and refining conditions are mentioned in Table-9. The power consumption was reduced considerably i.e. 556 K wh Tonne and pulp yield (67.84%). Alkali consumed during soaking of salai splints was 4.6% and pulp brightness 27% P.V. The cold caustic refiner mechanical pulp was bleached in multistage bleaching under identical conditions as followed in RMP & simulated TMP (Table-10). The brightness of the bleached pulp was increased upto 52% P.V. Fiber classification of bleached cold saustic salai pulp (Table-11) showed that fibers and fines retention was nearly the same as in RMP and simulated TMP from salai pulps. The cold soda salai bleached pulp 35°SR was blended with mill bleached pulp (48° SR) in different proportions. The strength properties were further improved. The pretreatment of caustic softens the fibers so that P and S, layers are peeled off the same way as in TMP[6] and results in improvement of physical strength properties of the pulps. It is concluded from Table-12 that 30-40% of bleached cold soda salai pulp could be blended with mill bleached pulp for cheap grade of paper.

CONCLUSION

It may be concluded that in the simulated thermo-mechanical pulping the strength properties

TABLE—12 PHYSICAL STRENGTH PROPERTIES OF BLEACHED COLD SODA REFINER MECHANICAL PULP BLENDED WITH MILL BLEACHED PULP.

Sl. No.	Particulars	Mill bleached pulp (100%)	Mill bld pulp+ Cold Soda bld. RMP pulp (80%+ 20%)	Mill bld. pulp+ Cold Soda bld RMP pulp (60%+ 40%)	Mill bld pulp+ Cold Soda bld RMP pulp (40%+ 60%)	Mill bld pulp+ Cold Soda bld RMP pulp (20%+ 80%)	Cold Soda bleached RMP pulp (100%)
1.	Final freeness of beaten pulp (°SR)	48	—	—	—	—	35
2.	Caliper (microns)	84	110	125	140	150	151
3.	Bulk (c.c./g)	1.42	1.848	2.140	2.360	2.580	2.670
4.	Brightness of pulp (% PV)	78.0	72.5	68.5	61.5	58.5	52.0
5.	Tensile index (N.m/g)	59.81	41.85	31.27	22.08	12.39	4.62
6.	Burst index (K. Pa.m^2/g)	2.73	2.38	1.51	0.99	0.59	0 34
7.	Tear index (m.N.m^2/g)	4.83	4.27	3.52	2.81	1.85	1.22
8.	Double fold	77	12	5	4	2	Nil

TABLE—13 PROXIMATE CHEMICAL ANALYSIS OF SAL, SALAI AND BAMBOO

Sl. No.	Particulars	Shorea* Robusta (Sal)	Boswellia[4] Serrata (Salai)	Dendrocal[4]-mus Strictus (Bamboo)
1.	Ash (%)	0.921	1.0	2 23
2.	Cold water solubility (%)	2.15	6.3	3 29
3.	Hot water solubility (%)	5.12	8.9	6.12
4.	1% NaoH Solubility (%)	15.30	15.5	—
5.	Alc/Benzene Solubility (%)	1.94	4.3	3.13
6.	Pentosan (%)	14 30	13.0	15.06
7.	Lignin (%)	28.60	27.3	27.85
8.	Cross & Bevan Cellulose (%)	--	50.7	59.91

* Analysis was carried out in Research Division Orient Paper Mills, Amlai.

TABLE—14 BULK DENSITY AND SPECIFIC GRAVITY OF SAL, SALAI AND BAMBOO CHIPS

Sl. No.	Particulars	Shorea Robusta (Sal)	Boswellia Serrata (Salai)	Dendrocalmus Strictus (Bamboo)
1.	Bulk density of chips (Kg/m^3)	271.0*	223.4[5]	225[5]
2.	Specific gravity (g/cc)	0.62*	0.45*	0.471[5]

* The bulk density and specific gravity were determined in Research Division, Orient Paper Mills, Amlai.

of bleached salai pulp was found better than salai RMP. On comparing these high yield pulping processes it is concluded that power consumption was lowest in cold caustic refiner mechanical pulping. The physical strength properties and brightness were improved considerably in cold caustic process although the bleached yield was reduced significantly. The lower yield of cold caustic refiner bleached pulp can be compensated by blending higher percentage of this pulp with mill pulp. By selecting proper plates for refiner, the yield and properties can be improved further. On the whole it can be concluded that cold caustic soda process for salai Wood is better than other high yield pulping processes.

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