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MORGOIL BEARING TECHNOLOGICAL UPGRADES IN TANDEM COLD MILLS[1]

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Abstract
Tandem Cold Mills have long service lives, but decades old bearings have been surpassed, and old mills need to be modernized to stay competitive. Conversion to modern technology allows old mills to produce the same high quality product at increased capacity and less cost than a new mill. This paper covers two upgrades at major cold rolling facilities, one in Europe and one in North America. Both were motivated by the need to increase production, productivity, and safety. The bearing upgrades were done through a process where MORGOIL® engineers worked with mill engineers, analyzing existing problems to upgrade the mill with the latest, most economical technology. There were many constraints common to both upgrades, such as reusing existing chocks, rolls, and bearing components where possible. The European upgrade was done with Siemens VAI in Austria, the primary contractor for the coupling of a 4-Stand TCM to a continuous processing line. It consisted of changing the bearings to MORGOIL® KT design, reducing roll force variation while at the same time allowing higher rolling loads and speeds. RM hydraulic locks were added to increase the speed, repeatability, and safety of chocking operations. The NA upgrade was a unique conversion of a MESTA TCM where multi-piece chocks were replaced by 1-piece chocks, and old mechanical roll balance equipment was replaced with modern hydraulics. Existing mechanical locks were replaced by hydraulic HM locks to improve efficiency and safety.
Key Words: Tandem cold mills; Mill modernization; Backup roll bearings; Hydrodynamic bearings.

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1 INTRODUCTION

The rapid escalation of construction and equipment costs for new tandem cold mills demands innovative ideas to increase the useful life of existing mills to increase the payback on the initial investment. Compared to a new greenfield mill, upgrades to existing mills reduces capital cost and allows a shorter payback period on the investment. With the proper design approach an upgraded mill can be as productive as a new mill with substantially less expense.

Since the early 1930's, when the first rolling mill oil film bearings were introduced, the MORGOIL Bearing Division of Siemens Metals Technology has pioneered numerous technological improvements in modern oil film bearings. A combination of traditional and new developments can be applied to existing tandem cold mill bearings that improve quality, productivity and safety, complimenting any mill upgrade.

2 UPGRADE OF MAJOR EUROPEAN 4-STAND TCM

In 2010, pre-project work began on an upgrade to a 4-Std TCM in Europe. Siemens VAI was to be the primary contractor for a project to couple a process line to the existing mill. As part of that upgrade the client decided to upgrade the bearings to improve quality, productivity, and safety.

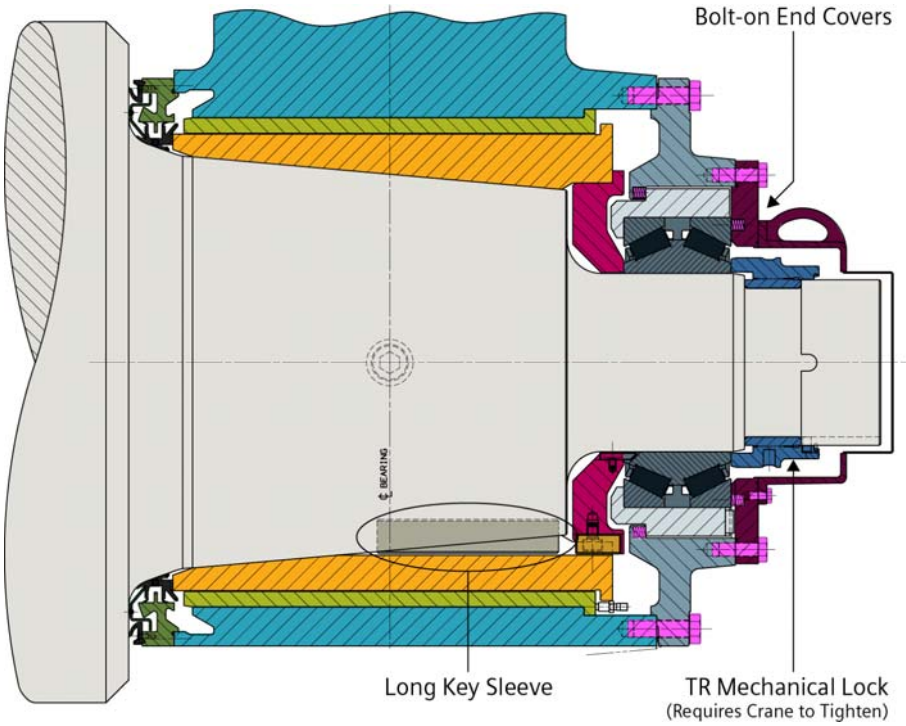

Figure 1. Existing Long-Key Bearing for 4-Std TCM. Note mechanical locks.

Figure 1 shows the original design of the existing bearing from the 1950's. The long key sleeve, while functional, is a known potential quality issue for use with HAGC systems. Migration away from this design started in the 1970's and improvement in strip quality is well documented. However there are many mills in the world today that still have this arrangement. As these mills are converted to configurations where better gauge control is required, the bearings must also be changed to a short key or keyless version.

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Figure 1 shows the old bearing design; note the single long key. This key extends under the high pressure field of the oil film in the load zone of the bearing. As the sleeve and roll neck wear, clearance around the key increases and as the key rotates through the load zone, the sleeve deflects causing high roll force variation. Figure 2 shows how the long key has been replaced by two shorter keys that are outside the high pressure area of the oil film. This change effectively eliminates key induced roll force variation. Old long key rolls can be reused, a filler is bolted into the old keyway and then the roll necks reground. As new rolls are purchased, they will have the new keyways. New sleeves are required for this since putting fillers in sleeves does not work well. If the upgrade is done in stages, the old sleeves can be used in old stands.

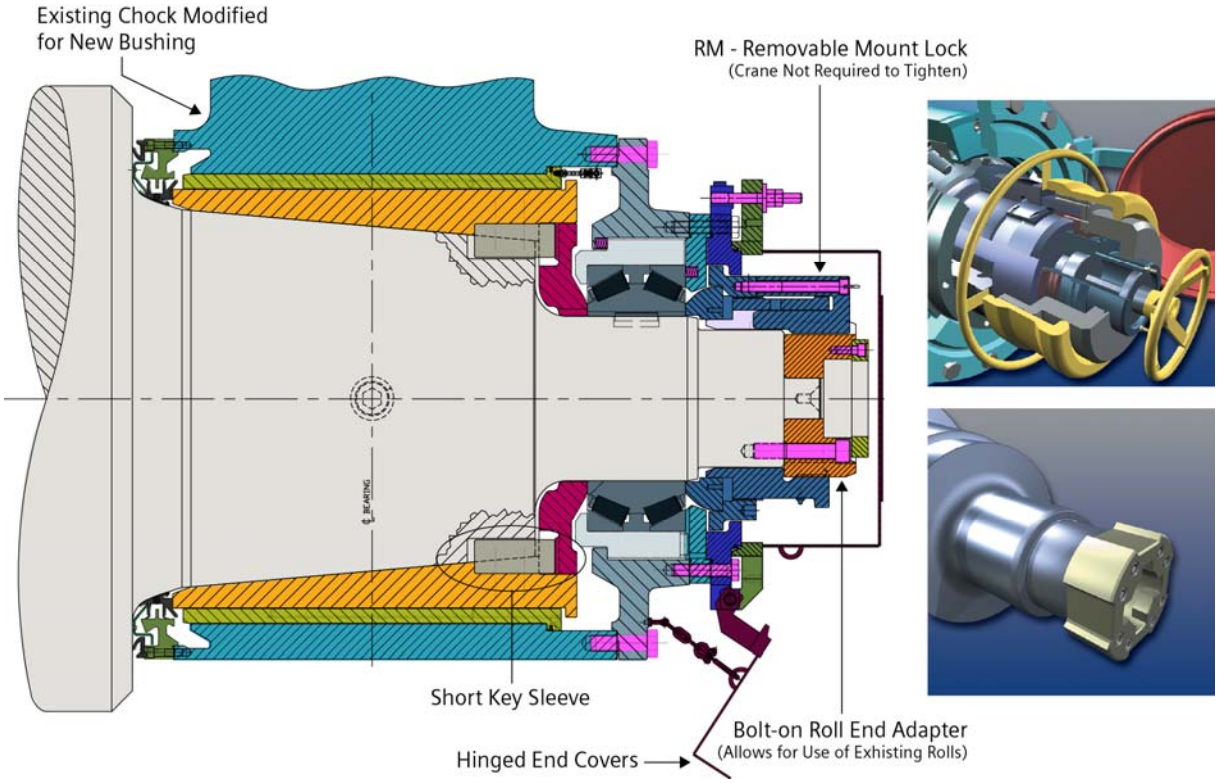

Figure 2. New Bearing for 4-Std Tandem Cold Mill

Figure 1 also shows the old TR (Threaded Ring) lock. This lock requires a crane to tighten, which has safety issues and provides inconsistent sleeve push-up force. Figure 2 shows how the lock has been replace with a RM (Removable hydraulic bayonet) lock. The end of the roll is machined off and a replacement bolt-on bayonet roll end is installed. The threaded ring is replaced with a bayonet ring that engages with the roll end when turned 45 degrees. A removable hydraulic tool is used to push the sleeve onto the roll neck and then a lock nut is tightened to hold the sleeve. The RM lock provides consistent mounting force without using a mill crane and it does it much quicker, easier, and safer than the old design. The bolt-on roll end is actually stronger than a one piece roll and has been used as a repair where roll ends have broken. A new outer end plate and end cover is generally required.

Existing chocks were reconditioned. All chock bores are inspected and a new over-bore size determined to allow all the chock bores to be the same diameter and be within tolerance for straightness. New bushings are then provided to fit the over bored chocks. If the job is done in stages, the old bushings can be used in the old

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stands. If hydrostatics are required, they are all upgraded with modern high pressure fittings. Many other components can be reused, such as roller bearings and chock end plates. Sleeve rings are evaluated for the specific loads.

These upgrades using existing chocks and rolls produce all the benefits of a completely new bearing with considerably less capital expense.

2.1 Upgrade of North American 5-Stand TCM

This 5-Stand Tandem Cold mill is currently on MORGOIL 42”-67 KL bearings that were originally upgraded about 20 years ago to eliminate the old MESTA™ Iverson bearings, shown in Figure 3. The Iverson is a 1930’s design that was highly standardized and produced through the 1950’s. It featured a 2-piece chock, split on the horizontal centerline and a very elaborate sealing system that had many small pieces. This bearing was very complicated and maintenance intensive.

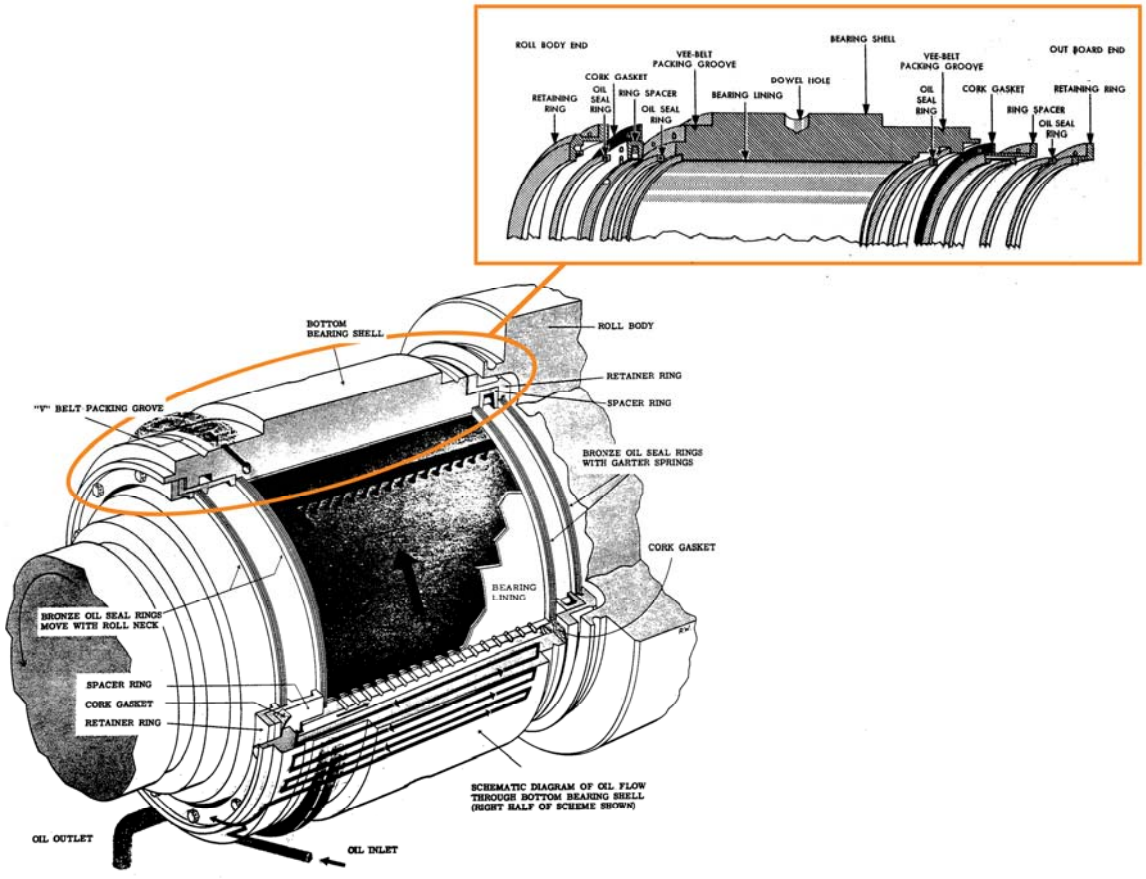

Figure 3. MESTA Iverson Bearing in 5-Stand TCM.

In the1980’s MORGOIL Engineering designed an upgrade that converted the Iverson bearings to KL type tapered neck bearings At the same time the sealing was changed to a MORGOIL design DF seal system and the locking was changed to a QC design. Both of these helped ease bearing assembly, mounting, and operation.

The DF sealing system was the best available at the time of this upgrade and is still an effective system. There are hundreds of mills using this design. It allows easy replacement of the sealing element and requires no interaction when mounting and dismounting bearings.

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The QC design still uses a thread to push the sleeve onto the roll neck, so still needs a crane for tightening and loosening during bearing mounting and dismounting. It has a split lock ring which was a big improvement at the time. Tightening with a cable has become a safety issue and requires use of the overhead crane.

At the same time, the two-piece chock was converted to a 1-piece chock by welding the chock halves together and machining them. That experience however showed that this approach was surprisingly expensive and that the welded 2-piece chocks did not hold up as well as would be expected in a TCM. Currently, the chocks have a surprisingly high degree of wear in the bores and require replacement or a complete and extensive reconditioning procedure. In fact the condition of the chocks after 20 years is so poor that it is more economically attractive to replace them with new conventional chocks.

Therefore, when the customer needed to improve mill quality, the upgrade path was to provide new chocks and modernize the bearing with new hydraulic locks.

Figure 4 shows the upgraded bearing. The chocks are new, so they fully support the bushing with proper alignment and clearances. The rolls, sleeves, and bushings are reused, providing significant cost savings. HL locks (Hydraulic with Lock ring) replaced the old QC design.

The HL locks provide full hydraulic mounting and dismounting, but do not use bayonet roll ends. Instead, they make use of the existing QC roll end without modification and use Lock Arms to engage the roll. The Lock Arms are two half rings that pivot from the top and swing to engage the roll in the existing QC lock ring groove. Using HL locks permits the upgrade with no roll modifications. The HL lock provides the consistent mounting force needed when rolling close tolerance strip. It also adds safety, speed, hydraulic dismounting , and frees up the overhead crane.

One of the advantages of including new chocks was the ability to add hydraulic roll balance for the back-up and work rolls, Figure 5. The old MESTA design used large coil springs built into the chocks for the roll balance function. These springs were expensive and a frequent wear item that was not highly reliable. In this case, the new bottom chocks were built with a custom designed hydraulic cartridge that has provisions for back up and work roll balance. The balance cylinders can be activated by a remote valve stand that was also part of the scope of the upgrade.

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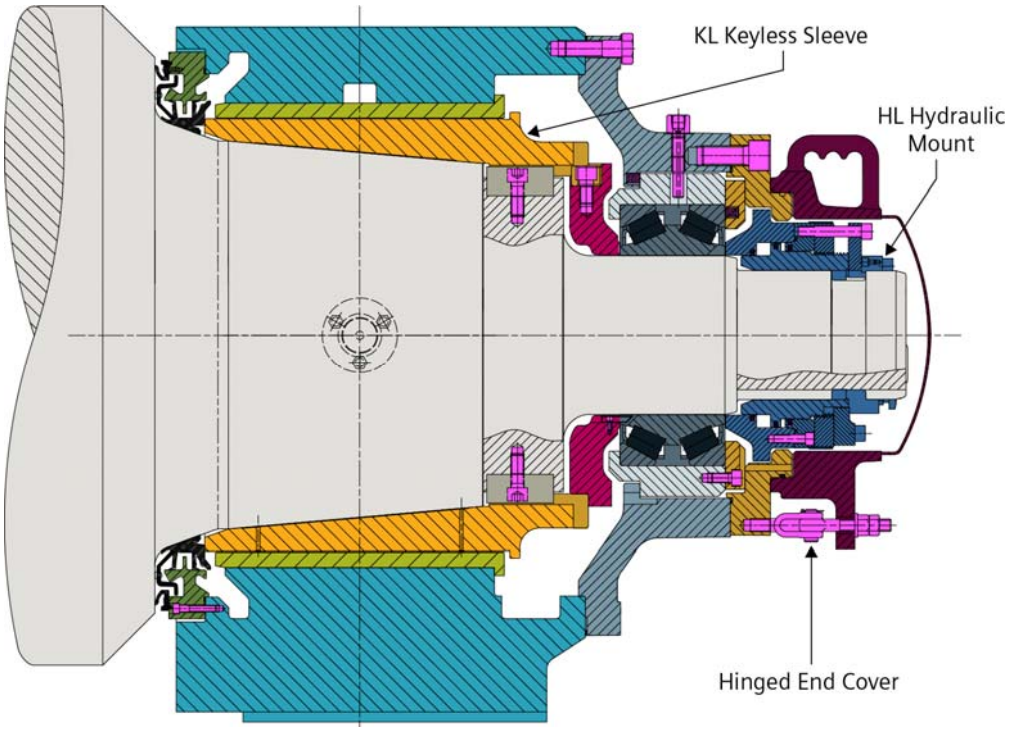

Figure 4. New 1-Piece Chock & Bearing Assembly

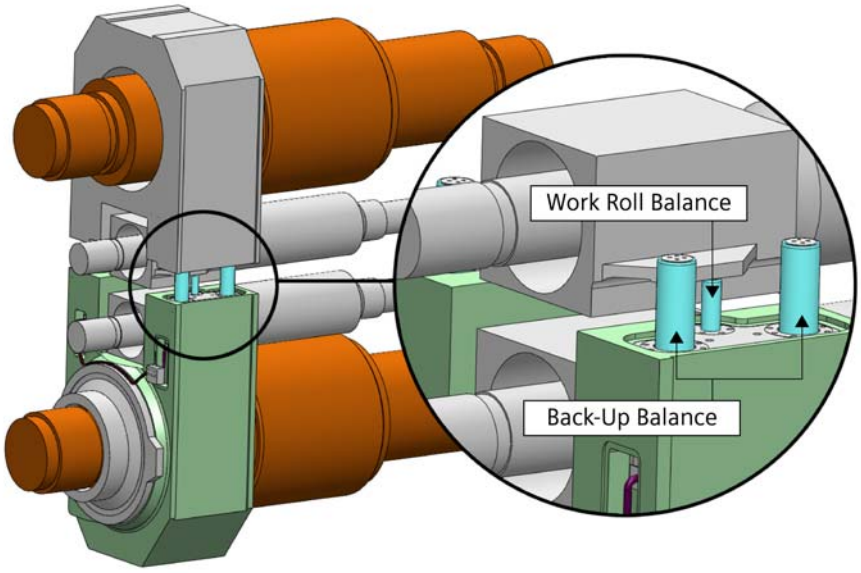

Figure 5. Hydraulics in Chock for 5-Std TCM Upgrade

2.2 Discussion of Upgrades for Existing Oil Film Bearings

The previous two case studies detail specific upgrades that have been done for mills. The following sections expand on further possibilities to improve mill performance.

2.2.1 Sleeves

The original MORGOIL long key “T” type bearing can be converted to a “KT”, or short key design sleeve, figure 6. This common conversion effectively eliminates

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keyway effect along with allowing an 18% increase in load rating of the bearing. This conversion can use the existing rolls with new keyways while filling the old keyways. If maximum capacity is needed the T bearing and the KT bearing can be upgraded to the latest KLX® bearing. The KLX bearing uses the latest technology thin sleeve design allowing for larger roll necks and higher unit loading. This conversion requires new rolls and bushings, but the increase in capacity can be up to 45% over a T type bearing. New rolls are needed with a KLX upgrade to cope with higher neck stress because of the large rating increase. This conversion is particularly attractive for older mills, where the mill operators want to bring a mill's capabilities up to that of a new mill, but don't want the cost of a new mill.

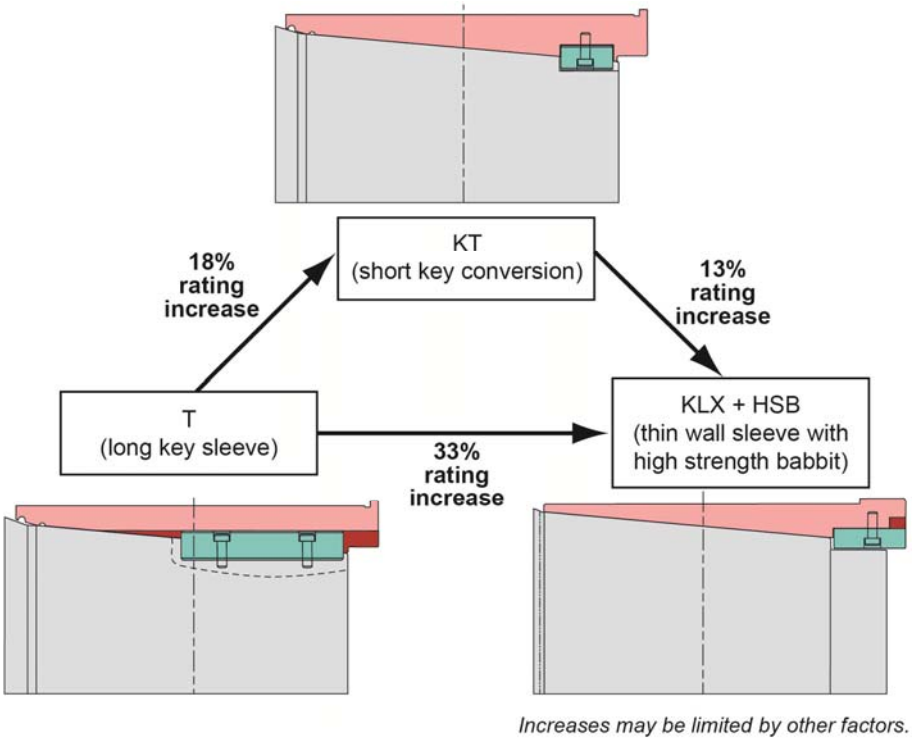

Figure 6. Sleeve Upgrade Path

2.2.2 Bushings

Bearing rating can be increased through the use of High Strength Babbitt (HSB) bushings. High Strength Babbitt can be used as a viable substitute for cadmium bushings. Thorough the use of a short key conversion of the sleeve combined with High Strength Babbitt bushings ratings can be significantly increased. Upgrading old "T" bearings to special short key sleeves and HSB bushings can increase the rating by up to 33%. The ratings of relatively modern KL® bearings can be increased by up to 13% with the use of HSB bushings, figure 7. All KLX bearings come with high strength Babbitt to enable them to reach their high ratings.

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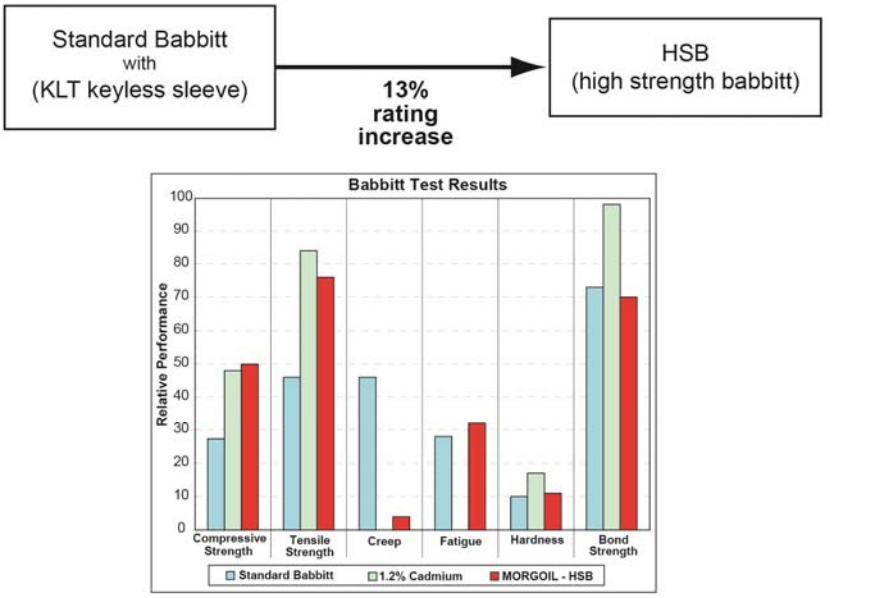

Figure 7. Bushing Upgrade Path

2.2.3 Seals

MORGOIL and MESTATM bearings can have their sealing systems converted to more modern designs to reduce maintenance time and increase effectiveness, figure 8. These conversions can be done by themselves, or in conjunction with other bearing upgrades. There is a class of large MESTA plate mill bearings where the existing sealing system limits discard back-up (BU) roll diameter. Changing to a more modern neck seal design allows the rolls to be turned down further.

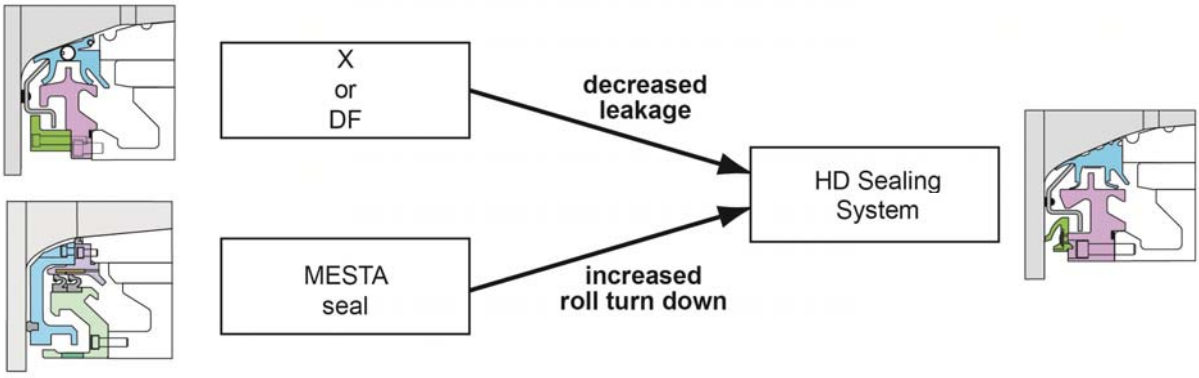

Figure 8. Seal Upgrade Path

2.2.4 Locking

Bearing locks have advanced significantly over the evolution of the MORGOIL bearing. The original Threaded Ring (TR) design and later Quick Change (QC) design have been replaced by more modern hydraulic concepts. On new mills one of three types of lock is standard: Hydraulic Bayonet (HB); Removable Mount (RM); or the Compact Bayonet (CB). Older mills with mechanical TR and QC can often be converted to Hydraulic Mount (HM or HL) and LD® Locks, figure 9, increasing the repeatability and speed of the locking process and eliminating the need to use an overhead crane to tighten the locks.

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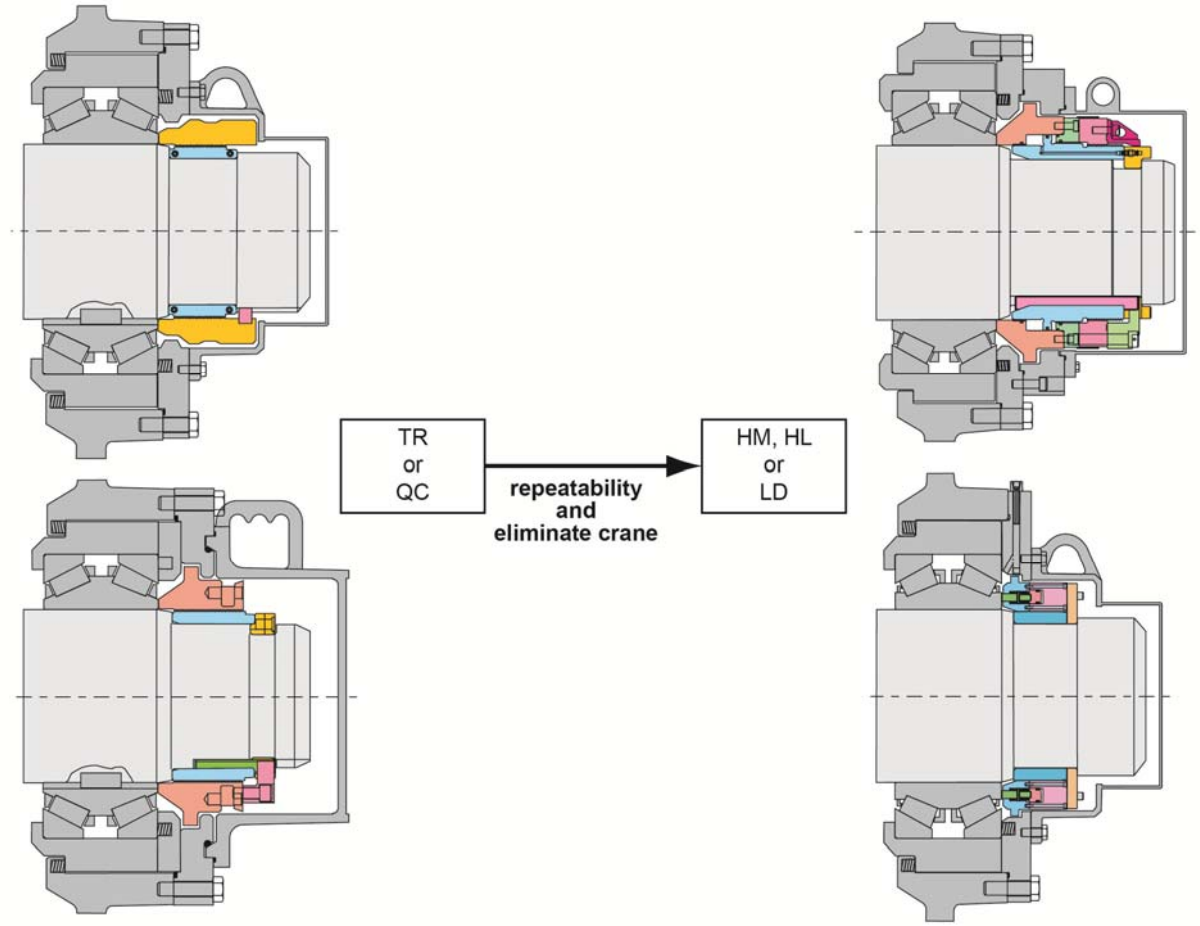

Figure 9. Locking Upgrade Path

2.2.5 Complete Bearing Conversion

In addition to upgrading various individual bearing components. MORGOIL can combine these upgrades for a complete bearing upgrade. The most effective of these is upgrading older style “T” and “K” bearings to the latest “KLX” bearing technology including High Strength Babbitt along with modern sealing and upgraded locks. This provides the maximum increase in performance and the greatest stiffness and lowest roll neck stress. It also provides better seal performance and the convenience of modern locking.

3 CONCLUSION

Bearing upgrades can be a much more cost effective solution for modernizing old tandem cold mills, as well as other types of mills. Upgrading eliminates all the site work required with new construction and uses a lot of existing equipment and infrastructure. Upgrading bearings can help an old mill produce strip to current market standards. Upgrades can also help to increase mill capacity and speed.

In the case of the European 4 stand TCM; the new locking, new chocks with hydraulics, and short key sleeve conversion enable the mill to improve quality, productivity, and safety. The North American 5 stand TCM updated with new chocks, including hydraulics, and new locking achieved the same types of improvements. Both mills can now produce much higher quality strip with higher efficiency making the improvements highly cost effective.