Reduced Power Consumption In Pulp Screening

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ABSTRACT

Advanced pulp screen rotor technology has been shown to provide substantial power reductions in a wide range of mill applications. Savings are obtained with only modest investments, since one typically needs only to replace the screen rotor and reduce rotor speed. In addition to saving power, benefits of using advanced rotor technology can include increased screen capacity, improved runnability and reduced screen wear. Several mill case studies are presented to demonstrate the superior performance of this screen rotor technology. In one particular case, the AFT GHC™ rotor was shown to provide 54% power savings and a 27% increase in volumetric screen capacity relative to the original screen rotor. Thickening factor was reduced from 1.40 to 1.18, which provides a direct benefit in "runnability". The advanced rotor technology also enabled the mill to use a 0.15 mm slot compared to a minimum slot width of 0.20 mm with the older screen rotor. The smaller slot led to shive removal efficiency increasing from 77.9% to 90.4%. Fundamental studies played a key role in guiding the development of the advanced rotor technology, which has now been applied in over 1000 pulp and paper mills worldwide. The combination of practical experience and fundamental understanding has proven critical to the success of this equipment.

Pulp screens are the most efficient means of removing oversize debris and ensuring the quality of pulp and paper products. The cylinder and rotor within the pulp screen are the engineered components that determine performance. The drive to use ever-smaller slot widths and achieve a more nearly-complete removal of oversize debris is balanced by the need to preserve screen capacity and runnability. Rotor speed may be increased to ensure capacity. Increased rotor speed, however, significantly increases power consumption and may also lead to increased wear on the screen cylinder, which increases operating and maintenance costs. At the same time, many mills are looking for opportunities to reduce energy consumption.

Pulp screening technology has advanced significantly in recent years and this is especially true for screen rotor technology. These advances have provided an opportunity to reduce power consumption, increase capacity, improve runnability, and use smaller cylinder apertures. The intent of this paper is to describe one such advancement in screening technology and to describe some examples of where it was put into practice in industry.

Literature Review

Screen rotors have hydrodynamic elements on their periphery which produce negative pressure (suction) pulses at the slot openings. The suction pulses backflush the apertures and clear them of pulp accumulations. The magnitude of the suction pulse has been shown to increase with the square of rotor speed (1, 2) and support increased screen capacity. Power consumption, however, increases approximately with the cube of rotor speed and small increases in rotor speed can result in large increases in power costs (3, 4). There is thus a strong motivation to seek improvements in rotor design which provide more efficient backflushing at lower rotor speeds.

The AFT GHC™ Rotor is shown in Figure 1. Mill trials and laboratory experiments have demonstrated how the rotor can increase capacity and debris removal efficiency while at the same time significantly reducing power consumption (5, 6). The AFT GHC™ Rotor has been certified by an independent power utility as "PowerSmart Technology" and has been the subject of a number of industry and government awards.

Figure 1. The AFT GHC Rotor features spiral elements with an optimal, hydrodynamic shape.

The cross-sectional shape of the rotor elements has been optimized to reduce hydrodynamic drag and enhance the suction pulse, so that strong backflushing pulses can be obtained at lower rotor speeds. The hydrodynamic elements in the AFT GHC™ Rotor are segmented along their length to ensure large debris can pass freely down the screening zone and into the reject stream without damaging the screen cylinder or rotor. The spiral-angled hydrodynamic elements cause axial pressurization towards the reject-end of the screening zone. This counters the tendency for a disproportionate amount of flow to pass through the feed-end of the screen cylinder and for reject thickening to obstruct the reject end of the cylinder. If the full cylinder can

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Figure 2. The M800 Centrisorter pressure screen with the AFT GHC™ Rotor and AFT MacroFlow™ Cylinder is shown in the centre of the photo. The M800 Centrisorter fitted with competitor components is on the left.

operate at the maximum slot velocity, overall capacity increases. Alternatively, smaller, more efficient, slots can be used without compromising capacity. Runnability is improved.

Results And Discussion

By the end of 2010, over 1000 AFT GHC™ Rotors had been installed in pulp mills around the world in a wide range of screen models, in all major market segments, and at various consistencies and capacities. University research has supported the ongoing optimization of the AFT GHC™ Rotor. Mill trials provide powerful evidence showing the strong benefits of using advanced technology as demonstrated in the Botnia mill case study (8). Other case studies demonstrate the effectiveness of this technology in a range of environments.

Botnia Äänekoski Mill Trials

The Botnia Äänekoski mill is a single-line kraft mill in Finland that produces approximately 500,000 tonnes per year of softwood and hardwood (birch) bleached pulp for use in printing papers and folding boxboard. The screening system consists of six primary and two secondary Ahlstrom Model 800 Centrisorter pressure screens. Prior to the trials, all screens had slotted cylinders with 0.20 mm wide slots. Mill trials were made to explore the potential for energy savings and increased debris removal efficiency that could be achieved through the use of advanced screening technology. Two of the primary screens were used in this trial and will be referenced below as the "AFT" and "Competitor" Screens. The AFT GHC™ Rotor and AFT MacroFlow™ Cylinder were installed in the AFT Screen (shown in Figure 2) while the Competitor Screen retained the original competitor rotor and wedgewire screen cylinder. AFT installed one of its variable-frequency drives (VFD) on the AFT screen so that rotor speed could be easily changed. The feed pulp was the mill's typical softwood bleached kraft pulp. Feed consistency to the primary screens was in the range of 1.8 to 2.0%.

While the pulp furnish in mill trials can be variable in terms of consistency, debris levels and fibre characteristics, having parallel, fully-instrumented screens and simultaneously sampling pulp screens led to an objective comparison of the two types of equipment. Two trials were held: the first using cylinders with the same slot size, and the second trial with smaller slots in the AFT Screen, which had been made practical by the AFT GHC™ Rotor. Smaller slots could not achieve the required capacity using the Competitor Rotor.

The first trial examined the performance of the AFT GHC™ Rotor and AFT MacroFlow™ Cylinder combination relative to the existing Competitor rotor and wedgewire cylinder. The AFT MacroFlow™ screen cylinder had a 0.20 mm wide slot, a 0.9 mm high contour and 4.8 mm wide wire. The competitor cylinder also had a 0.20 mm slot.

A range of rotor speeds was assessed for the AFT Screen during the trial. At each rotor speed the screen was allowed to come to steady state, the flow and pressure values were recorded, and samples were taken from the feed, accept and reject streams to evaluate consistency and debris levels. Flow

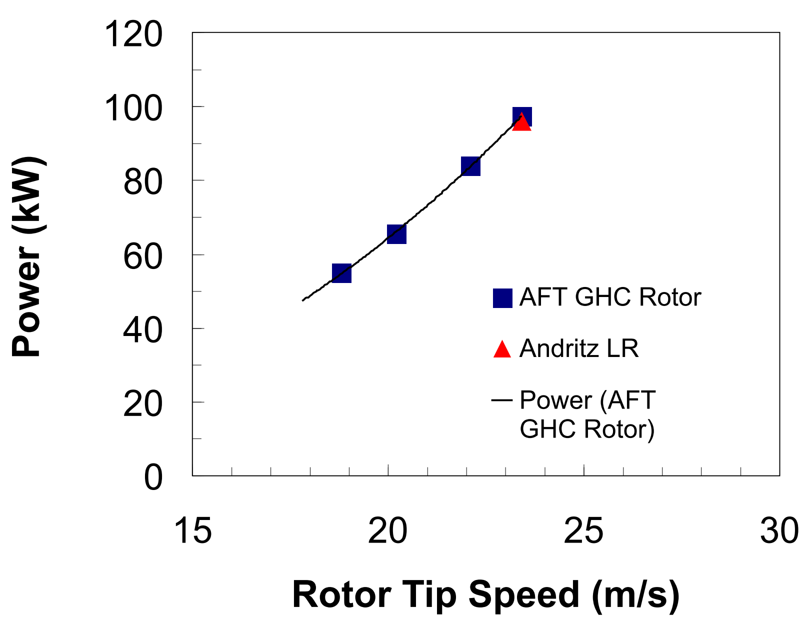

Figure 3.The ability to operate the AFT GHC™ Rotor at lower rotor speeds provides a dramatic opportunity to reduce power by 46% in this case

measurements and pulp samples were also taken from the Competitor Screen at each test point. The Competitor Screen was operated according to the standard operating conditions of the mill system throughout the trial.

More specifically, the standard operating conditions of the Botnia Äänekoski screens were: 1.8% feed consistency, 160 l/s accept flow rate, and 12% volumetric reject rate. The slot velocity was maintained at a value of ~2.6 m/s. Consistencies were corrected using standard methods for proportional error distribution. The standard rotor speed was 23.4 m/s.

Trial 1 yielded the following findings concerning the relative performances of the AFT and Competitor Screens:

- **Runnability**

The AFT GHC™ Rotor was shown to maintain good runnability even when the rotor speed was reduced from 23.4 m/s to 18.8 m/s.

- **Power**

The benefit of the slower speed is shown clearly in Figure 3, as power decreases from 97.5 to 55.0 kW, i.e. a net saving of 42%. At the same rotor speed of 23.4 m/s, the AFT GHC™ and Competitor rotors had approximately the same power consumption, which is somewhat surprising given the "drop-in" advantage shown in comparable pilot plant trials (8) but may be explained by differences in gap, rotor design details and screen power meter calibration.

- **Thickening Factor**

Figure 4 shows that the AFT GHC™ Rotor and MacroFlow™ cylinder combination had a lower thickening factor than the Competitor rotor and cylinder (1.30 versus 1.51) despite the bypass feature of the Competitor rotor that is designed to direct flow to the mid-zone of the rotor and minimize thickening. The lower thickening factor of the AFT configuration increases screen runnability and reduces fibre loss (for a given volumetric reject ratio). The lower thickening factor for the AFT Screen also resulted in the mass rejected from the screen being reduced from 50.8 to 43.5 odt/day, saving 7.3 odt/day or 14.4%.

- **Debris Removal**

The average debris removal efficiency of the AFT configuration was 76.8% versus 74.6% for the Competitor Screen. While the debris removal efficiency was initially perceived to be lower, one must remember that meaningful comparisons of debris removal efficiency must be made at the same mass reject rate. The change in thickening factor noted above, at a constant volumetric reject rate, led to a lower mass reject rate. To generate the above figures, efficiency was corrected to common value of R_M = 15% for both screens.

A second trial explored the potential to use a smaller slot in order to provide a further increase in debris removal efficiency and to capitalize on the superior runnability of the AFT rotor/cylinder combination. In particular, a 0.15 mm wide slotted AFT MacroFlow™ cylinder was installed in the AFT Screen in place of the 0.20 mm cylinder used in Trial 1. The Competitor Screen was configured as in Trial 1.

The rotor speed of the AFT Screen was varied using the VFD, as was done in Trial 1. Pulp samples were gathered from both screens at a series of progressively slower speeds and analyzed for consistency and debris content. The results are summarized in Figure 5.

- **Runnability**

The AFT GHC Rotor was shown to maintain good runnability -- even with the decrease in slot width to 0.15 mm, and even when the rotor speed was reduced to 20.2 m/s. Rotor speed was initially increased to 25.3 m/s because 0.15 mm slots had failed in the past with the original Competitor rotor, but runnability was shown to not be an issue with the AFT rotor and cylinder combination.

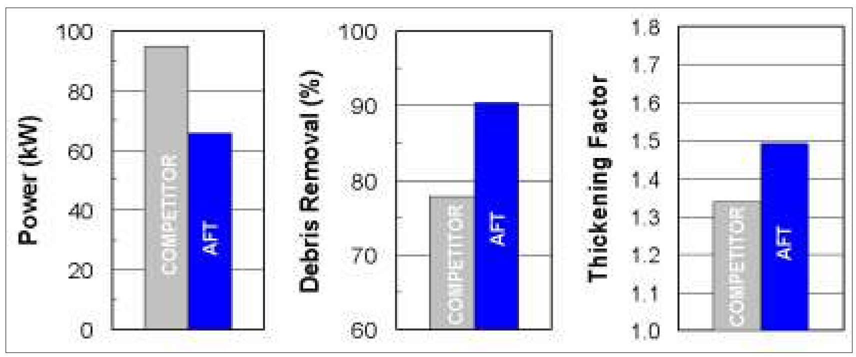

Figure 5.Trial 2 summary showing the benefits of AFT Technology for lower power, increased debris removal efficiency and lower thickening factor when using a 0.15 mm slot (AFT) versus Competitor's minimum slot width of 0.20 mm.

- **Power**

The use of the narrower (0.15 mm) slots had no direct impact on power consumption: At a tip speed of 20.2 m/s the AFT rotor drew 65.6, unchanged from Trial 1. Likewise the Competitor screen drew virtually the same power in both trials (95.5 kW and 94.9 kW) attesting to the good repeatability of the

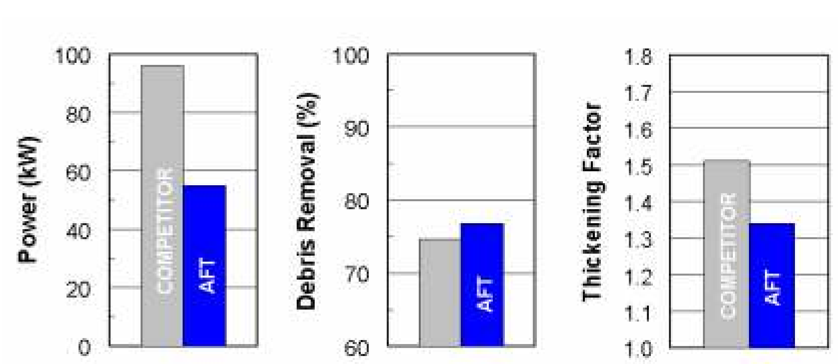

Figure 4.Trial 1 summary showing the benefits of AFT Technology for lower power (which follows on the lower speed), increased debris removal efficiency and lower thickening factor with comparable cylinders, i.e. 0.20 mm slot width.

trial data. There was, however, an indirect impact of the narrower slots since the minimum rotor tip speed with the 0.20 mm slots was 18.8 m/s, which reduced power to 55.0 kW, as shown in Figure 4.

- **Thickening Factor**

The narrower, 0.15 mm, slots in the AFT screen led to an increase in thickening factor: 1.49 m/s in Trial 2 versus 1.30 with the 0.20 mm slots in Trial 1. What was curious, however, was that the thickening factor of the Competitor Screen was lower in Trial 2 than in Trial 1 (1.34 versus 1.51). This may reflect changes in the pulp furnish that occurred over time between the trials.

- **Debris Removal**

The average debris removal efficiency of the AFT Screen with 0.15 mm slots was 90.4% versus 77.9% for the Competitor Screen with 0.20 mm slots, demonstrating the powerful influence of being able to operate reliably with a smaller slot. As with Trial 1, there was no clear relationship between rotor tip speed and debris removal efficiency. Debris removal efficiency values were corrected to a common mass reject rate.

Balkrishna Paper Mills Rotor Trial

Balkrishna Paper Mills is a duplex board mill with a capacity of 200 t/day located in Mumbai, India. The focus of this study is a Lamort CH5 pulp screen in the primary coarse screen position on the bottom layer line. The furnish for the bottom layer is mixed office waste (MOW). The flow to the screen was 2000 litres/min at a feed consistency of approximately 2.5%. The mill's goal was to reduce power consumption while increasing debris removal efficiency.

The Lamort CH5 screen was originally fitted with the Original Equipment Manufacturer (OEM) lobe-type rotor and a contoured cylinder with 1.8 mm diameter holes (18% open area). The rotor was operated at a tip speed of 19.1 m/s (730 rev/min). The installed horsepower was 56 kW (75 hp) and consumed power for this original configuration was 47 kW.

AFT provided a GHC™ Rotor like that shown in Figure 1. It was installed with the prescribed rotor speed of 20.9 m/s (800 rev/min). The screen cylinder remained with an aperture diameter of 1.8 mm. The following benefits were seen:

- **Power**

In spite of the higher tip speed, power consumption decreased by 28% to 34 kW. This saving led to a payback period under 9 months.

- **Debris Removal**

Mill personnel reported better cleanliness following installation of the AFT GHC™ Rotor. This is expected given that the GHC™ rotor pulsations are gentler than the OEM lobe-type rotor and less prone to forcing contaminants through the apertures or causing an excessive amount of backflush flow (which would increase the instantaneous velocity through the apertures during the forward flow). The higher rotor speed and associated higher tangential velocity on the feed side of the screen cylinder would also tend to prevent contaminant passage.

- **Runnability**

Routine inspection of the cylinder showed a reduced build-up of fibres, indicating a more effective cleaning action of the rotor and better screen runnability.

- **Capacity**

Screen capacity remained entirely adequate for the application.

Based on these very positive results, Balkrishna Paper Mills has since ordered AFT GHC™ Rotors for their other coarse screens.

Indian Board Mill

AFT GHC™ Rotor technology was also applied successfully at an Indian mill manufacturing 4-ply paperboard. The furnish to the mill is 100% waste paper including "white record", old newspaper, mixed waste and duplex cuttings. The focus of the study is a Black Clawson UV-100 pulp screen that is installed as a secondary coarse screen on the filler layer line. Feed consistency is approximately 2.8%. The mill's primary goal was power reduction.

The Black Clawson UV-100 screen was originally fitted with an OEM "NS" style rotor. The screen cylinder had 1.6 mm diameter holes (18% open area) and "UP" type bars. The rotor was operated at a tip speed of 22.1 m/s (705 rev/min). The installed horsepower was 56 kW (75 hp) and the consumed power level for this original configuration was 47 kW.

AFT provided a GHC™ Rotor like that shown in Figure 1. It was installed with a rotor speed of 23.0 m/s (732 rev/min). The screen cylinder was unchanged and has an aperture diameter of 1.6 mm. Power consumption decreased by 34%, from 47 kW to 31 -- despite the higher tip speed. All other rotor performance parameters were maintained. This very significant saving provided a nine month payback period for the rotor. The mill is now exploring the purchase of two AFT GHC™ Rotors in the for their top layer fine screening.

Summary and Conclusions

Mill trials at Botnia Äänekoski, Balkrishna Paper Mills and an un-named mill in India have provided positive results for the AFT GHC™ Rotor, consistent with the success that the rotor has enjoyed in hundreds of installations around the world.

Two trials were run at Botnia: one where both the AFT and Competitor Screens were operated with 0.20 mm wide slots and the other where the AFT screen used a 0.15 mm wide slot. AFT technology provided a 42% reduction in power consumption. The AFT GHC™ Rotor was shown to maintain good runnability even when operated at a lower rotor speed of 20.2 m/s and with 0.15 mm wide slots. Previous mill experience was that such small slots could not be operated with the Competitor equipment. The ability to operate a narrow, 0.15 mm, slot provided led to a 90.4% debris removal efficiency versus 77.9% with the traditional screening technology with 0.20 mm slots. In other terms, the amount of residual contaminants in the accept stream was reduced by over half by using the AFT GHC™ Rotor and narrow slots.

The AFT GHC™ Rotor was also used with great effect at Balkrishna Paper Mills. Power consumption was reduced by 28%, while debris removal efficiency and runnability increased. The payback period, based solely on the power savings, was less than nine months. An AFT GHC™ Rotor at another Indian paper mill provided 34% power savings. These results are typical of the performance that has led the AFT GHC™ Rotor to be the best-selling rotor in the world today.

Market demands have increased the importance of pulp quality, while mills are pressed to increase production, reduce power and save fiber. Mills in a range of industries are thus highly motivated to seek out, evaluate and adopt new technology which satisfies these needs. Advanced screening technology, such as the AFT GHC™ Rotor has been shown to provide increased pulp quality, reduced fiber loss, increased capacity, and power savings.

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