



As good as new?

Bearing remanufacturing? How can SKF offer such a service? What about the quality and performance of remanufactured bearings?

I get asked these sorts of questions all the time. Often they are from people who are for some reason reluctant to use remanufactured bearings. I tell such people that we have many satisfied customers and that remanufacturing can be a good way to reduce maintenance costs. I also tell them that it can help solve problems related to bearing availability or repetitive failure and contribute to better machine reliability.

The main article in this issue of SKF Pulp & Paper Practices is written by an engineer who was originally quite sceptical about bearing remanufacturing. Today, he agrees that if it is done in a professional way - taking into account the application and customer

needs - it is a valuable service that SKF can provide. Many of our customers clearly agree with him as today the pulp and paper industry is the largest user of our remanufacturing services.

We will continue to open more and more remanufacturing centres around the world to serve the pulp and paper industry, to reduce maintenance costs and to help keep the machines running. For me, remanufacturing is a great success and I would like to thank all of our customers for their trust in us.

Regards,
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Bearing remanufacturing

In this issue of SKF Pulp & Paper Practices, I write about bearing remanufacturing. Some people call it bearing repair or bearing refurbishment, but whatever you call it, it's taking a bearing that isn't too badly damaged and reworking it to extend its service life.

When I was an application engineer working with the French paper industry, I was often asked to come and look at large size bearings which were sometimes still mounted on the paper machine. The people at the mills wanted to know whether the bearings could be put back in operation. Such questions were never easy to answer.

With bearings still mounted on a machine, I could only gauge their condition by using a bent wire (see figure 1). Even with dismounted bearings where I could see all the surfaces and which appeared to be in good condition, I always wondered about the state of the steel under the surface. The fact of the matter is that a bearing can have raceways that look good despite the presence of micro cracks in the subsurface. These cracks - which are not visible to the human eye - mean that the bearing is near the end of its life.

Under normal operating conditions, a bearing has to withstand the maximum shear stress below the surface. If it is sufficiently loaded, after a while, the material structure will change and micro cracks will appear (see figure 2).

As such, I couldn't be sure of the real condition of any bearing that had been in operation for some time. With experience, and knowing the operating conditions plus the time in service, I could estimate whether a bearing was good for another year or not. I was normally right. Probably because most bearings in paper machine applications develop raceway surface damage before subsurface fatigue cracks appear and because the nominal rating life is often well

above 100 000 hours. This means that if everything is perfect 90 per cent of bearings working in identical conditions will last longer than 100 000 hours. Nevertheless, I was never completely comfortable telling a customer that a bearing could be put back into operation.

For bearings with minor surface damage, I felt that it was a pity to scrap them especially when availability of new bearings was an issue. As such, we often simply rotated the ring that was subject to a fixed load direction (generally the outer ring) so that there was a new load zone on it. For bearings that had significant damage to the rollers or the rotating ring, I'd recommend replacement with a new one.

Grinding the raceway surface and possibly changing the rollers was something that I had in mind in the early 1990s. I knew that some bearings were sent back to the factory for this even though it was disturbing the flow of the normal production. Even so, I still had concerns relating to the subsurface condition of the steel.

The answer, of course, was ultrasonics which has proven to be a good solution for finding subsurface micro cracks. There is a story from the days before remanufacturing centres existed in SKF. A Swedish paper mill asked SKF to remanufacture a large press roll bearing and we accepted the work on the condition that there were no subsurface micro cracks. The bearing ended up being remanufactured twice before the ultrasonic test showed that it should not be done a third time. While the bearing still looked in good condition, the work required to remanufacture it again - grinding the inner and outer ring raceways to remove the damage steel, replacing the rollers with oversized new ones to keep the same clearance class - would have meant it cost more than a new bearing.

Fig. 1 Figure 1 Bent wire with a point. You can see me using this tool on the front cover of SKF Pulp & Paper Practices, Issue 2.



Fig. 2 Micro crack caused by fatigue 130 microns below the surface.

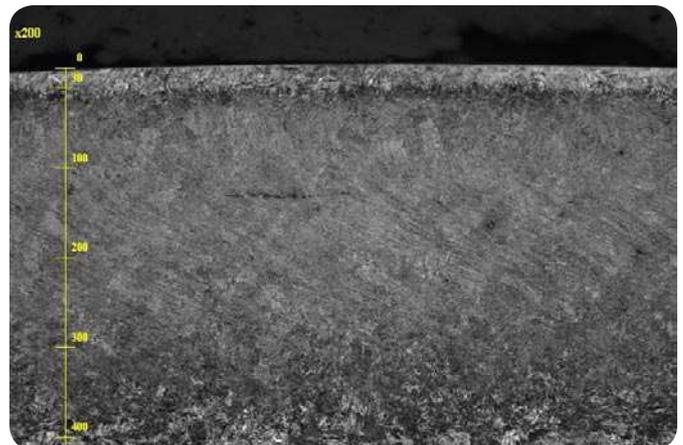




Fig. 3 Ultrasonic testing for subsurface micro cracks in the outer ring of a spherical roller bearing.

This story shows that had specialized remanufacturing centres existed, many more bearings could have been saved providing that appropriate ultrasonic tests had been available (see figure 3).

When our dedicated and specialized bearing remanufacturing centres started, they didn't use the same raceway and roller surface grinding and honing process that is used in our factories for new bearings. While this isn't an issue for some types like cylindrical roller bearings, it can be an issue for spherical roller bearings. For these, inner and outer ring raceway geometry and roughness differences guide the rollers to roll with a small skew angle that reduces internal friction and thus bearing operating temperature. The friction reduction is very noticeable when the bearing load is such that one row of rollers becomes unloaded. When remanufactured bearings merely have their raceways polished to remove minor surface damage, there might be not enough sufficient roughness differences between the raceways to optimally reduce friction.

Unlike facilities for mass production, it is not practical for remanufacturing centres to have machines dedicated to one bearing type or size range. Instead, more flexible machines are needed. However, with such machines it is either more time consuming or impossible to remanufacture some special bearings to the original SKF specifications. I'm thinking about very high running accuracy bearings like the VQ424 and VA460 variants here.

In addition, customers were – and still are – sending bearings to us for remanufacturing without any indication of the operating conditions or the amount of hours they had been in service. Furthermore, they weren't – and still aren't – opting for ultrasonic testing first. The risk of undetected subsurface micro cracks if no ultrasonic analysis is done isn't negligible. Several cases of remanufactured bearings developing spalling due to subsurface micro cracks after a few weeks or months in service stayed in my mind. For these reasons, I didn't think that remanufacturing was a good idea unless new bearings couldn't be sourced in time.

However, I had to face reality. This reality was that an increasing number of remanufactured bearings were being sent to satisfied customers who were saving money. The SKF remanufacturing centre in Steyr, Austria received 1 119 large size bearings from paper industry customers between 1998 and 2002. Of these, 149 were scrapped and all the others were repaired. Some paper mills were

reducing their yearly bearing spend by up to 10–12 per cent due to the savings from remanufactured bearings. Such bearings – ignoring ultrasonic testing – typically cost 50–80 per cent of the price of a new bearing.

It should be noted that a bearing doesn't always need to be remanufactured to the original specifications. It depends on the application. Let's look at some examples.

A spherical roller bearing mounted on a Yankee cylinder doesn't rotate at high speed and its operating temperature is dictated by the steam temperature. Friction isn't the most important parameter. Running accuracy and the steel quality are, on the other hand, important. So, if the bearing is just polished, that's acceptable.

A spherical roller bearing with C08 specification (i.e. four times better running accuracy than normal ISO precision) mounted on a solid plain press roll, doesn't always need to be C08 after remanufacturing. C08 means P5 running accuracy for the inner ring (suffix C02) and P5 running accuracy for the outer ring (suffix C04). The running accuracy depends mainly on the rings wall thickness variation and the roller diameter deviation in a roller set. As the inner ring rotates, it has to keep the original running accuracy. But the outer ring has a loaded zone that is normally less than half of the raceway circumference. If this is the case, wear is in the loaded zone and the unloaded zone still has the same geometry as when it was new. If the bearing is remounted with a previously unloaded zone as the new load zone, it is sufficient that the outer ring wall thickness variation in the new load zone is within original tolerances. This should normally be the case. While the bearing isn't C08 anymore, with the outer ring positioned correctly in the application, it will operate like a C08 bearing.

N.B. The remanufacturing traceability number on the bearing side face is positioned so that it coincides with the center of the new load zone (see figure 4).

Another example: A 23040 CCK/C4W33 drying cylinder bearing that has been stored in a humid environment. It has some standstill corrosion marks. Nearly all corrosion marks have been taken away during remanufacturing, but in one area – the outer ring – some were so deep that there are still some marks remaining. The remaining corrosion marks are in the unloaded zone of the outer ring when the bearing will be mounted and the bearing doesn't run at

Fig. 4 Traceability number indicating the centre of the new load zone. Here it is marked on the bearing inner ring since it is for a deflection compensating roll where the outer ring rotates with the cylinder.



very high speed meaning that the centrifugal forces pushing the rollers against the outer ring are small. The bearing can be put into operation with these remaining corrosion marks.

Some parts of the bearing do not need to be remanufactured. For example, corrosion marks on the face of the rings do not need to be fully removed if there is no load on the surface and or the surface has no influence in the bearing mounting, adjustment and operation.

Remanufacturing objectives

We must keep in mind that the objective isn't to remanufacture a bearing so that it is equivalent to a brand new one, it's to increase the service life of the bearing. Service life is generally limited by raceway damage due to lubrication, contamination, or marks due to bad handling or storage. On a paper machine, most of the bearings do not reach their potential service life. This is mainly due to lubrication and contamination issues. A dent created by an over-rolled hard particle, or a surface micro crack due to corrosion, disturbs the load distribution along the roller/raceway contact surface. It changes the stress in the subsurface. The stress is locally increased and accelerates fatigue. By removing the surface damage, the service life is increased compared to what it would have been if the surface damage was left in place.

Depending on the bearing operating conditions in the application, an appropriate remanufacturing work level can be selected avoiding costly, unnecessary operations. However, I wouldn't recommend remanufacturing certain bearings. For highly loaded, high speed bearings – sometimes running near, or even above their SKF General Catalogue speed limit – it is better to check with the local SKF application engineer on a case by case basis. I have in mind, for example, VA460 spherical roller bearings and CARB toroidal roller bearings designed for very high speeds mounted on plain press rolls and some special spherical thrust roller bearings for high speed refiners.

Also, some bearings are quite old having been more than 15 to 20 years in operation or having run more hours than the calculated rating life. In such cases, a better solution is to replace them instead of remanufacturing them. The SKF pulp and paper bearing expert team, comprised of application engineers with an average of 18 years experience in bearings and pulp and paper applications, has

created an internal guideline about bearing remanufacturing for the pulp and paper industry. In this guideline, we recommend not remanufacturing bearings that have achieved more than 50 per cent of the calculated SKF rating life L_{10mh} . Of course, this guideline can be ignored in situations where it's better to remanufacture rather than have a machine stopped due to the lack of availability of a new bearing. Once again, it's better to contact the SKF application engineer and take a decision based on the operating conditions.

If all this is understood, I'm fully convinced that remanufacturing is a good way to reduce total cost and limit waste.

Can all bearings be remanufactured?

No, of course not. There can be many reasons – technical or commercial – for this. While we have many bearing experts in SKF who can advise on whether a bearing should be remanufactured, sometimes specific circumstances like the lack of availability of new bearings can lead to an expert's recommendation being overruled. Nevertheless, for some damage – such as heavy spalling and fractures, remanufacturing is not an option. When it's too late, it's too late (see figure 5).

For some other damage, it can depend. Whether the bearing shown in figures 6 and 7 can be remanufactured depends on the depth of the corrosion and whether the rollers have to be replaced or not. A decision can only realistically be made after an in-depth analysis by an expert.

In other cases where damage is superficial, remanufacturing can be done at low cost. This is the case for the CARB toroidal roller bearing shown in figure 8. It was mounted on a belt calendar and has two standstill corrosion marks on the outer ring. These can simply be removed with polishing. However, no matter how simple the work involved, major damage can occur if it is not done by expert people.

Do not wait until the bearing has failed and the machine stopped before dismounting it. By that time, most bearings are too badly

Fig. 5 Heavy spalling means that this ring needs to be scrapped



Fig. 6 The corroded inner ring of a deflection compensating roll



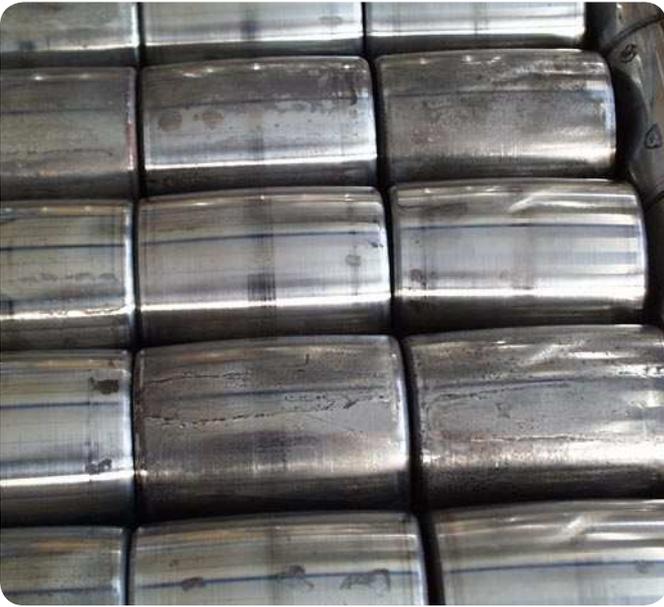


Fig. 7 The rollers of the bearing shown in figure 6

damaged and cannot be remanufactured. Often, it's even too late by the time you can feel or hear that something is wrong. Condition monitoring and oil analysis are the best tools to detect that bearings are beginning to develop raceway or roller damage. When detected early, plans can be put in place to dismount the bearings during a planned stop and maximize the chances of being able to remanufacture them at the lowest possible cost.

While customers often ask if a bearing can be remanufactured before sending it and incurring freight and customs costs, it isn't always easy to answer this question without seeing the bearing, dismantling it to check its condition and knowing the operating conditions. The first step – if you do not have an SKF specialist available – is to take good quality photographs and to email them to SKF together with information about the application, rotational speed and which ring has the rotating load.

Giving information about rotating load is important. Even though we can generally tell – based on marks on the raceway – which ring rotates compared to the load direction, it is best to indicate this anyway. Even simply telling us the bearing designation can also help sometimes. For example, a spherical roller bearing 23068 CC/C08W513 – a bearing with a cylindrical bore and lubrication holes in both the inner and outer rings – is quite often used on deflection compensating press rolls or as the front side bearing on old suction roll designs. That said, I have also seen this bearing mounted with a tight fit on a rotating shaft as a replacement for a 23068 CC/W33 so, the designation can only tell us so much.

Giving information about load, lubrication and the bearing's operating time is also helpful to evaluate the remanufacturing possibilities.

Regarding photographs, we often see pictures that aren't good enough quality to allow us to make a reliable judgement on the damage. While we don't expect to see professional quality photographs, we do need to see ones that are in focus, adequately lit and without the detail obscured by flash reflections. One other thing to keep in mind is that it is difficult to estimate the depth of any damage from a photograph. As such, any indication that you can give us about depth is very useful.

Even if a bearing is sent to an SKF remanufacturing centre directly, it's still important to give us the information mentioned above.

Let's take the example of a VQ424 (high running accuracy suffix) bearing, mounted on a high speed deflection compensating roll that has standstill corrosion marks on the outer ring. All the other parts are in good condition and will not need to be touched. The outer ring will have to be ground because we want to keep adequate roughness difference between the inner and outer ring raceways to minimise friction. Keeping the same roller set, the bearing will be a C4 clearance class instead of the C3 that it was originally because, before grinding, it was near the upper limit of the C3 clearance class. To make the remanufactured bearing C3, it would have to be equipped with new, oversized rollers. This would have a huge impact on the cost. However, if the SKF application engineer knows the application and operating conditions, he is able to tell whether C3 clearance is really needed and can advise his customer accordingly.

Fig. 8 Dismounted CARB toroidal roller bearing at a paper mill ready for inspection before being sent for remanufacturing



SKF remanufacturing centre services

SKF remanufacturing centres offer several service levels plus options depending on the bearing involved, the type of damage and, most importantly, the application.

When a bearing arrives at an SKF remanufacturing centre, it is visually inspected first and some parameters like residual magnetism and clearance are checked. This gives an initial impression about the state of the bearing and whether it can be remanufactured or not. After this, the bearing is disassembled and thoroughly cleaned (see figure 9).

The components are then inspected and their dimensions measured. Some measurements and inspections are optional. Ultrasonic testing, hardness, roller diameter set variation, outer dimensions are, for example, optional while ring wall thickness and ovality are examples of measurements that are always taken.

For bearings mounted in critical applications such as press rolls or Yankee cylinders where the operating hours are unknown, I would recommend the ultrasonic testing option. Remember that it's an option so, you have to request it when you send a bearing to an SKF remanufacturing centre.

Classification of the damage is done according to ISO norm 15243 for eventual root cause failure analysis. Following the ISO norm is important because it ensures that everyone has the same understanding of the terms and definitions used to describe bearing damage.

Following this, an offer with a report is sent to the customer though remanufacturing won't start unless a customer order is placed.

In SKF, there are 4 levels of service. Here's a quick overview of them:

- 1 Level 1 is just inspection and scrap
- 2 Level 2 is inspection, repacking with adequate protection and return to the customer
- 3 Level 3 is inspection, remanufacturing by polishing, repacking with adequate protection and return to the customer. For high speed applications, where low friction is a key parameter – or if the spherical roller bearing has to withstand high axial load – I recommend contacting your local SKF application engineer to decide whether level 3 or level 4 remanufacturing is necessary.
- 4 Level 4 is inspection, remanufacturing with some grinding (see figure 10) and/or part replacement, repacking with adequate protection and return to the customer. Note that with level 4, spherical roller bearings keep the inner and outer ring raceway roughness differences for minimum friction, due to the specific grinding techniques used.

Before being sent back to the customer, the bearing parts are quality checked (see figure 11) and reassembled with care. For example, figure 12 shows a plastic sheet placed between the outer ring and the rollers to avoid micro smearing marks when rotating and/or swivelling the inner ring while putting the rollers in position.

Fig. 9 Bearing being disassembled at an SKF remanufacturing centre.



Fig. 10 Level 4 grinding of a spherical roller bearing outer ring

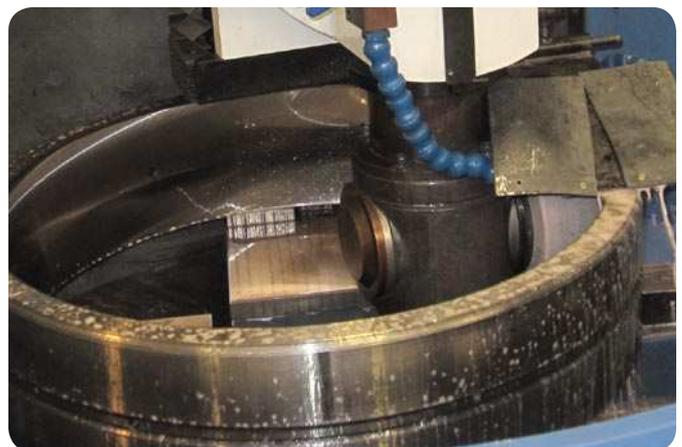




Fig. 11 Ring ovality and wall thickness variation measurement



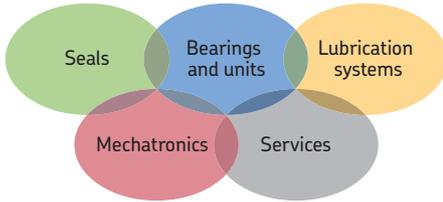
Fig. 12 Special care is taken during assembly to ensure that rollers do not mark the raceway.

I hope that this article has given you a better understanding of re-manufacturing and its limitations. Please keep in mind that:

- 1 Remanufacturing doesn't transform a used bearing into a brand new one, it simply increases its service life.
- 2 Information about the application, the running conditions and the operating hours helps SKF propose the most cost effective re-manufacturing process for you.
- 3 For critical applications when operating hours are unknown or when the bearing has been in operation for more than half its SKF rating life, I strongly recommend ultrasonic testing.



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The Power of Knowledge Engineering

Drawing on five areas of competence and application-specific expertise amassed over more than 100 years, SKF brings innovative solutions to OEMs and production facilities in every major industry worldwide. These five competence areas include bearings and units, seals, lubrication systems, mechatronics (combining mechanics and electronics into intelligent systems), and a wide range of services, from 3-D computer modelling to advanced condition monitoring and reliability and asset management systems. A global presence provides SKF customers uniform quality standards and worldwide product availability.

SKF Global Pulp & Paper Segment

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