alkaline grinding of short-fibred hard woods with special reference to boswellia serrata (salai)

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The 'Mechanical Pulping Process' requires huge amount of power. The development and progress of Newsprint 'Industry' would be retarded in power-starved countries. However, this has been overcome by introducing "Alkaline Grinding". The alkaline grinding of wood reduces the power requirement, and improves the newsprint streng.h characteristics, but it reduces the yield by 2.5% due to removal of Tannin.

Exploding population, increasing literacy, rapidly progressing civilisation and swelling tempo of industrialisation call for ever-increasing per capita consumption of paper/newsprint. And this eventuality ultimately forces the paper machines, including the Newsprint machines, to expand more and more, and that, in particular, poses a problem for the groundwood pulp manufacturers to correspondingly increase the output at the wood pulp grinders.

The Mechanical pulping process (Conversion of wood into groundwood), requires huge amount of energy, which has been, and is, a major bottleneck for the Newsprint industry in the country. It is quite possible that the available power may further be restricted, or due to certain other disturbances or unforeseen additional demand elsewhere, the normal power supply might be cut, and this might certainly hamper the Newsprint production.

For increasing groundwood pulp production, we are left with 2 alternatives :—

—Making available more total power
—Reducing the energy requirement of the Mechanical Pulping Process.

Lot of work[1-30] has been done over the past years at almost all places and especially during the last 10 years, there have been notable advances and developments in the technology of groundwood pulp manufacture and quality improvement/reduction of energy requirements in the grinding process. This work includes the following :

—Development/Improvement of the Pulpstone
—Development/Improvement of the Mechanical Pulp Grinders
—Grinding process variables.
—Consistency (pit)
—Temperature
—Pressure
—Burring Technique
—Pulpstone Composition
—Stone Speed (Peripheral)
—Stone Submergence
—Stone Surface/Friction coefficient
—Wood.

These studies have led to improvements in Mechanical Pulping Process, but still there are problems plaguing the uniformity and technical process control and the belief has been there, and is still there, that for the production of a good quality groundwood, we require high energy consumption.

Various other processes which have been employed for increasing the Pulp Strength and Grinder production are :

(i) Chemi-Groundwood (Great Northern)
(ii) ALB Semi Cell Process (Austrian Patent)
(iii) Cold Soda Process.
(iv) Chemi-Mechanical Process
(v) Refiner Groundwood or Chip Groundwood (i.e. Super groundwood)
(vi) Anker Process (Pitless Grinding)
(vii) Coarse Grinding followed with Refining.

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Besides all these laudable achievements, one more method of improving Groundwood Pulp is the addition of a chemical in the Grinding Zone of a Pulpwood Grinder (where the chemical gets activated by the High Temperature there and entails no other expenditure) so as to effect changes in pulp.

—Strength (Burst factor, Breaking length, Tear factor etc.)

—Brightness

—Energy unit consumption.

—Reduction in process problems (resulting from wood containing extractives and pitch.)

Such a logical approach has attracted the attention of a number of groundwood chemists and technologists ([1-30]), and that a large number of patents have been granted shows the awareness of the technologists to pull out the industry from all directions.

Australian Newsprint Mills Ltd., Boyer, Tasmania, Australia, had to face 'power rationing' from 15th November, 1963 to 1st March, 1964, because of water shortage in the main catchment area of Tasmanian Hydro-Electric Commission Stations.

In the words of the Hydro-Electric Commissioner, as published, where 'over the past 5 years Tasmanian High Land catchments have experienced a period of below average rainfall and at the end of October 1963 storages were no more than half full'. (Hydro News-Jan./March 1964).

In order to offset the adverse effect of "Power Rationing" at Grinders on the Newsprint production and subsequently Company's profits, an entirely new and novel process—Alkaline Grinding (developed by Australian Newsprint Mills Ltd. (A.N.M.) researchers some years ago for toning of the Newsprint colour). (i.e. Grinding in the psesence of Caustic Soda (NaOH) had to be introduced overnight). Following noteworthy advantages have been reported :—

- Satisfactory pulp (Ground wood) in Quality and Colour
- (Colour is battered because of Jannins removal)
- Reduced Power demand (i.e. Lower Power than the normal grinding).
- Superior Newsprint characteristics.
- No slashing of Newsprint production due to power shortage or attaining of target production (101,920 Tons). Even in the fiscal year ending on June 1955, A.N.M.'s record production was 104.319 short tons—an increase of 1235 tons on the previous years record. With renovation of No. 2 machine (Addition of new Headbox and Screens) in December 1965 resulted in enhanced sheet formation and with introduction of the Alkaline Grinding Process, the annual producton record is expected to soar high.
- A little relief in Bleaching costs.

The only shortcomings which are outweighed by the advantages are :—

—Higher cost of Caustic Soda

—A little lowered Recovery of Pulp from wood.

A.N.M. report that during the power rationing period, the volume/cost of production of newsprint were very near to planned levels and records were broken despite manoeuvres for Caustic Soda consumption at the expense of Pulp quality and the forced intake of lower quality pulpwood for some weeks due to forest fires. It is further stated that the knowledge gained in operation of Alkaline Grinding Process would be of enormous value, should power restrictions occur again or should the mill be expanded. True, "proper conducted Research is probably the best investment an organisation can make, the monetary value of production losses averted by adopting the Alkaline Grinding process developed by A.N.M. Research during restrictions of power was nearly as much as the total expenditure on Research by A.N.M. since production started at Boyer 23 years ago."

Recently Australian Newsprint Mills Rereach Division developed a new mechanical pulping process which would be installed as part of the expansion programme of raising Newsprint capacity from 93,000 T/year to 165.000 T/year, and construction has already begun. The method would be the use of autoclaves of a novel design and regrowth trees. Besides, larger washers (vacuum) would also be installed for still another process (again developed by A.N.M.'s Research Staff) for the production of a

Mechanical Pulp and Newsprint whiter than the Highest world standard. (Pulp and Paper International—June 1966 ; p.30).

"The Grinding of Eucalypt wood in the presence of Caustic Soda"[30] describes the Grinding of Eucalypt Pulpwood in the presence of Caustic Soda solution at a pH 9.3 resulting in a decrease of 20% in the energy unit consumption required for a pulp of constant strength characteristics, or a considerable increase in strength characteristics at an unchanged unit energy consumption. The alkali dissolves out some of the dark polyphenolic compounds present in the Eucalypt and after a washing and subsequently adjusting the pH to 4.0, the Alkaline Groundwood brightness is sufficiently improved and better than that of the normal groundwood.

The removal of these materials causes a decrease in loss of brightness suffered by the Newsprint containing this Groundwood in passage through the driver (Paper Machine) and this Groundwood is readily brightened by zinc hydrosulfite and under suitable conditions gain of 16-20 units is possible.
In the Mill trial of 'Alkaline Grinding' at A.N.M., the steps followed were :—

- Grinding in the presence of small quantities of NaOH—followed by washing for removing the polyphenolic (dark colored) substances immediately.
- Treatment with Zinc Hydrosulfite (ZnS_2O_4) at 50°C followed by adjusting the pH to 2.5 with Sulfuric acid (H_2SO_4).
- Washing to effect removal of reaction products from the bleaching treatment followed by subsequent adjustment of pH to 4-5 for the final Groundwood.

Alkaline Grinding was tried in both the grinders,—Great Northern and Tidmarsh ring grinders. During the normal grinding of Eucalypt, the pH of stock in the grinder pit is 3.8.

Table No. 1.

[Grinding results (mean) of 17 samples in Great Northern Grinders]

	Bulk	Burst Factor	Tear Factor	Breaking Length	C.S.F.	HPD/Ton	Brightness
Acid Grinding	2.79	8.3	21.1	1850	141	81.1	56·2
Alkaline Grinding	2.75	10.1	24.5	8230	148	70.9	60·3

PH—9.2 and % NaOH used 2.37

Table No. 3.

[Grinding on Tidmarsh Grinders]

	Bulk	Burst Factor	Tear Factor	Breaking Length	C.S.F.	Brightness
Acid Grinding	2.80	8.3	18.1	1810	89	57.7
Alkaline Grinding	2.76	10.0	21.2	2100	91	61.6

Table No. 2.

[Grinding results (mean) for a 10-week-period for Great Northern Grinders]

	% NaOH used on O. D. wood	Grinder Rate 1 ton O.D./Hr.	Unit energy HP on D/T	Burst factor	Tear factor	C.S.F.	Brightness Gd. Wd.*	Brightness Newsprint
Acid Grinding	—	0.868	79.8	6.9	19.3	53	58.3	54.7
Alkaline Grinding	2.52	1.134	61.6	7.7	20.7	54	56.3	54.3

pH=9.2 and % NaOH used 2.52.
* Groundwood.

A survey of the above tables shows that grinding at a pH of 9.2 and % NaOH usage 2.37-2.52 results in—

—A slight change in Freeness

—Increase in Burst Factor by 22.0% (Table No. 1)

—Increase in Breaking Length 18-20.0% (Table No. 1 and 3)

—Increase in Tear Factor 16.0%

—Energy saving of 12.58% or 10.2 H.P.D/Ton (Table No. 1) or Decrease in Grinding Power 22.8%—or 18.2H.P.D/T18.2

—Increase in grinding rate..... 30% (Table No. 2.)

Even sodium carbonate (Na_2CO_3) had been tried in place of Caustic Soda but the pH did not rise beyond 8. Calcium Carbonate ($CaCO_3$) cannot instead be used, because of serious discoloration by the Calcium ion (ca++).

No serious deterioration of Pulp-stones has been noted over a period of 1000 hours grinding except that a solution of 10 gpl NaOH when directed on the Pulpstone without dilution caused some ridges to develop in the surface. These were avoided by liberal dilution of the alkali solution. The hot alkaline solution rapidly destroys the bond in crystlon 37C Norton Pulpstones, whereas Alundum A and Alundum 38A stones resist more progressively.

Alkaline Grinding and Hardwood Groundwood Mill :

A look at the spectacular results of 'Alkaline Grinding' of Eucalypt at Australian Newsprint Mills, as mentioned above, shows that this process holds a great promise for groundwood mills based on Hardwoods, and the importance touches a new high when there is chronic power shortage. At Nepa, we have both Hardwood and shortage of Power at wood pulp grinders.

Restoring to 'Alkaline Grinding of Boswellia Serrata' (Salai) would give us :—

(i) Increased/improved groundwood pulp strength.

(ii) Pulp strength would increase further, if the energy units which this process claims to reduce are used or fed into the grinder and the stones be kept a little duller ; or at an equivalent energy consumption, the strength would go up.

(iii) Strength can still, or would still, go up if the stones are kept duller, as the grinding rate goes up by 30% or keeping the grinder production same or constant, the strength increases to a considerable extent.

We can, therefore, presume that we can have strength increase only because of 2 counts. (i) (ii) and production increase of 30%

or we can have strength increases because of 3 counts (i, ii,iii), keeping the production same.

"Alkaline Grinding" would give us dark coloured pulp at the grinders because of extraction of Tannins by the Caustic Soda, which would require good wash for removing the coloured compounds (may use a little sodium hypochlorite for bleaching and then give a 2nd wash to remove the residual alkali or may avoid bleaching) and give it a 2nd wash and then neutralise the pulp alkali with H_2SO_4 bringing down the pH to 4-5 at the the Decker Chest stage, thereby getting a reasonably bright groundwood pulp.

Following is a broad spectrum of advantages that will be accruing from the "Alkaline Grinding" (i.e. grinding of *Boswellia Serrata* in Caustic Soda) :—

—Improved strength/fibre length (better groundwood)

—Improved web strength.

—Equivalent drainage with less of fines/chop, splinters

—Reduced HP.D./Ton or energy unit consumption

—Improved final colour leading to improved Newsprint

—Brightness or else a relief in Bleaching costs

—Increased groundwood production

—Lesser or reduced Burning frequency—Better pulpstone life and (lesser downtime increased production.) (stones and burrs both being foreign exchange commodities)

—Bad dried stained wood (Rainy season) and fungi affected wood is not much of a problem (Alkali

present during Grinding would collect most of the dirt/fungi due to high temperature in the grinding, and that would be removed in subsequent operations—washing, bleaching, screening). Cleaner Groundwood presupposes cleaner Newsprint.

—Reduced pitch and slime troubles meaning cleaner paper-machine systems (wet end)—extended period of wash up—lesser Downtime

—and More production.

—No corrosion problems

No detrimental effect on Groundwood Mill operation

No adverse effect on paper machine operation

—Grinding at pH 9.2 no problem at Paper Machine as the pH of groundwood stock will be adjusted to 5% at Decker Chest before being processed further.

—Improved groundwood strength would mean lesser percentage of chemical pulp per ton of newsprint and lesser cost of newsprint.

—Improved groundwood strength also would mean improved paper machine run with lesser breaks—increased production meaning more profits.

—Increased groundwood production ultimately leads to more Newsprint production.

—Increased percentage of groundwood in Newsprint would mean better opacity, bulk and printability—welcome quality improvements.

—Not much of installation cost, nor any complicated process.

—%NaOH (on the basis of moisture free wood) be lesser as compared to A.N.M., as Nepa pH in the Grinder pit is 7-7.5 as against 3.8.

—Yield of pulp may drop by 2-5% or this figure may even be lesser—This being not much of a disadvantage as compared to ultimate benefits.

—Caustic Soda and Bleaching Chemicals at our doors.

—Caustic Soda consumption per day tolerable and not much, when compared to substantial benefits.

—Negligible or practically no stream pollution.

—Soften or swell the chips at present source of breaks at the Calender entailing a very heavy production loss.

—In short, an overall relief—lesser cost of newsprint per ton in the Long run; and power rationing or emergency cut at wood pulp grinders—whether temporary or chronic to worry none.

In not too distant a future, we shall have to switch over only to high speed machines, which demand better, longer and stronger Groundwood fibres. Newsprint furnish essentially needs such fibre, which can be prepared in a more convenient and economical way by Alkaline grinding. It gives better quality and better yield. Use of such mechanochemically prepared fibre in increasing quantity will consequently decrease the use of chemical pulps, and subsequently, the need of Soda Recovery System. Such trend in Paper Industry has to come up in course of time.

Hardwoods are most receptive to Alkali and so response of *Boswellia serrata* (Salai) to "Alkaline Grinding is more than sure and positive, as it has responded very well to chemical mechanical pulping (grinding of logs having been pretreated with NaOH) and cold soda pulping.

In the end, it can be safely said that the "Alkaline Grinding" (Grinding in the presence of Caustic Soda (NaOH) can be of utmost and immediate importance anywhere, where—

—the wood being ground is deciduous or Hardwood

—there is power emergency and shortage or rationing of power at the wood pulp grinders,

or

Even when there is normal supply of power at the grinders, the wood to be ground should normally be deciduous. "Alkaline Grinding" promises :

—Better strength pulp

—Increased production

—Better/Improved final product—Newsprint with increased production.

It can, therefore, be presumed that "Alkaline Grinding" can, or should, be a permanent, regular feature in the future Newsprint Mills where groundwood Mill is based on hardwoods (Deciduous species) and is a very economic and attractive proposition and would mean still bigger and better bonus for mills having their own units manufacturing "Bleaching Chemicals".

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16. Bhat R.V. and Virmani, K.C. — in their paper "Caustic Soda Treatment of Blue Gum Groundwood pulp", mention the improvement of strength, of groundwood pulp (Blue Gum) by treatment with caustic soda at 30°C, 50°C, 70°C. using in each case 2%, 3%, 4%, 5.0, NaOH on O.D. Weight of groundwood pulp.

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Simmonds, F.A. — in their paper 'observations on bleaching groundwood pulps with Hypochlorites' discuss the increase in Tensile strength of groundwood from certain woods on bleaching the 'Hypochlorites' besides slight changes in bursting and tensile strengths. The strengthening of the pulp is likely due to the alkali necessary for maintaining a pH of the order of 11 so as to retard the reaction rate of the Hypochlorite. Hypochlorites have a greater effect on tensile strength than sodium peroxide. Hardwoods are more responsive to Hypochlorite Bleaching than softwoods.

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21. Cochrane, J.A. — in his paper "The use of sodium sulfite (Na_2SO_3) at the grinder showers in the groundwood process" mentions that the sodium sulfite addition (0.8% on the Drywood weight of screened Groundwood) to the Grinder (Mechanical Pulp) showers.—

reduces grinder power consumption by 7-8% (from 73.5 to 57.5 H.P.D./Ton).

Increases groundwood brightness by 2.5 G.E.; Increases the production.

Has no significant effect on pulp yield; groundwood pulp strength or newsprint machine operation in the speed range of 700—1900 fpm..

At 0.8% sulfite treatment mill corrosion is reduced from that experienced with zinc Hydrosulfite Brightening, but would probably be increased slightly in comparison to no treatment. This process of reducing energy requirements for the production of groundwood pulp and for brightening groundwood has been in operation in the Power River Mills groundwood mill for 2-5 years.

22. Bersano, P. Dr. — in his paper 'Utilisation of poplar pulps' mentions of having tried chemicals in the dilution water at the grinders and achieving success as regards, for instance, brighteness through the addition of sodium bisulfite. Also tests have already been carried out by grinding previously impregnated wood for improving the strength and other characteristics. Poplar is responsive to impregnation, especially when logs are submitted to a hydraulic pressure of some Kg/Cm^2—the impregnation liquor consisting of sodium bisulfite and hydrogen peroxide. The results in respect of physical characteristics and brightness have been satisfactory but the economic difficulties in operation and the corrosion occurring in the grinders because of the presence of sulphur diosice (SO_2) in the pulpstone continuing in such a manner, the presence of sodium ($Na+$) can be prevented.

23. Swartz, J. N. Dr. — in his paper 'Newsprint from Broad Leaf Wood'—mentions that if the logs are chemically impregnated with $Na_2SO_3 + Na_2CO_3$ or NaOH solutions, the

grinding process results in pulps of higher strength/Fibre Length/and higher freeness, higher rate of grinding (i.e. production) and much lower energy, consumption than the untreated woods under the same grinding conditions, which would give short fibred and low strength pulps.

24. Chidester, G.H. — in his paper " Technical Progress enhancing utilization of Fibrous resources for Pulp and Paper " says that the broadleaf woods give weak/short fibred groundwood pulp and the pulp on treatment with a mild caustic solution appreciably improves in strength and is suitable for a number of uses.

25. In a Forest Products Laboratory, Madison, Wisconsin (U.S.A.), Bulletin Table No. 4. — On the " groundwood pulping of Aspen in Caustic Soda and Sodium Sulphite " the increasing percentage of NaOH used in the grinder pit results in better strength (burst factor—Breaking Length—Tear Factor), but the increase in strength tests is less pronounced when sodium sulfite is used instead. Even a mixture of NaOH and Na_2SO_3 has been tried and as given improved and better strength properties.

26. Sawhney, R.S. — prompted by the News in the Paper 'Brazilian firm starts big modern newsprint machine'—(Paper Trade Journal Sept. 23.1963) on Pre-treating of Encalypt Logs at Industries Klabin dos Parana de cellulose SA: Brazil. (South America) with 4% Caustic Soda (NaOH) at a temperature of 80°C in an impregnation pond for a period of 24 hours before grinding for making chemi-mechanical pulp to be used in the Newsprint, the extent of 35%—the rest being 35% Pine Groundwood, 20% sulfite Pulp and 10% Broke-treated Boswellia Serrata (Salai) Logs with 4-5% caustic soda for a period of 3-5 days at normal temperature and then ground in the Great Northern Grinder. The resulting Chemi-Mechanical Pulp had good strength properties (Burst Factor 6.0—8.0 and Breaking Length 1,200—2,400 meters) sheet weight 3.5—4.0 gms) as against the Burst factor 1-3 and Breaking Length 600-1,000 meters of our Normal stone Groundwood.

27. Kothari, P.S. — In his paper 'Indigenous Newsprint' (1964) mentions of having obtained quite satisfactory " Cold Soda Pulp " from Boswellia Serrata (Salai) having strength characteristics (Burst Factor 11.1; Breaking length 2,240 meters and Tear Factor 29.6) at a freeness of 137 C.S.F.

28. Henry, R.W. — in his paper " Cold Caustic Soda Pulp in Newsprint manufacture " (1960) (Pulp and Paper Prospects in Asia and the Far East) (FAO-UN-TOKYO), mentions that Hardwoods are more suitable and responsive to cold soda pulping than softwoods. The cold soda pulp forms an important component of the newsprint furnish and the freeness recommended is 90-130 C.S.F. for an optimum, combination of drainage/wet strength. The newsprint furnish at Australian Newsprint Mills consists of 17% Semi-bleached Pinus Radiata kraft, 23% Eucalypt Cold Soda Pulp. 60% Eucalypt Groundwood now as against the original furnish containing 18% Pinus Radiata semibleached kraft and 82% Eucalypt groundwood. Machine speeds of 1,500 fpm. have been attained and a speed of 1,400 fpm. is being regularly run on a machine with an open Head Box and open draw at Couch. Substitution of 23% Cold Caustic Pulp for Groundwood has led to increased Machine speed by 6.5%. Burst Factor of mixed stock increased by 3 points and Tear Factor by 5 points and a corresponding increase in strength of finished newsprint of 2 points

Burst factor and 2 points Tear Factor (cross and Machine Direction both). Provided Brightness is within 5 points G.E. of the remaining components of the furnish, all characteristics of Newsprint made upto 30% Cold Soda pulp would remain satisfactory excepting a small decrease in opacity.

29. Mardon, J. — in his paper 'Australian Paper Making Scene' mentions that in North American practice, Grinding in the presence of Caustic Soda has not met with sufficient success because of reduction in opacity and because extractives remain with the pulp instead of being dissolved out with the Eucalypt; the extractives are easily removed on the washers and the opacity is not affected. This not only results in a better quality pulp but at the same time, in much less power consumption for the "Australian Industry."

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