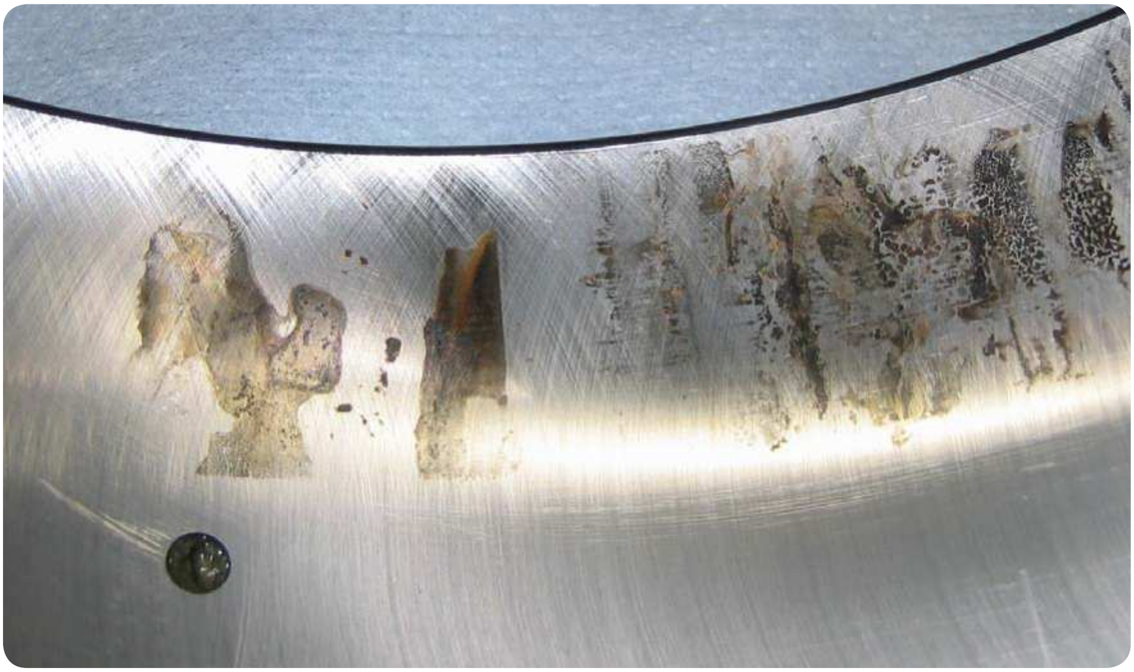
SKF Global Pulp & Paper Segment | Volume 3 | No. 10 | February 2014

SKF Pulp & Paper Practices



Standstill corrosion on a bearing due to process water contaminated grease.

Idled machines still need maintenance

Imagine that you are the proud owner of an expensive classic car. It drives well, but for some reason or another you need to leave it in the garage for a while. Months later, you charge the battery before trying to start it. To your delight it starts at the first attempt, so you decide to take it out for a drive. Everything goes well until you apply the brakes and discover you have a problem with asymmetrical braking. It was caused by the hydrophilic brake fluid and the resulting corrosion on your brake caliper pistons which no longer slide properly.

You were lucky. A lot of other things could have happened. Your tyres might have gone flat or the rubber could have degraded, your fuel could have evaporated leaving deposits in the tank, the fuel tank might even have developed a leak due to rust caused by free water in the petrol and so on.

Many of us have experienced such problems or know someone who has. The repair costs mount up and can be higher than the value of the car. The sad thing is that they could have easily been avoided if a few simple steps had been taken. Basic things like changing the brake fluid, emptying the fuel tank, turning the engine over every so often, taking the car out for a short drive once in a while etc.

By now, you're probably asking yourself what cars have to do with the machinery used in the pulp and paper process. The answer is simply that they all contain a lot of steel components that don't react very well to moisture.

As you know, it's not unusual for paper mills to stop production for long periods for rebuilds, overhauls or economic reasons. When this happens, remember the car left in the garage and that free water can cause standstill corrosion on bearings and other steel components in less than a day.

My experience is that most bearings on paper machines stopped for a few weeks will have a short service life unless preventive measures are taken. As such, this issue of SKF Pulp & Paper Practices contains recommendations on what to do during stops to prevent problems when machines are restarted.

Regards,
Philippe Gachet
Senior technical consultant
Philippe.gachet@skf.com

Restarting production after a long stop can be costly if you don't do it right

As many of you will remember, there were strikes in the Finnish paper industry a few years ago. Eventually, the parties involved came to an understanding and production was resumed. In the following months there was a significant increase in the number of incidents disrupting production and some of these were bearing related. This was hardly surprising as the frequency of failures when restarting machines is largely dependent on what precautions are taken before stopping them. If the precautions taken are insufficient, problems with corrosion and contamination are to be expected.

Over the years, SKF has seen hundreds of bearings that have failed after restarting production following prolonged stops. Most of them could have been prevented if the proper precautions had been taken beforehand. Given that market downtime is a reality for many markets and grades these days, we thought it would be useful to share some guidelines about preserving bearings during prolonged stops.

1. Causes of bearing damage during stops

The number one cause of bearing damage during prolonged stops in the paper industry is standstill corrosion. This is hardly surprising given the humid environment, the use of high-pressure cleaning, condensation forming in bearings and housings as they cool down and because bearings are predominantly made of steel and are therefore very sensitive to corrosion. Bearings are especially at risk during stops because water or process fluids easily separate from the lubricant (see **figure 1**) and cause damage (see **figures 2 and 3**)

The number two cause of damage is false brinelling. This is caused by vibration in the direct surroundings of a bearing that is not rotating. Due to this vibration, the rolling elements of the bearing are subject to micro-movements that free microparticles from the bearing raceways which corrode and act as an abrasive. The result is marks that look like indentations caused by pushing the rolling elements into the raceways, but with no burrs of displaced material (see **figure 4**).

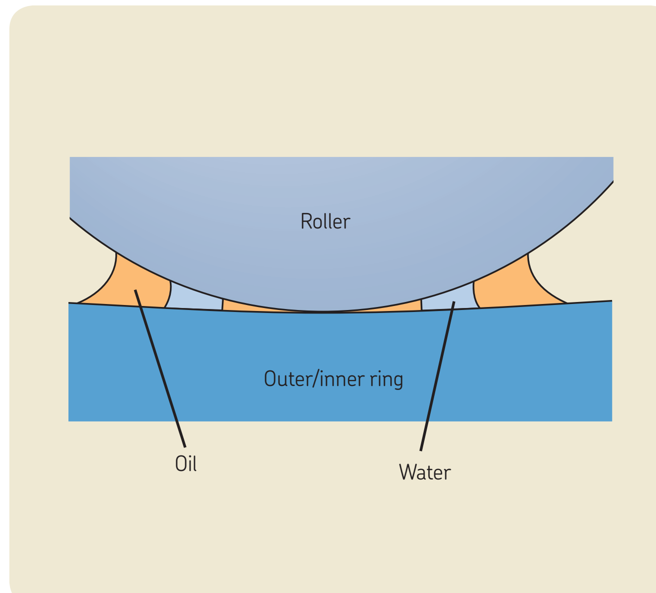


Fig. 1 Water or process fluids can easily separate from the lubricant.

Fig. 2 Standstill corrosion in a needle roller bearing from a tissue converting plant. The machine it was mounted on had been cleaned with high pressure water.

2. Preventing standstill corrosion

The actions recommended to prevent standstill corrosion vary according to the lubrication method that is used.

2.1 Grease lubrication

Over time, paper industry lubricants get contaminated with water from the process and the environment. To prevent this from having a negative effect, bearings and housings should be relubricated with fresh grease before the machine is stopped.

We recommend regreasing just before the machine is stopped because it is important that the bearings are rotating so that the grease can distribute itself into all the spaces and contacts in them. If, for whatever reason, regreasing takes place when the machine is stopped, the roll or cylinder that the bearing is mounted on should be rotated by hand.

For short maintenance stops, the normal regreasing procedure recommended by the machine supplier should be followed. For longer stops, the bearing should continue to be relubricated until excess fresh grease is purged from the housing. This should be readily apparent from the colour of the grease. With such an approach, it is important to remember that the temperature inside the housing when the machine is restarted may be higher than normal due to overfilling. However, excess grease will quickly be purged and the temperature will soon return to normal levels.

The fresh grease used should be suitable for the application and show a result of 0-0 with SKF Pulp & Paper artificial process water or with 0,5% NaCl in the SKF EMCOR test (ISO 11007/DIN 51802) for wet section applications, machines operating in a humid environment or those where the bearings could be contaminated with process water. A test result of 1-1 is acceptable for 0,5% NaCl in dryer section applications.

When centralised grease lubrication systems are used, fresh grease should be pumped through the pipes starting with the main lines, then the branches and finally the bearing housings and/or seals. Pipes can be disconnected at the connection points to verify that fresh grease is making its way through the complete line. This should be readily apparent from the colour of the grease.

***Fig. 3** The outer ring of a spherical roller bearing that was mounted on a paper machine.*

***Fig. 4** An outer ring of a self-aligning ball bearing that has been subjected to false brinelling.*

The SKF EMCOR test

SKF developed this test to measure the ability of a grease to protect a bearing against corrosion even with the presence of water. Testing is done in a dynamic way with bearings running and standing still. Even when the bearings are standing, the thin oil film left in the contact zone between the rollers and raceways must be able to protect the bearings against corrosion.

For more information about the SKF EMCOR test please contact your local SKF office or visit skf.com.

2.2 Oil bath lubrication

Oil analysis is strongly recommended and if the water content exceeds 200 parts per million (ppm), it needs to be changed. It is also important to discuss the analysis with the lubricant supplier to verify that the oil will protect machinery during prolonged shuts. For longer shuts, completely replacing the oil should be considered.

If no oil analysis is undertaken, we recommend changing the oil as soon as the machine stops and rotating the bearings on a regular basis. Doing this once a week, for example, will help to make sure that the oil is even distributed over the bearings and that all parts are covered.

The oil used should pass the SKF EMCOR test with a 0-0 result with distilled water and/or SKF Pulp & Paper artificial process water. Furthermore, anti-corrosion additives are recommended,

Note: Bearings that are lubricated with oil baths should be rotated periodically to allow the bearing elements to get a fresh coat of lubricant. How often this should be done depends on the ambient conditions and will vary from once a week to once per month.

2.3 Circulating oil lubrication

The water content of the oil should be no more than 200 ppm before the machine stops and, once again, an oil analysis is strongly recommended. As with oil bath lubrication, it is important to discuss this analysis with your lubricant supplier to verify that the oil will protect machinery during prolonged shuts.

It is advisable to keep the lubrication system running to avoid failures at a later date though the flow rate can be reduced. If the machine is stopped for a long time, we advise running the system at full flow rate at regular intervals and checking the flow meters until you are confident that oil has circulated throughout the system and returned to the reservoir tank.

The water content of the oil should be kept to a maximum of 200 ppm to avoid corrosion problems. This is particularly important if carbonised iron lubrication piping is used.

As for oil bath lubrication, the oil used should pass the SKF EMCOR test with a 0–0 result with distilled water and 1–1 with artificial process water or the mill's actual process water. Lesser anti-corrosion properties can be accepted since the system should be in operation on a regular basis and the water content controlled. If this is not the case, the same advice as for oil bath lubrication should be followed.

3. Preventing false brinelling

Sources of vibration like stationary engines should be removed or not operating while the machine is stopped. To further reduce the risk, it is advisable to rotate the bearings at regular intervals. This can be achieved by rotating the roll/cylinder. How often this should be done depends on the vibration levels that are created by the surrounding machinery, but can be once per week or even more frequently.

4. Piping

A number of lubrication system piping related problems can occur during stops. For example, it is not always made of stainless steel and, as such, there is a substantial risk of corrosion inside the pipes while the lubrication system is not in use. This can lead to problems with corroded particles being transported to the bearing by the lubricant when the system is restarted.

Impurities in the lubricant can settle when circulating oil systems are not in use and may cause blockages when they restart. With grease lubrication systems, the lubricant can harden during prolonged stops and cause blockages whose exact location can be hard to detect.

5. Restarting machines when standstill advice has not been followed

As we explained earlier, if a machine is stopped without taking precautions there is a risk when it is restarted of bearing failures due to corrosion, blocked lubrication pipes and so on. However, even in such cases there are some actions that can be considered to minimize the associated impact on costs and production.

It may be necessary to replace all the bearings. While this sounds very time-consuming and costly, it can be worth it in the long run. To minimize the costs involved, dismounted bearings can be sent to your local SKF Solution Factory for inspection and possible repair. Those bearings that can be restored by polishing and grinding can be reused. This will offer significant savings over buying new bearings.

Lubrication pipes that are not made from stainless steel should be replaced. The risk is that they will be corroded inside and there is no way for them to be repaired. While this is a major undertaking, the benefits in terms of production time saved should outweigh the costs involved.

Stainless steel lubrication pipes should be checked for blockages. If any are detected, it may be possible to remove them by flushing with a solvent after first disconnecting the piping from the circulating oil system and bearing housings. Some mills decide to take the risk and run the machine while monitoring the flow meters though SKF does not condone this approach due to the risk of lubrication starvation and subsequent associated damage.

Consider replacing the return pipes even if they are made from stainless steel. They are at the wrong side of the bearing. While feed pipes contain clean oil that has been filtered, the return pipes contain oil with contaminants and wear particles. When the machine is stopped, these will settle. To clean these pipes will probably mean that you have to flush – likely back towards the bearing – and risk contaminating it. The alternative is to disconnect return pipes, which are generally larger than the feed pipes, and connect each one to a pump. It's normally safer and more economical to simply replace the return pipes and avoid the risk of failures due to contamination.

Think twice before flushing lubrication systems. Over the years particles will have accumulated in dead spots and flushing may force them into the lubrication system again. Furthermore, the flushing fluid may stay in the circulating oil system for some time and even if it is compatible with the oil, it's unlikely to be the best thing to lubricate bearings with. If, having read this, you are still considering flushing your system, contact the lubricant supplier for advice on what fluid to use.

Clean the oil sump. At most mills I visit, they are cleaned once a year during the annual stop. They should also be cleaned before restarting a machine after a prolonged stop. Oil bath systems need attention as well. We advise draining the sump, cleaning it and refilling it with fresh oil.

Run your circulating oil systems for around 15 minutes and check that all lines are feeding by checking the flow meters or sight glasses before restarting your machine. This helps ensure that all bearings are properly lubricated before they start rotating. If this is not done, there is the risk that they will run dry or with insufficient lubrication which may lead to subsequent failures later on.

Pump all grease lubrication points through until fresh grease is purged from the seals or drain holes before start-up. This should be done via the normal grease point to check that everything is functioning normally and that there are no blockages. The reason we recommend this is because the grease may have "bled out" during standstill. When this happens, some of the oil has leaked out of the grease and what is left is a partially dried up soap than can block pipes, nipples and even bearings. If it is done properly, the bearings will be overfilled and it is advisable to start the machine slowly so that surplus grease is purged over the course of several hours without large temperature increases. In some cases, the bearing housing will need to be opened up and surplus grease removed manually.

Start the machine slowly after a long standstill. Gaskets and stuffing boxes may have dried out and opened up. With a slow start they have a chance to readjust. If not, at least you are able to locate and replace them before a large amount of oil has leaked out.

In conclusion, paper machines can be restarted without too many major mechanical problems after a prolonged stop if appropriate standstill preparations were taken. Even if they were not, there are a number of actions that can be taken to mitigate the effects.
Too many companies, in my experience, are so eager to get started again that they neglect to do these things. This can often be a costly mistake.

If you are ever in the situation that you need to shut down one of your machines for some time, we recommend following the advice given in this article to avoid unnecessary and costly maintenance before restarting your machine.

Regards,
Rene van den Heuvel
Maintenance Solutions Manager
rene.van.den.heuvel@skf.com

Small things can matter

When you visit a paper mill workshop, you'll often find a stack of pulleys somewhere on the shelves. They're actually rope sheaves from the tail threading system which guides a strip of paper through the paper machine at the start of production (see figure 5). You might wonder, as we did, why so many of them are lying around?

Part of the reason is that a paper machine can have as many as 200 rope sheaves. They're only needed at the start of production and serve no purpose once the tail threading process is complete. Nevertheless, they still keep running and at considerable speeds. A 200 mm core diameter sheaves on a paper machine with an operating speed of 600 m/min can be running as fast as 955 r/min, for instance.

Rope sheaves – operating conditions and challenges

Most rope sheaves have a very simple design. They're simply a metal pulley, with two ball bearings in the hub, mounted on a shaft (see **figure 6**). The shafts are mounted on paper machine frames and, therefore, the bearing inner rings do not rotate. Bearing outer rings, in contrast, are fixed in the hub of the sheaves and do rotate.

The most commonly used ball bearings in this application have a 35 mm bore diameter. Under ideal conditions, 70 °C on a horizontal shaft with radial load in a clean environment, such bearings only need to be relubricated every 20 000 hours which means once every 27 months. In reality, the conditions in a paper mill are far from ideal.

In the wet section, temperatures are acceptable, but the humidity is high. During production and cleaning, the sheaves are exposed to water and the damp environment. With a 27 month relubrication interval, there are lots of opportunities for bearings to corrode and for lubrication films to be rendered ineffective.

In the dryer section, the conditions are more difficult. It's hotter with an average ambient temperature of 100 °C and there's a lot of dust. For every 15 °C over 70 °C, the relubrication interval needs to be halved. This means relubricating the sheaves in the dryer section every six months instead of every 27 months. The dust causes its own problems. It collects on the shaft and the hub (see **figure 7**) and can act as a wick that drains the oil out of the grease.

In general, many rope sheaves are in inaccessible locations on the machine. This often leads to them not being relubricated resulting in lubricant starvation for the bearings. Even when they are, it's quite common for them to be over-greased and for surplus grease to end up on the hub, the floor or the paper.

Fig. 5 The tail threading process.

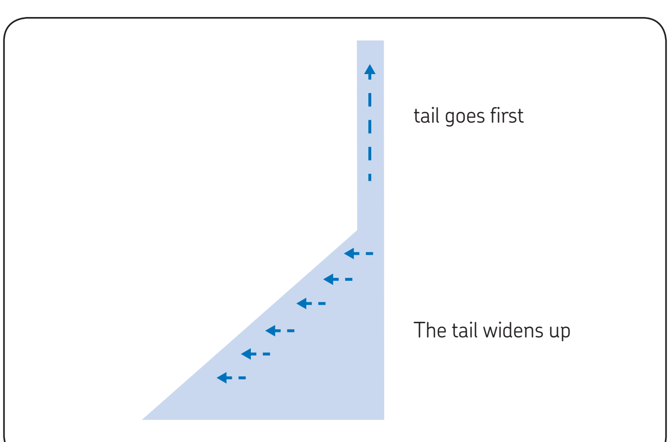
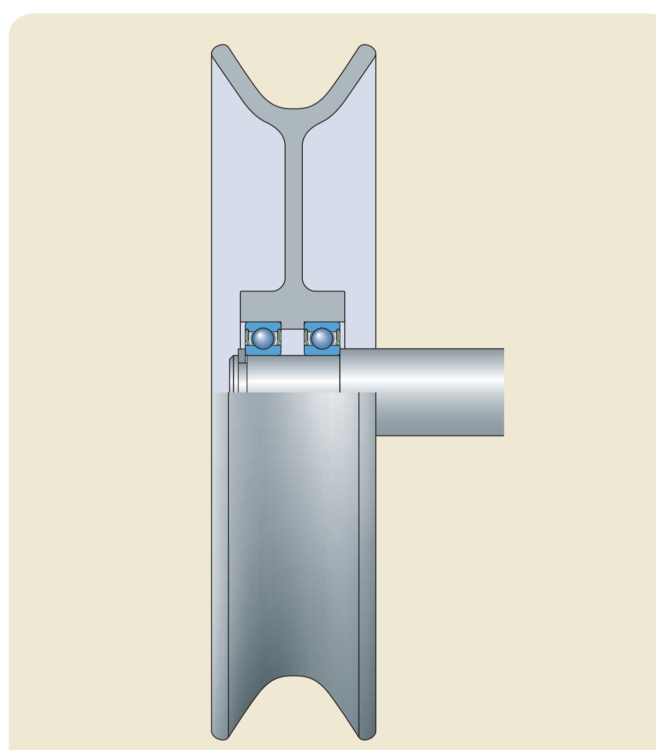


Fig. 6 Rope sheave bearing arrangement.



Unfortunately, rope sheave failures can be quite difficult to detect and normally sheaves are not part of a mill's vibration monitoring routes. While ones that have stopped rotating are the easiest to spot, those that are still moving, but not at the required speed, are much more challenging. This is a problem because it can cause rope wear and, in extreme cases, sheaves can drop off their shafts. As well as being a safety hazard this risks damaging machine parts, wires or fabrics.

Failed or failing sheaves are often only detected during tail threading. They can lead to tail breaks with several attempts necessary to get production started. In some cases, cleaning the machine is necessary, which leads to extra downtime. Consequently, many mills replace sheaves at every stop.

Sheaves that have been in operation for weeks or months are dismounted from the machine and have their bearings replaced. This happens in the workshop which is why they can be seen lying around so often. As new ball bearings are relatively cheap and because replacing them is not a lot of work, it's generally not seen as a problem. However, with time and bearing replacements, the hubs and shafts of the sheaves start to wear out. Once they are outside the required tolerance range, replacement bearings will start to creep (turn) in the hub or on the shaft and bearing service life will be significantly reduced.

On average, it takes two men two hours to replace a rope sheave. Some mills replace 10–15 sheaves per quarter which would mean 40–60 replacements and 160–240 man hours per year. Add in the time needed to mount new bearings in existing sheaves, any extra downtime resulting from rope sheave problems and possible safety issues and you have a fairly costly situation. Costly enough for some mills to have sought a better solution.

Fig. 7 Dust collects on shafts and hubs.

The SKF solution

In 2001, Stora Enso Kvarnsveden approached SKF in Sweden about a problem they'd experienced with a dryer section rope sheave. Due to a bearing failure, the sheave fell six metres and narrowly missed hitting one of their workers.

After investigation, SKF concluded that the bearing failure was predominantly related to lubrication and sealing issues. In addition, they found that the combination of outer ring rotation and high rotational speed created centrifugal forces which forced grease out of the bearings.

SKF developed a solution with a static outer ring and inner ring rotation. A deep labyrinth seal combined with bearing seals were designed in to protect the bearings. Ceramic balls were used in the bearings to increase the relubrication interval and a high performance grease, suitable for the application, was selected. The new rope sheave units were designed in such a way that existing sheaves could be modified. For rope alignment purposes, an adjustable angle unit was developed. Finally, the new units had a patented lock to stop sheaves falling in the unlikely event of bearing failure.

Tests were successfully completed in the same year and Stora Enso immediately replaced 68 sheaves with the new SKF rope sheave units (see **figure 8**). The new units run for four years before there is any need for inspection (Note that this is in the dryer section of a fast machine and that with more favourable conditions longer service lives have been achieved). If necessary, they can be refurbished with replacement bearings, grease and seals. The other parts can be reused which, over time, leads to substantial cost savings.

Fig. 8 The SKF rope sheave unit in operation.

The new generation

Following the success of the original SKF rope sheave units, a second generation unit was developed with improved sealing and a lower price. In addition, it was possible to reduce the sheave core diameter from the 150 mm of the original design to 110 mm on the new one (see **figures 9** and **10**).

The basis of the design is an SKF car hub unit. After all, if they can withstand water, mud, salt, heat, cold, high pressure cleaning, high rotational speeds, high axial forces and shock loads, why not use them as the basis for rope sheaves on paper machines? Some modifications were made, of course. The metal balls were replaced with ceramic ones and the high performance grease used in the original design was selected.

Fig. 10 New generation SKF rope sheave unit in operation.

Fig. 9 New generation SKF rope sheave unit.

Due to the design, units with two or more independently running sheaves are now possible (see **figure 11**). This creates a wide range of application possibilities for the paper industry.

If, after many years of trouble-free operation, the unit needs to be replaced, the sheave and shaft can be reused (see **figure 12**). Only the bearing hub unit needs to be replaced, which is supplied fully assembled and ready to be used.

In conclusion, our experience – and that of the mills using our rope sheave units – is that apparently minor problems such as rope sheave failures can have a surprising impact on maintenance and production. Also that install and forget solutions allow people to focus on other higher priority issues that need addressing. That said, it's usually worth trying to eliminate problems that use lots of resources or impact on production. It's all part of reliability improvement which is something that SKF is always happy to help with.

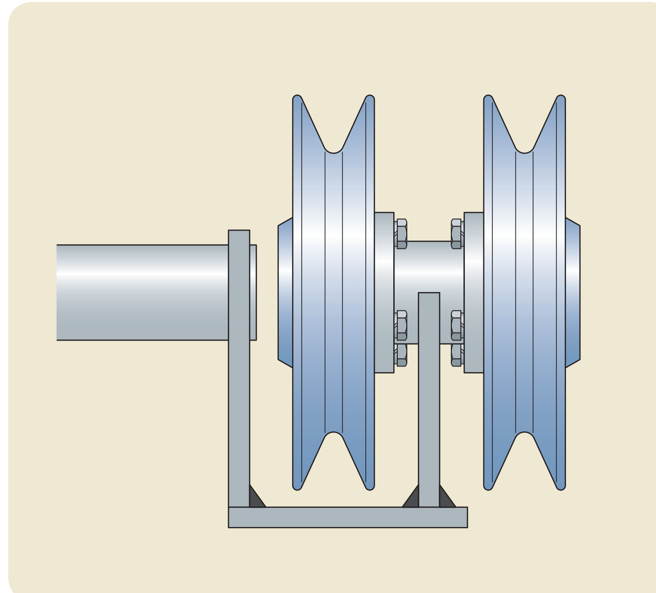
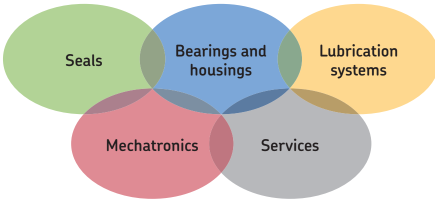


Fig. 11 A double independent unit.

Fig. 12 The sheave and shaft can be used again.

Regards,
Rene van den Heuvel
Maintenance Solutions Manager
rene.van.den.heuvel@skf.com



The Power of Knowledge Engineering
Combining products, people, and application-specific knowledge, SKF delivers innovative solutions to equipment manufacturers and production facilities in every major industry worldwide. Having expertise in multiple competence areas supports SKF Life Cycle Management, a proven approach to improving equipment reliability, optimizing operational and energy efficiency and reducing total cost of ownership.

These competence areas include bearings and units, seals, lubrication systems, mechatronics, and a wide range of services, from 3-D computer modelling to cloud-based condition monitoring and asset management services.

SKF's global footprint provides SKF customers with uniform quality standards and worldwide product availability. Our local presence provides direct access to the experience, knowledge and ingenuity of SKF people.

SKF Global Pulp & Paper Segment

Contact/Responsible editor
philippe.gachet@skf.com

PUB 72/S9 11147/9 EN · February 2014