Executive Summary

Low intensity refining requires a fine bar pattern that with a conventional refiner would reduce hydraulic capacity and efficiency. OptiFiner Pro™ enables considerably higher installed power and throughput, raising refining efficiency and achieving the necessary fibrillation of the fibers without cutting.

Considerable volumes of steam are produced in the making of mechanical pulp. The traditional method for separating pulp and steam has been via pressure cyclones, but a new approach uses mechanical separators (PeriFeeder™ and PeriSplitter™) for different positions in the process.

Leakage costs money. Valmet SealMax™ mechanical seals provide optimal sealing for increased availability and reduced maintenance, and also protect the internal and the external environment.

The OptiFlex™ digester screen has a unique, flexible design making it a suitable replacement to all kinds of older digester screens. OptiFlex features a long lifespan and low maintenance costs.
OptiFiner Pro - Improving efficiency in stock preparation

To get the best from short eucalyptus fibers, low intensity refining requires a fine bar pattern that with a conventional refiner would reduce hydraulic capacity and efficiency. OptiFiner Pro enables considerably higher installed power and throughput, raising refining efficiency and achieving the necessary fibrillation of the fibers without cutting.

Apart from a few short periods, the cost of energy and especially electricity has been increasing over the past decades. In order to maintain competitiveness, paper mills and single paper machines continuously need to look for process solutions and equipment with less electricity consumption.

The electricity consumption of a paper machine depends not only on the machine line characteristics, such as width and speed, but also on raw materials, i.e. the furnish used. For example in a WFU machine the origin of short fiber can vary from annual to wood fiber, likewise the amount of long fiber or filler. However, modern, relatively fast WFU machines typically have furnish based almost entirely on wood pulps, and bleached short and long fiber kraft pulps.

A WFU machine’s stock preparation is the biggest single energy consumer (Figure 1), and within stock prep the Low Consistency (LC) refining is the biggest energy consumer (Figure 2). Thus, energy saving improvements carried out in the refining area result in significant savings in a paper machine’s running costs and therefore also improve its ability to compete in paper markets.

The energy used in LC refining varies according to the paper grades and raw materials used; below are the 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

![Figure 1. Electricity consumption of WFU fine paper machine, total 600 kWh/reel t.](image1)

![Figure 2. Electricity consumption of stock preparation in a WFU paper machine, including agitating and pumping, total 278 kWh/reel t.](image2)
A revolution in refining technology

With the cost of energy and raw materials continuously on the increase, Valmet has made concentrated efforts to improve the efficiency of stock preparation equipment. Reducing energy consumption and increasing capacity while retaining or improving the quality of fiber treatment have been the key objectives behind the new LC refiner. OptiFiner Pro is a new refining concept that, in the first two commercial installations, has set new standards in terms of refining performance and efficiency.

The refining stage in stock preparation plays an important role in developing the properties of stock for paper production. In the refiner, the appropriate fiber treatment greatly affects the runnability of the paper machine and the quality of the end product. Economies of scale have pushed the manufacture of ever larger refiners but the basic concept has changed very little.

Utilizing years of experience with all kinds of refiners, Valmet has developed a refiner where the stock treatment efficiency has been raised to a new level. The principal difference to 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 in the refining zone where fiber treatment occurs. All of the stock is treated equally, providing a higher refiner loadability and better energy efficiency.

Tremendous flexibility in operation is obtained with the new concept as well as easier installation owing to the smaller physical size (Figure 3). In its optimal configuration, one OptiFiner Pro can replace two traditional refiners and deliver 20% electrical energy savings. The new design is suitable for all kinds of LC refining applications, including short hardwood fibers, as well as recycled fibers requiring fibrillation at low refining intensities.

Flow-through principle

Typically, refining intensity has been defined as the specific energy applied to a unit mass of fiber per refiner bar impact. A longer retention time gives a higher probability for individual fibers to become treated, but no account is made for fibers treated too many times, leading to 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 ensures that all the stock is subject to treatment with fresh stock entering the refining zone directly. This increases the number of fibers that receive the proper refining treatment and the residence time of the pulp in the refining zone is no longer the key factor determining intensity.
In addition, a slightly larger fillings gap is enabled, allowing a thicker mat and more fiber on fiber action for more gentle treatment, which is especially important with hardwoods and deinked fibers.

**Capacity**
As well as the 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 the 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 by the wear of both the stator and the rotor segments, which alters the pumping capacity and thus the pressure drop across the refiner.

The new OptiFiner Pro concept enables a considerably higher installed power and throughput, raising the refining efficiency far above that of earlier designs. Additionally, the throughflow principle means that the hydraulic capacity of the refiner is not sensitive to fillings wear. The refiner’s pumping curve is also lower and more uniform than with conventional refiners.

**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 the viscous drag effects of the rotor in the fluid. No-load power increases with the diameter and rotational speed of the rotor as well as being affected by the hydraulic section ratio and groove depth.

Valmet’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 to traditional refiners of similar capacity and it has a big impact on the total applied power for the desired refining result. The OptiFiner Pro concept utilizes a well proven conical design where gap control is achieved using a moving rotor with a new generation loading system comprising a servomotor and its control. This enables quick and precise power control.

**Refining intensity**
Because of the high utilization of the whole refining area and all refining bar lengths, the OptiFiner Pro refiner treatment intensity is much higher than that of any other refiner.

In conventional refiners, refining bars are not utilized in the most effective way and parts of the bars have low utilization. The efficiency of the refining bars becomes even lower in larger refiners.

The utilization degree of the refining bars is greatly increased in OptiFiner Pro (Figure 4), hence the theoretical average edge load can be much higher than in conventional refiners and it can be used without damaging the fiber.

![Figure 4. Better stapling of fibers on the bar surface increases the efficiency of the new design.](Image)
Mill experience

One of the first installations of the new refiner was in the PM 6 stock preparation line at Sappi’s Biberist mill in November 2010. Sappi Biberist’s PM 6 produced 80,000 tpy of uncoated office grades. The furnish to the machine was 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 PM 6, this was achieved with six conical refiners. Typically, four of the six refiners were used in series to refine the eucalyptus stock.

The disadvantage of this approach was the high no-load power consumed by the four refiners, which contributes nothing to the overall fiber treatment. Additionally, the four refiners could not be driven any harder and to achieve the 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 Valmet in Finland (Figure 5) 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 was started up on November 17, 2010. The compact size of the refiner was a major 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 than 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 use of about 25 kWh/t refining energy (about 150 kW power draw). Even at that point, the promised 60% energy savings could be seen.

On December 12, the specific energy target was increased to 75 kWh/t. The refining degree was increased to 25 °SR. By refining the eucalyptus more, the softwood content and softwood refining energy could be reduced. In total, the reduction in refining power was 200 kW.

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 (Figure 6). In mid-2011 Sappi closed its Biberist mill. Due to the excellent results achieved on PM 6, the OptiFiner Pro was transferred to another PM in the Sappi group.

**Saves more than just money**

Improvements in technology, design and construction continually offer improved solutions for stock preparation processes. Extensive research and development is first proven in Valmet’s own pilot plants before releasing the product 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, while also providing positive environmental benefits.

OptiFiner Pro is a revolutionary new refiner that can replace two conventional refiners and deliver considerable energy savings. Its small rotor results in low no-load power, up to 50% lower than that of a traditional refiner of similar capacity. Since there are fewer refiners in the system, the OptiFiner Pro reduces maintenance costs, leading to a reduced overall life cycle cost. Increased efficiency and cutting

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**Figure 6.** Tensile strength comparisons, the four old refiners on PM 6, two conventional refiners on PM 8, the Finnish pilot trial and results of the new OptiFiner Pro at start-up and two follow-up periods at 6 and 9 weeks of operation.
down the number of refiners also reduces environmental impact. OptiFiner Pro not only improves your process and results in savings, but it also helps create more sustainable operations.

By February 2012 several OptiFiner Pro refiners had been sold throughout Europe for different refining applications. All these mills have one thing in common: their will to lower energy costs substantially and improve stock preparation efficiency.

**Valmet steam separation technology provides energy and environmental benefits**

Considerable volumes of steam are produced in the making of mechanical pulp. It is generated by, for example, the moisture content of the chips as well as the amount of energy applied when refining the chips to pulp. Harnessing the energy content of the steam is very important. This is achieved by separating the pulp from the steam in a separator. The steam is then carried to a steam reclaiming system to be used elsewhere in the pulp or paper mill.

The traditional method for separating pulp and steam has been via pressure cyclones. A new approach has now been introduced which offers a number of major advantages. Instead of using cyclones there are now mechanical separators for different positions in the process.

**What are the benefits?**

A mechanical separator offers considerably better separation efficiency. A negligible amount of fiber accompanies the steam. This minimizes the problem of operating stops for cleaning the heat exchange system. A dirty heat exchange system results in a large amount of energy being discharged directly into the air and waste water together with accompanying fiber.

In other words, the mechanical steam separator contributes to reducing energy consumption and improving the environment. There are several other benefits also:

- The machine is much smaller than a pressure cyclone. When positioned at the stage between the refiners it replaces several pieces of equipment such as the pressure cyclone, cyclone discharger and the refiner feeder.
- It also increases refiner segment service life since a refiner being fed by a mechanical separator can be run with more stable disc clearance.
- Fiber/pulp loses brightness at high temperatures. This loss of brightness must be compensated by using more chemicals in the subsequent bleaching stage. Since retention time in the separator can now be cut by approximately 30 seconds this loss of brightness has been virtually eliminated.

**Different types**

There are two primary types of mechanical steam separators - PeriFeeder (Figure 7) and PeriSplitter.

![Figure 7. PeriFeeder installed at Norske Skog, Skogn, Norway](image-url)
PeriFeeder is located in the stage between the refiners and also serves as a refiner feeder. It is currently available for Valmet refiner models RGP 60/65, RGP 70/76 CD, RGP 82 CD, RGP 268 and SD 65.

PeriSplitter (Figure 8) is positioned after the final refining stage and is available in two sizes depending on the capacity required. This machine can even be installed in all types of refiner lines, regardless of the make of the original equipment.

The PeriFeeder and PeriSplitter steam separators will be discussed separately, but share the following advantages:

- Minimal fiber carryover
- Higher fiber yield
- Greater steam reclamation
- Reduced maintenance and cleaning costs
- Space saving
- Low operating costs
- Increased availability
- Low installation cost
- Low load variation in the refiner
- No disturbances from the cyclone doctor blade
- Stable operation
- Short retention time

**PeriFeeder mechanical steam separator**

PeriFeeder is a mechanical steam separator which separates the steam from the fiber before it is fed into the second or third-stage refiner. This machine replaces the existing cyclone, cyclone discharger as well as the refiner feeder and can be installed without modification of the refiner foundation.

Pulp and steam are blown into the machine’s inlet where they are then separated. The feeder screw carries the pulp to the refiner intake while the separated steam is taken to the steam outlet.

**Simple and stable**

PeriFeeder makes the refiner extremely easy to run since it responds very quickly. The fiber is transported from the first to the second stage without passing a cyclone where there can be delays and fiber build-up. This keeps retention time down which improves the fiber’s optical characteristics.

Since the machine works under full system pressure the returning steam can be utilized in the steam recovery system. The result is substantial energy savings. The separated steam also has very low fiber content.
PeriFeeder provides great benefits
Because in new installations, PeriFeeder replaces the cyclone, cyclone discharger and the refiner feeder, investment costs are reduced and installation is simplified.

PeriFeeder also eliminates a number of drives, which facilitates maintenance and reduces the need for spare part stocks. The segment service life is extended since a refiner fed by a PeriFeeder can be run with a stable disc gap.

PeriSplitter mechanical steam separator
Steam recycling is an important aspect of the energy-demanding refining process. It is a well-known fact that fiber carryover in the recycled steam can cause problems such as plugging, operating stops for cleaning and, in some cases, emitting fiber and steam into the surroundings.

TMP mills are frequently forced to interrupt production to clean heat exchangers and steam piping. The reason is that traditional pressure cyclones are not sufficiently effective. The fiber carryover is significant and the limited operating time period can, in the worst case, result in purging which means that the bulk of the fiber is discharged together with the steam.

Replacing the conventional steam separation equipment with a PeriSplitter results not only in a minimum amount of fiber carryover, it also means better utilization of the available fiber.

The working principle behind PeriSplitter is that the fiber separates from the steam if sufficient centrifugal force is applied. This is accomplished by having the rotor’s horizontal blade accelerate the fiber to the same speed as the rotor is turning. A horizontal plug screw, mounted below the PeriSplitter, returns the gathered fiber to the process.

SealMax – Optimal sealing for pulp and paper applications
Leakage costs money! Having minimal leakage from equipment not only increases availability and reduces maintenance, but also protects the internal and the external environment. SealMax mechanical seals are well-proven and specially designed for your current application.

Standardization is the key to success
Mechanical seals are increasingly coming into focus, not only with regard to equipment availability, but also in terms of access to spare parts and replacement units. Therefore, it is essential to minimize variants while standardizing whenever possible.

There can be hundreds of seals installed in a pulp and paper mill. Consequently, service and parts availability is important to ensure uninterrupted operation.
SealMax for Valmet equipment…

The vast majority of Valmet machines can be equipped with SealMax seals from the factory and existing machines can be upgraded. SealMax seals come in ready-made packages, which fit without modification (Figure 11). Valmet can help you upgrade your machines to achieve optimal results.

SealMax for machines from other manufacturers…

Valmet also provides optimized mechanical seals for machines from manufacturers other than Valmet. Since it is essential to standardize whenever possible, once the seal need is identified, the correct sealing solution is selected based on the standards adopted. The goal is always to minimize the number of variants in order to reduce inventory costs.

Sealing design

The SealMax design is based on technology developed to optimize their lifetime. Flexibility, both axially and radially, is characteristic of that design. These seals compensate for thermal expansion of the shaft at high temperatures, as well as shaft deflection under extreme operating conditions. Since most seals installed are double seals, great emphasis has been put on keeping the springs and other critical driving elements outside the sealing water space to reduce the risk of clogging.

Flexible elastomers

Most mechanical seals are dependent on some form of secondary sealing, such as an O-ring. O-rings play a very important function because they seal the gaps in the construction and between the seal and the shaft or shaft sleeve. Secondary seals in hard inert materials are good for chemical resistance but are less flexible. Therefore they can be hard to assemble.

The O-ring seals in SealMax family use only high quality flexible elastomers. The use of this type of elastomer enables a user to renovate the seal on site. No special tools or special installation procedures are required to replace them. Continuous evaluation of new materials and design is critical. Working with tough applications in demanding operating conditions leads to the innovation from which all seals in SealMax family benefit.

Standard seals and special seals

Seals for Valmet pumps, screens and mixers are designed not only to fit in these machines, but also to suit most of a client's standard applications. However, materials and operating limits are carefully controlled to meet the intended applications.

The SealMax concept therefore means that mills can use these products as a suitable base in their standardizing efforts such as with process pumps and other equipment in standard applications. Accessories such as adapters and shaft sleeves specifically designed for various pump manufacturers are also available.
Seals to OptiFiner, OptiSlush Broke Pulpers and the Defibrator system are unique customized sealing solutions, designed only for these specific applications. Valmet can develop sealing solutions for older models of machines in the Valmet catalog or for special machines of other makes where an upgrade of the seal is justified.

**Spare parts kits and renovations**

All SealMax seals are designed so that mill staff on-site can carry out most of the service regarding replacement of worn parts on site. Our Spare Parts Kits (Figure 12) contain all the vital wear parts. Detailed step-by-step instructions show how to dismantle and install and how to replace components in the seal.

Standard seals are kept stocked at our logistics centers. When in need of major renovation, seals are sent to our service center where you can choose to renovate the seal or buy a replacement seal if the need is urgent. The submitted seal is renovated to mint condition and placed in storage.

**OptiFlex – The new Valmet screen for continuous digesters**

The unique, flexible design of the OptiFlex digester screen makes it a suitable replacement for all kinds of older digester screens. The evolutional self-supporting design of OptiFlex allows it to fit perfectly even if the digester is not completely round.

**Larger open area**

A traditional slotted screen typically has ~15% open screen area. An improved slotted screen has an open screen area of ~18-20%. The OptiFlex digester screen has an open screen area of 25-40% depending on the screen geometry and slit width. A larger open area means more screen capacity at the same screen size and is an advantage if scaling is a problem. Thanks to this large open area, the pressure drop over the OptiFlex digester screen is low, reducing the mechanical stress on the screen panels. The low-pressure drop also contributes to a steady chip column movement.

The OptiFlex digester screen has a self-supporting structure. This, in combination with reduced mechanical stress, increases the expected life span and results in lower maintenance costs.

**Self cleaning design**

The T-shaped stave profile reduces the risk of chips plugging the screen (Figure 13). If chips get wedged between the staves, they will be pushed downward by the moving chip column. At the bottom of the screen the chips are forced out from the slot and back into the chip column.
Benefits
The advantages (Figure 14) of using the OptiFlex continuous digester screen include:

- Existing screen bed can be used
- Self-cleaning function
- Larger open screen area
- Increased throughput
- Improved chip column movement
- Rigid design
- Longer life span

Summary
Valmet has introduced several beneficial developments for the pulping and refining processes. These include: OptiFiner Pro for considerably higher installed power and throughput, raising refining efficiency and achieving the necessary fibrillation; PeriFeeder and PeriSplitter for advantageous steam separation in mechanical pulping installations; SealMax mechanical seals for optimal sealing with increased availability and reduced maintenance; and the flexible OptiFlex digester screen for long lifespan and low maintenance costs.

This white paper combines technical information obtained from Valmet personnel and published Valmet articles and papers.

Valmet provides competitive technologies and services to the pulp, energy and paper industries. Valmet's pulp, paper and power professionals specialize in processes, machinery, equipment, services, paper machine clothing and filter fabrics. Our offering and experience cover the entire process life cycle including new production lines, rebuilds and services.

We are committed to moving our customers' performance forward.