Energy Savings from Advanced Screen Rotor Technology

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Advanced rotor technology can provide substantial energy reductions. Mill trials conducted in the brown stock screen system at Canfor-Northwood's mill showed how a 52% energy reduction could be obtained by installing an AFT Gladiator HC™ rotor and operating it at a reduced rotor speed. This amounts to a saving of 60 kW per screen and payback period of 12 months for the rotor. The mill trials were conducted as part of a BC Hydro demonstration project. A variable frequency drive was installed on the trial screen to optimize rotor speed and establish the sensitivity of power, efficiency and capacity to speed changes. The AFT Gladiator HC™ rotor was shown to reliably operate at a tip speed of 24 m/s – relative to a speed of 29 m/s for the existing rotor. Shive removal efficiency was shown to be about 98% with the AFT Gladiator HC™ rotor and a 3 m/s passing velocity. The change in rotor and speed led to reduced reject thickening. Maximum screen capacity increased by 20%. Pilot plant trials were conducted to complement the mill study and provide fundamental insights into the power savings. These trials confirmed the advantages of the AFT Gladiator HC™ rotor relative to conventional rotors in terms of power, capacity and reject thickening. There trials also showed that power consumption increases with rotor speed to the third power.

INTRODUCTION

Canfor is a Canadian, integrated forest products company based in British Columbia, and is a major producer of bleached kraft pulp, specialty kraft paper, BCTMP, lumber, plywood and oriented strand board. Canfor manufactures a range of premium reinforcing pulp products, using fibers with unique properties from the slow-growing forests of western Canada. The Northwood mill, located in Prince George, British Columbia, is a 2-line mill that produces 570,000 tonnes of fully bleached softwood kraft pulp per year.

Pulp screening is a critical unit operation in the production of high quality pulp and paper products. This is especially true in bleached softwood kraft pulp production where there are stringent limits on debris, such as shives (uncooked fiber bundles). plastic, bark and other contaminants from the pulp. These contaminants are unacceptable in finished paper and are removed by pulp screens to ensure the finished product meets customer specifications.

The rotor and cylinder are the performance components of a pulp screen. Narrow-slotted cylinders are used to ensure high debris removal efficiencies. Slot widths as small as 0.15 mm for hardwood pulps and 0.20 mm slots for long-fiber softwood pulps are now common. However, to maintain high capacity with these narrow slotted cylinders, the screens are required to operate at high rotor speeds that have significantly higher power and maintenance costs. In the province of British Columbia alone, 150 GWh/yr of electrical energy, worth approximately $7 million is estimated to be consumed by pulp screen rotors.

Rotors have specially-shaped hydrodynamic elements on their periphery to produce negative pressure pulses at the slot openings. The negative pressure pulse momentarily backflushes the apertures and clears them of pulp accumulations. The elements also accelerate the fluid to a high tangential velocity inside the cylinder to provide a high debris removal efficiency. The magnitude of the pressure pulse increases with the square of rotor speed [Feng et al. 2005]. Thus increasing the rotor speed can increase screen capacity (i.e. the accept mass flow rate). Power consumption, however, increases with the cube of rotor speed [Turcotte et al., 2003] and small increases in rotor speed result in large increases in power costs. The optimal hydrodynamic element shape is one that provides the highest possible negative pressure pulse for reliable capacity at the lowest possible speed to reduce energy costs.

The shape of the elements on the AFT Gladiator HC™ (GHC™) rotor is the result of an extensive development program. Laboratory and pilot experiments established that the GHC™ rotor could significantly reduce energy while boosting screen capacity.

The GHC™ rotor is shown in Figure 1. The hydrodynamic rotor elements are segmented along the length of the rotor to ensure that large debris can freely pass down the screening zone and into the reject stream. The angled elements distribute the pressure pulse evenly over the cylinder surface. The optimal element shape provides an effective pulse that reduces thickening.

Figure 1 - The AFT Gladiator HC™ rotor

Canfor recognized the energy savings opportunity of the new rotor and worked in a partnership with AFT and

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BC Hydro to carry out a trial at the Northwood mill. This paper reviews some of the data from the original development of the GHC™ rotor and then extends this through to discussing its performance in the mill trials at Northwood.

Lab and Pilot trials

To optimize the element shape on the AFT Gladiator HC™ rotor, a series of laboratory and pilot experiments were carried out. The pulse magnitude of a number of element shapes was measured in a laboratory cross sectional screen at the University of British Columbia (Pinon et al., 2003) and the effect of gap, element height, etc. was assessed (Li et al., 2006). Further pilot studies were conducted using an M200 screen to confirm the laboratory results, to optimize the element shape on a larger screen and to determine the power performance of the rotor [Turcotte et al, 2003].

A series of pilot trials were conducted at Herty Foundation's pilot screening facility to determine the maximum capacity, power requirements and thickening performance of the GHC™ rotor. The tests were done with narrow slotted cylinders and comparisons were made to screen performance using a commercial foil rotor. The screen used in all the pilot trials was an Ahlstrom Model F1 and the pulp was a deink

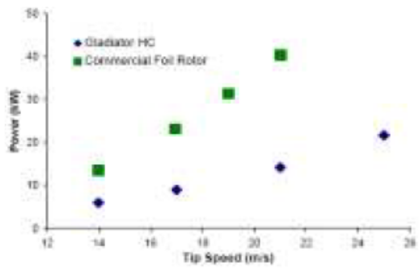

Figure 2 - Rotor power consumption increases with tipspeed for both the foil and the GHC rotor

market pulp that arrived in bales and was repulped on site. The consistency was approximately 1.3% and the operating temperature was 32 degrees C. The CSF (i.e. Canadian Standard Freeness) was 300ml. The screen cylinder used for all pilot trials was an advanced wedge wire design with 1.2 mm high contour, a 3.2 mm wide wire and a 0.10 mm wide slot.

Figure 2 shows the increase in rotor

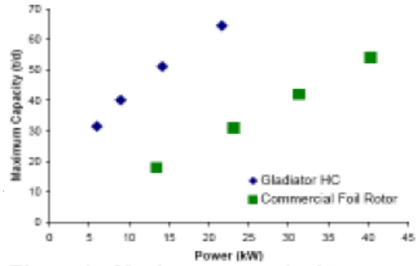

Figure 3 - Maximum capacity increases with increasing rotor power

power consumption with rotor tip speed. For both rotors, power increased with the cube of tip speed, which agrees with previous studies [e.g., Olson et al, 2004]. The foil rotor consumes significantly more power than the GHC™ rotor when operating at the same tip speed. This is most likely due to the non-aerodynamic shape of the foil rotor.

It is useful to compare power to capacity, since increasing rotor speed can increase capacity. Figure 3 shows the maximum capacity versus required rotor power for all rotor speeds tested. The power required to achieve the same capacity with the GHC is approximately 75% less than what is required by the commercial foil rotor.

Kraft Mill Trials

A partnership consisting of Canfor, Advanced Fiber Technologies (AFT), UBC and BC Hydro proposed a screen rotor trial at the Northwood mill to demonstrate the performance of the new GHC™ rotor to effectively screen northern softwood kraft fiber. This project could demonstrate to other Canadian mills the opportunity to reduce power consumption, improve throughput and efficiency by replacing the existing rotors with the GHC rotor. BC Hydro supports the implementation of new technology that can reduce electrical energy consumption thus their interest in this project.

The trial was conducted on Canfor Northwood's A-Line brown stock, swing screen (Figure 4). The screen is Centrisorter Model 212 equipped with flow meters on the accept, reject and dilution lines (Figure 5). The screen cylinder was an AFT MacroFlow™ wedgewire with slot width of 0.20 mm (0.008") and a contour height of 1.2 mm. The feed was a softwood kraft pulp with consistency in the range of 1.6 to 2.0%. The average slot velocity was 3.0

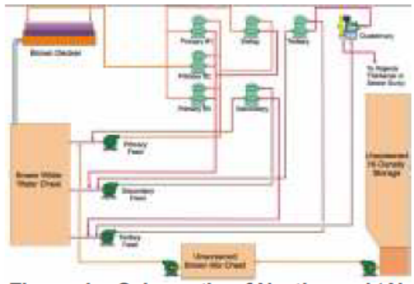

Figure 4 – Schematic of Northwood 'A' screening Line

Figure 5 – Northwood Swing Screen

m/s (approximately 165 L/s accept flow). The screen had a 200 HP motor and a competitor solid core rotor that was considered state-of-the-art. The competitor rotor was newly rebuilt in order to ensure a consistent and fair comparison. Likewise the screen cylinder was virtually new.

AFT's variable frequency drive was installed and connected to the distributed control system. This enabled rotor speed to be varied in the control room where flow and pressure could also be monitored and controlled. To ensure consistent power measurements, BC Hydro installed a power meter with data logging capability to accurately determine the power drawn by the rotor. The power recorded by this meter is used throughout this report.

Power readings and pulp samples were taken with the competitor rotor before the new AFT rotor was installed. These pretrial pulp samples were taken on the feed, accept and reject lines to determine the debris and consistency of the pulp and provide baseline values. Debris was determined with a 0.20 mm (0.008") Pulmac shive analyzer.

Following the installation of the GHC™ rotor, data was collected while operating at the same speed as the old rotor. A trial was then conducted to identify the slowest running speed the rotor could run without plugging the screen. At full motor speed, the competitor rotor was turning at 912 RPM -- or a tip speed of 29 (m/s). The AFT rotor was slowed down in increments of 2 m/s while monitoring the differential pressure (DP) across the screen and maintaining the normal feed and accept flow rates. At a rotor tip speed of 20 m/s, the DP started to rise rapidly, indicating the screen was plugging. With the competitor rotor, the normal DP was 0 kPa. When the DP went above 20 kPa, the screen was near plugging. With the new rotor, the screen did not begin to plug until the DP was over 40 kPa, suggesting that the screen would have a different operating point

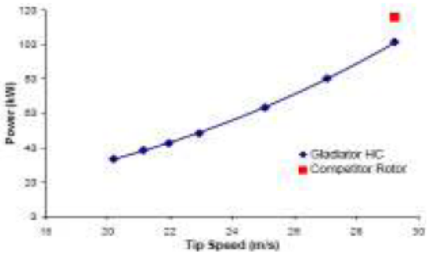

Figure 6 - Rotor power consumption for the GHC™ at a range of rotor speeds, and the competitor rotor at its recommended operating speed

than the old screen. At each speed change, pulp samples and power consumption readings were taken.

The results from the first day of this test showed that, with the GHC™ rotor, the screen could run continuously at a rotor tip speed as low as 22 m/s. Although the screen was shown to be able to operate at 22 m/s, rotor speed was increased to 24 m/s to ensure reliable operation. At this speed the screen required 52% less energy than the competitor rotor. Since the trial and the removal of the VFD, the mill has installed sheaves to slow down the rotor to speed of 25 m/s. A sheave arrangement that would allow a speed of 24 m/s was unavailable.

The rotor power requirements for the GHC™ rotor and the competitor rotor are shown in Figure 6. The GHC™ power was confirmed to increase with the third power of tip speed. At a speed of 29 m/s, the GHC™ rotor consumed 15% less power than the competitor rotor. At the minimum tip speed of 20 m/s, power consumption was 33 kW relative to 116 kW for the competitor rotor.

On the second day of the trial, shive removal efficiency was tested. The GHC™ rotor was operated at 24 m/s and pulp samples were taken as the feed to the screen was increased to a maximum while keeping the DP below 42 kPa. The maximum feed flow rate was approximately 210 L/s. As a

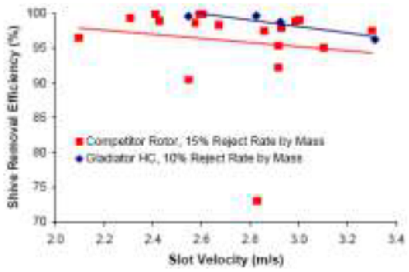

Figure 7 - Shive removal efficiency for a range of accept flow rates. The GHC™ rotor has a slightly higher efficiency – even with a lower reject rate.

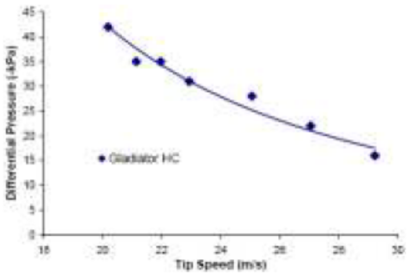

Figure 8 - The pressure drop across the screen is shown as a function of rotor tip speed for the GHC rotor

comparison, with the competitor rotor, the maximum feed rate was approximately 185 L/s.

Shive removal efficiency is shown in Figure 7 for the competitor rotor operating at a tip speed of 29 m/s and the GHC operating at 24 m/s. As noted previously, the screen is equipped with a cylinder with 0.2 mm (0.008") wide slots. This slot width ensures an effective barrier screening action and provides a debris removal efficiency approaching 100%. Using the GHC™ rotor and lowering the tip speed is

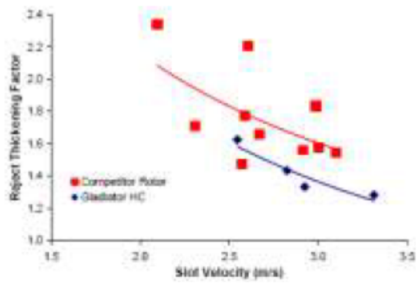

Figure 9 - Reject thickening factor for a range of accept flow rates for the Competitor and GHC rotors

shown to increase shive removal efficiency from about 95 to 98% -- even while the reject rate by mass has decreased from 15 to 10%. Figure 7 also shows that increased slot velocity decreases efficiency, but only slightly.

The pressure drop across the screen is shown in Figure 8 as a function of increasing rotor speed. For the GHC™ trial, the screen was operated at a slot velocity of 3.1 m/s, 1.9% feed consistency and 1.7% accept consistency – which yields a 250 t/d accept mass flow rate. The reject rate by mass was approximately 10%. The normal operating rate at the mill is approximately 210 t/d with a 15% mass reject rate.

As rotor speed increases, the pressure differential decreases. This is due to a number of factors, including the reduced accumulation of fibers in the slot and the increased pumping induced by the rotor.

The reject thickening factor is shown in Figure 9 for the competitor and GHC™ rotors at a range of operating conditions. The GHC™ rotor had a consistently lower reject thickening factor than the competitor rotor. The lower reject consistency reduced loading on the secondary screen and supported the superior runnability of the GHC™ rotor.

CONCLUSIONS

From these pilot and mill trials comparing the AFT Gladiator HC™ rotor to conventional rotor technology it was concluded that:

1. The power consumption of the AFT GHC™ rotor was significantly less than the competitor rotor.

2. The GHC™ rotor can operate at a lower speed and provide a total power savings of 52%, resulting in a payback period of 12 months for the Northwood screen.

3. Power increased with the cube of speed. Small increases in rotor speed will result in relatively large changes in consumed power and operating costs.

4. The GHC™ rotor provides higher capacity and reduced reject thickening. Reduced reject thickening also

contributes to the lower power consumption of the GHC™ rotor.

5. The GHC™ rotor, in combination with narrow slotted screen technology, was shown to provide slightly higher shive removal efficiencies – even though the mass reject rate was decreased.

In general, improved screening technology can be used to provide a range of benefits. For example, the power savings advantage can be traded for improved efficiency: that is, by significantly increasing screen capacity, it may be possible to reduce slot width and thus increase debris removal efficiency. Likewise the increased capacity may enable a parallel screen to be permanently shut down, saving on maintenance and operating costs. How the technology is implemented depends on the application and the mill priorities.

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