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VALMET'S NOVEL SLEEVE ROLL TECHNOLOGY TRANSFORMS FORMING SECTION

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SUMMARY

The idea of Sleeve roll technology is to compress a web between two forming fabrics against a small radius shoe. Depending on the values of the forming fabric tension and the small radius shoe, it is possible to achieve a very high dewatering pressure level of up to 150 kPa. With the basic circle of the Sleeve roll, the pressure created by the fabric tension is moderate. When passing over the variable radius shoe, the dewatering pressure increases steadily toward the maximum compressing pressure.

Depending on the forming concept, the Sleeve roll has very low ingoing consistency, typically about 4 to 6 percent, and its outgoing consistency is constantly high, from 12 to 14 percent. Sleeve roll technology significantly reduces the need for a vacuum in the forming section, and when there are few friction components before the Sleeve roll, the drives' power consumption can decrease by 10 to 20 percent. This entails lower CO_2 emissions. Mechanical dewatering pressure with the Sleeve roll shoe and forming fabric tension also improves the web's quality and strength properties. The Sleeve roll is an established production-scale technology in Valmet's rebuilds and new board machine lines.

Keywords: dewatering; energy efficiency; forming; new former technology; quality

INTRODUCTION

The forming section is the biggest user of vacuum energy on paper and board machine lines. Until now, forming section drainage has relied on gravitation and dragging vacuum elements set along the forming fabric's journey. Sleeve roll technology does not require vacuum energy, and the power loss due to drag is minimal. Sleeve roll technology therefore saves energy in both the vacuum system and drives of the forming section. Increasing the board production process's energy efficiency was the starting point for Valmet to develop this new forming technology.

The idea of Sleeve roll technology is to create very high dewatering pressure between the forming fabrics with a small shoe. Depending on the values of the forming fabric tension and the small radius shoe, it is possible to achieve a very high dewatering pressure level of up to 150 kPa. With conventional forming section technologies, dewatering pressure is typically around 15 to 40 kPa, and with a couch roll or HiVac, it is typically around 60 to 70 kPa. With the basic circle before the shoe of the Sleeve roll, the fabric tension creates moderate pressure. When passing over the variable radius shoe, the dewatering pressure increases steadily toward the maximum compressing pressure. The steadily increasing dewatering pressure in the Sleeve roll shoe causes no defects to the web, even with very low ingoing consistency. With Sleeve roll technology, web strength properties are good, and the web dryness profile is even.

Sleeve roll technology removes water from the web very effectively. Depending on the forming concept, the Sleeve roll has very low ingoing consistency of about 4 to 6 percent, and the outgoing consistency from the Sleeve roll is high, at about 12 to 14 percent. The Sleeve roll does not need a vacuum or high pulsation to remove water from the web maintaining an internal bond. Water comes out from the web with increasingly high compression pressure and centrifugal force. The water jet is collected in a water saveall pan after the Sleeve roll. Sleeve roll technology significantly reduces the need for a vacuum in

the forming section, and when there are few friction components, the drives' power consumption can decrease by 10 to 20 percent.

The Sleeve roll structure consists of a static beam, a small radius dewatering element called a shoe, rotating heads, and lubrication feeding and evacuation systems. The Sleeve roll is also equipped with a lubricated polyurethane belt, which rotates around it. This Valmet Sleeve Roll Belt responds to the strict requirements (e.g., hardness, roughness, elasticity) for both belt oil side and paper or board side surfaces.

Sleeve roll technology is already established technology in production-scale hybrid and board gap concepts. The first Sleeve roll former was started up in April 2021 in South Korea, and the second in July 2021 in Germany. The third former with Sleeve roll technology will be started up in 2024 in South Korea. Valmet has successfully tested Sleeve roll technology on many concepts and positions in pilot trials. The Sleeve roll shoe can be positioned in almost any compass direction.

EXPERIMENTAL

Principle of Sleeve roll technology

The idea of Sleeve roll technology is to compress a web between two forming fabrics against a small radius shoe. Depending on the values of the forming fabric tension and the small radius shoe, it is possible to achieve a very high dewatering pressure level of up to 150 kPa. The dewatering pressure of Sleeve roll technology is affected by outer forming fabric tension and the Sleeve roll shoe. Dewatering pressure can be calculated with the following formula [1]:

$$P=T/R$$

P=pressure, T=outer fabric tension, R=radius of the shoe (1)

With the basic circle of the Sleeve roll, the pressure created by the fabric tension is moderate, while when the web passes over the variable radius shoe, the dewatering pressure increases steadily toward the maximum compressing pressure. Figure 1 shows the web's compressing pressure curve. The steadily increasing compressing pressure in the Sleeve roll shoe does not cause any defects to the web, even with very low ingoing consistency.

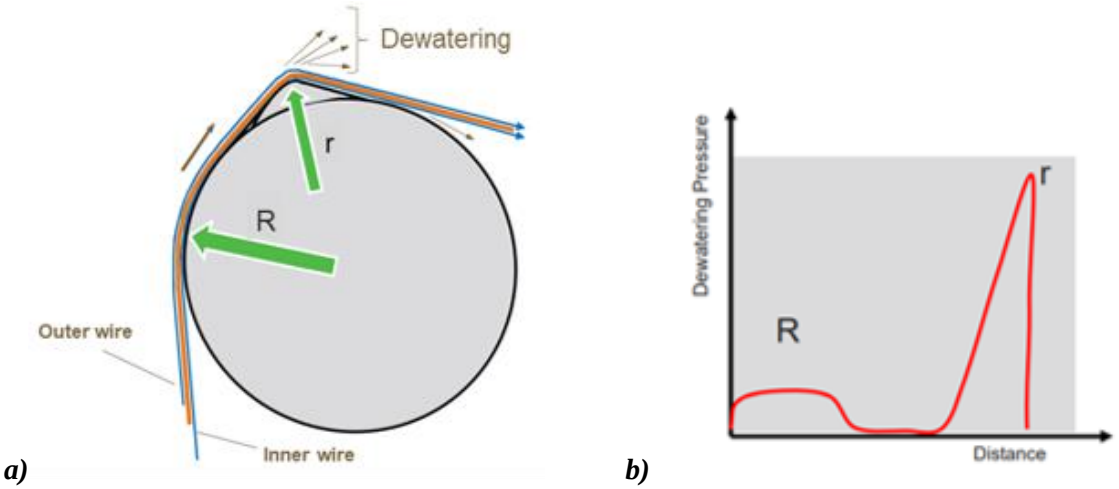

Figure 1. a) Difference of roll radius over the Sleeve roll b) Compressing pressure over the Sleeve roll

The dewatering pressure with conventional forming section technologies is typically around 15 to 40 kPa, and with a couch roll or HiVac, it is typically around 60 to 70 kPa. Compressing with Sleeve roll technology is a significantly more efficient way to remove water from the web in the forming section than creating a high vacuum.

Construction of the Sleeve roll

The Sleeve roll features a variable small radius shoe, a stationary beam, a gliding surface before the shoe, and lubrication feeding and evacuation systems. The Valmet Sleeve Roll Belt rotates around the Sleeve roll, and it is supported by the stationary beam, the shoe, and internal plastic supports. Figure 2 shows the construction of the Sleeve roll.

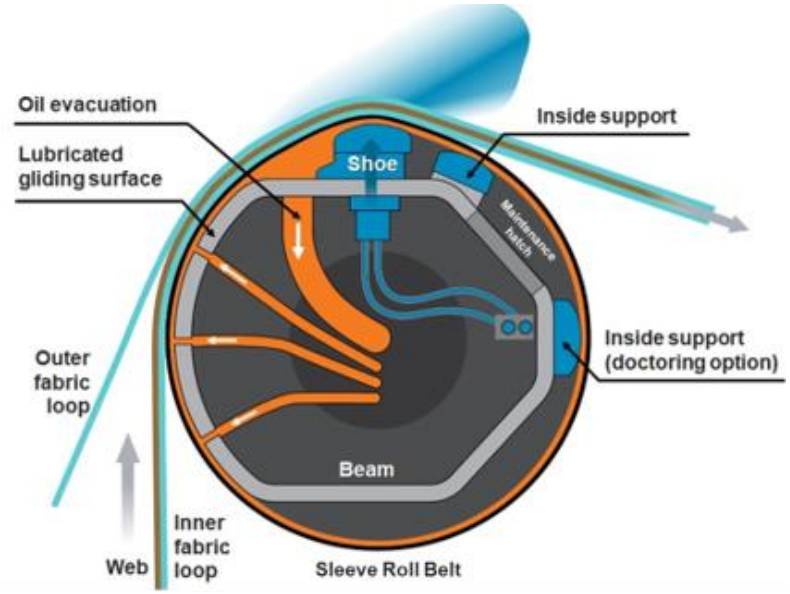

Figure 2. Construction of the Sleeve roll

The Sleeve roll's variable small radius shoe is convex and extrudes from the roll's basic circle. With the small radius shoe and the forming fabric tension, it is possible to achieve a very high dewatering pressure level. The Sleeve roll has a mechanism to move the shoe's home and operating positions during start-ups. At low speed, the shoe is in the home position inside the Sleeve roll's basic circle, but when the forming section speed increases, and oil starts to circulate within the belt inside the Sleeve roll, hydraulic cylinders move the shoe to the operating position. When the shoe is in the operating position, the Sleeve roll starts to remove water efficiently from the web.

The Sleeve roll's stationary beam is a steel cell construction, and the gliding surface is integrated with the beam. The stationary beam is stiff, and an accurate design minimizes deformations. The Sleeve roll's gliding surface is before the shoe. On the gliding surface, the initial dewatering of Sleeve roll technology is initiated. With the gliding surface of the Sleeve roll, the pressure created by the fabric tension is moderate. On the gliding surface, water is directed away from the web through the outer forming fabric.

The lubrication flow reduces friction and removes heat. The Sleeve roll is lubricated between the polyurethane belt and sliding elements, called the shoe and gliding surface, but also in head bearings and seals. The Sleeve roll has lubrication pumps and high-pressure pumps. The lubrication pumps feed oil to the sliding components, and the high-pressure pump keeps the shoe in the out position and stretches the rotating heads. There is also an air pressure system to maintain the belt's shape and for oil evacuation requirements. Over-pressured air pushes oil out of the Sleeve roll. The Sleeve roll also has crawl oil evacuation, with a membrane pump to evacuate oil during start-up.

The Sleeve roll needs an elastic and durable polyurethane belt that rotates around it. The Valmet Sleeve Roll Belt is especially designed for this roll technology, in which the belt and forming fabric need to work together. In Sleeve roll technology, the belt is exposed to different stresses than in a shoe press in the press section. For example, hardness, roughness, and elasticity are required from the belt, set for both the belt oil side and paper side surfaces. The Sleeve Roll Belt is stretched in the CD direction with a hydraulic cylinder of rotating heads and in the MD direction with over-pressured air inside the Sleeve roll.

RESULTS AND DISCUSSION

Production-scale Sleeve roll technology references

Valmet has delivered two production machines running with Sleeve roll technology. The first former with Sleeve roll technology was started up in 2021 on Ajin P&P's PM 3 in South Korea. This hybrid former rebuild produces recycled fluting grades. The target was to increase production and improve end-product quality. In this rebuild, a top fabric loop, a forming roll, and the Sleeve roll were added to a conventional fourdrinier.

The second production-scale Sleeve roll was delivered to the Palm Aalen PM 5 in Germany. This board gap former with Sleeve roll technology was also started up in 2021, and it is the world's widest high-capacity containerboard line, producing recycled fluting and liner grades.

The third former with Sleeve roll technology will be started up in 2024 on Ajin P&P's PM 2 in South Korea. This is a repeat order of Sleeve roll technology from Ajin P&P. Sleeve roll technology is placed in a combining position in a multi-fourdrinier rebuild to produce test liner grades. The aim of the rebuild is to improve the bonding of the two combined plies while increasing the machine capacity.

Dewatering with Sleeve roll technology

Sleeve roll technology removes water from the web effectively. Depending on the forming concept, the Sleeve roll has very low ingoing consistency of about 4 to 6 percent, and the outgoing consistency from the Sleeve roll is constantly high at 12 to 14 percent. Sleeve roll technology is not sensitive to ingoing dryness, and it is possible with this technology to achieve stable dryness in the MD and CD directions, which improves runnability. The Sleeve roll does not need a vacuum or high pulsation to remove water from the web. Water comes out from the web with an increasingly high compression pressure and centrifugal force. The water jet is collected in a water saveall pan after the Sleeve roll. Figure 3 shows the dewatering of Sleeve roll technology on Valmet's board gap former.

Figure 3. Valmet's board gap former with Sleeve roll technology

The dewatering capacity of Sleeve roll technology is visibly high. With Sleeve roll technology, dewatering in the board gap former has been up to 15 l/s/m, depending on the former speed and the web's ingoing consistency in the Sleeve roll. A normal plain roll does not remove any water in this position. Dryness after the forming section has also featured highly in Valmet's Sleeve roll technology production-scale references. High dryness after the forming section with Sleeve roll technology enables fewer vacuums in the forming section than with conventional forming section technologies.

Quality of web and performance with Sleeve roll technology

Sleeve roll technology has the potential to improve the forming section's production capacity. On a hybrid former rebuild project, production capacity has increased after Sleeve roll installation by up to 10 to 18 percent, depending on basis weight. Sleeve roll technology removes water effectively, and ingoing consistency can be fairly low, enabling the former speed to be increased without extending table length. Figure 4 shows the effect of Sleeve roll technology on the production capacity of a hybrid former rebuild.

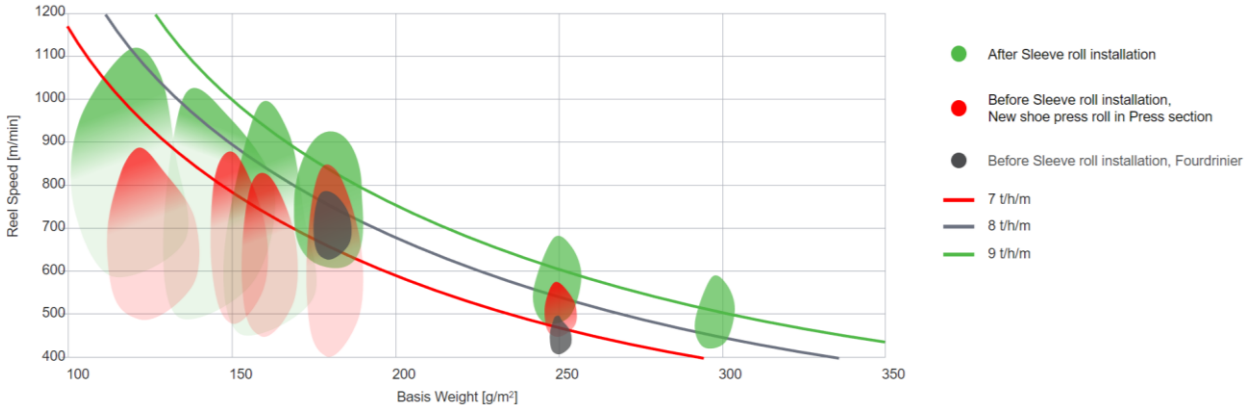

Figure 4. Production capacity increased in a hybrid former rebuild with Sleeve roll technology

In the forming section, the web's quality properties can be modified to a consistency of 6 to 8 percent. There is also a possibility to change fines and filler distribution in the Z direction. After consistency of 8 percent has been reached, the main principle in the forming section is to increase the web's dry solid content. [1] Sleeve roll technology allows low ingoing consistency to the Sleeve roll, and high mechanical pressure enables web properties to be formed with Sleeve roll technology. Mechanical dewatering pressure with the Sleeve roll shoe and forming fabric tension therefore improves the web's dryness and strength properties. The web's better strength and quality properties enable efficient raw material use with Sleeve roll technology. Results from trials and production show that the biggest quality improvement with Sleeve roll technology is in bonding strength. Compressing dewatering makes the web more uniformly dense, which positively affects the bond between the fibers.

With Sleeve roll technology, it is also possible to achieve stable dryness in the MD and CD direction, which improves runnability and time efficiency. Hybrid former rebuilds have seen fewer breaks and quick changes of basis weight on the board machine line after the Sleeve roll installation.

In the Sleeve roll technology rebuild, formation increases by 15 to 20 percent compared to a traditional fourdrinier, as Figure 5 shows. Sleeve roll technology removes water very effectively from the web and is robust for the web's ingoing consistency, which enables a higher headbox flow. Better formation usually means better and equal quality properties.

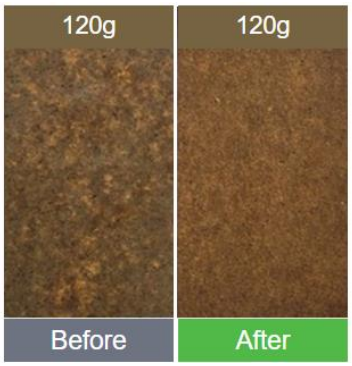

Figure 5. Formation before and after Sleeve roll installation

Energy-efficient forming section with Sleeve roll technology

The forming section is the single biggest user of vacuum energy on paper and board machine lines. Until now, the forming section drainage has relied on gravitation and dragging vacuum elements set along the forming fabric's journey. Sleeve roll technology does not require vacuum energy, and the power loss due to drag is minimal. Sleeve roll technology will therefore save energy in both the vacuum system and the drives of the forming section. In conventional technologies, the vacuum system and sectional drives constitute approximately 80 percent of the energy usage of the forming section. Figure 6 shows the distribution of the forming section's power consumption.

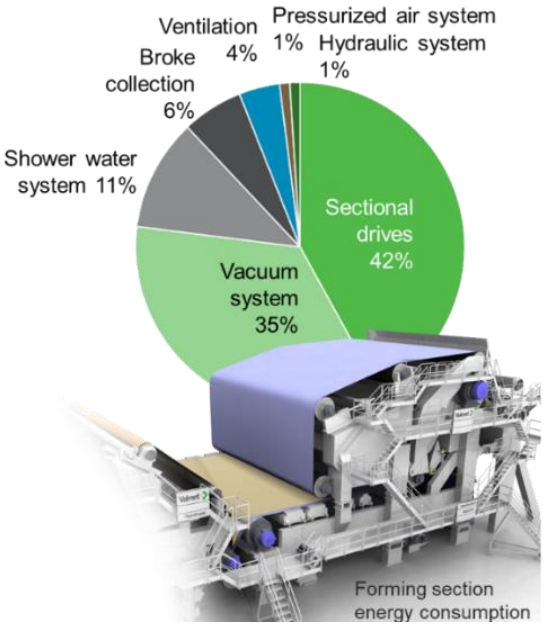

Figure 6. Distribution of the total energy consumption of the forming section

Sleeve roll technology significantly reduces the need for a vacuum in the forming section. The dewatering of the forming section is effective, and this is clearly visible in the power consumption of the drives and the vacuum pressure in the forming section. Reducing the vacuum immediately reduces drive power because there is less friction between stationary dewatering elements and forming fabrics. A pilot-scale hybrid former has seen up to 10 to 20 percent lower drive power consumption in the forming section drives and thus lower CO_2 emissions. The board gap reference has been able to reduce the energy consumption of forming section drives by 10 percent when there is no vacuum before the Sleeve roll.

Possibility to use Sleeve roll technology in different forming sections

Valmet has successfully evaluated Sleeve roll technology for many concepts and positions in pilot trials. The position of the Sleeve roll shoe can be in almost any compass direction, so this new technology is applicable for both new board lines and rebuilds. Figure 7 shows the applications for the available concepts of Sleeve roll technology.

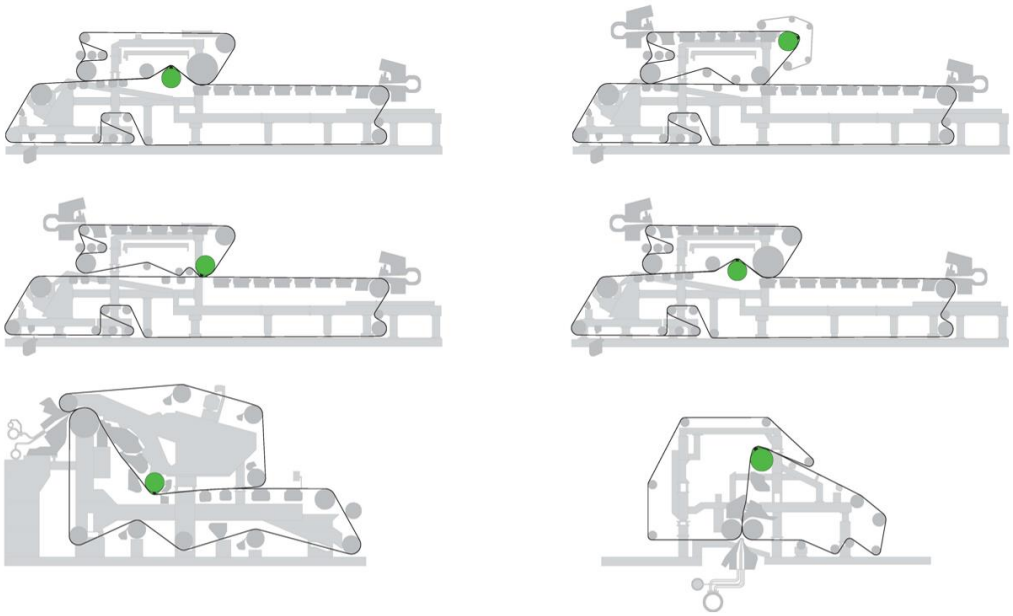

Figure 7. Sleeve roll technology applications

Sleeve roll technology is an already established technology in production-scale hybrid and board gap concepts. In the hybrid former concept, the Sleeve roll is placed in the twin fabric area after the forming roll to increase the forming section's dewatering and production capacity. The web's ingoing consistency to the Sleeve roll is low, enabling the length of the forming table to be reduced. It also reduces the forming section's energy consumption. Mechanical compressing also positively affects product quality. The board gap former with Sleeve roll technology has a high dewatering capacity in the Sleeve roll position, and this is visible in the power consumption of drive and vacuum systems. With Sleeve roll technology, the web is even in the MD and CD directions, which also improves runnability in light basis weights.

Sleeve roll technology can also be used to combine two layers. With conventional technologies combined, the layers only just come into contact at the combining point. It can therefore be challenging to achieve the required ply bond between combined layers in some cases. Sleeve roll technology creates very high dewatering pressure between forming fabrics to compress the plies together. The compressing pressure increases the flowrate from the combined web and allows the web's densification layers. The densified web improves ply bond strength and can reduce the need to use wet end starch. In the combining position, the Sleeve roll can also increase multi-fourdrinier production capacity, without extending the fourdrinier table. There are also a couple of possibilities to utilize Sleeve roll technology in the combining position. The direction of dewatering through the top or bottom ply affects the concept choice.

At the multi-fourdrinier end of the forming table, Sleeve roll technology improves the production capacity of the top fourdrinier without extending the fourdrinier table. The dewatering capacity of the top forming suction unit is replaced by Sleeve roll technology in rebuilds.

In a gap former with shoe and blade technology, the Sleeve roll is placed in the couch roll position. Sleeve roll technology does not need a vacuum to remove water from the web. So vacuum power consumption is significantly reduced when there is no need for a couch roll. Sleeve roll technology has a high dewatering capacity, and this enables the need for vacuum components and the level of vacuums before the Sleeve roll in the vertical part of the gap former shoe and blade concept to be reduced. With Sleeve roll technology in the gap former with a shoe and blade, it is also possible to achieve better strength properties for the web and a high production capacity performance.

CONCLUSIONS

Sleeve roll technology is an established production-scale technology in Valmet's rebuilds and on new board machine lines. Valmet has successfully conducted extensive research and development work with Sleeve roll technology. The Valmet Paper Technology Center has tested many Sleeve roll forming concepts and positions, with good results. The position of the Sleeve roll shoe can be in almost any compass direction. With Sleeve roll technology, water is efficiently removed from the web. Mechanical compressing with the forming fabric tension and the small radius shoe also improves the web's quality and strength properties. Sleeve roll technology reduces the need for a vacuum in the forming section, and this also decreases the forming section drives' power consumption. Compressing with Sleeve roll technology is a more efficient way to remove water from the web than creating high negative pressure with the vacuum system.

REFERENCES

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