New Trends and Technology in Refining

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ABSTRACT

Cost reduction has, for some time, been the main driver in most of the development actions taken by paper mills and technology suppliers. Energy consumption will remain one of the main issues. Stock preparation accounts for up to one third of the electricity consumption of the paper mill. As low-consistency refining accounts for a significant part of the energy consumption, it offers huge saving potential.

Refining is one of the most important operations for tailoring the fibers to obtain the desired paper properties. The key to efficient refining is using the correct refiner fillings in the correct refining conditions. Recent advances in refining technology at Metso have concentrated on improving fiber development, reducing energy consumption and minimizing plate wear to reduce maintenance costs.

Figure 1. Electricity consumption of WFU fine paper machine, total 600 kWh/reel t (Metso Paper)

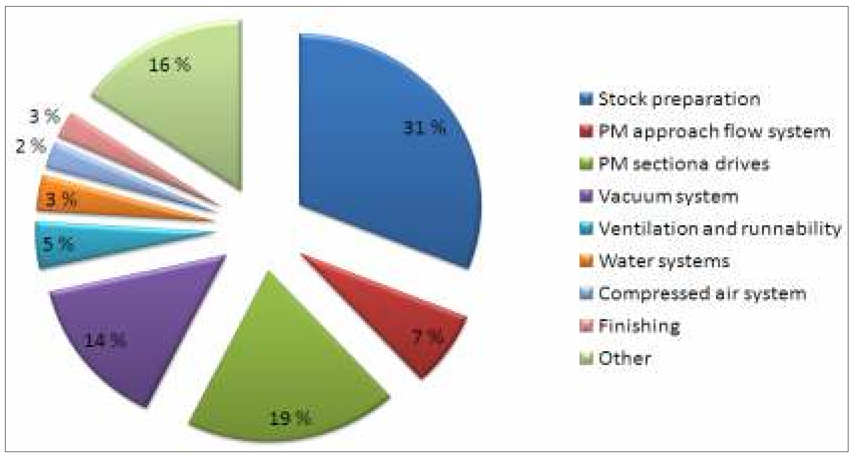
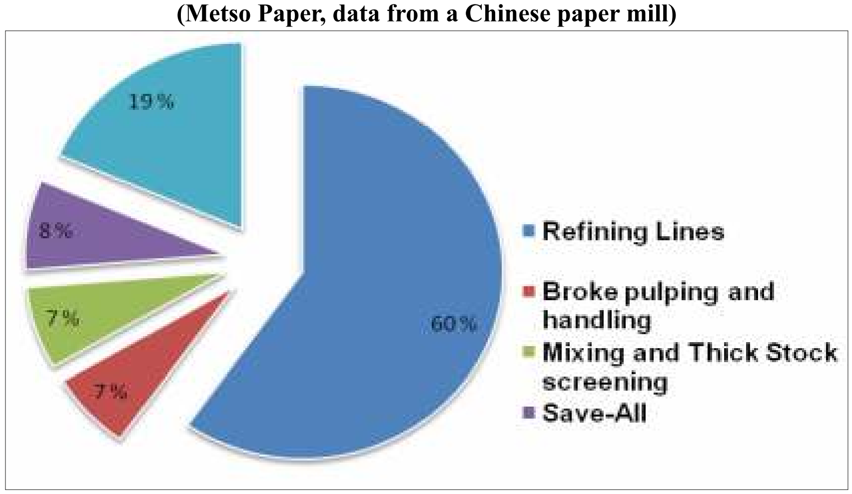


Figure 2. Electricity consumption of Stock Preparation in a WFU paper machine, including agitating and pumping, total 278 kWh/reel t (Metso Paper, data from a Chinese paper mill)



In 2010, Metso introduced a new low-consistency refining concept with the OptiFiner Pro refiner. Unlike conventional refiners, OptiFiner Pro feeds the stock evenly across the bars directly into the refining zone where fiber treatment occurs. All of the stock is treated equally, providing a higher refiner loadability and better energy efficiency.

This paper will present several developments to illustrate how these new trends and technologies in refining can improve final product quality, raise efficiency and reduce operating costs.
The cost of energy and especially electricity has, apart from some short periods, been increasing over the past decades. In order to maintain competitiveness, paper mills and single paper machines need to continuously look for process solutions and machines with less electricity consumption.

A paper machine's electricity consumption depends on not only a PM's characteristics, like width and speed, but also on raw materials, i.e. furnish used; for example in a WFU machine the origin of short fiber can vary from annual to wood fiber in many percentages, likewise the amount of long fiber or filler. However, modern, relatively fast WFU machines typically have furnish based almost only on wood pulps, and bleached short and long fiber kraft pulps.

A WFU machine's stock preparation is the biggest single energy consumer as is Low Consistency (LC) refining within stock preparation. Thus, energy saving improvements carried out in the refining area result in remarkable savings in a PM's running costs and therefore also improve its ability to compete in the paper markets.

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The energy used in LC-refining varies according to the paper grades and raw materials used; below are some typical ranges (kWh/t line production) used for some paper grades:

- Softwood for SC paper reinforcement 150-250 kWh/t
- Eucalyptus for fine paper 60-120 kWh/t
- Post-refining of mechanical pulp for printing papers 30-150 kWh/t
- Unbleached Kraft for liner, paperboard 150-250 kWh/t

Discussion

Hardwood and mixed pulp refining with Microbar

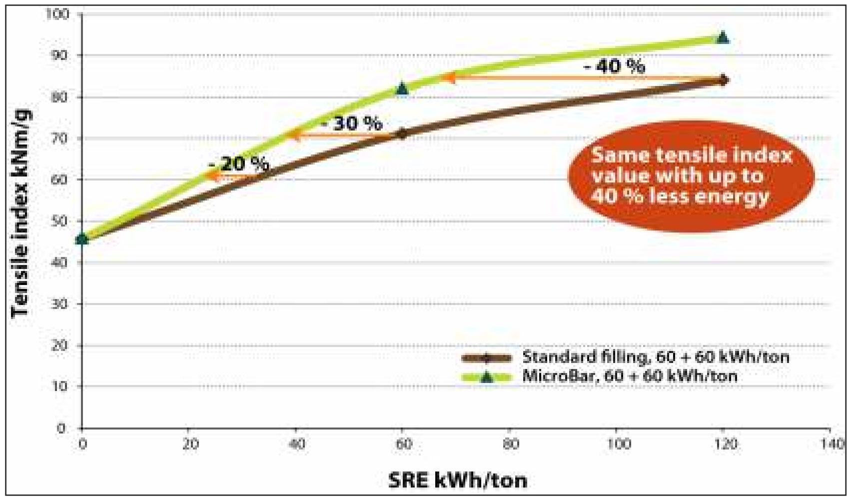
Over previous years the trend in papermaking has been to use a higher content of short fiber raw-materials. This has been driven by a constant demand for higher printing performance and cost reduction in the pulp furnish. The trend to replace softwood with hardwood improves formation, opacity and printability, but the furnish changes create challenges for the existing stock preparation LC-refining lines.

With the right fiber treatment, papers made from eucalyptus pulps feature good stiffness and bulk with high opacity. This, together with production economics, has increased the use of eucalyptus for many grades with a corresponding reduction in northern hardwood usage. Eucalyptus pulps also give good surface uniformity and formation, but compared with birch, for instance, involves some fine-tuning of stock preparation, especially refining. Eucalyptus has large vessel segments that collapse in pulping to produce flat particles that are wider than the fibers and do not easily bond with them. Without sufficient refining, excessive starch or surface sizing is required to avoid picking, where vessel segments separate from the paper surface on the printing press, taking coating and ink with them.

Short eucalyptus fiber is harder to refine, requiring finer bar patterns to get the best from the pulp. The finer bar pattern has narrow grooves, which, with conventional refiner fillings, reduce the hydraulic capacity and efficiency of the refiner. Metso's solution is the MicroBar design that enables higher loadability compared with standard fillings. The unique combination of a densely designed refining zone and capacity grooves results in an extended cutting edge length and very high hydraulic capacity. With MicroBar, refining energy consumption is reduced by as much as 40 % for eucalyptus and up to 10 % in mixed pulp applications for the same SR or tensile levels. With refining accounting for a fifth of the total electricity consumption of a typical fine paper production line, the opportunity for savings is considerable.

For mixed pulp refining, MicroBar has shown easy runnability with good loadability and less plugging compared with standard fillings with high variations in SW/HW ratios. The Microbar design, with more bar-edge crossing points, provides a gentle refining action for better fiber fibrillation and greater strength development. The lower intensity refining also contributes to longer filling lifetime because of less bar wear and reduced plate-to-plate contact. Increased refining efficiency can also translate to fewer refiners providing additional capital savings as well as lower operating costs.

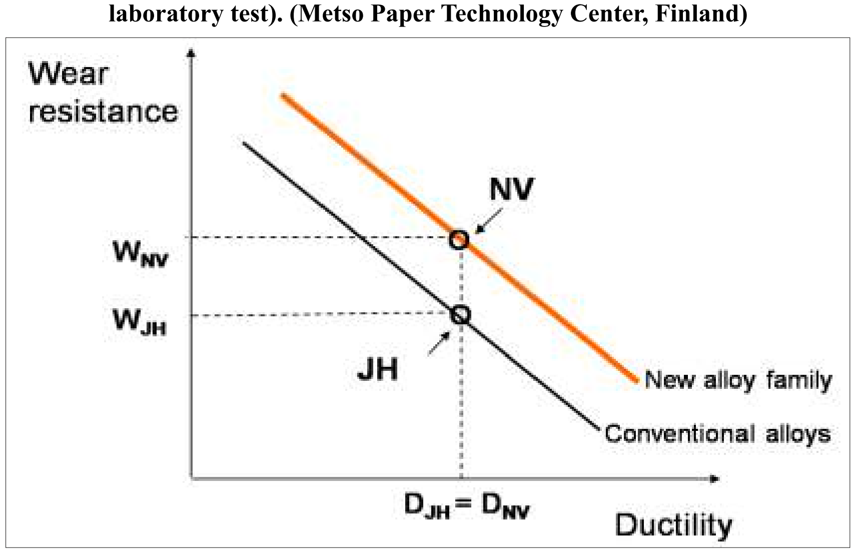
Figure 3. Energy savings with MicroBar in eucalyptus refining (Metso Paper Technology Center, Finland)



Extending filling lifetimes with new alloy

Fiber quality, energy efficiency and production runnability all depend on the mechanical condition of the refiner. As fillings wear, a drop in energy efficiency will be first noticed, followed by worsening fiber quality until replacement is needed. As well as wear, mechanical damage can also occur, but careful selection of materials used in the manufacture of the refiner fillings can mitigate both. Bar wear is

Figure 4. Compared with JH alloy, the impact strength of NV is on the same level, and the wear resistance is up to 80 % higher (abrasive wear laboratory test). (Metso Paper Technology Center, Finland)



measured as a loss in bar height, caused by abrasion and corrosion. Abrasion can be worse in stock flows with high sand content, such as annual pulps like straw, but larger contaminants, for instance in recycled furnishes, can cause severe mechanical damage. Bar-edge rounding has the most significant effect on quality and efficiency, as the leading edge of the bars as they pass each other is where most fiber treatment occurs.

Assuming a refiner is being run within its operating parameters, metallurgy is the key to extending filling life. Unfortunately, increasing abrasion resistance with conventional alloys increases brittleness and thus reduces resistance to mechanical damage. Metso is pioneering the use of the NV alloy family which features improved wear resistance with no loss of impact strength. Using special alloying provides the NV alloy microstructure with a remarkable amount of hard and wear resistant carbides. Unlike conventional carbide formers (e.g. chromium), this special alloying does not form netlike structures in the microstructure. Hence, the impact strength does not decrease in the same proportion as wear resistance increases. Metso has applied for a patent for this application.

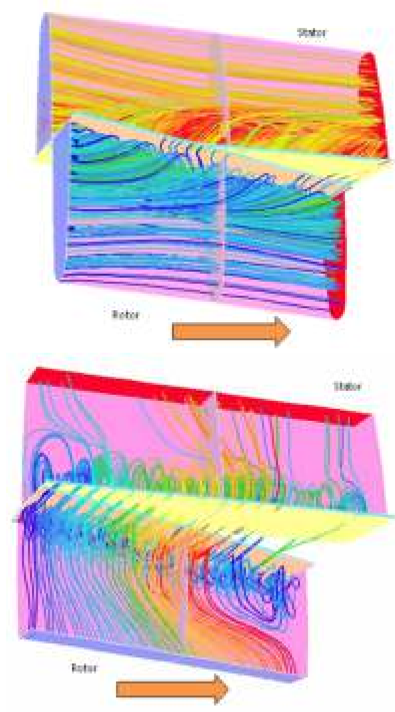
The New-Generation refiner

Utilizing years of experience with all kind of refiners, Metso has developed a refiner where the stock treatment efficiency has been raised to a new level. The principal difference with conventional refiners is the way the stock is fed into the refining zone. Unlike conventional refiners, OptiFiner Pro feeds the stock evenly across the bars directly into the refining zone where fiber treatment occurs. All of the stock is treated equally, providing a higher refiner loadability and better energy efficiency.

Refining intensity has typically been defined as the specific energy applied to a unit mass of fiber per refiner bar impact. A longer retention time means there is a higher probability the individual fibers will become treated, but no account is made for fibers treated too many times, leading increased fines, weakening of the refined fibers and inefficient delivery of energy to the fiber. In conventional refining, all the fibers have to travel the full length of the refining zone, with no guarantee of equal treatment. Some fibers follow the segment grooves from inlet to discharge; for example in a disc refiner as little as 30 % of the fibers are refined in the first pass-through. In these instances, fiber treatment efficiency and energy efficiency is low.

The new OptiFiner Pro concept enables all the stock to be subject to treatment with fresh stock entering the refining zone directly. This increases the number of fibers that receive proper refining treatment and the residence time of the pulp in the refining zone is no longer the key factor determining intensity. A slightly larger fillings gap is also enabled, allowing a thicker mat and more fiber-on-fiber action for gentler treatment, which is especially important with hardwoods.

Figure 5. Flowcharts in a refiner's segments, conventional (left) vs. OptiFiner Pro flow through principle (right) (Metso Paper)



Refining energy

Not all of the power applied to a refiner is imparted to fiber treatment. As much as 20 % of the applied power, the no-load power, is consumed by viscous drag effects of the rotor in a fluid. No-load power increases with diameter and rotational speed of the rotor as well as being affected by the hydraulic section ratio and groove depth. Metso's new LC-refiner concept uses a smaller rotor because of the improved fiber flow with increased impact occurrence. This reduces the no-load power by almost 50 % compared with similar capacity traditional refiners and has a big impact on total applied power for the desired refining result. The new refiner concept utilizes a well-proven conical design where gap control is made by a moving rotor with a new-generation loading system comprising a servo motor and its control. This enables quick and precise power control.

As well as available net power, which limits the amount of refining that can be done, the capacity of a traditional refiner is also limited by its volumetric flow capability. The flow capacity of a conventional disc refiner is determined by its diameter, its operating speed and the hydraulic section (ratio of groove width to the sum of bar and groove width) and angle of the refiner plates. The disc refiner acts like a centrifugal pump with force created by rotation of the stock, which in turn is dependent on the bar height. This is further complicated with the wear of both the stator and the rotor segments, altering the pumping capacity and thus the

Figure 6. Better stapling of fibers on bar surface increases the efficiency of the new design (Metso Paper Technology Center)

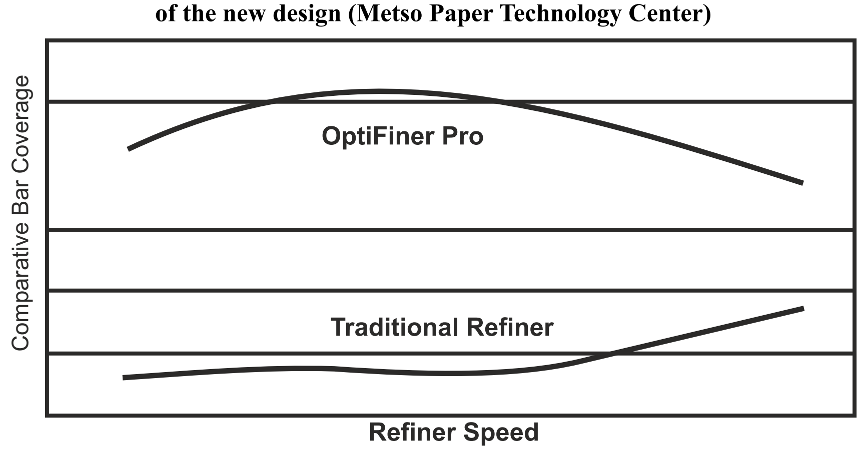
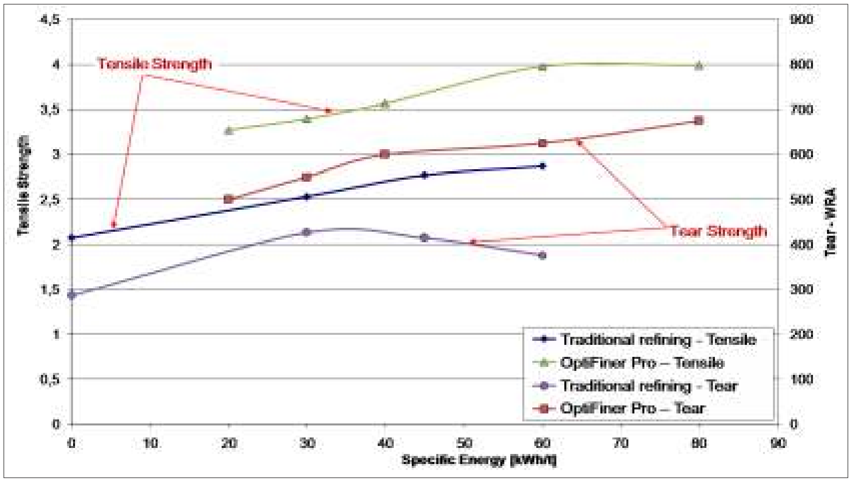


Figure 7. Comparison of strength development between a traditional refiner and OptiFiner Pro, pulp euca (Metso Paper Technology Center, Finland, pilot trials)



pressure drop across the refiner. The new OptiFiner Pro concept enables a remarkably higher installed power and throughput, raising the refining efficiency clearly higher than earlier designs. Additionally, the through-flow principle means that a refiner's hydraulic capacity is not sensitive to fillings wear. The refiner's pumping curve is also lower and more even than with conventional refiners.

Figure 8. OptiFiner Pro mill installation (Sappi Biberist mill)

The improved performance of OptiFiner Pro enables refining with a reduced number of more compact refiners, thus reducing investment and maintenance costs significantly. The high energy efficiency provides operational cost savings and supports sustainable development with lower entire life-cycle cost and less environmental stress.

Conclusion

Low-consistency refining offers huge energy-saving potential. Improvements in technology, design and construction continually offer improved solutions to stock preparation processes. Extensive research and development is first proven in Metso's own pilot plants before release to the market, thus ensuring results from the very first customer installation. The introduction of the new refining concept improves process sustainability through increased economy and performance providing positive environmental benefits.

References

MicroBar

The BM 1 board machine at Kyro was rebuilt in 1994 and today produces 150,000 tpa of folding boxboard for beauty care and other demanding packaging products. During the rebuild, two parallel JC03 refiners were installed for birch pulp treatment before the machine chest, where the stock is blended with pine pulp. The two refiners were necessary to provide the gentle low-intensity refining for short fiber treatment.

With short fiber coarse-type (SC) fillings, high specific edge loads and low throughput, refining efficiency was poor, but one refiner would have given an unacceptably high refining intensity and was not an option at that time. In Metso's refining audit, it became clear that utilizing Metso's new refining technology would enable the mill to do the job with one refiner. Today Kyro is using eucalyptus in addition to birch in short fiber supply and refining has to be exactly right. One refiner is easier to run and control. Eucalyptus refining presents an extra challenge as the fibers are smaller than birch and harder to refine, with an increased possibility of plate clashes.

One refiner was fitted with the new Turbine Housing and MicroBar fillings in the summer of 2010 and the second refiner was shut down. Turbine Housing is a new type of housing for low-consistency refiners that can increase the production of the refiner by 30 % and provide longer fillings life. It replaced the existing radial outlet design with a tangential outlet that allows easier stock flow through the refiner and thus increases outlet pressure. This enables more production through the refiner and can improve pulp properties as finer patterns can be used. The energy savings potential is also consirable, with a reduction of stock pump speed or reducing the number of refiners needed.

The Turbine Housing provided the increase in capacity from the refiner and MicroBar gave the correct refining intensity. Metso took many stock samples before and after the modification to ensure stock quality did not suffer, and it did not: Quality is at the same level and the no-load power on one refiner saves us 100 kW. A reduction in the specific energy control target enabled by MicroBar saves another 15 to 20 kWH/ton.

OptiFiner Pro

One of the first installations of the new

OptiFiner Pro refiner was to the PM6 stock preparation line at Sappi's Biberist mill in November, 2010. Sappi Biberist's PM6 produces 80,000tpy of uncoated office grades. Furnish to the machine is approximately 80% Brazilian eucalyptus, which with the right fiber treatment features good stiffness and bulk with high opacity. Low intensity refining is needed in order to achieve the necessary fibrillation of the fibers without cutting and for PM6, this was achieved with six conical refiners. Typically four of the six refiners were used in series to refine the eucalyptus stock. The disadvantage to this approach was the high no load power consumed by the four refiners that contributes nothing to the overall fiber treatment. Additionally, the four refiners could not be driven any harder and to achieve desired sheet quality, the degree of soft wood refining had to be increased. The introduction of the new refiner concept and subsequent pilot trials by Metso in Finland proved that one OptiFiner Pro could replace the four in-series refiners, improve the refining result and offer substantial energy savings.

The OptiFiner Pro was purchased by the mill to replace the conventional conical refiners and started up on Wednesday, November 17, 2010. The compact size of the refiner was a big advantage during installation as space was limited next to the existing six refiners.

After just over two months of operation at the end of January 2011, the mill confirmed that the new refiner had met the operational guarantees. These included:

- Maximum capacity of 35 l/s @ 5 %
- 30% lower energy consumption when compared to 2xRF-3 @ 30 SR level
- Same or better quality as with 2xRF-3 refiners
- 60% energy saving @ 23 SR level when compared to old refiners

The fiber development with the new refiner was at least equal if not better to the Finnish pilot trial. At the start, the refining target was the same Schopper-Riegler (°SR) level (17-23 °SR) as with the four old refiners in series, which meant about 25 kWh/t refining energy use (about 150 kW power draw). At that point, the promised 60 % energy savings could be seen.

The mill has been satisfied with the OptiFiner Pro performance. Quality and energy savings have been as good as promised with noticeable increases in tear and tensile strength. During February 2011, the SEC limit in the controller program was increased from 90 kWh/t to 120 kWh/t. This corresponds to 500 kW power draw at current production rate of 3.74 t/h.