Centralized Refining System: A Step Towards The Energy Conservation

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ABSTRACT

The pulp and paper industry is an energy-intensive process industry. The energy cost may be as high as 25-30% of the variable cost of paper. Due to shortage of conventional resources to produce energy and the ever increasing energy cost, energy conservation has become a necessity in the paper industry. For the development of required pulp properties, refining process consumes substantial energy. It is, therefore, very important to study the performance of individual refiners and the system as a whole particularly in those mills which have multiple machines and employ number of refiners. An idea of centralized refining system was implemented to reduce power consumption in refining operation while maintaining the refining degree to achieve desired paper properties. A study was carried out on the operating parameters of existing refiners and its impact on pulp and final paper properties. Three refiners (DDR for PM-1 and DDR & TDR for PM-2) were in use for two paper machines having pulp draw of 3.0-4.0 MT/hr while maintaining the desired pulp freeness of 28°SR. with the existing refiners, the specific edge loads was 1.14 Ws/m in case of DDRs and 1.17 Ws/m in case of TDR with the total power consumption of 138 kWh/MT of paper. A new TDR of 24 inches with different refiner plate pattern yielding specific edge load of about 0.79 Ws/m was installed in place of three refiners for both the machines. The power consumption reduced by about 14-31 kWh/MT of paper while maintaining same degree of freeness. This also resulted in ash increase of about 1.5% without any affect on paper quality. There was consistency in wax pick value, which helped lower rejection of paper due to consistent operation in respect of refining operation.

Key words: Refiner, Specific edge load, Power consumption, Plate pattern, Fiber classification Ash content and Wax pick

INTRODUCTION

Energy Conservation is multifaceted with power, water and environmental management. Ever increasing price of energy has become a serious concern for paper mills as cost of energy is substantial part of the manufacturing cost of paper. Any saving in energy obviously improves the profitability. Refining is main operation of stock preparation and consumes lot of energy. Despite small size of paper making fibres i.e. less than one mm fibre length and 100 micron diameter on the upper limit, refiners with plates exceeding 1 m in dia and motor load in excess of 500 KW are common.

Pulp refining is mechanical treatment of pulp fibres to develop their optimum paper making potential. Refining action results in development of certain sheet characteristics alongwith degradation of others and is generally a compromise to enhance as many of the desirable properties as possible while minimising the undesirable effects on others. Refining of chemical pulp results in increased fibre flexibility due to internal fibrillation or delamination, external fibrillation of the fibre surface, fines formation and fibre shortening. Each type of paper requires particular type of treatment for optimum results depending upon the type of furnish.

Some of the variables affecting refining are related to the furnish, equipment characteristics and process variables. Refining tackles are, in most cases, the most cost effective way of changing the type of refining. By changing the bar configuration of refiner tackles, the action of refiners can be varied from fibrillation to cutting. The main parameters of refiner tackles are: number & width of bars, cutting angle of bars, material of bars and depth of grooves and their width. The refiner plate should be developed to provide optimum treatment to the furnish in a cost effective manner.

STUDY ON PULP REFINING AND REFINERS'S PARAMETERS

At Bilt - Shree Gopal unit, we have 6 paper machines and one blade coater, manufacturing different grades of uncoated paper and coated board. Two machines are almost identical and old which have been modified from time to time. These are slow speed machines equipped with size presses and we manufacture almost same type of paper on these machines. GSM range of PM-1 is 60 to119 g/m² and at PM-2, it is 80 to 170 g/m². For these two machines, we have three (3) refiners, (One DDR for PM-1 and One DDR & one TDR for PM-2). Specific edge load is about 1.14 Ws/m for both DDRs and 1.17 Ws/m for the TDR. We maintain freeness of 28 °SR in refined pulp. Refining process at PM-1 & 2 is shown in Fig. 1 & 2 respectively. The rise in SR values during refining is about 10° i.e. from 18 to 28°SR. Details of refining parameters are given in Table-1.

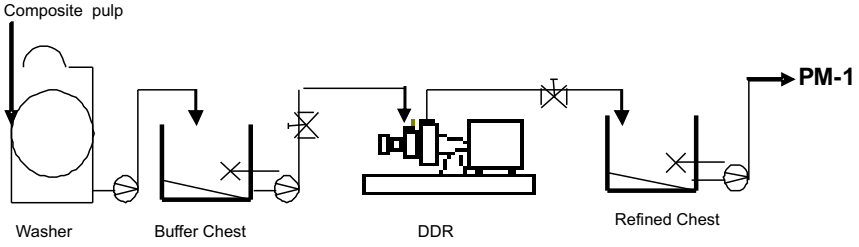

Fig. 1. Refining process at PM-1

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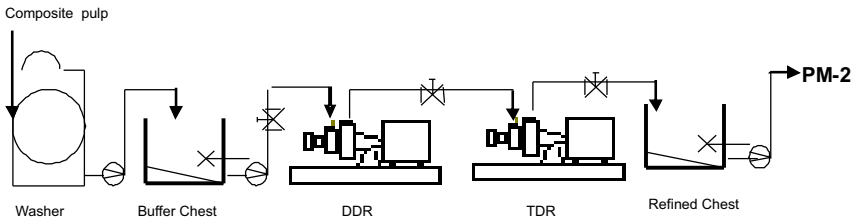

Fig. 2. Refining process at PM-2

Table-1. Refining parameter

Parameters	PM-1	PM-2	
Refiner	DDR	DDR	TDR
Disc size, inches	20	20	21
Motor rating, kW	250	250	250
Tackle no.	PA 1600 E	PA 1600 E	PA 2527J
Pattern, mm	3.2*3.2*8*5	3.2*3.2*8*5	3*3.5*12*10
Cutting length, km/rpm	6.58	6.58	6.4
Cutting length, km/sec	105	105	102
Max. load, kW	180	180	180
No load, kW	60	60	60
Net load, kW	120	120	120
Specific edge load, Ws/m	1.14	1.14	1.17

Table-2. Refiner performance and lab handsheets properties

Particulars	Refiner Inlet pulp	Refiner outlet pulp	
Quality		PM-1	PM-2
		Super ptg 80gsm	Super ptg 100gsm
pH	6.4	6.4	6.4
Cy, %	3.80	3.75	3.82
°SR	18	29	30
FLI , g/10g	0.340	0.216	0.222
Fiber classification			
Retained, %			
+28	42.9	38.2	38.5
-28+50	16.8	19.2	17.2
-50+100	16.5	18.6	19.1
-100+200	4.3	2.2	2.8
-200	19.5	21.5	22.4

Hand sheet properties : Unrefined pulp beaten in PFI mill, 60 gsm handsheets

Pulp	Unrefined	Lab PFI mill at 3000 Rev.	Plant refined pulp PM-1	Plant refined pulp PM-2
°SR	18	30	29	30
Grammage, g/m²	60.6	61.0	61.8	61.3
Thickness, micron	86	79	83	82
Bulk, cc/g	1.44	1.29	1.34	1.33
Burst Factor	27.5	49.9	46.6	47.6
Breaking length, m	4205	7210	6140	6210
Double fold, No.	10	53	36	42
Tear factor	72.5	69.1	68.3	66.5
Gurley Porosity, sec/100ml	5	34	32	27

Hand sheets were conditioned before testing at 65±2% RH & 27±2 °C temp.

REFINING PROCESS BEFORE INSTALLING NEW REFINER

A laboratory study was conducted on unrefined and refined pulps collected from stock preparation to analyze the pulp quality. The furnish is 20% Bamboo and 80% Hardwood (Eucalyptus 15% and poplar 65%). The pulps were analyzed for fiber distribution using Bauer-McNett fiber classifier. Consistency, °SR, and Fiber length index (FLI) of unrefined and refined pulp were determined. Unrefined pulp was beaten in PFI mill at freeness of 30 °SR. Lab. beaten and plant refined pulps from both machines were evaluated for physical strength properties. The handsheets 60 GSM were made on British Handsheet machine at neutral pH 6.8-7.0. The handsheets were pressed, air-dried for 15 minutes and finally dried in oven for another 15 minutes. The handsheets were then conditioned in controlled environment (RH 65±2% & temperature 27± 2° C). Pulp analysis and testing of handsheets were done as per the standard*.

The results are given in Table - 2. **Standards used (Fiber classification T 233 cm-95, Burst factor T 403 om-02, Breaking length T 456 om-03, Tear factor T 414 om-98, Double fold SCAN-P17:17, Gurley porosity T 460 om-02).*

STUDY WITH THE NEW TDR

To reduce power consumption in the refining process, a new 24" TDR was installed. All three refiners used on PM-1 and 2 were stopped and new single TDR with tackle no. PA 4579, (pattern 5*5*10*5 mm) was installed. We have determined °SR of unrefined and refined pulps. The freeness (°SR) of unrefined pulp and refined pulps were 18°SR and 24°SR respectively. The rise in °SR values after refining was only 6 point. Rise in °SR values was not sufficient to meet the desired freeness and physical strength properties of final paper. The refined pulp was also subjected to fiber classification. The results are given in Table-3. The results indicate that refining treatment was not adequate. The specific edge load was also calculated for new refiner, which was found to be 2.18 Ws/m. It was on higher side for the furnish used. The refining with new TDR was, therefore, discontinued. The matter was discussed in detail with supplier and finally, a finer plate pattern with the objective of refining at a lower specific edge load of

Table -3. Refining performance

Particulars	Refiner Inlet pulp	New TDR Refiner (Tackle PA 4579) outlet pulp PM-1 & 2
Quality		Super ptg 70 & 80gsm
PH	6.5	6.5
Cy, %	3.85	3.75
°SR	18	24
FLI , g/10g	0.375	0.305
Fiber classification		
Retained, %		
+28	45.0	43.5
-28+50	17.0	17.7
-50+100	15.1	15.8
-100+200	3.7	3.6
-200	19.2	19.4

Table-4. Refining parameters of new TDR refiner

Parameters	New TDR with Tackle PA 4579	New TDR with Tackle PA 4579 G
Disc size, inches	24	24
Motor rating, kW	350	350
Pattern, mm	5*5*10*5	2.8*3.3*8*10
Cutting length, km/rpm	5.15	14.2
Cutting length, km/sec	82.4	227.2
Max. load, kW	320	320
No load, kW	140	140
Net load, kW	180	180
Specific edge load, Ws/m	2.18	0.79
°SR rise	6	10
Pulp flow, MT/hr	3.0	3.0
SEC, kWh/°SR/MT	10.0	6.0

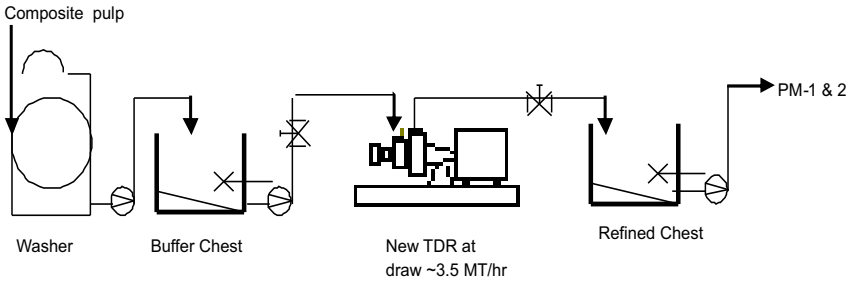

Fig. 3. Modified Refining process at PM-1&2- System A at draw of ~3.5 MT/hr.

about 0.79 Ws/m (plate tackle no. PA 4579 G, pattern 2.8*3.3*8*10 mm) was installed. Details of refining parameters for these two plate patterns are given in Table-4. As earlier, the unrefined pulp was beaten in PFI mill at 30 °SR.

Lab beaten and plant refined pulps from both PM-1 and PM-2 were evaluated for physical strength properties and compared with the new TDR. The handsheets of 60 GSM were made with plant refined pulps (both machines) and lab beaten pulp on British Handsheet machine at the neutral pH 6.8-7.0. Pulp analysis and testing of handsheets were done as per the standard*. Modified refining process chart is shown in Fig-3. The results are given in Table - 5.

New TDR with plate pattern PA 4579G was found adequate for both paper machines at a production rate of approx. 3.5 MT/hr. When draw at PM 1 & 2 is more than 3.5 MT/hr in case of heavier grammage, we have to run one old TDR along with the New TDR to meet the refining demand. However, the old TDR is now dedicated for PM-1.

POWER SAVING DUE TO CENTRALIZED REFINING

The power consumption during refining process with newly installed refiner was calculated and compared with earlier refining practice. The comparative refining load and power saving are given in Table-6

Power saving calculations

Normal

Average load on DDR2 for PM-1 = 175 kW
Average load on DDR3 for PM-2= 184 kW
Average load on TDR for PM-2= 124 kW
Total load = 483 kW

Centralized refining system with new TDR refiner

a) At 3.0 MT/hr draw of both machine during lower grammage 60-90 g/m²

Average load on new TDR refiner for both machine = 320 kW

Power saving = (483-320)=163kW

b) At 3.5-4.0 MT/hr draw of both machine during heavier grammage

Average load on TDR for PM-1= 124 kW
Average load on new TDR refiner for PM-2 = 309 kW
Total load = 433 kW
Power saving =(483-433)=50kW

Cost saving (@3.79Rs/kWh)

New refining system no. a) runs average 6 days in one month = Rs. 0.51 lacs/month

New refining system no. b) runs average 24 days in one month= Rs. 1.07 lacs/month

Table-5. Refining performance and lab hand sheet properties

Particulars	Refiner Inlet pulp	Refiner outlet pulp		
		Draw ~3.5MT/hr	Draw 3.5-4.0 MT/hr	
Refiner		New TDR* PM-1 & 2	Old TDR PM-1	New TDR* PM-2
Quality		Super ptg 70 & 80gsm	Super ptg 80gsm	Super ptg 100gsm
pH	6.4	6.5	6.4	6.4
Cy, %	3.70	3.75	3.80	3.72
°SR	18	29	29	28
FLI , g/10g	0.374	0.225	0.235	0.239
Fiber classification				
Retained, %				
+28	44.6	39.0	38.5	40.7
-28+50	17.2	18.0	18.2	17.5
-50+100	15.3	19.3	19.0	17.6
-100+200	3.9	2.2	2.6	2.5
-200	19.0	21.5	21.7	21.7

Hand sheet properties : Unrefined pulp beaten in PFI mill, 60 gsm handsheets					
Pulp	Unrefined	Lab PFI mill at 3000 Rev	Plant refined pulp, PM-1&2	Plant refined pulp, PM-1	Plant refined pulp, PM-2
°SR	18	30	29	29	30
Grammage, g/m²	61.6	61.8	60.5	60.8	60.8
Thickness, micron	87	78	83	85	82
Bulk, cc/g	1.41	1.26	1.37	1.39	1.34
Burst Factor	31.9	50.0	46.0	45.0	40.5
Breaking length, m	4435	7010	6150	6250	6160
Double fold, No.	14	72	44	46	42
Tear factor	70.2	68.3	67.4	68.0	66.7
Porosity, sec/100ml	4	52	32	35	20

**New TDR of plate PA 4579G, Hand sheets were conditioned before testing at 65±2% RH & 27±2 °C temp.*

Table-6. Comparative Refining performance

Parameters	Normal			After new refiner		
	PM-1	PM-2		Draw : 3.0MT/hr	Draw : 3.5-4.0 MT/hr	
				PM-1 &2	PM-1	PM-2
Refiner	DDR2	DDR3	TDR	NEW TDR	DDR	New TDR
Initial °SR	18	18	18	18	18	18
Final °SR	28	28	28	28	28	28
°SR rise	10	10	10	10	10	10
Avg. load, kW	175	184	124	320	124	309
Total load. kW	483			320	433	
Avg. draw, MT/hr	3.5			3.0	3.5	
Power consumption, kWh/MT	138			107	124	
Power saving, kWh/MT	14-31 kWh/MT of paper					

Net saving approx. = Rs. 19.0 lacs/annum

REFINING SYSTEM STUDY BY M/S ANDRITZ

To run single refiner for 30 days at PM-1&2, a study was conducted by M/s Andriz. They have suggested a Pilao Pattern of 1.5*3*9*25 with low specific edge load of 0.6 Ws/m. This design is expected to provide more fiber treatment and about 15% higher level of fiber compression, which translates into more fiber development and strength for the same applied power. Details of refining parameters with proposed plate pattern and new TDR refiner are given in Table-7.

RESULTS AND DISCUSSION

We manufacture different grades of writing/printing and watermark papers with a wide range of grammage at PM-1&2 at a draw of 3.0-4.0 MT/hr. At PM-1, we manufacture papers having grammage range of 60 to 119 g/m² and at PM-2 grammage range is from 80 to 170 g/m². Refining requirement increases with manufacture of heavier GSM papers. We had earlier three refiners (one TDR and two DDR for these two machines). To fulfill the refining requirement at both paper machines, we have now installed a new TDR to save refining energy. Our observations are as follows.

- With refiner tackle PA 4579 (5*5*10*5) the specific edge load was high i.e. 2.18 Ws/m. The °SR rise was only 6 points which was less than our requirement of 10 point rise. The refining was not adequate with this plate pattern.

- Study of fiber classification revealed very little change in fiber distribution. Retention on 28 mesh was 45% in unrefined pulp and 43.5% in the refined pulp.

- After discussion with the party, the plate pattern was changed with new PA 4579 G, (2.8*3.3*8*10). This finer plate pattern yielded lower specific edge load of 0.79 Ws/m. The desired °SR of 28 was achieved with rise of 10 point during refining.

- Fiber classification study revealed the fines were same as in the earlier refining practice i.e. fines retained on 200 mesh was in the range of 20-22%.

- Physical strength properties of handsheets were comparable before and after installation of TDR at both the machines. Before installation of new refiner, breaking length and tear factor of refined pulp at PM-1 were 6140m & 68 respectively. Similarly at PM-2, breaking length and tear factor of refined pulp were 6210m & 67 respectively. After installation of new TDR refiner, breaking length and tear factor were 6150m & 67 respectively.

- Refiner load was 483 kW in normal running of three refiners (two DDRs and one TDR). After installation of final refiner (TDR), it reduced to 320 kW while running only new refiner TDR at the draw of ~3.5 MT/hr and 433 kW while running two refiners - one old TDR at PM-1 and new TDR at PM-2 at the draw of 3.5-4.0 MT/hr for both machines. The comparative results are given in Table-6 and power consumption shown in Fig. 4.

Table-7. Refiner parameters of proposed tackle

Parameters	New TDR tackle PA 4579 G	Proposed tackle of Pilao Pattern
Refiner	New TDR	New TDR
Disc size, inches	24	24
Motor rating, kW	350	350
Pattern, mm	2.8*3.3*8*10	1.5*3*8*25
Cutting length, km/rpm	14.2	18.75
Cutting length, km/sec	227.2	300
Max. load, kW	320	320
No load, kW	140	140
Net load, kW	180	180
Specific edge load, Ws/m	0.79	0.60
°SR rise	10	11.5
Pulp flow, MT/hr	3.0	3.0
SEC, kW/°SR/MT	6.0	5.2

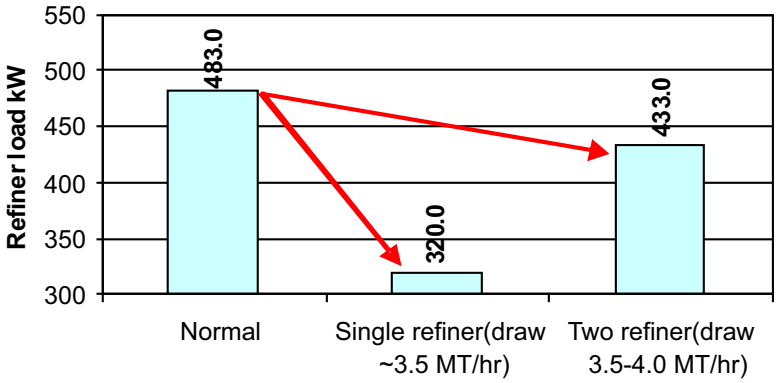

Fig. 4. Bar chart of power consumption

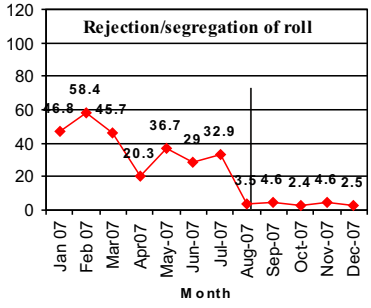

Fig. 5. Run chart of rejection/segregation of paper due to low wax pick

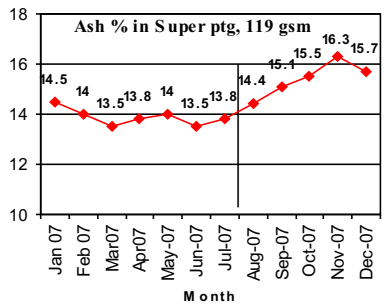

Fig. 6. Run chart of ash content in paper

QUALITY IMPROVEMENT

We used to get lower wax pick values particularly in higher GSM papers due to inadequate refining in our earlier refining system. Refining requirement increases with heavier grammage to meet desired value of freeness and to meet physical strength properties of final product. We occasionally had to reduce ash content in paper to meet the requirement of paper properties and wax pick. Also, paper rolls were sometimes rejected/segregated due to low wax pick values i.e. below 13. After installation of new refiner, we were able to achieve the desired °SR values even at higher GSM papers on both the machines. We have also been able to increase ash content in paper while maintaining physical strength properties. The run chart of ash content in paper and rejection/segregation of paper due to low wax pick are given in Fig. 5 & 6 respectively.

- There was increase in ash content in paper by 1.5%.
- Rejection/segregation of paper was reduced by 90% due to wax pick below 13.

CONCLUSIONS

- We have achieved reduction in refining power by reducing specific edge load from 1.14 & 1.17 Ws/m to 0.79 Ws/m, which could be possible through use of a new refiner plate to suit our refining requirement.
- The specific energy consumption (SEC) reduced from 12.0 to 6.0 kWh/°SR/MT while running single refiner at the draw of 3.0 MT/hr and 10.3 to 8.6 kWh/°SR/MT while running two refiners (One TDR for PM-1 and New TDR for PM-2) at draw of 3.5 MT/hr.
- Reduction in the rejection / segregation of paper due to low wax pick below 13.
- Ash content increased by 1.5 points from 14.0% to 15.5% in 119gsm.

RECOMMENDATION / FUTURE PLAN

To further reduce refiner energy, we are planning to run single refiner with the new plate pattern of 1.5*3*9*25 with the specific edge load of 0.6 Ws/m as suggested by the study of M/s Andritz. This design is expected to reduce refiner energy by 15%.

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