Cold Caustic Soda Pulping from Boswellia serrata (Salai) and its Roll in the NEPA Mills Expansion

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The National Newsprint and Paper Mills Ltd. have an annual capacity of 30,000 *tonnes of Newsprint. They have undertaken an expansion programme to increase this capacity to* 75,000 *tonnes. This is being achieved by using one of the recent trends in the 'High Yield Pulping of Hard Woods', (Cold Caustic Soda Pulping of lacally available Hardwood species). The process yields nearly the same quantity of pulp as is obtained from the conventional stone grinding process. The pulp obtained is far better in strength than that of the stone groundwood pulp.*

The present furnish which consists of approximately 60% *of stone groundwood from hardwood and* 40% *of kraft Pulp from Bamboo, shall be modified to equal parts of all the three components i. e. stone groundwood from salai, cold caustic soda pulp from salai and kraft pulp from bamboo.*

This new progress has been choosen after carrying out careful series of experiments in the laboratory to achieve a stronger pulp from this hardwood without reducing the yield.

The advantages of cold caustic soda pulping process have been mentioned. It is hoped that this shall open a new era in the utilisation of the forest resources of this country. The mill is already planning to use the other hardwood species (which have responded well to this process) available in the surrounding areas.

The National Newsprint & Paper Mills Ltd. are manufacturing 30,000 tonnes of newsprint by using mechanical pulp (by conventional grinding process) from a hardwood species — **Boswellia serrata** (Salai) and the chemical pulp (by kraft process) from **Dendrocalamus strictus** (Bamboo). Out of the two species, **Dendrocalamus strictus** (Bamboo) is being used in the country for pulping, chiefly by the kraft process for about last 40 to 50 years.

The use of **Boswellia serrata** (Salai) for the manufacture of mechanical pulp has been pioneered by this mill for the first time in the country. The successful use of the unusual hardwood for the production of the mechanical pulp to be used as the furnish in the newsprint manufacture, has been an achievement by itself. However, the mill is having a substantial expansion programme in its hands. After the expansion the mill shall manufacture 75,000 tonnes of newsprint. It shall use a furnish of mechanical and cold caustic soda pulp from salai and other hardwoods (Eucalyptus and others) and chemical pulp from Bamboo. The factors that led to this change in the furnish and made the expansion possible, are proposed to be discussed in this article. The expansion raised the hope that better and stronger newsprint shall be available by the proposed change in the furnish.

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Boswellia serrata (Salai) is a a hard wood species which grows gregariously in the surrounding areas. To further augment the supply of the raw material, an extensive programme of the plantation of Eucalyptus species has also been taken up by the Forest Department of the Government of M.P. The trees of B. serrata are moderate sized. They ordinarily attain a height of 30 to 50 feet with somewhat drooping branches. The logs from the branches are generally crooked — a property that causes troubles during the grinding and influences the strength properties of the pulp. The wood is moderately hard, whitish and resinous with heartwood which varies in colour from dark brown to blackish shade. The fibre dimensions are given in the **Table I.**

Table I — Fibre dimensions of B. serrata (Salai)

	Length m.m.	Width m.m.
Maximum	1.20	0.039
Minimum	0.60	0.014
Average	0.88	0.024

Table II. — Comparative tests on Mechanical Pulp from Hard and soft wood species. (Tests carried out on Indian Raw material — Mill grinders)

Mech. Pulp from	Fr.	B.F.	T.F.	B.L.
Boswellia sarrata (Salai)	74	2.84	17.4	812
Spruce	80	10.30	45.3	1820
Fir	80	9.3	46.0	2100

As expected mechanical pulp from **B. serrata** (salai—a hardwood) yields a relatively poor pulp in comparison with the pulp available from the soft wood species e.g. spruce, fir etc. **Table II.**

The already short fibres undergo further damage during the grinding. This pulp could, to some extent, be improved at the cost of comparatively higher power consumption. However, since the electricity is comparatively costlier and was available in limited quantity only, it was necessary to strike a balance. This comparably low quality pulp resulted in the use of a higher proportion of the costlier chemical pulp which subsequently influenced the cost of the manufacture of the newsprint. Thus the production of a better quality of pulp from B. serrata at a cheaper cost was an absolute necessity for the will.

LABORATORY TRIALS

Attempts were made to supply such treatment and pulping technique that needed the least modifications in the existing plant and equipments of the mill. The following procedures were tried one after another with a view to obtain mechanical pulp with better characteristics.

1, — Treatment of the manumanufactured pulp with various chemicals.

2, — Use of chemicals during the grinding process — either in spray or in the pit.

Table III — Treatment of the mechanical pulp with Chemicals

S. No.	Treating Chemicals	% on B D. Pulp	Treating Temp. oC.	Treating Time Hrs.	Strength Tests B.F.	Strength Tests B. Length metres
1.	Untreated Pulp	Nil	—	—	1.23	585
2.	Caustic Soda	2.0	80	1	1.70	630
3.	-do-	2.0	70	1	1.27	600
4.	-do-	2.0	60	1	1.22	505
5.	-do-	2.0	50	1	1.10	615
6.	Sodium Sulphite	2.0	80	1	1.74	776
	-do-	2.0	70	1	1.12	610
	-do-	2.0	60	1	1.03	400
	-do-	2.0	50	1	0.90	535
1.	Untreated pulp	—	—	—	1.42	575
2.	Sodium Sulphite	5.0	80	1	1.15	533
	-do-	5.0	70	1	1.83	6663
	-do-	5.0	60	1	1.70	583

Table III A — Effect of Caustic Soda Treatment of Salai G.W.P.

S. No.	Treatment	Treatment condition Time Mts.	Treatment condition Temp. °C.	5.0% NaOH on B. D. Pulp B.F.	5.0% NaOH on B. D. Pulp B. Leng. metres.	2.0% NaOH on B. D. Pulp B.F.	2.0% NaOH on B. D. Pulp B. Leng. metres.
1.	Untreated Unbleached Pulp	—	—	2.48	828	2.36	640
2.	Untreated but bleached	—	—	2.64	744	—	—
3.	After treatment with Caustic Soda and bleached with 10.0% Chlorine in two stages	15	55	3.4	980	2.40	640
		30	55	3.14	784	2.32	754
		45	55	3.06	916	2.23	676
		60	55	2.51	1016	2.36	640

Table III B — Effect of Lime Treatment on Salai G.W.P.

Sl. No.	Treatment.	Time Mts.	Temp. °C	10.0% Lime		5.0% Lime	
1.	Untreated unbleached	—	—	2.66	1024	2.16	960
2.	Untreated but bleached	—	—			2.82	1036
3.	Lime treated	15	60	3.58	1296	3.22	1144
4.	-do-	30	60	3.96	1288	3.20	1252
5.	Lime treated, followed with bleaching with 10.0% Chlorine	15	60	3.50	1156	3.12	1056
		30	60	3.56	1160	3.24	1192

3, — Treatment of the logs before grinding with chemicals and or steam.

4, — Treatment of chip with or without the use of the chemicals and/or steam (heat energy).

1) **Treatment of the Pulp with Chemicals :**

Various chemicals were used either singly or with others. Even mechanical treatment was also tried in the presence of the chemicals. The results are given in the Table as under.

Table III — shows the effect of 2.0% caustic soda and 2.0% and 5.0% Sod. Sulphite on B.D. Pulp at different temperatures (from 50°C to 80°C).

Table IIIA — shows the effect of 2.0% and 5.0% caustic soda on B.D. Pulp for various durations followed by bleaching with 10.0% chlorine (as hypochlorite).

Table IIIB — shows the effect of lime in stead of caustic soda under conditions similar to those in Table IIA.

Table IIIC — shows the effect of bleaching and the combined effect of treatment with lime with simultaneous bleaching. In this case mixtures with chemical pulp have also been tested.

These tables indicate that some improvement is possible by treating the normal pulp with the chemicals with or without simultaneous bleaching. However, the im-

Table III C : Effect of Lime treatment with simultaneous bleaching with chlorine on Salai G.W.P.

S. No.	Treatments.	Freeness C.S.F.	B.F.	T.F.	B. L. m.	Remarks.
	Tests on 100% G.W.P. from Salai.					
1..	Untreated pulp	49	1.06	—	586	
2.	Bleach G.W.P.	59	1.04	—	520	
3.	Treated & Bleached	78	1.55	—	688	
	Tests on 75: 30 Mixture sheets with Bamboo Chemical Pulp after the treatment with lime and simultaneous bleaching.					
1.	Untreated Pulp	138	5.34	38.5	1095	
2.	Bleach Pulp	142	5.85	45.0	1190	
3.	Treated & Bleached	133	7.10	47.6	1434	

Table IV: Effect of the chemicals used during the Grinding.

S. No.	Particulars	Control.	Spray trial	Hydraulic trial.
1.	Concentration of the treating solution.	Nil	10.0 gpl	100.0 gpl
2.	Rate of spray.	Water 0.3 GPM	Caustic 0.3 GPM	Water 0.9 GPM
3.	Pressure during the grinding trial.	1.6 kg./ cm^2	1.6 kg./ cm^2	1.6 kg./ cm^2
4.	pH of the grinder pit	6.6	11.5-12.0	11.8-12.5
5.	Average rate of grinding cms./mts.	12.1	11.1	14.0
6.	Behaviour during screening.	Easy	slow	slow
7.	**Characteristics of the pulp.**			
	a. Freeness C.S.F.	148	203	113
	b. Brust factor.	1.65	1.91	1.39
	c. Tear factor.	20.8	14.4	19.7
	d. Breaking length metres.	1040	1245	1175
8.	**Strength of the 60: 40 Mixture with the chemical pulp.**			
	a. Freeness C.S.F.	325	235	266
	b. Brust factor.	6.25	2.80	10.54
	c. Tear factor.	48.0	54.5	49.0
	d. B. Length metres.	1214	1865	2007
9.	Colour of the G.W.P.	Normal	Dull yellow	Dull yellow

Note : Spraying of the Caustic Soda solution does not appear to be very beneficial. The grinding rate is reduced and the colour of the pulp is also deteriorated. Hydraulic treatment with the cold caustic soda solution at high concentration and pressure gave sheet of mixed stock having quite improved strength but of somewhat poorer colour. However, the penetration of the caustic soda was very poor. The ratio of the volume of the wood where the liquor has penetrated, to the volume where it has not penetrated shall fall to a considerable extent when a log of 4' length is considered in comparison to a billet at 1 1|8" x 1-1|8" x 6". The improvement is thus likely to be neutralised when the logs are to be treated in this manner.

provement indicated in the mechanical pulp and the consequential increase in the strength of the mixed stock, is negligible and still give poorer test as compared to the convential mechanical pulp from the softwood species.

2. **Use of chemicals during the grinding process :**

Since the damage to the fibres already done during the grinding process could not be made good by the treatment of the chemicals, it was desirable to study the treatment of the logs before the grinding so that the fibres were easily liberated without much damage :

With a view to assess the influence of the use of chemicals during the grinding, trials were conducted as described below :

a, — Normal grinding to serve as control grinding trial.

b, — Spray of 10.0 g.p.L. caustic soda solution in place of normal water spray during the grinding.

c, — Before grinding the billets were subjected to the treatment with a 100 g.P.L. solution of Caustic Soda, at room temp., by placing them in a digester and applying hydraulic pressure with a hand pump upto the range of 150 p.s.i. (appro. 10.0 Kg./cm^2), to force the caustic soda solution to enter inside the body of the billets to impregnate them completely. Though the pressure was applied for two hours, it was found on breaking and inspecting one of the billets, that the entry of the caustic soda solution had been only superficial. The solution had penetrated upto the depth of only about ¼". The results of the grinding trial are given in the **Table No. IV.**

Table V : Effect of the treatment of the logs before grinding :

S. No.	Treatment	Freeness C.S.F.	B.F.	T.F.	B. L. m.	Remarks
1.	No treatment for control	105	2.57	17.6	680	
2.	Hot water under pressure. Temp. 150°C.	130	2.30	19.5	750	dull colour
3.	Caustic soda solution. 50.0 GPL — 120°C.	150	2.80	20.5	760	dull colour
4.	Chemi Ground Wood (Neutral solution of Sod. sulphite)	100 to 250	4.0 to 6.0	30.0 to 40.0	1800 to 2500	dull colour

Note : It shall be observed that in the above table against S. NO. 4 ranges are given against the tests. This has been mentioned in this manner to give roughly the test range of a large number of trials carried out under various conditions. About 70 to 80 trials were carried out by controlling different variables such as the temperature, hydraulic pressure, time for the treatment, concentration of the treating solution and the ratio of sodium sulphite to sodium carbonate etc.

3) **Treatment of logs before grinding :**

Logs were treated in a steam jacketted, double walled, laboratory digester. The logs were treated with hot water, caustic soda solution and sodium sulphite solution that was neutralised by the addition of sodium carbonate generally known as Chemi-groundwood. Results of various treatments are given in the **Table V.**

Though the treatment of the logs before the grinding specially the chemi-ground wood pulping gave substantial improvement in the strength of the pulp, the improvement was still not sufficient. With further rise in the strength (which was found to be possible by increasing the severity of the treatment) the colour of the pulp deteriorated to such an extent that it became difficult to bleach within the economic range. The search was, therefore, still necessary.

4. **Treatment the chips and the conversion of the treated chips in to the pulp :**

Since the treatment procedures tried on the pulp and the logs failed to give sufficient improvement in the quality of the mechanical pulp, it was found desirable to investigate the procedures that involved the chips of Salai, as it was reasoned that the chips would provide comparatively a very large surface for the penetration of the chemicals into the body of the chips. (compare — penetration of caustic soda in logs described earlier).

The logs were chiped in the mill chipper and the chips were taken for trials. The chips were subjected to various treatments and were disintegrated, to be refined, to yield the mechanical pulp for use as a part of the furnish for newsprint. After the treatment, the chips were disintegrated either in the Noble & Wood Cycle Beater or later in the La-

General observations to compare the conventional G. W. P. from Salai with the Chemi-ground wood from it.

S. No.	Particulars	Conventional grinding at the mill grinder or at the lab. grinder	Chemi-groundwood at laboratory grinder
1)	Rate of grinding	10-15 cms./minute when the pocket is filled properly.	Chemi-groundwood at laboratory grinder.
2)	Freeness	Generally less than 100 C.S.F.	Comparatively higher under similar conditions of grinding.
3)	Brightness of the Pulp	Depending on the percentage of heartwood and the duration of stacking.	Depending on the percentage of heartwood duration of stacking and the severity of treatment. The last condition tends to reduce the brightness to a very great extent.
4)	Yield on B.D. Wood	at Lab. grinder upto 90% in mill 75% — 80%	at lab. grinder 65.0 — 80.0% depending on the severity of treatment.
5)	Bleachability	Hypochlorite gives better brightness but a yellowish tinge. Peroxide bleaching depends on the percentage of heartwood & storage, when retreatment with hypochlorite is necessity	Same as normal G.W. except pulp from harsher treatment needs greater quantity of bleaching chem. till at one stage it becomes unbleachable.
6)	**Strength properties : Tests :**		
	i) Freeness	generally less than 100 C.S.F.	Comparatively higher upto 250 C.S.F.
	ii) Burst factor	1.5 to 2.5	4.0 to 6.0
	iii) Tear Factor	12.0 to 18.0	30.0 to 40.0
	iv) B. Length Metres	500, to 800	1800 to 2500
	iv) Fibre classification :		
	a, — plus 28	1.0 to 4.0	2.0 to 5.0
	b, — „ 48	5.0 to 8.0	18.0 to 25.0
	c, — „ 100	15.0 to 20.0	20.0 to 30.0
	d, — „ 200	18.0 to 25.0	10.0 to 15.0

boratory Model 12" Single Disc Sprout — Waldron Refiner. The disintegration proceeded by gradually reducing the clearance between the essential parts of the equipments. In the beater the clearance between the bed plate and the roll knives was gradually reduced after a predetermined period of time while in the case of the refiner the clearance between the discs was reduced after a fixed number of passes after every adjustment by following a pattern nearly similar to that folowed by 'Sommerville'. During the refining, the samples were taken after fixed intervals and tested for the strength and other tests. The results obtained are given in the **Table VI.**

It may be noted that the pulps obtained from the treatment of the chips with cold caustic soda and also with Neutral Sodium Sulphite possess quite good strength. The Neutral sulphite Semi Chemical Pulp was found to be having the higher strength while the cold caustic soda pulp ranked second. Comparision is evident from the following photographs of the microscopic slides of salai G. W. & Cold Caustic Soda pulp. The choice had to fall on any of the two types of the pulp. However, the choice fell on the cold caustic soda pulp for the following reasons :-

a. A sustained demand of the sulphur for producing the treating chemicals and the uncertainty of availability, it may be noted that the country is short of sulphur.

b. The possibility of greater volume of abnoxious effluent which was likely to give great difficulties during treatment.

c. Availability of caustic soda in the mills' own caustic soda and chlorine plant.

d. The corrosion action of the chemicals in the N.S.S.C. process needed costlier material of construction in the plant.

Once the choice fell on the cold caustic soda pulp, further trials were undertaken to study the effect of many possible variable factors such as i) the effect of the concentration of the treating solution, ii) the effect of the treating time, iii) the effect of the hydraulic presure applied during the treatment and iv) the effect of the size and type of the chips etc. The extent to which the treating solution could be reused with proper refortification was also studied. It can only be mentioned at this stage that the cold caustic soda pulping process is quite well suited to this species. Once certain minimum

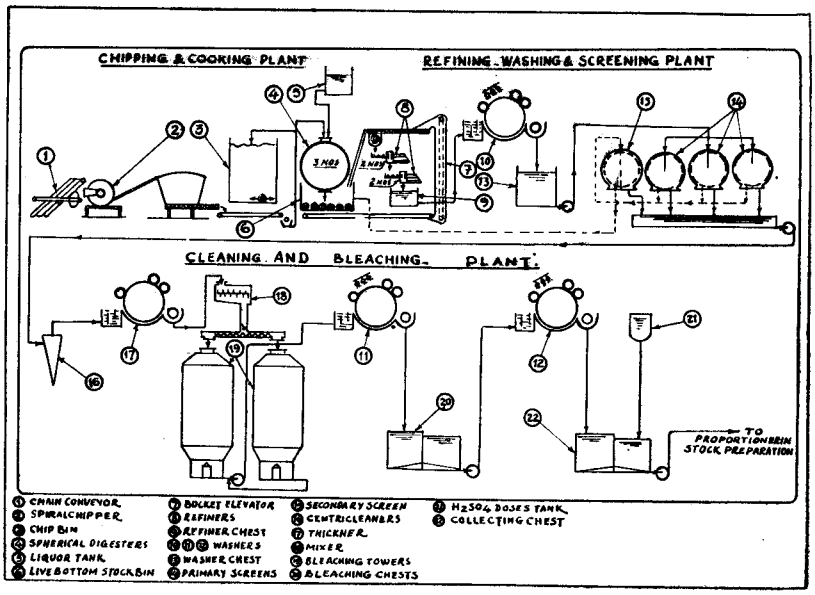

Fig. 1. Flowsheet of cold soda pulp mill at Nepanagar, U.P.

Table VI: Tests on the pulp obtained from the treatment of the chips.

S. No.	Particulars of Treatment	Freeness C.S.F.	B.F.	T.F.	B.L. (mtrs)
1.	Refined without any treatment	258	Very course pulp		
		146	Very brittle sheet		
		108	1.46	14.8	230
2.	Steamed	215	Brittle sheet		
		104	1.27	12.8	158
3 a.	Chips treated with Cold Caustic Soda solution. (100.0 gpl).	318	7.75	29.4	1750
		273	7.40	30.6	1820
		196	10.30	29.0	2640
		150	12.95	29.8	3320
		106	15.20	31.8	3820
3 b.	Caustic soda solution (25.0 gpl.)	307	7.5	31.5	1714
		249	8.15	32.75	1918
		195	10.4	29.72	2317
		175	12.2	30.10	1804
		137	11.07	29.60	2240
4.	Neutral sulphite semi-chemical pulping	446	16.27	60.5	2180
		368	18.85	59.80	3474
		269	21.40	61.60	4110
		190	27.50	60.50	4855
		169	29.80	60.59	5831

conditions are satisfied the pulp obtained from the process shows the desired strength which does not very to any great extent by increasing the severity of the treatment as in the case of the chemi-groundwood pulping. It has also been confirmed that the physical characteristics of the cold soda pulp can be very well controlled during the refining and thus enabling the operator to produce a uniform quality pulp. The experience gained in the laboratory and the results, also confirmed by the tests carried out on salai by the other foreign laboratories prompted the mill to undertake the expansion scheme which would take into consideration all the problems related to the manufacture of newsprint from the mechanical pulp from hardwood only which adversely influences the quality of the product. The cold caustic soda pulping process has been applied to a large number of wod species that grow in the areas surrounding the mils. While taking the species for the trial, atempts have been made to see if they are comparatively fast growing species. It has been found that some of them respond fairly well to this process.

Steps are, therefore, already being taken to use whatever quantity of these hardwoods is available. Since in almost every case similar pulping conditions have been maintained to ascertain the suitability it appears to be quite certain that mixture of these speices in almost any proportion (of the individual species) would yield quite suitable pulp.

The use of these hardwoods in mixed forms provides all the added benefits of cheaper exploitation of the forest, yield per acre of the raw material etc. These species are — Acacia auriculiformis, Albizzie procera, Cassia Siamia, Diospyros melonoxylon, Melia azederech, Pithecolomium saman, Poinciana regia, Terminalia arjuna and Terminalia tomentosa.

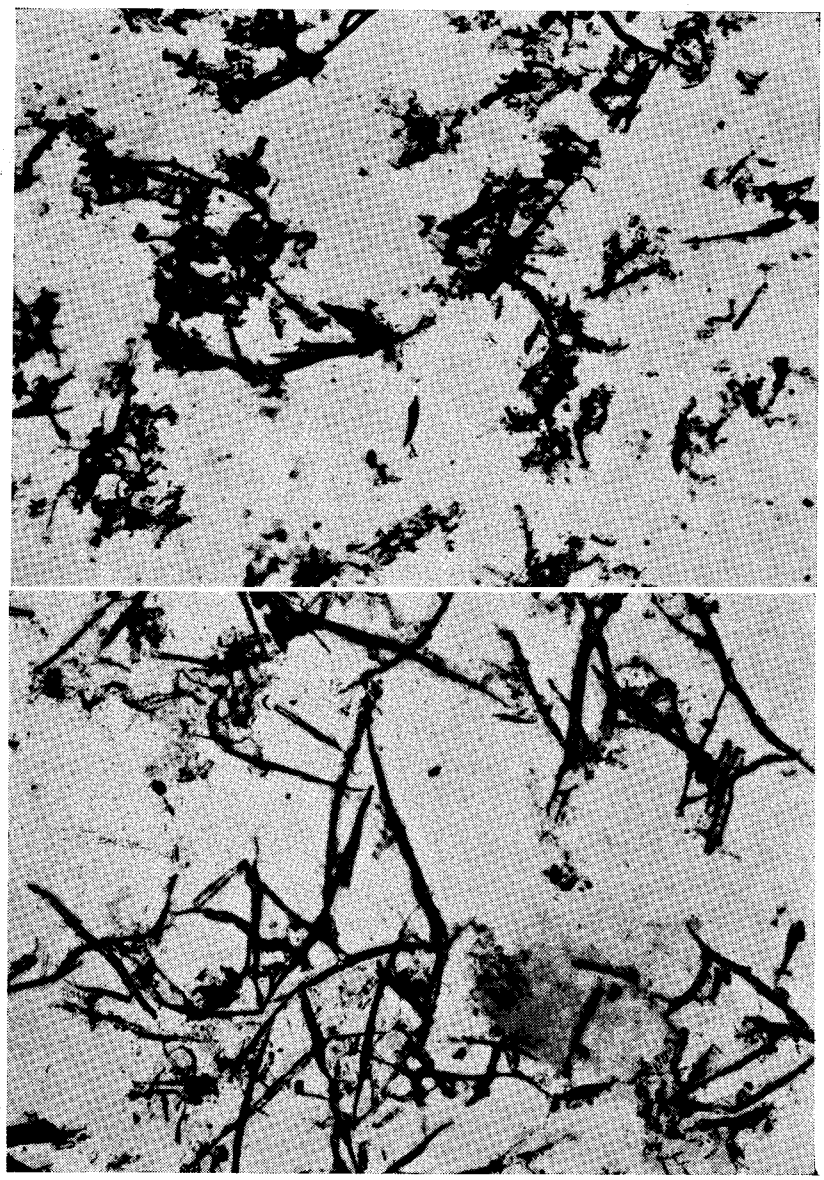

Fig. 2 Photomicrographs: (Top) Groundwood pulp, (bottom) Cold caustic soda pulp.

MILL EXPANSION

As already mentioned earlier, it is planned that the cold caustic soda pulp would provide 1/3rd of the total requirement of the furnish to produce 75,000 tones of newsprint annualy. A 90 tonne/day of bleached cold soda pulping plant is, therefore, being installed. The plant is expected to go into operation some time in the year 1971. A brief description of the plant illustrated in the schematic flowsheet (below) is given below. **Fig. 1.**

Chipping :

Freshcut logs, with their bark removed in the forest, would be fed to a spiral chipper which is designed to produce uniform

chips of approximately 25 mm width x 5 mm thickness. This type of chips are well suited for an increased rate of impregnation of the treating liquor, because of an increase in the area exposed for this purpose. The chips are also quite uniform and, therefore, a chip screen and the rechippers are conveniently omitted. These chips are pneumatically convyed to the digestors directly or through the storage bin.

Impregnation :

The chips will be impregnated with 4.0% to 5.0% caustic soda solution in suitable rotary, spherical digesters where high hydraulic pressure would be provided by centrofugal pumps with a view to speed up the impregnation.

Ring type screens are fitted inside the digesters for the removal of the excess liquor after impregnation. This liquor will be reused again and again after proper fortification with concentrated caustic soda solution. It is expected that after a number of cycles it would be necessary to discard the spent liquor. At this stage this liquor shall be sent to the recovery section of the Kraft Mill for the recovery of the alkali.

The digesters shall be emptied out (by rotating them) into a live bottom bin from where the treated chips shall be conveyed at a constant rate to a distributing and metering device provided for feeding the disc refiners, while the excess chips shall return to the live bottom bin. A batch process has been adopted to provide more flexibility in operations.

Fiberizing :

The impregnated chips are fed to the disc refiners without any intermediate washing as it is reported to have been established that the presence of alkali during the fiberizing and refining not only assists in smooth disintegration but also produces a better quality pulp. After disintegration in the primary refiners (2 Nos.) at a high consistency, the final refining shal be completed in the secondary refiners (2 Nos.) at a normal consistency. The refined pulp shall now be washed on a rotary vacuum washer, in order to minimise the foaming effect in the subsequent operations.

Screening and Cleaning :

A conventional extensive screening and cleaning system has been provided. The rejects from the primary centrifugal screens shall go to the secondary centrifugal screen. The accepted stock from the secondary screen shall go ahead of the primary screen, while the reject shal go back to the live to bottom bin mentioned above. The accepted stock of the primary screen shall be cleaned further in a three stage centricleaning system.

Bleaching :

The accepted stock from the centricleaners shall be thickened on a vacuum filter. The thick stock from the thickner shall be distributed in to two high density towers after the required quantity of calcium hypochlorite solution is mixed in a high consistency mixer. After sufficient retention in these towers, the bleached pulp shall be washed and led to the storage chests for further bleaching to obtain uniform degree of brightness in the final pulp.

The finally bleached pulp shall be washed on a vacuum washer and continuously treated with acid in a high speed mixer from where it shall be led to the stock properation plant. The above plant is being supplied by Indian manufacturers, M/s. Utkal Machinery Limited in collaboration with M/s. J. M. Voith, GmbH, West Germany.

It is expected that the commissioning of this plant shall open a new chapter not only in the manufacture of newsprint but also enable the country to exploit the untouched sources of many hard woods species for different uses. It has been established in the mill laboratory that a large number of locally available hard wood species respond favourably to the cold caustic soda pulping. The Nepamills can rightly feel proud in being pioneers not only in the field of manufacturing newsprint from quite unconventional hardwood (Boswellia sarrata) but also for taking a bold step towards the application of the cold caustic soda pulping process on the hard woods.

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