

# Valmet

## Technical Paper Series

## Roll Modernizations: Deflection Compensated and Other Rolls

### Executive Summary

Roll modernizations improve roll performance to a higher level than when the roll was new, thereby increasing machine performance while reducing maintenance costs. Regular roll inspections minimize unexpected downtime. Scheduled maintenance ensures operational performance and availability. Reconditioning will increase roll reliability while modernizing a roll enhances performance.

A Roll Mechanical Audit is the first step, in order to learn the past behavior of the rolls and document current requirements for roll maintenance intervals or any needed process improvements.

Swimming and shoe types of deflection compensated rolls have specific modernization paths, including: seal modernization (non-rotating and mechanical), upgrading with the RG gear, bellows replacement with LR seal, improved oil circulation with double oil circulation via shower pipes and separate gear lubrication, cooling of TS and DS bearings, lubrication and sealing of the plain bearing, updated shaft locking key, shoe maintenance and modified bearings. Tube, fly and spreader rolls also have several unique modernization options, all of which are detailed in this white paper.

A **Roll Mechanical Audit** is typically the first step in a roll modernization, and is performed to learn the past behavior of the rolls and document current requirements for roll maintenance intervals or any needed process improvements. In most cases, reconditioning of the rolls is enough, but in some cases roll improvements, modernizations, cover changes or complete replacement is required to achieve the target.

### Why modernize your rolls?

Roll modernization can improve roll performance to a higher level than when the roll was new. This is an economical way to increase machine performance and/or to reduce maintenance costs.

### Valmet has the Power to Serve

Valmet provides paper mills with comprehensive services through its extensive network of over twenty one-stop roll service centers (**Figure 1**) around the world. Situated close to customers, equipped with the latest technology and staffed by roll service professionals, these centers are dedicated to handling all deflection compensated roll related process and maintenance issues.



*Figure 1. Valmet's experts reconditioning a deflection compensated roll at a roll shop.*

The services range from grinding, scheduled maintenance, repairs, reconditioning, and modernizations to long-term agreement-based maintenance programs - always according to customer needs. In addition to maintenance, roll covers and replacement rolls are also available.

### Inspections minimize unexpected downtime

Regular roll inspections are the key to avoiding unexpected failures. Valmet's experts compare inspection results with the original roll specifications, then, based on that comparison, provide the mill with maintenance recommendations. For example, regular crack inspections minimize risks of unexpected shell failures, provide valuable information on the status of cracks, and improve roll reliability. These roll inspections also show how the latest roll technology can boost the performance and reliability of your existing rolls.

### Scheduled maintenance keeps the process going

Scheduled maintenance, e.g. inspections, grinding and seal changes, aims at ensuring each roll's operational condition and performance in the machine. The scope of scheduled maintenance is based on long-term benchmarking and an understanding of the needs of roll performance and maintenance. During scheduled maintenance, only the most critical roll parts are inspected and wearing parts are replaced with new ones.

### Reconditioning increases reliability

Over the years, roll fits, shapes and dimensions change. Depending on the position, rolls wear out due to corrosion, micro movements, stress relief, thermal movements, overloading (e.g. due to automation

failure), and normal wear. To avoid unnecessary shutdowns and other related problems caused by rolls, Valmet highly recommends full-scope reconditioning every four to six years.

The aim of reconditioning is to restore the roll to as close to the original condition as possible, and to increase the roll's operational reliability. During reconditioning (**Figure 2**), a roll will be completely disassembled, all critical parts inspected and the necessary repairs made based on recommendations.

### Modernization enhances performance

Valmet performs roll modernizations regardless of the original manufacturer of the roll or the type of roll. Rolls that are modernized include suction and deflection compensated rolls as well as other rolls such as tube, fly and spreader rolls (**Figure 3**).

When a mill wants to increase paper machine speed, enhance roll reliability, extend maintenance intervals, improve paper quality, or eliminate maintenance problems, a roll modernization is the perfect solution. It can raise roll performance to a level higher than before.

Modernizations are usually needed for:

- higher machine speeds
- increased operating reliability and maintenance intervals
- increasing paper quality
- eliminating maintenance problems
- changing roll cover types to correct paper moisture and caliper profiles

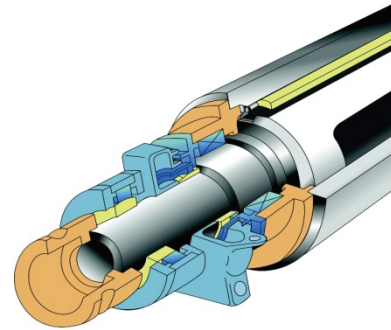
### Customized service agreements

The best way to ensure that rolls are utilized to their full potential is to enter into a long-term service agreement with Valmet. With combined targets and shared expertise better results can be achieved not only in terms of improved roll performance and extended service intervals, but also in annual maintenance cost savings.

## Modernizing deflection-compensated rolls

Deflection-compensated rolls are used in nipped press and calender positions and are among the most important process rolls on paper production lines. Their operation must be flawless, since it often has a direct effect on product quality and the performance of the entire line.

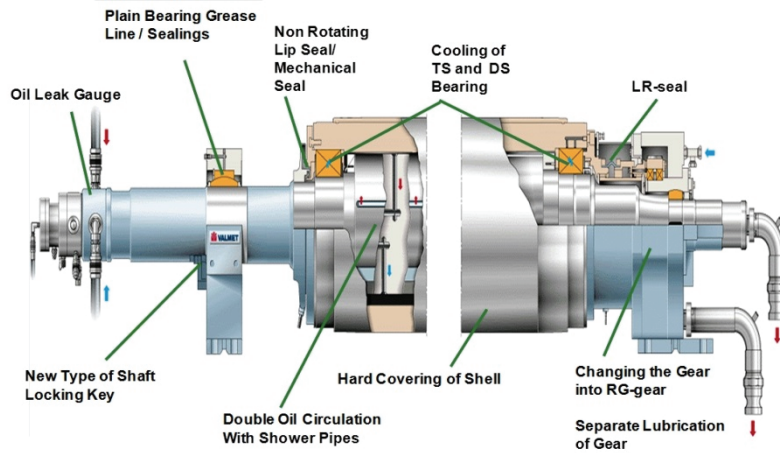
There are two main groups of deflection-compensated rolls: the swimming type (e.g. SymRoll) and the shoe type (e.g. SymZ, SymZS, SymZL, SymCD and CC rolls).



**Figure 2.** During reconditioning, the roll is disassembled and checked out.



**Figure 3.** During the modernization process deflection-compensated rolls are thoroughly inspected by our skilled roll service professionals.



**Figure 4. Swimming roll modernization options.**

The swimming type (**Figure 4**) is used in press and calender positions of older machines, as well as in smaller and slower new production lines where the advantages of the shoe type are not so important. Shell deflection is controlled by adjusting the hydraulic oil pressure in the sealed nip side chamber between the roll center shaft and the inner shell surface.

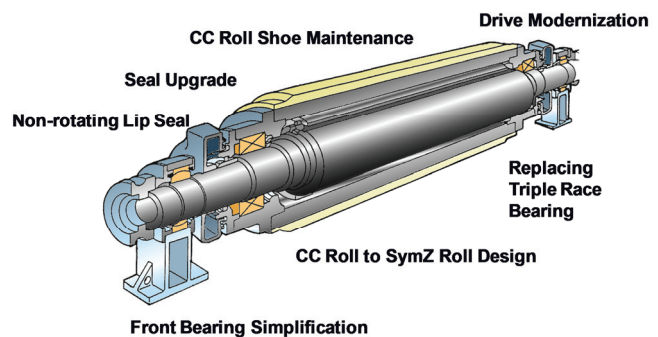
The shoe type (**Figure 5**) is divided into zone-wise and shoe-wise controlled rolls. Shell deflection and deformation are controlled with hydraulically loaded elements (shoes). In the zone-wise controlled rolls, the loading elements are grouped into 1 to 8 zones across the shell length. In the shoe-wise controlled rolls, hydraulic pressure is controlled separately in each loading element.

Zone-wise controlled rolls are used in the press sections and calenders of new, fast machines, where high running accuracy, maximized mechanical reliability, energy efficiency and some profiling capacity are needed. Shoe-wise controlled rolls are used in calender positions where very accurate caliper profiling is required. In these demanding positions, traditional induction-based profilers are nowadays replaced with shoe-wise controlled rolls (e.g. SymCD rolls).

By making full use of Valmet's extensive range of professional roll services you will provide the best care for your deflection-compensated rolls. The benefits of deflection-compensated roll maintenance include:

- Better runnability without vibrations, barring or speed limitations
- Higher, more stable quality with even moisture, gloss and caliper values
- Longer roll maintenance intervals, with shutdowns always according to plan
- Better environmental sustainability and occupational safety

Several suction roll modernization services are also available for deflection-compensated rolls. Those specific to deflection-compensated rolls will be described in the following pages.



**Figure 5. CC roll modernization options.**

## Seal modernization

Oil leaks in rolls and gears cause problems in paper mills. Even a small amount of oil on the web will ruin paper quality. Oil on the floor poses a safety hazard and oil in the drains constitutes an environmental problem. In the worst case, rolls that leak externally must be changed before the end of their regular service interval. A seal modernization of your rolls and gears can prevent leaks and ensure that rolls operate reliably through the roll service interval. A modernization performed on older rolls is based on seal solutions that have been proven on new rolls.

New improved seal materials and counter-ring coating methods significantly increase seal lives. Modernization of old seal designs and the use of new materials extend the life of seals. Multiple solutions are available, including non-rotating lip seals, mechanical seals, and new solutions for gears. All can be customized for your specific roll or gear unit.

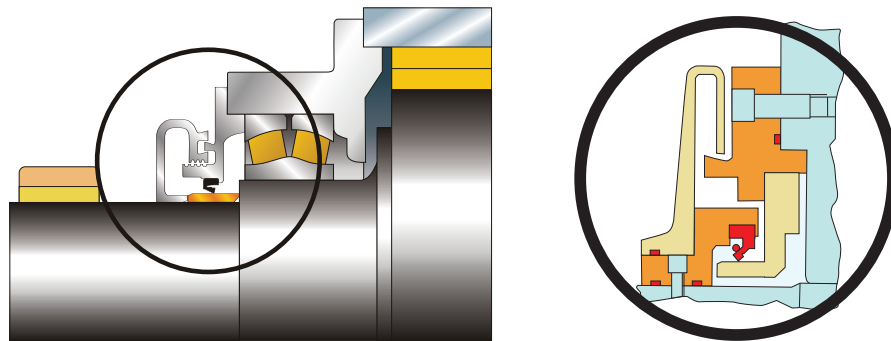
### Non-rotating seal

With a stationary lip seal (**Figure 6**), sealing is not affected by deflection of the roll shaft. When the roll shaft bends between the bearing centerline and the sealing position, a rotating seal must work in a non-centric position related

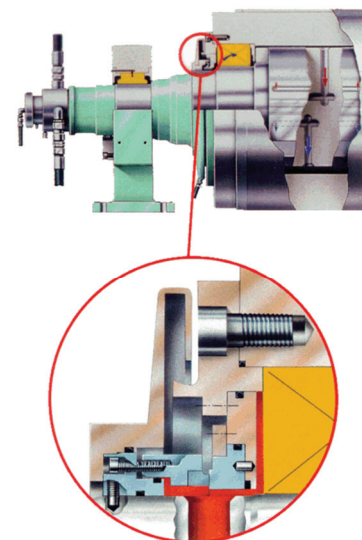
to its mating surface. When the seal is non-rotating, the sealing lip doesn't have to continuously change its shape. Front side sealing is improved, especially at higher speeds. Advantages of the non-rotating seal include optimal design regarding runout, permits slight eccentricity, no continual seal adaptation and no centrifugal force opening effect. Results to be expected include a significant increase in seal life, optimized roll service intervals and minimal leaks.

### Mechanical seal

Mechanical seal (**Figure 7**) advantages are: more resistance to pressure shocks than lip seals, permits misalignment, permits eccentricity, wear-resistant materials, good heat resistance/conductivity and can be reconditioned. Results include an optimized life for various applications, extended service intervals and minimal leaks.



**Figure 6. CC roll with rotating lip seal (left) and stationary lip seal (right).**

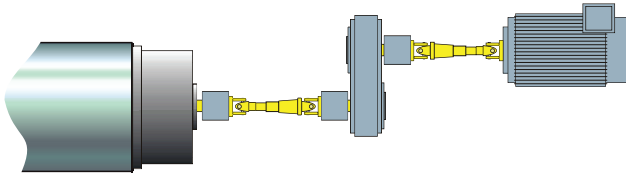


**Figure 7. Mechanical seal.**

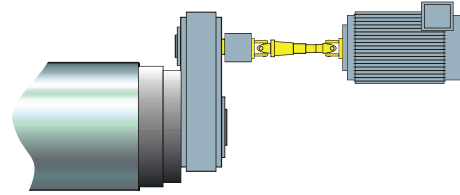
## Upgrade with RG gear

The high cost and long delivery times of triple race bearings can be a serious operational problem. In addition, lubrication problems with an existing gear unit, and plugging oil leaks at the DS end of a deflection compensated roll can present safety and runnability concerns. For these situations, Valmet recommends a gear modernization. The RG gear modernization includes modification of the gear, separate lubrication of the gear, and the LR seal.

The existing gear unit (**Figure 8**) is replaced with a Valmet RG (**Figure 9**) and ZSPG gear unit. The gear unit is attached to existing roll. Deflection compensated roll RG or ZSPG gear units are installed directly on the roll rotating head or they are part of roll supporting system. All these gears have a misalignment



*Figure 8. Before RG gear modernization.*



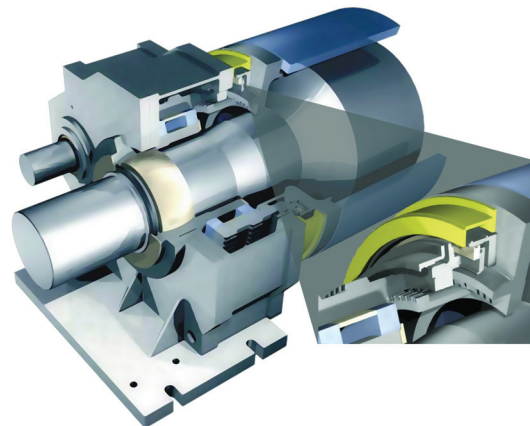
*Figure 9. After RG gear modernization.*

elimination system to avoid vibration problems. All the gears are also equipped with newest technology seal systems and separate oil lubrication. Gears are compact, simple and of sturdy design, which means longer maintenance intervals and less maintenance cost. Additional advantages include higher power capacity and the possibility to attach the roll gear unit to a non-driven roll.

## LR seal – an improvement over bellows

The new LR Seal consists of a seal ring that allows up to  $\pm 10$  mm eccentricity, which is much better than other current solutions. Furthermore, the LR Seal permits larger axial movements and twisting. The construction is excellent, based on low friction and seal ring material hardness. In addition, the ring has very wear-resistant seals in both the axial and radial directions.

If a bellows is torn or a clamp breaks, the leak is usually so great that production must be stopped – an unwelcome surprise. The LR Seal (**Figure 10**) eliminates this risk of an uncontrolled oil leak. Seal wear can be predicted and any leaks caused by the seal can be controlled.

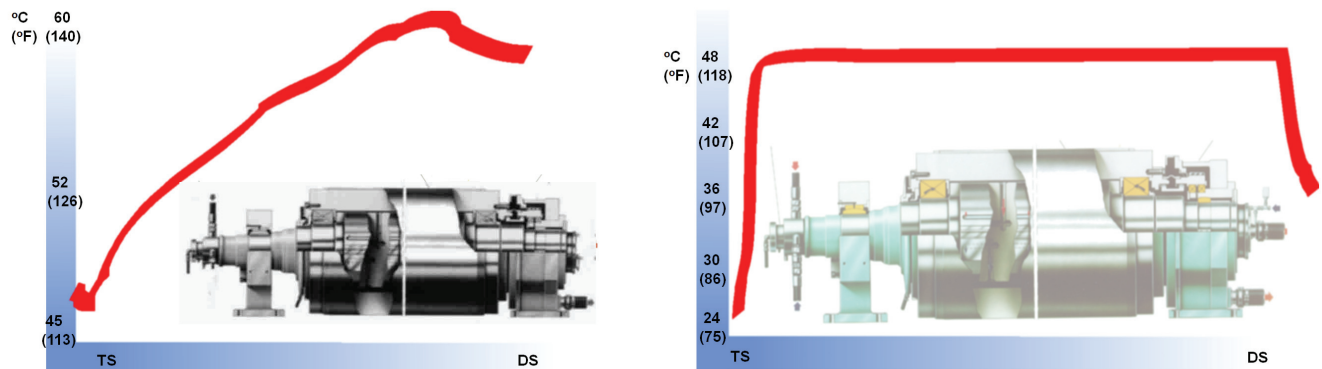


*Figure 10. The LR seal (located under the yellow oil shield) provides reliable risk-free operation.*

Retightening seals, a necessity for bellows seals shortly after installation, is typically difficult due to hard-to-access tightening locations. Neglecting or being unable to carry out this task is extremely risky. In comparison, the LR Seal is user-friendly, with no need for retightening after installation. Plus, the structure of the LR Seal ensures that it will stay firmly in place while installing or lifting the roll. When alignment and eccentricity checking are needed, the LR Seal's clocking sectors are clearly visible.

## Improved oil circulation solutions

Improved oil circulation provides more effective internal cooling and an even shell temperature (**Figure 11**). The precise roll shell temperature control results in an extended lifetime for a polymer roll cover, protecting it from damage due to overheating. As a result of the even shell temperature and uniform thermal expansion, the nip loading profile can be kept straighter. Also, extra cooling is provided to compensate for excessive heat coming from a thermo roll or a CalCoil system.



Swimming roll with conventional oil circulation

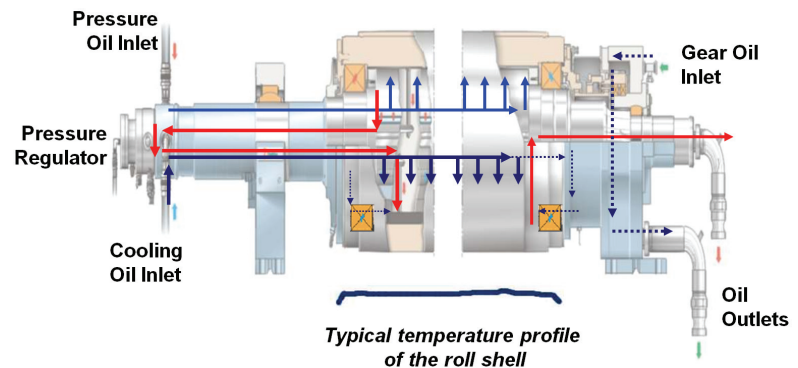
Swimming roll with improved oil circulation

**Figure 11.** Improving oil circulation provides an even shell temperature across the face of the roll.

## Double oil circulation with shower pipes

Double oil circulation is needed when speeding up rolls, and on wide/high speed application. It is also helpful on narrower/slower machines when the roll has a temperature-limited soft cover, and when more even nip profile is required.

In **Figure 12**, the dark blue arrows in the lower half of the figure show the double oil circulation. When all the oil goes into the roll into the plus and minus chambers, it ends up in the minus chamber, and comes out the oil outlet (red outlet). The cooling oil inlet shows oil being pushed from outside the bearing and pushing into and through the roll, which results in good oil flow – otherwise the same oil will stay in the roll and keep the roll and bearing heated.



**Figure 12.** SymRoll with double oil circulation (and gear oil cooling).

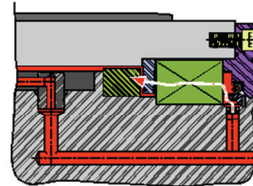
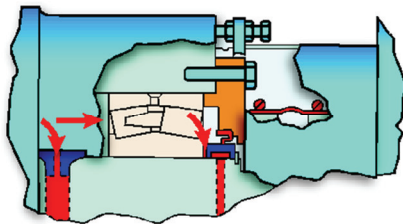
## Separate lubrication of gear

**Figure 12** also shows separate lubrication of the gear via the gear oil inlet (top right of the figure). If there is no separate lubrication, then return oil is used. In that case the outgoing oil is pushed through the gearbox. Without separate gear lubrication, you are limited in pressure to about ~7psi due to not wanting to blow the lip seals - so the oil doesn't spray, it just flows. However, with separate lubrication you can use ~30psi and spray lube to the gear rollers and where it's needed. This improves gearing and mesh lubrication and reduces internal pressure on the roll thus getting rid of lip seal leaks and failures.

## Cooling of the TS and DS bearings

Many swimming rolls suffer from reduced TS or DS bearing life. They may also produce moisture or caliper problems in the sheet. In these cases, papermakers should check the cooling of the bearings, and possibly upgrade the cooling method used.

Standard bearing cooling is shown in the left graphic of **Figure 13**. Oil (shown in red) is coming in from the left side. But the oil will go through the easier path downward through drain line (the large red hole on the lower left side) that all the oil inside the shell goes through. Very little cooling oil actually goes to the right and through the bearing. Sometimes there is a restriction (shown in dark blue) in the drain line to try to force the oil to go through the bearing. However, having this restriction means that not as much flow can be pushed through the now-small drain hole. In some installation, there isn't an axial hole on the



right side of the bearing; therefore there is no way for the oil to leave the far side of the bearing.

The Valmet preferred method of bearing cooling is shown in the right graphic of **Figure**

**Figure 13. Conventional (left) and Valmet (right) improved bearing oil cooling methods.**

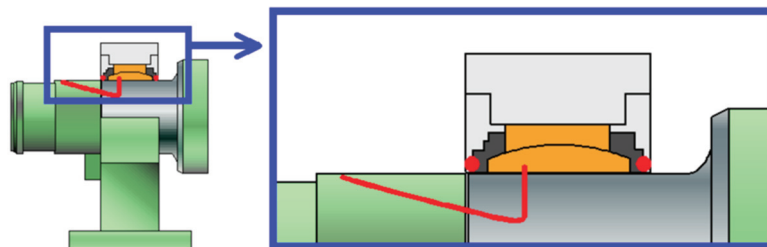
**13.** Oil flow is shown in orange. Cooling oil comes in the left side in the lower inlet, and moves downward and to the right, then up and through the bearing, exiting on the left via the upper outlet. Let's say you have a standard 29 gallon pump and want 2 gallons of cooling oil to circulate through each of the TS and DS bearings, while the remaining 25 gallons cools the shell. As part of the bearing cooling modernization, Valmet would use a flow calculation program to determine both the shower pipe hole size and the bearing nozzle size.

## Lubrication and sealing of the plain bearing

Press section sym rolls have a lot of moisture. If there is no lube line connection between the center shaft and spherical plain bearing, the bearing seizes to the center shaft. When this happens, the roll cannot expand, which in turn generates axial forces to the bearings on the other end. When you finally disassemble the roll you have to torch the plain bearing and repair the center shaft surface at the plain bearing because it's corroded.

With the Valmet method (**Figure 14**), the red check shaped line on the left is a drilled hole through which grease is forced into the plain

bearing to make a grease film. This film keeps water out and prevents corrosion, while allowing the center shaft to expand due to heat. The two small red circles are rubber hoses that work like an o-ring, i.e. seals, preventing water from entering and grease from leaving.



**Figure 14. Modernization of the plain bearing lubrication and sealing.**

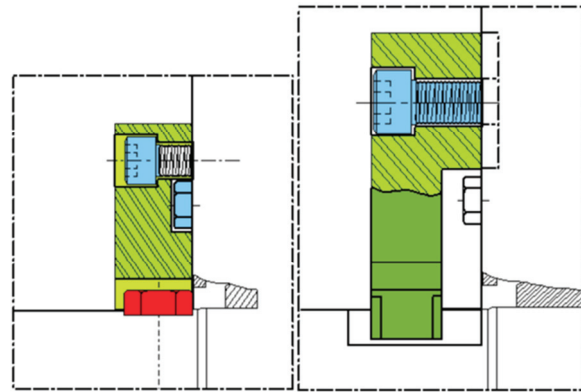


## New type of shaft locking key

Valmet has a new type of shaft locking key that improves on the conventional version (**Figure 15**).

The locking key is shown in green, the center shaft is the lower dashed section and the pedestal is the right side dashed section.

In the conventional method of shaft locking there is a hex head screw (shown in red) that is the key portion and the part that connects to it is the opening. However the head of the screw doesn't provide enough surface to align and hold the center shaft in a non-drifting alignment.



**Figure 15. Conventional (left) and Valmet (right) shaft**

Thus, with the conventional shaft locking method angle misalignment can occur. The conventional shaft key allows the center shaft to turn a few degrees and the load mechanism to move away from the nip. A portion of the loading force is lost because it doesn't go against the mating roll. So there is uneven nip and the operator has to compensate by increasing the load to get as much as he needs. The conventional shaft key is unreliable as well, because it will eventually give up completely and the center shaft will rotate. This in turn will cause all the fixed hoses to be ripped off, with oil leaks onto the floor and unscheduled shutdown.



**Figure 16. New style of shaft locking key in place on a roll.**

The new method (**Figure 16**) of shaft locking also uses a key that is bolted into the pedestal, however the key now extends downward into a slot in the center shaft. There is no chance of center shaft drive, so the loading force is always right on target.

## Shoe maintenance

The most critical part of a CC roll is its shoe, whether it is a hydrodynamic or hydrostatic type. The shoe must transmit high loads through a thin film of oil. Valmet's shoe maintenance services include: shoe inspections, shoe evaluations, shoe repairs, and shoe replacements.

Backed by our extensive CC roll engineering and manufacturing experience, and the ownership of the OEM engineering drawings and specifications, Valmet insures the efficient and precise operation of your CC roll. With Valmet's shoe roll maintenance, you can expect to reduce maintenance cost, extend CC roll life, eliminate hot spots in the shell, reduce machine downtime, establish uniform sheet and moisture profiles, and improve sheet quality.

## Modified bearing sections

Given enough running time bearings will eventually fail. However, in many instances this is hastened due to an incorrect selection of the correct bearing type for the application. Perhaps the operating parameters have changed from what they were originally. If you are experiencing constant bearing failures and nothing seems to help, perhaps your current bearing is not the most suitable selection anymore. Maybe your drive speed and nip load have increased. Or perhaps the load has decreased to zero or is just the weight of the roll, and the bearing is now too big. Bearings need some load in order to work.

Bearing availability is important as well. Some bearings, such as triple race bearings and Timken bearings, require a longer lead time, are unavailable or more complex to install.

Valmet can redesign the bearing, selecting a different bearing size and type as appropriate for your current running conditions. New bearing types are available now, such as SKF CARB bearings. The bearing choice should be based on the application – speed, load, etc. Precision spherical roller bearings (**Figure 17**) allow smooth and vibration-free operation at all speeds. A spherical roller bearing also endures high loads and angular misalignment caused by suction box deflection.



**Figure 17. Spherical bearing in Valmet shop.**

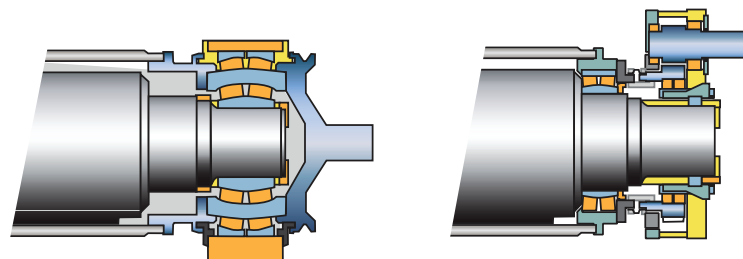
## Upgrading the driven CC roll bearing arrangement

In some of the driven CC roll designs (LX 389 and LX 200) (**Figure 18**) the original drive side bearing arrangement with rolling element bearings has been found to be problematic. In some cases this original design has led to repeated bearing failures.

Replacing the failed bearing has often not been enough as other parts in the roll have been

damaged as well due to loose bearing metal traveling with the lubrication oil through the roll. When these types of bearings need to be replaced they may be very expensive and might have a long delivery time. Some of the bearing types used previously now have only limited availability.

Valmet offers two ways to replace the original CC Roll bearing arrangement. These methods provide an economical way for mills to improve their existing CC Roll reliability and performance. If the existing CC Roll performance has become unsatisfactory or the bearings are no longer available, Valmet can modernize the rolls to meet today's requirements.



**Figure 18. CC bearings before (left) and after (right) modernization.**

## Modernizing other rolls – tube, fly, spreader

For most rolls, seal improvements (previously discussed) are the most common modernization. However, there are other available options such as head fit improvements and end lubrication that are specific to the roll type being upgraded: tube, fly, spreader, etc.

Your rolls will be in service for a very long time, running nonstop: and they are able at any moment to bring the entire machine to a screeching halt. Some roll manufacturers or rebuilders use lower cost items on rebuilds: spherical roller bearings, fabricated couplings, low cost paint, copper tubing at the end lube, low cost grease. Valmet uses high quality components in those areas where cost equals runnability and reliability, such as: self-aligning ball bearings, vulcanized couplings, Devco coating, stainless hardware at the end lube, Kluber Lube high temperature grease. Plus, Valmet has the ability to regroove rolls on the lathe, to OEM specifications.

### Tube roll modernization

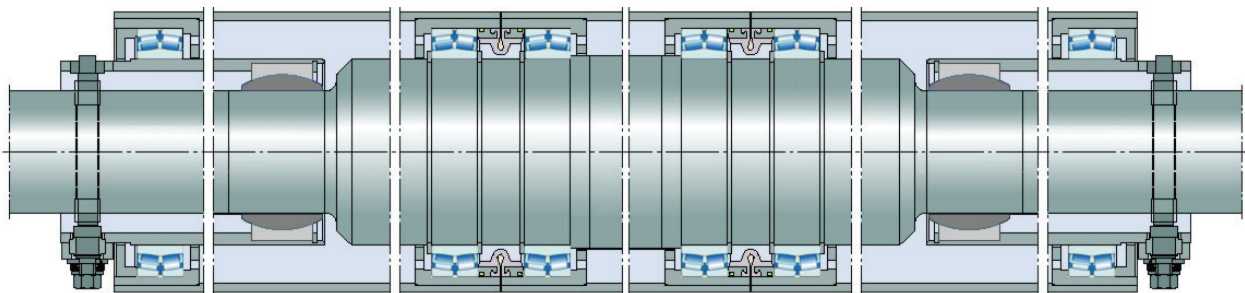
Regularly scheduled maintenance of tube rolls will ensure their optimum performance in the paper machine. The best results are obtained when combining a tube roll manufacturer's know-how with the mill's own experience with the operation of the tube roll. Typically, a full tube roll service involves: disassembly, check balancing, assembly, patch painting and run-out measurements. During this process, bearings, bearing housings and journals will be inspected. The roll's performance can be inspected while the roll is in the balancing machine, before shipping and installing the roll into the paper machine.

During the detailed inspection additional roll performance issues may be found, which might generate other service items to be performed while the roll is in the Valmet shop. Or these may be pre-requested by mill personnel. Some of these optional tube roll services are: non-destructive (NDT) journal crack inspection and reports; repairing journals or bearing housings by sleeving, thermal spraying or electroplating; replacing journals; painting; and dynamic balancing.

### Example: Supercalender fly roll modernization

Spreading the paper web is the main purpose of fly rolls. Fly rolls keep the web straight as it travels through the supercalender.

Typically, multiple items are addressed in a roll modernization. For example, a common problem with some older fly rolls has been the heat generation of the main bearings. This heat buildup has a negative

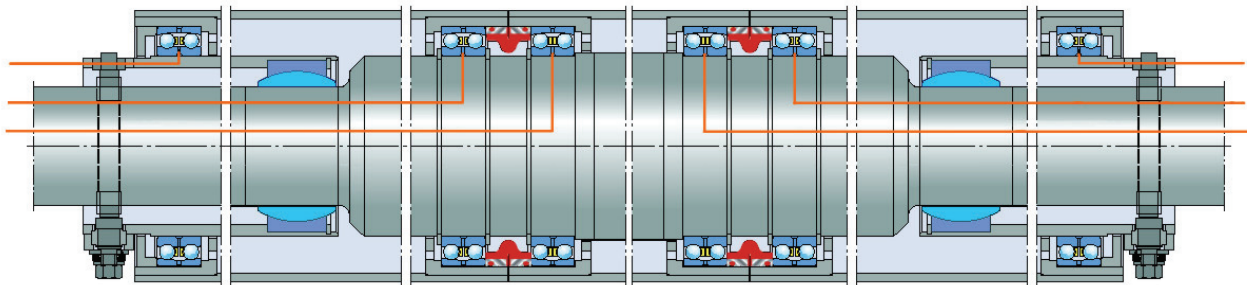


*Figure 19. Fly roll before modernization.*

impact on runnability of the fly rolls (lifetime of the bearings and/or coupling rings), and paper quality coming out of the supercalender (variation in cross directional gloss value).

Before modernization (**Figure 19**), there are double row spherical bearings, with slippage between the rolling elements which generates heat. Manual regreasing is possible only through the shell segments; regreasing is not possible when the roll rotates, and automated regreasing is impossible. There are rubber coupling rings between the shell segments, which fail due to aging and thermal effects on the rubber. Also, the rubber couplings are relatively stiff, making rolls harder to rotate.

In this case, the roll was brought into the Valmet roll shop, completely disassembled and cleaned. After a comprehensive inspection, each shell segment was checked for balance and rebalanced if needed. Bearing



**Figure 20. Fly roll after modernization.**

regreasing lines were machined and assembled. The fly roll (**Figure 20**) was reassembled with the new style of bearings and coupling rings. Finally, it went through a test run. At this point, there were further options available to the customer. These included regrooving and/or coating of the roll shell, reconditioning of the bearing positions, or addition of new self aligning ball bearings.

There are now pregreased self aligning ball bearings with automated regreasing from the roll ends (manual greasing is also possible). This results in less heat generation, easier roll rotation and allows regreasing while the roll is on the run in the supercalender. In addition, there are new style coupling rings between the shell segments, resulting in fewer coupling ring failures and easier roll rotation.

### Benefits of modernization

In this fly roll example, there were several positive results seen by the customer immediately upon use of the newly modernized roll. They included:

- The temperature profile over the web cross direction is more even, i.e. less gloss variation.
- The roll rotates much easier, due to new style bearings and coupling rings. This also results in more effective web spreading, and less of a speed difference between the web and the roll (less slippage).
- Reliability of the bearings and coupling rings is increased, yielding longer maintenance intervals.
- It is now possible to lubricate the fly roll bearings while the roll is on the run in the supercalender (via manual or automated lubrication). This results in increased bearing reliability, therefore longer maintenance intervals and less down time.

## Conclusion

This white paper has presented modernization options for deflection compensated, tube, fly and spreader rolls. A separate Valmet white paper is available which reviews upgrades for suction rolls. Some modernizations are common to different types of rolls. A careful perusal of all upgrades is recommended for a mill interested in improving overall roll and process performance.

Regardless of the roll or modernization chosen, Valmet will work with the mill to prepare a realistic return on investment (ROI). Typically, the ROI is determined by calculating the annual cost of the roll problem and dividing by the total modernization cost. In order to move forward with the modernization, the ROI must be positive over a one to two year span, and meet the mill's project ROI requirements. Valmet field service sales personnel have decades of experience looking for roll performance issues, analyzing and recommending applicable solutions that have a rapid payback.

Valmet's global roll service network provides high-quality maintenance and modernization services for all types of rolls, regardless of the original roll supplier. As a roll and machine manufacturer, roll maintenance for us is not only about repairing and changing consumables, it is also about continuously looking for potential improvements to maximize maintained roll performance and machine uptime. Valmet's innovative roll solutions help mills improve the runnability and reliability of their existing rolls.

*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.*