Application of Refiner Plate Technology to Improve Pulp Quality and Reduce Energy

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ABSTRACT

RTS™ and TMP mill case studies were conducted, utilizing FiberMaxX™, FiberMaxX-EX™, and VPZ™ refiner plate patterns, to reduce refining energy, improve pulp quality and increase production rates depending upon the specific application. In the studies the refiner plate designs selected provided from 200 to 280 kwh/odmt energy reduction. In addition pulp strengths were either maintained or improved by as much as 20%. Production rate increases of 10 to 18% also resulted from all of the case studies.

INTRODUCTION

The current global situation, of lower wood quality, increased paper machine speeds, lower basis weights, and ever increasing energy and raw material costs, presents major competing challenges for refiner mechanical pulp producers. Typically making adjustments to the normal refiner operating parameters and even applying advanced supervisory control systems has not been sufficient to fully compensate for the major impact of these current demands upon the refining system. Improved tools that impact the physical method of fiber treatment and development inside the refining zone itself are needed. Refiner plate designs and their proper application in actual full scale refiners have been shown to be effective tools for changing the refining action sufficiently to meet a major portion of the stringent quality and energy requirements being faced in today's global marketplace.

The objective of this paper is to document the effectiveness of creatively designed and applied refiner plates in meeting many of the critical refining demands, through three examples of successful applications of state of the art refiner plate designs in actual mill case studies. Although mill trials provide some risks and require extra effort in a production environment, prior refiner plate application experience combined with an understanding of refiners and operation of the surrounding process, can minimize the risk and result in major benefits and cost savings.

CASE STUDY 1 – LOW ENERGY & IMPROVED QUALITY

A two line RTS™ plant **(1)**, combined with an RT chip pretreatment system **(2)** for extractives removal from the loblolly pine furnish, initially achieved energy reductions of 15 – 25% **(4)** at higher pulp quality levels compared to an existing TMP plant (1980's vintage Bauer counter-rotating refiners). After about 5 years of operation, the mill began to detect a shift in raw material with a significant increase in juvenile wood levels. This raw material change was evident in a noticeable reduction in burst and tear strength from the high speed, 2300 rpm RTS™ refiner lines.

In an attempt to boost pulp quality, at the expense of increased energy consumption, the mill removed the gearbox, between the primary Andritz Twin 66 refiner and the drive motor on one line(Line A), reducing the rotational speed from 2300 to 1800 rpm **(3)**. Pulp quality measurements taken over the week following the gearbox removal indicated that the adjacent refiner line(Line B), still at 2300 rpm, was generating burst and tear strengths that were 13% and 30% lower respectively than Line A, now at 1800 rpm. A comparison of average quality data over a one week period is shown in **Table I**.

	Burst Index(kPa.m2/g)	**Tear Index**(mNm2/g)
Line A (1800 rpm)	1.24	8.5
Line B (2300 rpm)	1.08	6.0
% Change	**- 13**	**- 30**

Table I – Quality Comparison before Line B Primary Refiner Plate Optimization

Although Line A pulp quality had increased significantly with the reduction in refiner rotational speed from 2300 to 1800 rpm, the accompanying mainline refining energy increase of 15% resulted in a significant increase in the mill cost per ton to produce their mechanical pulp. In an effort to restore pulp quality while maintaining the 15% lower energy cost of the 2300 rpm primary refiner operation, the mill in cooperation with Andritz personnel embarked upon a process and refiner plate optimization program for the Line B RTS™ system.

Up to this point refiner plate optimization had focused upon other refiner positions rather than the primary refiner as the primary refiner operation and plate life had been relatively stable. However, as the primary refiner sets the pulp quality and energy consumption fingerprint for the pulp, particularly in systems utilizing a loblolly pine furnish, and the rotational speed change that restored pulp quality was conducted in the primary position, the new refiner plate optimization process was initiated in Line B primary refiner.

Refiner Plate Optimization

During the RTS™ system start-up 5 years earlier, a primary refiner plate combination, incorporating the patented Variable Pitch™ bar and groove construction, was found to produce pulp quality and energy levels that met the system design specifications **(1)**. On the rotor was a coarser, more typical primary pattern, 66SA010, was utilized while the stator utilized a traditional secondary plate pattern, 66SA002. These plates are shown in **Figures 1 and 2** along with the typical calculated intensity level for each in kilometers per revolution(km/rev).

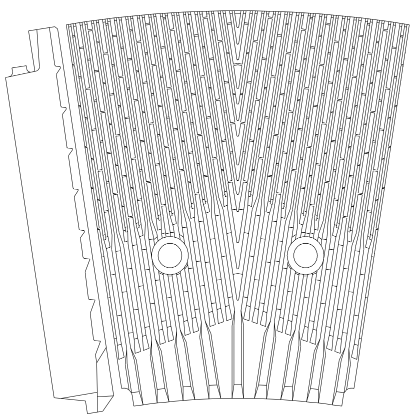

Figure 1. Rotor 66SA010, 228 km/rev

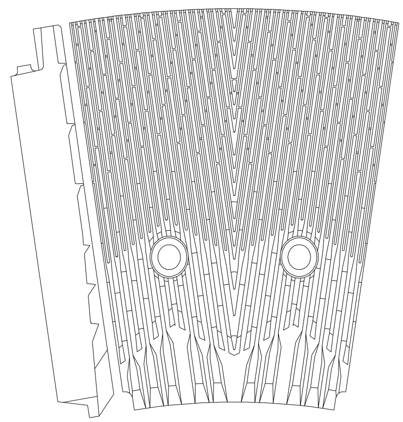

Figure 2. Stator 66SA002, 340 km/rev

Previous primary refiner plate optimization work in numerous 2300 rpm RTS™ systems worldwide **(3)** led to the development of the ultra-low intensity FiberMaxX™ plate concept. With the excellent pulp quality improvement seen with this concept in other similar applications, the 68SA016 FiberMaxX™ plate pattern **(Figure 3)** was installed on the rotor and stator in the 2300 rpm, Line B, primary Twin 66 refiner.

The calculated refining intensity of the FiberMaxX™ plate was 5% lower than the previously utilized standard Variable Pitch™ plates.

303 km/rev – (((228 km/rev)^2 + (340 km/rev)^2))/2)^1/2 = 14 km/rev

14/303 = <u>5% Lower Intensity</u>

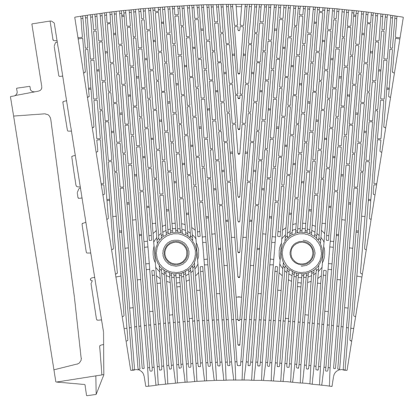

Figure 3. Ultra-low Intensity 68SA016 FiberMaxX™ Refiner Plate – 303 km/rev

Pulp Quality

The resulting pulp quality improvement with the FiberMaxX™ plates was much more dramatic than the calculated intensity change might indicate. For the 18 days following the installation of the FiberMaxX™ plates in Line B primary RTS™ refiner, the average secondary pulp quality met or exceeded that of the 1800 rpm Line A TMP system. The secondary refiner plates were identical in both lines. Line B with an 8% higher CSF level had only 3% lower burst and < 1% lower tear strength. As is evident from the data in **Table II**, at an equivalent CSF, Line 8 strength properties would have been even higher than Line 7. A comparison of the average pulp quality after installation of the FiberMaxX™ is shown in **Table II**.

	Burst Index(kPa.m2/g)	**Tear Index**(mNm2/g)	**CSF**
Line A (1800 rpm)	1.16	6.62	262
Line B (2300 rpm)	1.12	6.57	283
% Change	**- 3**	**- .6**	**+ 8**

Table II – Quality Comparison with FiberMaxX™ Plates in Line B Primary Refiner

In the following month, Andritz personnel did a number of complete pulp quality and specific energy audits. To insure accuracy, the production rates utilized for the specific energy calculations were determined by average flow rate measurements from the latency transfer tank combined with a laboratory consistency measurement. The results in **Table III** indicate that the 2300 rpm RTS Line B produced equivalent quality to the 1800 rpm TMP Line A at 15% lower specific energy. Again this quality level was significantly better than the older TMP lines on site, just as had been documented during the initial start-up of the RTS™ lines 5 years earlier.

With the use of the FiberMaxX™ primary plates, the pulp quality at 2300 rpm primary refiner operation was increased dramatically (burst strength, + 13% and tear strength, +30%), matching the 1800 rpm levels on the adjacent refiner line but with 15% lower refining energy consumption and the accompanying major reduction in production costs. As a result of the successful refiner plate and process optimization effort, the mill re-installed the speed increaser into Line A to return to 2300 rpm RTS primary refiner operation with the FiberMaxX™ plates, thus regaining the significant energy cost savings in that refiner line as proven in Line B **(4)**.

Quality Summary - 14 Aug to 15 Sep 2004

		Line A	Line B	Difference	Reference Lines	
				TMP / RTS	Lines C&D	Lines E&F
Item	**Units**	**TMP**	**RTS**	**%**	**Feb 2003**	**Sep 2004**
Specific Energy (Main-Line)	MWh/BDMT	1.87	1.59	**-15**	-	-
Production Rate	BDMTPD	429	470	**10**	-	-
Freeness (CSF)	mL	251	256	2	234	237
Burst Index	kPam2/g	1.38	1.33	-4	1.15	1.14
Tear Index	mNm2/g	8.7	8.5	-2	7.4	7.0
Tensile Index	Nm/g	25.6	25.7	0	22.0	22.5
Bulk	cm3/g	3.55	3.55	0	3.70	3.7
Scattering Coefficient	m2/kg	47.6	47.9	0.6	51.0	51.6
TEA	J/m2	19.4	19.1	-2	15.8	15.2
Brightness (ISO)	%	53.2	53.3	0.6	53.6	55.5
Opacity	%	89.4	89.6	0.4	90.7	89.3
FQA LW Average Fibre Length	mm	1.79	1.76	-2	-	-
Fibre Bonding Index (14/28)	Nm/g	3.4	4.4	**29**	-	-

Table III – Quality & Energy with FiberMaxX™ Plates in Line B Primary Refiner

CASE STUDY 2 – ENERGY REDUCTION & PRODUCTION INCREASE

Another RTS™ refining system utilizing primary Andritz 3068 refiners and Norway Spruce as the furnish was looking to further reduce refining energy and increase production rates beyond the initial level obtained through the conversion to RTS™ **(3)**. The FiberMaxX™ plates **(Figure 3)** utilized in Case Study 1, were the standard plates that established the baseline quality and energy levels for the refining line prior to further refiner plate optimization. In light of the demands in numerous TMP systems for further energy reduction while maintaining the pulp quality levels achieved with the FiberMaxX™ plates, Andritz developed the FiberMaxX-EX™ refiner plate concept **(see Figure 4)**, to run on the rotor against the standard FiberMaxX™ plate**(Figure 3)** on the stator.

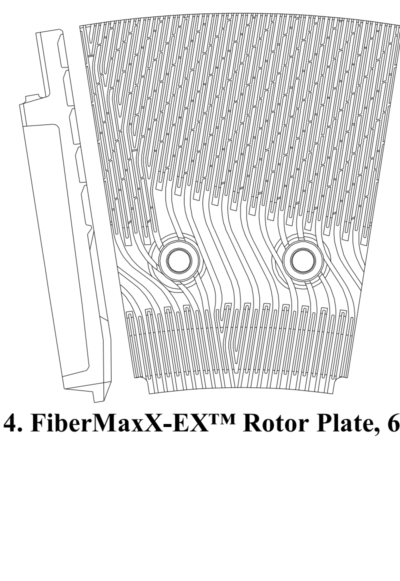

Figure 4. FiberMaxX-EX™ Rotor Plate, 68SA502

Refining Zone Temperature Measurements

To further detail the changes in the actual refining zone with the FiberMaxX-EX™ plate, temperature sensors measuring eight separate radial locations in the stator plate, were utilized to measure the temperature profile for both the standard FiberMaxX™ plates, rotor and stator, and with the new FiberMaxX-EX™ on the rotor keeping the FiberMaxX™ on the stator. The two temperature profiles are shown in **Figure 5**. The curve labeled Standard is the FiberMaxX™ plate, rotor and stator, while the Experimental curve details the profile with the new FiberMaxX-EX™ plate on the rotor. As show, there is a .1 meter shift of the temperature peak outward radially in the refining zone from about .65 to .75 meters. Previous work by Johansson **(5)** concluded that reducing the energy applied at the inlet area of a refiner improved the refining efficiency significantly and similar results were seen in this study.

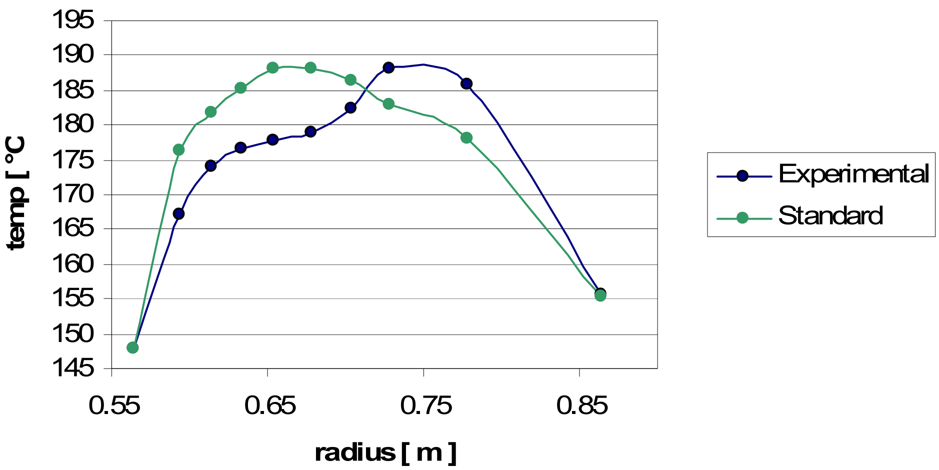

Figure 5. Refining Zone Temperature Profiles

Energy Reduction and Production Increase

With the FiberMaxX-EX™ rotor plate, the total refiner specific energy to reach 140 csf exiting the secondary refiner was reduced to 1.4 mwh/odmt, a savings of 200 kwh/odmt or 12.5% compared to the standard FiberMaxX™ plates. As a result of this reduction in specific energy, the production rate was increased from 12.5 to 14 t/h or 12% at the same primary refiner mw load.

Further Refiner Plate Optimization

Additional refiner plate trials are scheduled to further optimize the energy/pulp quality relationship. The next step planned is to maintain the FiberMaxX-EX™ rotor plate and utilize a directional FiberMaxX™ stator plate pattern. Directional plates utilize the angle of the plate bars to either hold or feed the pulp in the refining zone. The bar angles can be adjusted, depending upon the radial location on the plate, to increase or decrease the feeding or holding of the plate **(5)**. Typically more feed angle is utilized in the plate inlet to enhance feeding into the refining zone while less feeding and potentially even holding angle is used in the outer portion to retain the fiber to allow the required power application for developing the desired pulp properties.

CASE STUDY 3 – REDUCED ENERGY & INCREASED PRODUCTION WITH IMPROVED PULP QUALITY

In the early 1990's a number of primary Bauer counter-rotating refiners were converted from 1200 rpm feed end disc rotational speed to 1800 rpm for the purpose of reducing refining energy **(6)**. One such Northern Spruce mill developed, in cooperation with Andritz, refiner plate patterns **(Figures 7& 8)** that enabled the energy saving and pulp quality goals of the initial conversion project to be realized. These refiner plate patterns continued to meet the mill energy and pulp quality requirements. Recently however, increased production costs for energy and other raw materials forced a further refiner plate optimization process with the target to increase production rates and pulp quality. With both primary and secondary refiners in the two stage line being loaded to the maximum drive motor capacity, the only way to increase production was to decrease the specific refining energy.

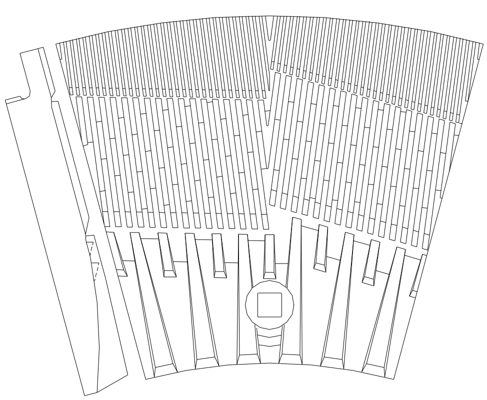

Figure 7. Feed End, 55377

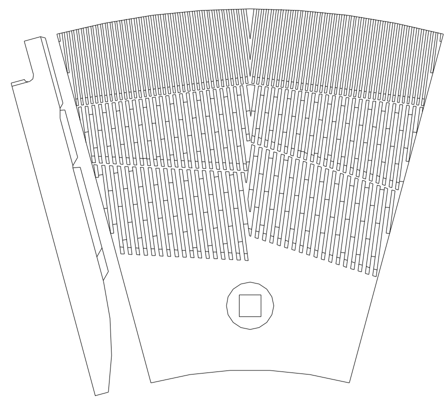

Figure 8. Control End, 55130

Refiner Plate Selection

Prior successful mill experience with the VPZ™ refiner plate concept in Bauer counter-rotating refiners **(7)** led to the selection of this concept as the basis for this more recent primary refiner application. The unique requirements of the high speed(1800 rpm) feed end disc and the high applied motor load(10.2 mw) had to be taken into consideration, leading to the use of what were traditionally designated as secondary refiner plate patterns **(Figures 9 & 10)**. In addition, the single line TMP operation demanded that the trial plates meet production and quality requirements immediately upon start-up. To assure that targets were reached immediately upon starting operation with the VPZ™ plates, a pre-treatment process was applied to the plates to eliminate the initial 1 to 2 day higher specific energy period, normally seen when new refiner plates are installed.

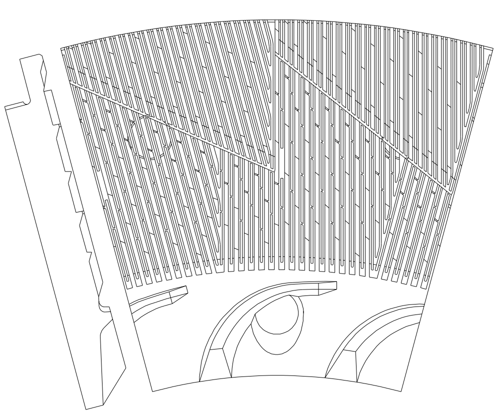

Figure 9. Feed End VPZ™, 55BJ021

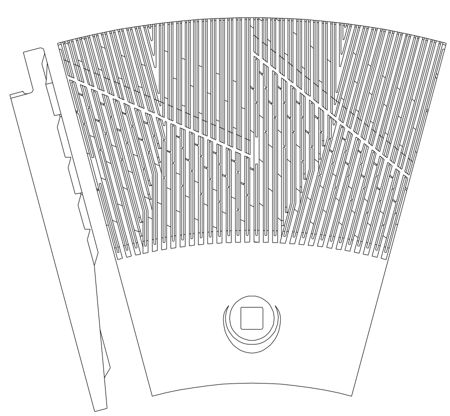

Figure 10. Control End VPZ™, 55BA017

Results

With the standard refiner plate **(Figures 7 & 8)** and both primary and secondary refiners fully loaded, 10.2 and 8mw respectively, the average production rate was 230 odmt/d with peaks to 245 odmt/d. With the new VPZ™ refiner plate combination, the mill was able to set a new daily production record of 270 odmt/d, an increase of 17% with peak rates as high as 275 odmt/d. Since the primary and secondary refiners were fully loaded with both the standard and VPZ™ plates a specific energy reduction of 17% was also realized. Also the mill reject screening and refining system was already at its' maximum 65 odmt/d capacity at the 230 odmt/d mainline production rate. Therefore the added 40 odmt/d of production had to be accepted through the mainline screening and cleaning system, thus requiring higher quality pulp from the secondary refiner that could be sent forward to the paper machines without the benefit of additional refining from the rejects system.

The pulp quality improvements were confirmed as the combined mainline and reject cleaner accept pulp hand sheets indicated a 10% increase in tensile strength and a 20% increase in tear strength at 10% higher csf. In addition positive benefits were seen on the paper machines with a 16 odmt/d reduction in softwood kraft reinforcement pulp levels.

At the higher production rates with the VPZ™ refiner plates the mill was able to at times exceed the paper machine pulp demand and idle the TMP line for periods, allowing the electrical power normally used in the refiners to be sold back to the local power company for additional cost savings.

Further Optimization

With the major improvement seen with the VPZ™ primary plates, trials are currently underway in the secondary refiner **(Figures 11 & 12)**. Targets for the secondary trials are further improvements in pulp strength and a further reduction in pulp shive content.

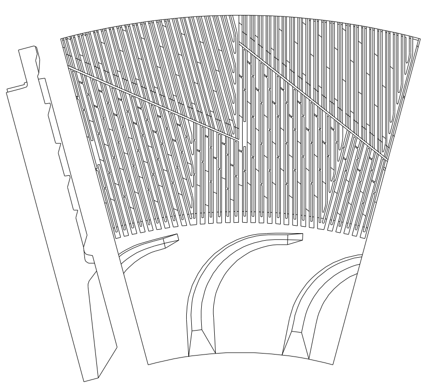

Figure 11. Feed End, 55BD021

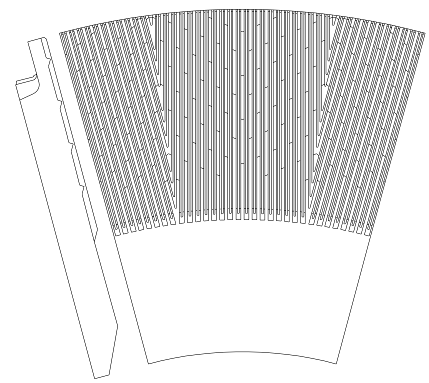

Figure 12. Control End, 55BD019

CONCLUSIONS

- Application of FiberMaxX™ refiner plates restored the required pulp quality in a loblolly pine RTS™ mill with increased juvenile wood levels, enabling the 15 to 25% energy reduction and associated cost savings to be maintained.
- Application of FiberMaxX-EX™ refiner plates provided an additional 12% energy reduction and resulting 12% production increase in a Norway spruce RTS™ refining line.
- Application of VPZ™ refiner plates in a northern spruce TMP mill resulted in an 18% energy reduction and production increase while increasing pulp strength properties by 10 to 20%.
- Innovative refiner plate designs that are effectively applied can significantly reduce specific energy and increase production rates while improving the pulp quality being produced in existing TMP and RTS™ systems worldwide.

ACKNOWLEDGEMENTS

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