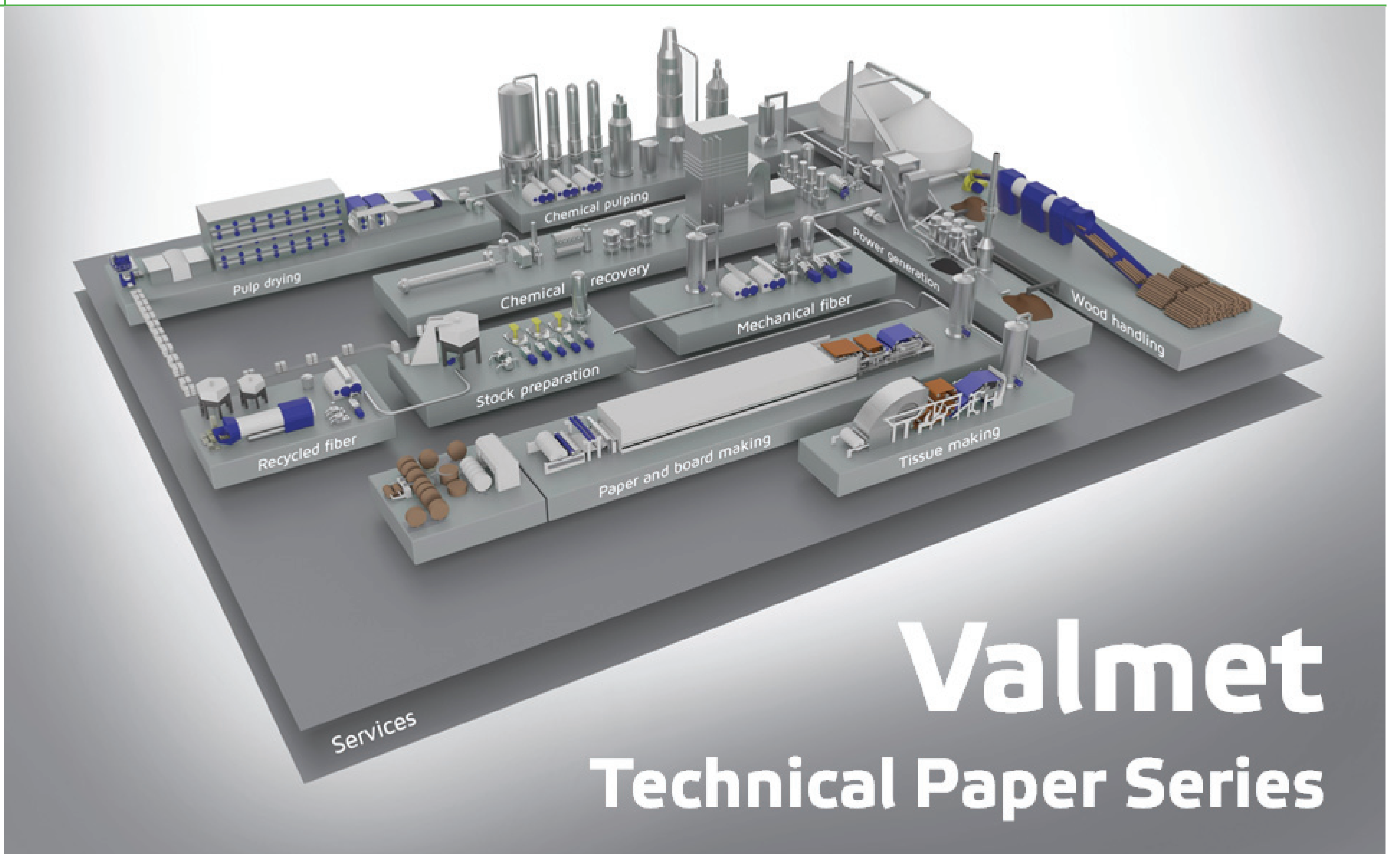

The Mini Shoe Press Rebuild Concept

Executive Summary

Replacing a conventional roll press nip with a shoe press has several benefits. This paper will discuss the differences in technology and functionality.

A mini shoe press rebuild is designed for small and medium-sized paper and board lines. It is a simple and practical solution to a normal large rebuild. The mini rebuild solution makes it possible to boost production with minimal changes to the press section geometry along with minimum down-time and low investment costs.

Also discussed in this paper is the mini shoe press application, how the shoe press works, the shoe roll, the hybrid shoe and the theory behind it, and other important parts of the shoe press rebuild.

Introduction

There are several considerable benefits that support a press section rebuild by replacing a conventional roll press nip with a shoe press. A shoe press will increase dryness after the press section by several percentage units compared to a conventional roll press. The increased web dryness yields numerous significant benefits - better runnability in the beginning of the dryer section, higher speed, energy savings and greater production on machines with limited drying capacity, increased web strength and improved moisture profile.

The press section rebuild scope greatly influences the investment cost. By minimizing the changes to the existing frame structure required to install a shoe press, there will be fewer costs related to machinery and civil work. Machine downtime will be shorter and the machine will go from paper to paper sooner. Investment payback time will also be shorter as line production will quickly surpass the pre-rebuild level.

A new mini shoe press rebuild has been introduced for small- and medium-sized paper and board making lines. This rebuild solution makes it possible to boost production with a press rebuild with minimal changes to the press section geometry. In a standard shoe press rebuild, the linear load varies between 600 and 1,000 kN/m, and the nip length between 180 and 290 mm. The mini shoe press rebuild applies a shoe roll with a nip length of only 90 to 120 mm and linear load of 250 to 400 kN/m.

Shoe press technology is a standard solution today, with hundreds of successful references worldwide. Its benefits are now within easy reach of a larger group of paper and board makers through the mini shoe press rebuild.

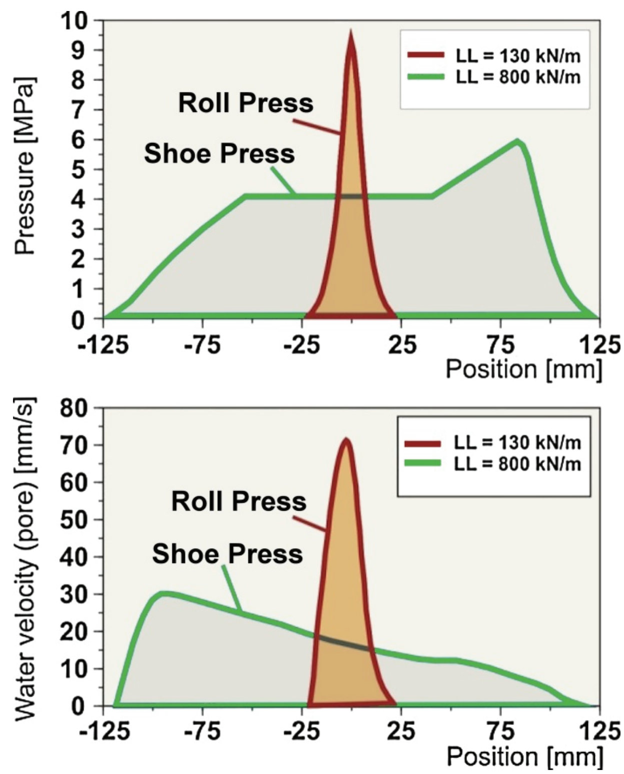

Figure 1. Comparison of nip length: long shoe press nip vs. roll nip

Shoe Press Nip vs. Roll Press Nip

The technology of the press nip with a shoe roll differs considerably from that of a conventional roll press nip. A longer dewatering time (dwell time) is the biggest functional difference (**Figure 1**). The shoe press permits high linear loads and, therefore, high press impulse. Compared with conventional press rolls, the press impulse of a shoe press nip can be as much as 10 times higher.

The shoe press has added several new dimensions to wet pressing, one of which is the increased press impulse. An increased press impulse gives high wet web strength, which is important to minimize breaks in the open draw into the dryer section. The exceptional dewatering capacity has led to a dryness increase of 5-10% compared to the conventional roll press. This considerably improves runnability and increases machine speed (**Figure 2**, next page).

The shoe press also provides quality advantages thanks to a slower dewatering speed, which improves even-sidedness in comparison to a roll press. For bulk-sensitive paper and board grades, the shoe press offers major advantages due to the gentle dewatering and the low specific pressure on the fiber network. This leads to increased bulk in the final product compared to roll pressing in the same dryness level, thus improving the important bending stiffness properties.

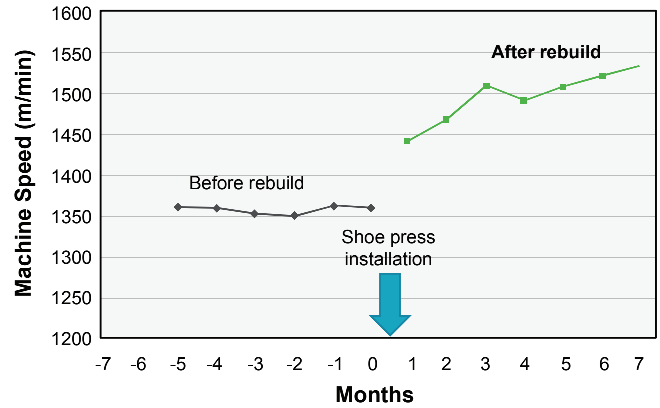

Figure 2. With a shoe press rebuild it is possible to achieve a remarkable increase in paper machine speed.

Quick And Simple Mini Shoe Press Rebuild

In high-speed machines, a standard shoe roll press section rebuild usually requires relatively extensive changes to the press section geometry. For small and mid-sized paper and board machines it may often be the case that a large rebuild is not feasible - either because of the high investment cost or that there is no need for such a big maneuver. It is more essential to remove a runnability bottleneck, or reduce the number of web breaks, and slightly increase the machine speed.

A very practical and simple alternative for these small and mid-sized production lines is a mini shoe press roll where the shoe press nip length is only 90 to 120 mm and the linear load is 250 to 400 kN/m. This rebuild solution improves machine runnability through an increase in dryness and makes it possible to slightly speed up the machine without extensive changes to the press section frame construction (**Figure 3** next page, **Table 1**).

	Roll Press	Mini Shoe Press	Standard Shoe Press
Linear load (kN/m)	120-130	250-400	600-1000
Nip length (mm)	40-50	90-120	180-290
Maximum pressure (MPa)	6-9	4-6	4-6
Press / Shoe press roll (mm)	700-900	1095	1250-1595
Counter roll (mm)	Solid roll	SolidL roll	SymZLC

Table 1. Comparison of roll press, mini shoe press and standard shoe press nips

The key features of the mini shoe roll are the same as those of the standard shoe roll, such as the efficient oil evacuation system and a hybrid shoe. The counter roll is typically a solid roll. Both the shoe press roll and counter roll diameters are minimized. The shoe geometry gives a pressure curve that results in the highest possible dryness with certain paper properties.

Thanks to the limited changes to existing frame structures (**Figure 3** next page), components around the shoe press and the control system, the mini shoe rebuild shutdown time is approximately half that of a standard shoe press rebuild. The testing period is also shorter, and controls and hydraulics can easily be embedded into the existing mill system. The existing overhead crane can be used and production can start sooner, which leads to a shorter investment payback time.

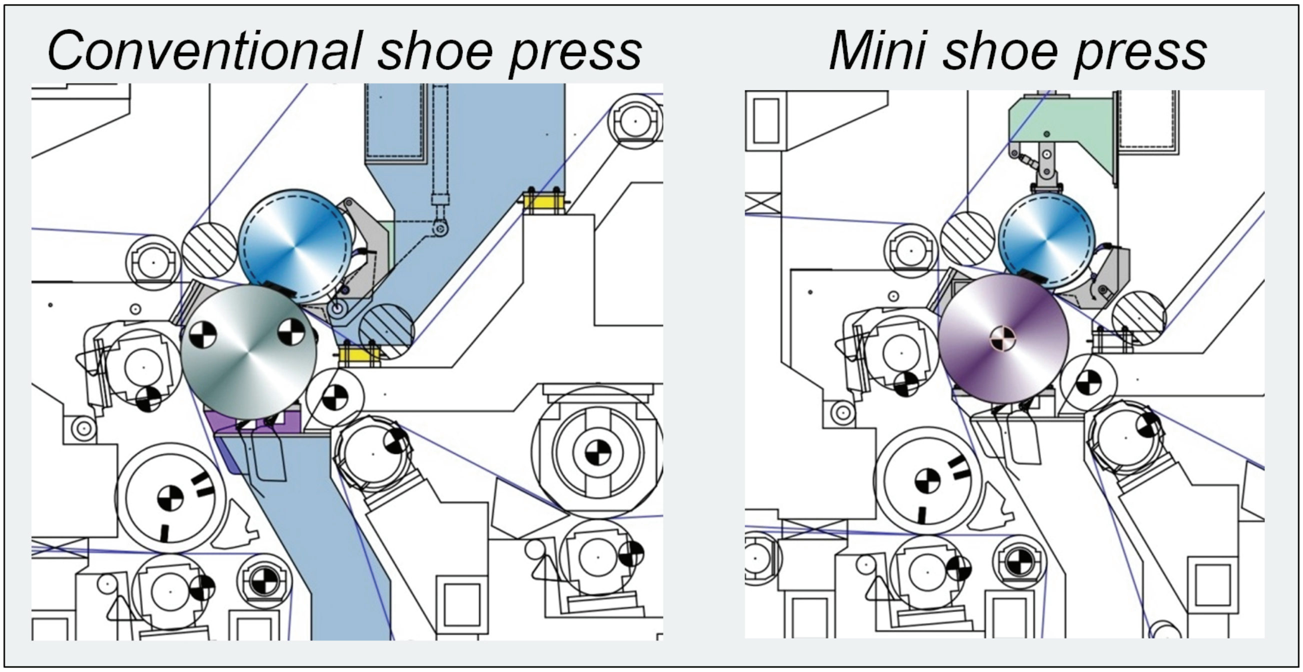

Figure 3. In mini shoe press rebuilds, changes to existing frame structures are minimal, which leads to shorter downtime.

The mini shoe press rebuild gives a dryness increase of 2 to 3 %, which considerably improves runnability and can reduce breaks by 50 %. Bulk and roughness behavior remain about the same.

	Before Rebuild	After Rebuild
Shoe Press Roll Diameter		1100 mm
Linear pressure		400 kN/m max.
Shoe width		95 mm
Peak surface pressure		4 MPa
Center roll diameter (mm) & type		1220 mm, solid
Dry content after press		Increased by 2.4 to 3%
Steam consumption		Decreased by approx.. 8%
Total draw		Reduced
Wet web breaks		Reduced by approx.. 40%
Average paper production rate	1140 m/min	1200 m/min
Average daily production	420 t/day	480 t/day

Table 2. Mini shoe press rebuild results after rebuild (Fine paper machine Asia, design speed 1300 m/min, wire width 5800 mm)

Mini Shoe Press Application

In rebuilds, the position of the mini shoe press nip is studied case by case. Runnability related production bottlenecks and targets as well as quality issues have an impact on the decision. Typically, the mini shoe press may be located either at the center roll or in a separate press position.

The longer dwell time of shoe pressing compared to a roll press intensifies dewatering on flow-restricted wood free paper grades in particular. Also wood containing grades, such as newsprint and LWC applications are possible.

On bulk-sensitive coated board grades a mini shoe press rebuild is a good alternative for a roll press replacement.

Presently, mini shoe press rebuilds have been carried out on machines producing wood free uncoated and newsprint grades. Experiences are very positive. (**Table 2**, previous page) presents results of a mini shoe press rebuild that was started up in 2007.

The main targets of the rebuild were to improve web strength and reduce the number of breaks and, finally, increase machine efficiency and production output. The existing overhead crane could not carry the load of a standard shoe press, and therefore the mini shoe press concept offered an optimal solution.

The Shoe Roll

A shoe press consists of a shoe press roll and a counter roll (**Figure 4**), which can be a solid roll or, for higher speeds and wider machines, a deflection-compensated roll. A separate load joint between the bearing housings of the shoe roll and the counter roll carries the linear load of the shoe press. High forces only affect between the rolls. There is no need for extra civil work in the foundation.

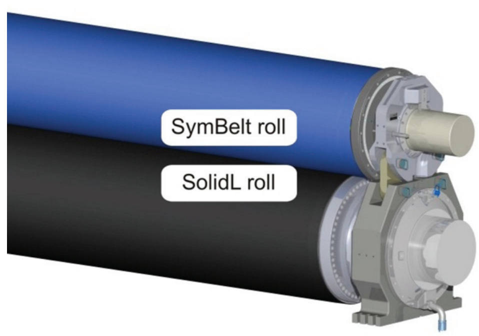

Figure 4. The simple mini shoe press nip package with a solid roll as counter roll.

The shoe roll is covered with a polyurethane belt (sleeve). The belt usually has a grooved surface for efficient water handling. Loading in the nip takes place with hydraulic cylinders located under the shoe. The cylinders in the shoe roll press against the shoe, which, in turn, presses against the counter roll (**Figure 5**, next page).

Belt life time of over 200 days is common but there are also examples with operating times between one to two years that have been reported. The gentle pressure pulse created in a shoe press is also beneficial for the felt running times. About 60-80 days are common on machines producing corrugated medium or test liner of 100% mixed waste.

Hybrid Shoe

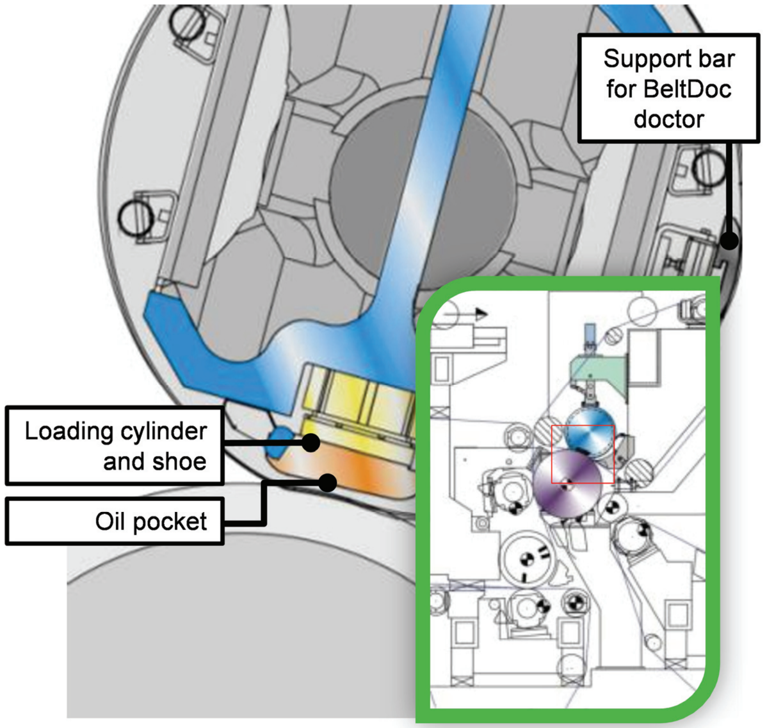

Figure 5. A mini shoe press rebuild with a shoe roll with a roll diameter of approx 1,100 mm and a solid roll is a flexible and quick rebuild solution. Nip length varies between 90 and 120 mm, at a linear load of 250 to 400 kN/m.

The unique hybrid shoe consists of both a hydrodynamic part and a hydrostatic part, i.e. a shoe with an oil pocket. This design leads to an increased belt lifetime. In comparison, a hydrodynamic shoe is a shoe without a pocket and dynamic contact with the belt from the beginning to the end of the shoe.

The entrance part of the hybrid shoe is hydrodynamically lubricated, which creates a smooth build-up of pressure in the nip (**Figure 6**). In the center, the hydrostatic section provides a nearly constant specific nip pressure with extremely low friction. The final and exit part of the shoe is also hydrodynamically lubricated. This gives a very stable and consistent operation that explains the high belt lifetime obtained with this type of shoe design.

Oil is fed into the central zone of the shoe to provide lubrication between the shoe and the flexible belt rotating around the shoe roll. The thick oil film in the hydrostatic area results in:

- reduced power consumption
- lower shoe and belt temperatures
- reduced shear forces on the belt surface, and
- reduced sensitivity to paper wads thanks to improved lubrication.

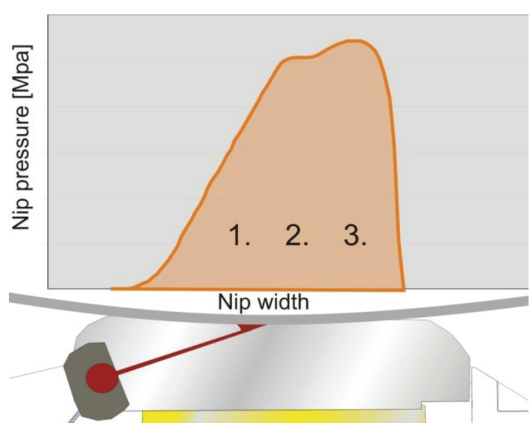

Figure 6. Dewatering phases of the hybrid shoe - 1) slow pressure build-up for gentle dewatering, 2) stable dwelling zone for high dewatering capacity and 3) peak pressure zone for maximum dryness. Mini shoe press rebuild shoe roll, nip length 90 to 120 mm.

Hybrid Shoe Theory

The power consumed running the shoe press is a sum of all the losses in the system, of which a major part is the power loss between belt and shoe. The power loss between belt and shoe is proportional to the sum of the shear stress in the fluid (the oil) and can be seen as a temperature increase in the oil.

The power consumption can be reduced by decreasing the shear stress between belt and shoe. Decreased shear stress also means decreased belt temperature and lower shear on the surface of the belt, leading to increased belt life.

The shear stress is a result of shoe geometry, speed, load and oil viscosity. Increased speed affects the shear stress much more drastically than increased load. Decreasing the viscosity can decrease the shear stress to some extent. By optimizing the shoe geometry, the shear stress can be reduced even more and belt life can be increased while power consumption is decreased.

Mathematical integration of the shear stress on the surface of the belt will give the total shear force and power loss between belt and shoe. The analyses show that the hydrostatic oil pocket will decrease the total shear force (**Figure** 7).

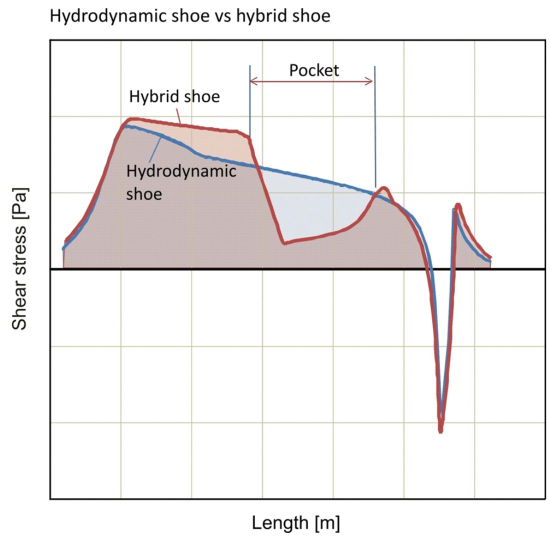

Figure 7. Comparison of shear stress between a hydrodynamic shoe and a hybrid shoe. The oil pocket is clearly beneficial for power consumption, shoe temperature and belt life.

At 1,500 m/min the shear forces will decrease so much that the total power loss between belt and shoe is approximately 25% lower for a hybrid shoe compared to a hydrodynamic shoe without a pocket. **Figure 8** shows the result at 1,500 m/min.

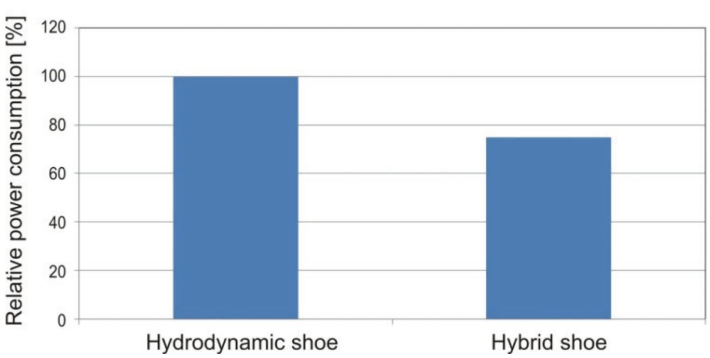

Figure 8. Power consumption at 1,500 m/min for hydrodynamic vs. hybrid shoe

The oil film thickness in the pocket is so thick that the shear forces are very small over this segment of the shoe (**Figure 8**). The total power loss between the belt and shoe is the shear stress integrated over the whole shoe length, i.e. the surface under the graphs.

This clearly explains why the pocket is so beneficial for power consumption, shoe temperature and belt life.

The oil feed in the pocket also ensures an efficient displacement of warm oil with cool oil flow to both sides of the pocket. In this way a small temperature difference between the shoe ingoing side and shoe outgoing side can be maintained for all running conditions (**Figure 9,** next page). This is important in order to maintain a straight and uniform shoe. Cool oil flows on both sides of the pocket and ensures the low and even temperature of the shoe and a low belt temperature, which leads to increased belt life.

The hybrid shoe and low oil viscosity together with low load ensure low power consumption, equal to that of a roll press.

Importance of Oil Evacuation

It is important to evacuate the oil efficiently in order to keep the temperatures of the oil and shoe at a low level. If the oil is not evacuated properly, power consumption will increase. Because of insufficient oil removal, the extra oil remains inside the shoe roll and its temperature rises. Consequently, temperature of the shoe will rise as well. If the temperature is too high, belt life will be reduced.

The oil that exits the shoe on the outgoing side has a higher temperature than the ingoing oil due to the viscous shear forces. The oil follows the belt to the ingoing side where it hits the shoe edge. The flow then changes direction towards the opening of the oil evacuation tray and the oil be removed immediately.

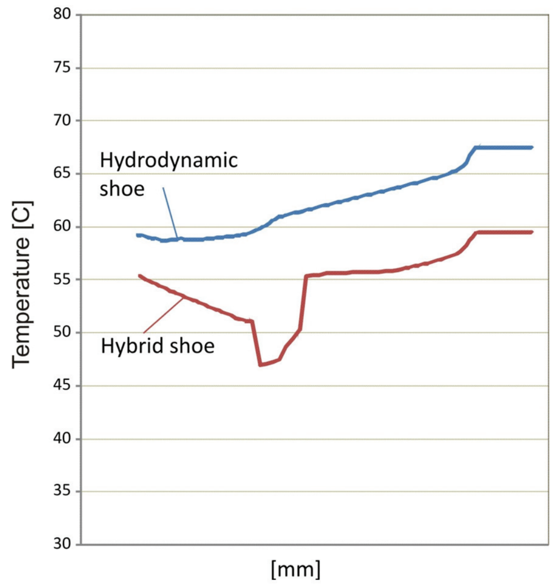

Figure 9. The oil pocket equipped hybrid shoe with low oil viscosity ensures reduced oil temperatures and lower power consumption in comparison to a hydrodynamic shoe without pocket.

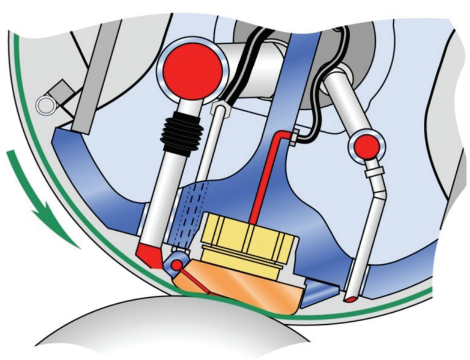

Figure 10. The effective oil evacuation system keeps the temperatures of the oil and shoe at a low level and guaranteeing low power consumption.

Another important feature is that the evacuation pipe is connected to the shoe and is allowed to move with the shoe (**Figure 10**). The position with regard to belt and shoe can be kept constant in the cross machine direction, even though the beam moves (due to bending). This then guarantees efficient oil evacuation over the whole width of the machine, assisted by the air pressure inside the roll and the vacuum in the oil drain line.

Shoe Roll Dimensions and Saveall

The shoe roll beam is manufactured from cast iron and the cross section has been optimized to obtain maximum bending stiffness for a certain outer diameter and a certain weight. Rolls with small dimensions can therefore be used even for high loads and wide machines. This makes it ideal for rebuilds with little space available. This way, a roll with a diameter of 1,100 mm can be used for nip widths up to 8 meters at 1,000 kN/m.

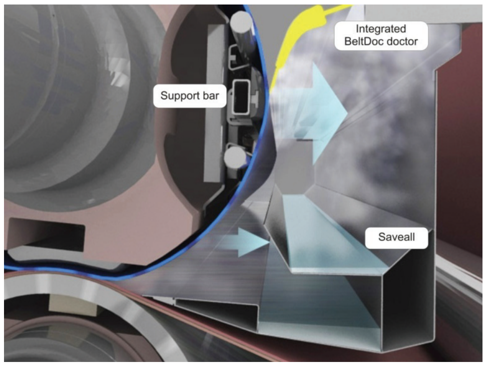

Figure 11. The integrated saveall doctor effectively eliminates upstream nip dewatering and minimizes misting around the shoe nip.

The shoe roll is delivered with a saveall and an integrated doctor (**Figure 11**). Together with internal sleeve support, upstream nip dewatering is eliminated effectively and misting around the shoe press is minimized. The internal support for the doctor is nearly frictionless which reduces wear on the belt.

The integrated belt doctor with internal support ensures:

- good and even doctoring of water
- efficient nip dewatering
- less need for felt conditioning (UhleBoxes)
- savings in vacuum and energy
- minimized wear internally and outside, good doctor blade lifetime

Solid Roll With Ceramic Coating

A solid roll with heavy duty bearing assembly acts as the counter roll in the mini shoe press rebuild. It has a large roll diameter that ensures good press geometry and doctoring. Roll weight has been minimized. Lubrication is taken care of by the roll's own lubricating unit, which ensures the best possible viscosity and oil purity.

The solid roll is a very economical solution for the mini shoe press rebuild. It requires very little maintenance and has low power consumption. The solid roll life cycle cost is only 20 % of that of a deflection-compensated roll. The solid roll is in a very demanding position as a center roll, and the ceramic roll cover must be corrosion-resistant and durable, and ensure good runnability. Several high-quality ceramic coatings are available for all paper and board grades and press applications. There are hundreds of references of rolls with ceramic coatings operating successfully.

Ceramic roll covers withstand the most demanding operating conditions of all types of press sections. The anionic surface and hydrophilicity give this ceramic coating excellent release properties, and keep the draw low and stable. The raw material combination makes the coating ideal in terms of doctoring, while its low depositing tendency improves the overall runnability of the press section.

Conclusion

The mini shoe press rebuild includes a shoe press roll on which the shoe length and roll diameter have been minimized. The diameter of the counter roll, a solid roll, also has been optimized. The rebuild can be carried out with minimal changes to the existing press section geometry, frame and surrounding components, which significantly shortens shutdown time. Paper and board makers will get from paper to paper sooner and the increased production and efficiency thanks to the rebuild yields a shorter investment payback time.

A mini shoe press rebuild gives 2 to 3 % higher dryness, which improves runnability and enables a higher speed, thus enhancing productivity. The mini shoe press is a true possibility to boost production economically, which has been evidenced by the very positive reference experiences.

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

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