

# Advanced Screen Rotor Technology For Reduced Energy

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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 a mill typically needs to only replace the screen rotor, or in some cases to also 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 in this study to demonstrate the superior performance of advanced rotor technology. In one case, the AFT GHC™ Rotor was shown to provide a 54% power savings and 27% increase in screen capacity relative to the original screen rotor. The mill was able to use a 0.15 mm slot compared to the minimum slot width of 0.20 mm with the older rotor. The smaller slot led to shive removal efficiency increasing from 77.9% to 90.4%. In two other cases, recycled paper mills in India demonstrated energy savings of approximately 40% through the use of AFT GHC Rotors. The combination of practical experience and fundamental understanding has proven critical to the success of this rotor technology.

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, to a great extent, determine screen performance. Advances in cylinder and rotor technology have served to address a broad range of industry needs.

Increasing demands on screening technology have arisen from many of the current trends in industry: Increasingly high contaminant levels in recycled furnishes coupled with publisher demands for greater cleanliness, have led to the use of smaller cylinder apertures to achieve higher levels of debris removal. The desire to increase production in older mills without adding equipment has led to increases in both slot velocity and feed consistency. At the same time, there is a need to reduce energy consumption, but without compromising screen runnability. Increased rotor and cylinder lifetimes are sought in order to reduce maintenance costs.

The challenge is that while strategies exist to achieve each of these industry demands (e.g. narrow screen slots for higher debris removal or lower rotor speeds for energy savings and increased cylinder lifetime) these strategies typically exist in conflict with each other. Thus in traditional screen applications, one might use smaller slots to increase debris removal, but have to compensate with higher rotor speeds and increased energy costs. The deeper challenge has thus been to satisfy a range of needs without simply trading-off one attribute for another. This challenge has been met by the technical advances in screen rotor technology which provided an opportunity in many cases to simultaneously reduce power consumption, increase capacity, improve runnability, and

use smaller cylinder apertures. The intent of this paper is to describe one such example of advanced screen rotor technology and how it was put into practice in industry.

## Literature

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 therefore 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 that 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.

The cross-sectional shape of the AFT GHC 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 on the AFT GHC Rotor are segmented along their length to ensure large debris can pass freely down the screening zone (i.e. the zone between the rotor and screen cylinder) and into the reject stream without

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

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 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 2012, over 1300 AFT GHC Rotors had been installed in pulp mills in 28 countries around the world – in a wide range of screen models, in all major market segments, and at various feed consistencies. University research has supported the on-going 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] which is also an occasion to show the correct means for objectively interpreting mill data. 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 the “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 its variable-frequency drive (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 possible by the AFT GHC 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 Macro Flow cylinder used in this trial 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 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. 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.



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.



Trial 1 yielded the following findings concerning the relative performance 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, with a reduction in power 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.

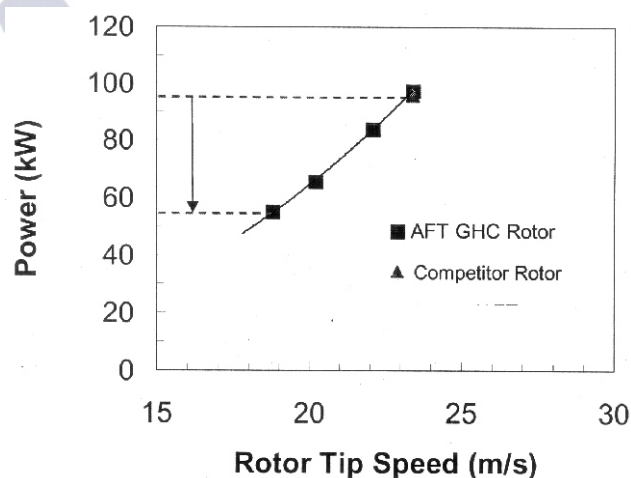


Figure 3. The ability to operate the AFT GHC Rotor at lower rotor speeds provides a dramatic opportunity to reduce power – by 46% in this case

- **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 results 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% of the previous reject mass flow.

- **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 RM = 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 analysed for consistency and debris content. The results are summarized in Figure 5 and reviewed below:

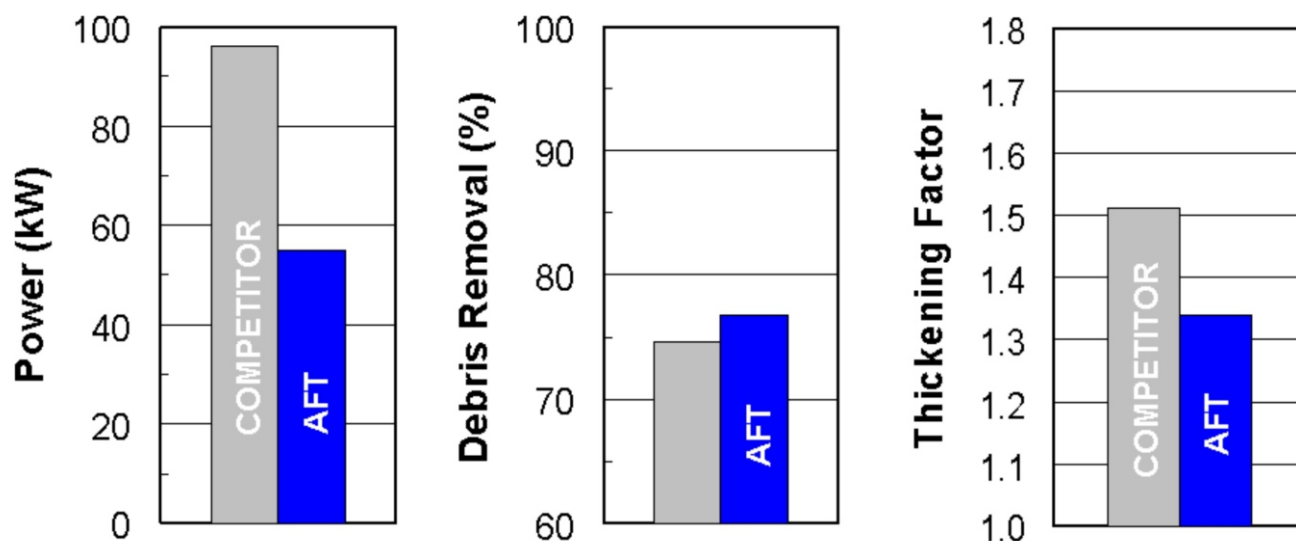


Figure 4. Trial 1 summary showing the benefits of AFT Technology for lower power (which follows on the lower rotor speed), increased debris removal efficiency and lower thickening factor. Comparable (i.e. 0.20 mm slot width) cylinders were installed in both screens.

#### • 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.

#### • 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 kW, 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 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.

In summary, the trials at Botnia Äänekoski demonstrated the ability

of superior rotor technology to achieve reduced power consumption, improved debris removal and superior runnability without having to compromise one attribute for another.

### 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 was a Lamort CH5 pulp screen in the primary coarse screen position on the bottom layer line. The furnish for the bottom layer was mixed office waste (MOW). The flow to the screen was 2000 litres/min at a 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). Installed horsepower was 56 kW (75 hp) and the consumed power with the OEM rotor was 50 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 40% to 30 kW. This saving led to a payback period of 6 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

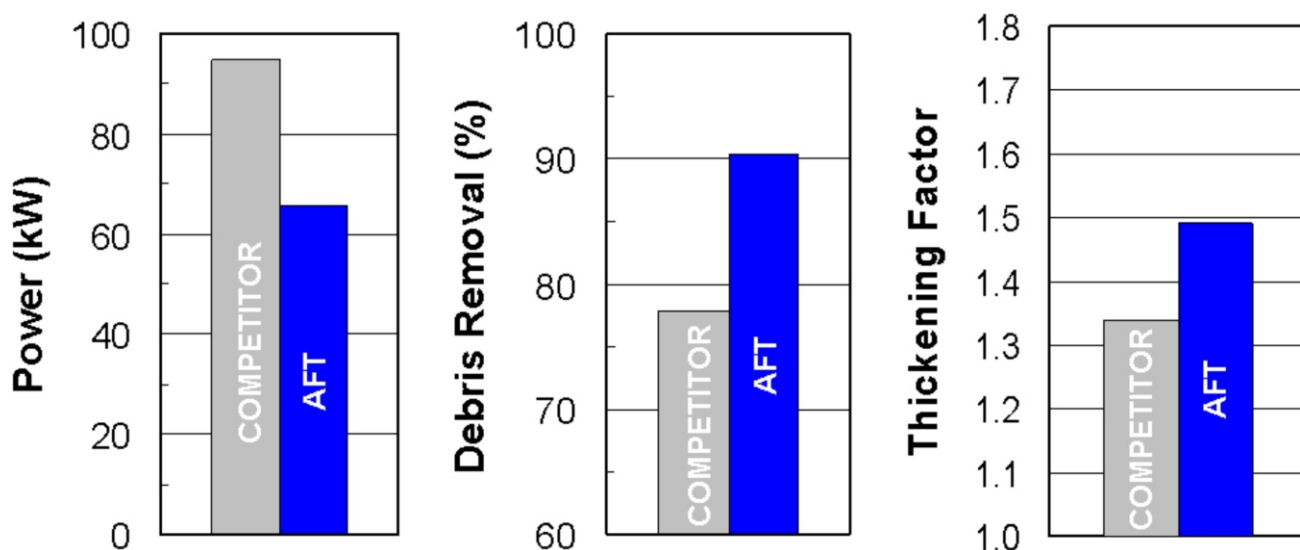


Figure 5. Trial 2 summary showing the benefits of AFT Technology for lower power, increased debris removal efficiency and lower thickening factor when using a 0.15 mm slot (AFT) versus Competitor's minimum slot width of 0.20 mm.



instantaneous velocity through the apertures during the forward flow part of the cycle). 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 Recycled Paper Mill

Additional examples of the use of advanced rotor technology can be found at a mill in Tamil Nadu manufacturing 287 t/day of boxboard from a blend of recycled furnishes, such as old newspaper (ONP), MOW and white record. In one instance, this mill wished to replace the OEM LP1 rotor in a UV400 screen operated in a primary fine screen position. The screen had a AFT Macro Flow cylinder with 0.20 mm slots, and this was not changed when the new rotor was installed. Likewise the rotor tip speed of 25 m/s remained unchanged. The simple substitution of the AFT GHC Rotor for somewhat outdated LP1 rotor technology caused energy consumption to decrease from 135 kW to 83 kW, i.e. a 39% power saving. Runnability was excellent following the installation of the AFT GHC Rotor. The significant power savings led to a payback of less than one year. Further savings are available by reducing the rotor speed from 25 m/s to 22 m/s, which is more typical of AFT GHC Rotor speeds in this application.

In a second application at this mill, the mill sought to upgrade the OEM (NS-type) rotor in a UV100 Black Clawson screen operated in a secondary coarse position. The screen had a drilled cylinder with 1.6 mm diameter contoured holes and UP bars. The OEM rotor was operated at a tip speed of 22 m/s and power consumption was 43 kW. After the AFT GHC Rotor was installed, the power decreased to 27 kW, representing a reduction in power consumption of 37%. Runnability of the screen was excellent. The payback period for the rotor was less than one year.

## Summary And Conclusions

Rotor trials at a kraft mill in Finland and two recycled paper mills in India provided positive results for the AFT GHC Rotor that are consistent with the successful application of the rotor 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 led to a

90.4% debris removal efficiency versus 77.9% with the traditional screening technology with 0.20 mm slots. In essence, 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 shown to be very beneficial at Balkrishna Paper Mills. Power consumption was reduced by 40%, while debris removal efficiency and runnability increased. At another recycled paper mill in India, a 39% power saving was obtained in a primary fine screen and 37% saving was seen in the secondary coarse screen. In all cases, the payback period was less than one year.

Market demands have increased the importance of pulp quality, while at the same time, 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 – such as the AFT GHC Rotor.

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