Suitability and Adopting of P-RC APMP Pulping Technology for Bagasse Mechanical Pulp Production

Gnanasekaran A, Govindarajan S., Narasimhan K., Krishnan R.V., Venkoba Rao G., Tara M.K.

Tamil Nadu Newsprint and Papers Limited, Kagithapuram-639 136 Dist. Karur, Tamil Nadu

ABSTRACT

Mechanical pulping of Bagasse through conventional CTMP process produces mechanical pulp having lower bulk, lower light scattering coefficient and higher shives content. In-turn, it affects the quality of newsprint produced. Adopting the P-RC (preconditioning followed by refiner chemical treatment) APMP process for Bagasse mechanical pulping instead of existing CTMP process, better quality mechanical pulp can be produced with lower specific refiner energy consumption, lower shives content, higher bulk and higher light scattering coefficient. Even though for adopting the P-RC APMP process for pulping of bagasse requires the improved compression ratio which is achieved with impressafiner. For an effective chemical impregnation system with adequate retention time, followed by atmospheric refiner system the existing facilities available in the plant designed for CTMP process, with some modifications to run the P-RC APMP process, superior quality mechanical bagasse pulp was produced in the plant scale trials and the results of these studies are presented in this paper.

INTRODUCTION

TNPL is the first mill in the world producing Newsprint from Bagasse having a furnish of about 35% Kraft chemical pulp from Bagasse, about 10% Kraft chemical pulp from mixed Hardwoods (comprising mainly of Casuarina and Eucalyptus Tereticornis) and 40% mechanical pulp from Bagasse and supplemented by about 15% long fibre softwood CTMP. While evaluating the runnability of these furnish in Newsprint machine, it was found that runnability of the machine was affected when mechanical bagasse pulp exceeded 40% and Newsprint of lower opacity and higher showthrough was produced when chemical bagasse pulp was increased to improve the runnability.

Using of non-wood fibre for the paper making continues to grow as wood resources are limited and taking care of environmental cosiderations, it has been demonstrated that the two typical nonwood fibres viz. Kenaf and wheat straw using alkaline peroxide pretreatment followed by refiner mechanical pulping can be converted into chemimechanical pulps having strength properties comparable to aspen APMP. Kenaf fibre was relatively easy to bleach and its APMP pulps have higher tensile strength and higher bulk than aspen APMP. These results suggested that Kenaf APMP pulp has potential for applications similar to aspen APMP or market, which is currently used in printing/writing, tissue and high brightness paperboard grades. Straw APMP pulps were limited to low brightness grades such as newsprint and low brightness paperboards until a more effective bleaching method was developed (1).

For high brightness grade applications, further bleaching by alkaline peroxide bleaching becomes necessary. The APMP process is recommended to maximise light scattering, bulk, tear and stretch at a given tensile strength. It has been shown that the post bleaching of CTMP reduced bulk and light scattering significantly for a given tensile strength while improved tear to a certain extent (2).

The investigation has demonstrated that for a given brightness target H_2O_2 addition, other pulp properties can be controlled by using different combinations of temperature and pH, High temperature/low pH combinations tended to give a better bleaching efficiency, higher optical properties (Opacity and light scattering) but lower stregnth property development, when compared to low temperature/high pH combination. Among the pulp properties, tensile index had a close correlation with the initial bleaching alkalinity and other pulp properties may be correlated with changes in the tensile strength (3).

The APMP pulp could be bleached to a brightness of 85% ISO, whereas the CTMP pulp was difficult to bleach to a brightness of 85% ISO for pulping of Aspen. In a multistage APMP system, the distribution of chemicals at the impregnation stages has a substantial influence on final bleachability (4).

Preconditioning followed by refiner chemical treatment (P-RC)

It has been shown that the P-RC alkaline peroxide mechanical pulping process is able to convert all the hardwoods studied in to a pulp with good strength (40 to 60 N.m/g) is sufficient, Hardwood P-RC APMP pulps are much better in improving bulk of the hand sheets. Bulk is considered to be one of the important properties for applications such as tissue, printing/ writing and paperboard grades (5).

The mechanism suggests that: the bleaching rate is first-order dependent on H_2O_2, when he peroxide concentration is relatively low. The rate will become independent of peroxide concentration if H_2O_2 increases above a certain level. Under constant conditions and very low consistency, the bleaching rate either remains unchanged or increases with higher consistency at the same chemical concentration. In a conventional medium or high consistency process, where H_2O_2 and pH are not controlled, the bleaching rate will decrease at higher consistency with the same bleaching chemical concentration. In terms of bleaching efficiency, however consistency is generally expected to be more efficient (6).

Plant scale mechanical pulping of Bagasse was studied using Sodium hydroxide and Hydrogen peroxide as impregnating chemicals as being done in Alkaline Peroxide Mechanical pulping (APMP) process technology. Along with Sodium hydroxide, Sodium silicate and Magnesium sulphate were also dosed. Impregnation and refining were carried out in two stages. It was found that the APMP pulps were having higher scattering coefficient at the equal level of strength properties as compared to conventional CTMP pulps from bagasse where the impregnating chemicals were sodium hydroxide and Sodium sulphite. However there was not much reduction in shives content. To find a way out laboratory studies were carried out for the reduction in shives content by the pulp after first stage refining and carry out bleaching and second stage refining and compare the shives content of the pulp with the conventional method of first stage refining, second stage refining followed by screening and then bleaching (7).

EXPERIMENTAL

Pilot plant trial at andritz inc, USA

Experiments were carried out in the atmospheric refining system consisting of atmospheric double disc refiner with 36" diameter disc and two 300 HP motors operating at 1200 RPM (motor rated 400 HP each at 1800 RPM). System was operated as the primary, secondary and tertiary stages of refining. Chip impressing system consisted of Pressafiner/ Impressafiner with 300 HP motor and submerged discharge device and modular screw device. System is used for fibreization of chips, water removal and chemical application at the discharge of the press.

Full fledge plant trial

Full-fledged plant tiral was taken with the existing plug screw, which has lower compression ratio (instead of impressafiner), and the steaming tube, which has lower retention time (instead of chemical impregnator), along with the pressurized primary refining (instead of atmospheric refining). Atmospheric refiners were used for secondary refining and rejects. Separate peroxide bleaching stage was used to maintain the final pulp brightness.

RESULTS AND DISCUSSION

Pilot plant trial at Andtriz Inc, USA

The APMP (Alkaline Peroxide Mechanical Pulping) process was first introduced at the 1989 International Mechanical Pulping Conference. Since then, a number of studies have been reported from the Andriz Inc. pilot plant in Springfield, on the characteristics of the APMP process by using various raw materials. Many trials of APMP were conducted on variety of wood species and the process was implimented in plant operations at Mallette, Quebec, Dangdong, and Quqihar-China. However very little work was available on APMP of Bagasse. In order to apply this new process to "BAGASSE" lab scale trials were conducted followed by the plant trials in June 2000. The results were quite encouraging and based on this three more plant trials were conducted in Aug-2000, Dec.-2000 and April-2001. There was an increase in optical properties and considerable reduction of shives at refiners. The results did not show any definite trend of improvement of properties. at this juncture, proper impregnation of chemicals by the raw material was found lacking in our system. To check whether bagasse can be compressed to higher ratios and then allowed to expand in a bulk of impregnation chemicals, some quantity of Bagasse was sent to Andtritz pilot plant. In their impressafiner they ran it at compression ratios 1:4, 1:8 and 1:11 and confirmed that bagasse can be compressed to the extent of 1:11 compression ratio. Later about 3 tonnes of Bagasse was shipped to Andritz pilot plant to find out the suitability of Bagasse for

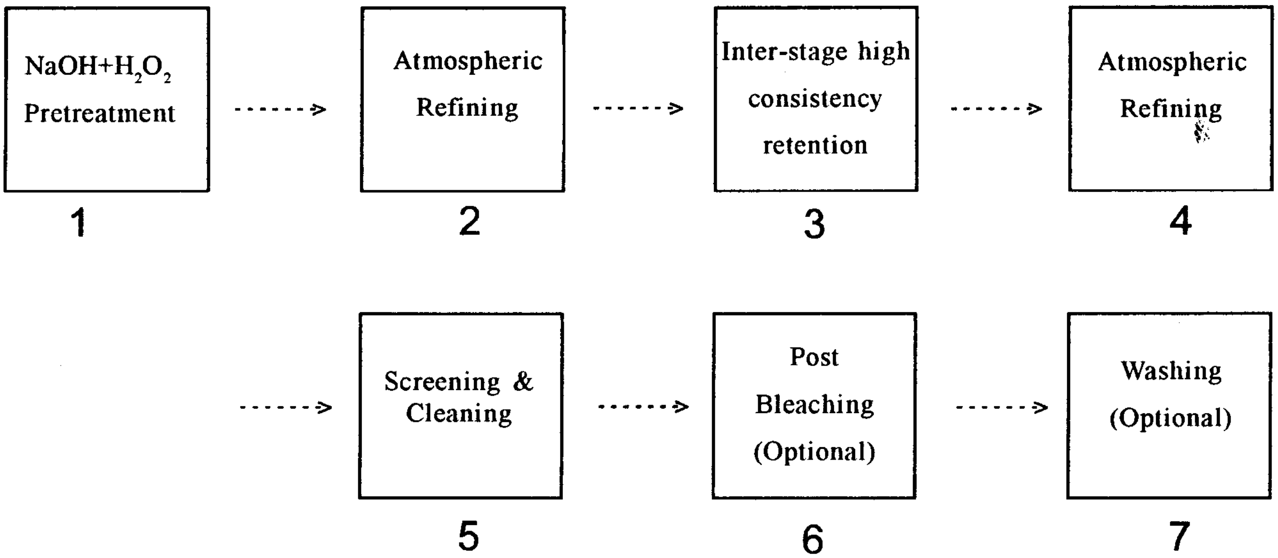

Fig. 1 P-RC APMP process flow sheet-1

APMP process and to adjust the process variables in that process by conducting plant scale trials. The key to the success of any Chemimechanical process especially APMP process lies in chemical impregnation. The goal at the impregnation stage is to achieve the best efficiency with the chemicals used. To meet this goal the following parameters must be optimized.

- Compression ratio in the impressafiner
- Chemical concentrations and the ratios among them in the chemical liquor
- Temperature and retention in impregnation

Another important principle applied during the trial is P-RC concept, preconditioning followed by refiner chemical treatment. This new concept emphasized a mild temperature preconditioning after the alkaline peroxide pretreatment, and uses the atmospheric refining process for most of the chemical reactions desired for brightening the pulp. The P-RC APMP process as shown in the flow sheet (Fig. 1) is more flexible than the conventional APMP design in terms of pulp property development and process efficiency (Chemical, Energy, and pulp yield).

Trials were conducted with 4:1 compression ratio and on 8:1 compression ratio. The places of chemical additions were (a) at impregnation stage (b) at refining stage that is at the eye of the refiner. The third option was the combination of the (a) and (b). The process variables for the trials were fixed after through analysis of work so far carried out in our lab and plant and also through study of literature on APMP and discussion with Research personnel of M/s. ANDRITZ INC.

Trial-1

Bagasse was kept soaked in water for four hours before the trial. The soaked bagasse was fed in to impressafiner (to compress to ratio of 4:1) and impregnated with water. During the second run through the impressafiner chemicals (NaOH, H_2O_2, $MgSO_4$ and Na_2SiO_3) were added for impregnation and a 30 minutes retention under cover was given. After the retention the impregnated bagasse was refined in a double disc atmospheric refiner running at 1200 rpm. The collected pulp was subjected to secondary refining under different refiner loads. The obtained pulp was neutralized and analyzed. The chemicals applied are Total Alkali 4.5%, H_2O_2 2.8%. The freeness obtained was 245 mlCSF. The brightness of the pulp was 49.1% ISO, Opacity was 94.3%, Light scattering coefficient was 47.2 m^2/kg and the shive content was 4.18%. The test data summary is given in Table 1. The normal shive content of our conventional CTMP of Bagasse is about 10% in the pulp going for screening.

Trial-2

For this trial the compression ratio maintained was 8:1. Soaked bagasse was impregnated with water after passing it through impressafiner. After 30 minutes of retention it was again processed through impressafiner and impregnated with part of the total chemicals used.

Table 1. Pilot trial of P-RC APMP for bagasse at Andritz Inc, USA

Particulars	Units	Trial-1	Trial-2
Compression ratio		4:1	8:1
Chemical at impregnation			
NaOH	%	4.5	2.2
H_2O_2	%	2.8	1.4
Chemical at Primary refining			
NaOH	%	nil	nil
H_2O_2	%	nil	nil
Chemical at Secondary refining			
NaOH	%	nil	1.6
H_2O_2	%	nil	1.0
Total power consumption	Kwh/t	1769	2625
Pulp Properties			
Freeness	m/CSF	245	110
Bulk	cc/gm	2.86	2.64
Breaking length	Meters	2640	2690
Tear factor		45.9	33.7
Burst factor		10.4	11.2
Brightness	% ISO	49.1	51.5
Opacity	%	94.3	93.6
Light scattering coefficient	m^2/kg	47.2	50.9
Unscreened pulp shives (Pulmac-0.10 mm)	%	4.18	1.18

It was retained for 30 minutes and then subjected to primary refining with the addition of balance chemicals. Again 30 mintues retention time was given and the pulp was subjected to secondary refining at three different loads. The chemicals applied during impregnation were TA 2.2%, H_2O_2 1.4%. the chemicals applied during primary refining were TA 1.6%, H_2O_2 1.0%. The freeness obtained was 113 mlCSF. The brightness of the pulp was 51.5% ISO, Opacity was 93.6%, Light scattering coefficient was 50.9 m^2/kg and the shive content was 1.18%. The test data summary is given in Table 1.

Full fledge plant trial

Our target mechanical bagasse pulp quality parameters are given in Table 2 along with the regular pulp produced from CTMP process. To incorporate the above P-RC APMP concept in our regular mechanical pulping cycle, Plant trials were conducted with the existing plug screw which has lower compression ratio (instead of impressafiner) and the steaming tube which has lower retention time (instead of chemical impregnator) along with the pressurized primary refining (instead of atmospheric refining). Conditions were modified periodically, after review of the pulp properties. The pulp produced was drawn continuously by paper machine for newsprint production. The chemicals applied during refining and during bleaching stage were varying to maintain above 50% ISO final brightness, which are given in Table 3. Final pulp properties are also given in Table 3. Conditions were selected for further trials based on the final mechanical pulp quality and the cost of production.

Pulp quality and cost effectiveness

From the pilot plant tirals of P-RC APMP process for bagasse, it was observed that at the minimum dosage of H_2O_2 2.8% and 2.4% gave the pulp quality of higher bulk density, higher light scattering coefficient, and very low shives content. From the plant trials with existing facilities available, it was observed that Hydrogen peroxide consumption was found to be more. Effectiveness of Hydrogen peroxide at pressurized refiners was not felt probably due to some docomposition at higher temperature. Marginal reduction in specific energy consumption is observed in refining. No significant changes were observed during screening and cleaning.

Environmental benefits

Environmental benefits like colour reduction in the

Table 2. Target final pulp quality by P-RC APMP with CTMP bagasse pulp

Particulars	Units	Expected P-RC APMP bagasse	Regular CTMP bagasse
Final pulp properties			
Freeness	m/CSF	180	200
Bulk	cc/gm	2.80	2.42
Breaking length	Meters	3000	3000
Tear factor		50.0	45.0
Burst factor		12.0	12.0
Brightness	% ISO	55.0	51.5
Opacity	%	94.0	90.0
Light scattering coefficient	m^2/kg	48.0	42.0
Screened pulp shives (Sommervelli-0.15 mm)	%	0.50	2.00

Table 3. Full fledge plant trials adopting P-RC APMP conditions

Particulars	Units	Set-1	Set-2	Set-3	Set-4
Chemical applied during refining					
NaOH	kg/t	55	57	61	48
Na_2SiO_3	kg/t	31	30	16	37
H_2O_2	kg/t	72	76	72	55
Chemical applied at bleaching stage					
NaOH	kg/t	9	9	9	9
Na_2SiO_3	kg/t	20	20	20	20
H_2O_2	kg/t	28	28	28	28
Temperature at bleaching	^0C	65	65	65	65
Retention time	hrs	3	3	3	3
Total power consumption	Kwh/t	2016	1545	105	1670
Final pulp properties					
Freeness	ml/CSF	230	245	250	210
Bulk	cc/gm	2.67	2.89	2.76	2.57
Breaking length	Metres	2490	2115	2183	3000
Tear factor		41.5	34.8	40.0	43.9
Burst factor		11.1	8.4	9.6	12.7
Brightness	% ISO	51.0	51.8	52.5	47.5
Opacity	%	92.5	93.5	93.0	95.3
Light scattering coefficient	m^2/kg	45.8	47.8	46.6	49.1
Final pulp shives (Pulmac-0.10 mm)	%	0.93	0.71	0.76	0.80

effluent of mechanical pulping line by 60% was observed. The colour of the effluent from mechanical bagasse pulping plant had come down from earlier level of 3000 Pt. Co units to 800-1000 Pt. Co units. Presence of Sulphur (Sodium sulphite) was eliminated from the system in turn sulphur pollution is totally eliminated from the system.

CONCLUSION

Adopting the P-RC APMP process for Bagasse mechanical pulping in-place of existing CTMP process, better quality mechanical pulp can be produced with lower specific refiner energy consumption, lower shives content, higher bulk and higher light scattering coefficient. Adopting the P-RC APMP, process for bagasse requires the improved comparession ratio with impressafiner, chemical impregnation system with good retention time, and atmospheric refiner system.

ACKNOWLEDGEMENT

The authors would like to thank the TNPL management for their kind permission for publishing the results of the study.

REFERENCES

1. Eric chao xu, APMP pulp from non-wood fibres Part 1 : kenaf and straw, **Appita J.** 54, (5) (September 2001).
2. Eric chao xu, Chemical treatment in mechanical pulping, Part 2: North American aspen (process and properties), **Pulp & Paper Canada** T59, 100 (2) (1999).
3. Eric chao xu, Chemical treatment in mechanical pulping, Part 4: H_2O_2 bleaching and pulp property development, **Tappi pulping proceedings,** p. 183, (1999).
4. Eric chao xu, Mark J. Sabourin, Evaluation of APMP and BCTMP for market pulps from South American Eucalyptus, **Tappi J.** 82, (12) 75, (December 1999).
5. Eric chao xu, P-RC alkaline peroxide mechanical pulping of hardwood, Part 1: aspen, beech, birch, cottonwood and maple, **Pulp & Paper Canada** T52, 102 (2) (2001)
6. Eric chao xu, H_2O_2 bleaching of mechanical pulps. Part 1 : Kinetics & Mechanism, **JPPS** 25, (10), (October 2000).
7. S. Udayshankar, A. Gnanasekaran, S. Govindarajan, K. Padmanabha Reddy and G. Venkoba Rao, APMP Process-Key to Optical properties of Mechanical Bagasse pulp, **IPPTA J.** 12, (4), (December 2000).