

SKF Pulp & Paper Practices

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Better make sure that your bearings are properly lubricated

A mill was experiencing repeat failures on drying cylinder bearings and the only clue we had was oxidized, discoloured oil with some black carbon deposits. This suggested a number of possible causes: overheating, the oil ageing too quickly, poor quality oil etc. I obtained all the information that I needed on operating conditions for a technical study, but everything seemed normal so I could offer no explanation for the failures.

During my next visit to the mill, I noticed the flow meters on the circulating oil system in the basement. The sight glasses were dark, but we could still just about make out the position of the float and the scale. The floats were between 20 and 30, so I asked what the relationship was between the scale and the oil flow in litres per minute. The panel showing this was missing, but people thought the oil flow was between two and three litres per minute. In fact, it turned out to be below one litre per minute.

Low oil flow rates is not just a problem with old machines as you can also find it on modern machines with online condition monitoring. I remember, for example, asking to see the oil flow to the drying cylinders in the control room of a six year old paper machine. The oil flow should have been between three and four litres per minute, but the monitor showed a reading below two litres per minute. Nevertheless, there was no alarm and nobody was taking any corrective action.

While low oil flow can cause problems, the most common and important issue I see is oil leakage through the bearing housing seal assembly. This is generally because oil cannot be evacuated quickly enough through the dirty return pipes. Another fairly common issue is mills reducing oil flows while starting up from cold and forgetting to increase them when the machine is hot.

SKF can help with lubrication system checks and proposing corrective actions, where needed. This issue of SKF Pulp & Paper Practices, written by Dana Hatton, covers lubrication system audits. Dana's an engineer in our lubrication division and supports our customers in North America. He has worked in the industry since 1965 holding positions in mills in maintenance and engineering. Since 1989, he has been with SKF and specializing in lubrication systems.

Regards
Philippe Gachet
 Senior Application Expert
 SKF Application
 Competence Centre
philippe.gachet@skf.com



What to expect from a lubrication system audit

In North America the vast majority of paper, pulp and tissue machines built between 1940 and 1985 received extensive rebuilds and were modified once, twice or even three times by 1990. Machines built after 1985 have also undergone the same types of improvements once, twice or more by 2017.

The justification for the owners of these machines to spend the large amounts of capital required for these rebuilds was and is, most often, to increase production of the paper grades they produce or to make a better, more profitable product. A machine rebuild typically includes modifications to change the machine speed, improve product drying or both. Press sections get replaced and improved with bigger, faster and newer technology, steam pressure in dryer sections gets increased, complete dryer sections are sometimes added, machine hoods are replaced to improve control of temperature and moisture and machine drives get improved.

About 1980 the paper industry began to use terms such as uptime and runnability. The operators of these machines began to better appreciate that every hour their machines did not run large amounts of money was being lost. That began the industry wide effort to try to better understand what was causing their downtime and poor runnability numbers. They began tracking downtime caused by maintenance issues versus downtime from production related events.

Many companies became involved in the search for answers to the many problems the paper makers had. The original equipment suppliers and engineering firms got involved. Much of the early data related to rotating equipment failures started to show us that incorrect lubrication was one of the bigger problems with this type of equipment.

In 1989 some SKF colleagues and I began conducting audits of these machines and the lubrication systems and practices being used

to keep them running. It soon became evident to us that almost all of the paper and tissue machines we audited were operating very differently when compared to what they were first built to do. In the majority of cases these machines had been rebuilt one or more times with little if any consideration for the effects the modifications could have on their lubrication requirements.

In one extreme case we audited a machine that was experiencing extreme wear and failure of its dryer, intermediate and transfer gears. The gear manufacturers had investigated the problem. The dryer alignment had been checked. The mill was using the proper lubricant but the lubricant supplier also looked at the situation and did not find the reason for the problem. Then they contracted SKF to do a complete audit of the machine and its lubrications systems and process. In the process of doing the audit our team learned the mill had added a complete dryer section six years prior. The new dryer section had 70 lubrication points which were added to the existing oil circulation system. When the machine was started up after this rebuild the oil circulation system that supplied the original machine very well, would not stay running. It kept shutting down due to low oil pressure. The original oil pumps could not pump enough oil to satisfy the larger machine. To keep the machine and lubrication system running the mill's decision at that time, in the heat of battle, was to shut off the oil flow to half of the lubrication points that supplied oil to all the drive side machine gears, the same gears that were now failing. That solved the low pressure situation and quickly the machine was up and making paper. Soon everyone involved forgot that the gears were getting just half the recommended and necessary oil flow.

By the time the gear failures became a noticeable problem the people who were part of the decision to shut off the oil flow to half the lubrication points for the gears had retired or moved on to other jobs. Our crew, after finding many of the oil flow meters shut

off on the drive side of the machine, traced the lubrication lines connected to them to the lower gear nips lubrication points. At that point we asked why they were shut off. The lubrication technician for this machine said, "That's the way it was when I took over this job". His foreman had only been at the mill a year or two so he could not help.

When we pointed out that this was a very serious problem and could be the reason for the gear failures, mill management, in an effort to learn why the lubrication points had been shut off contacted a retired lubrication technician who had spent many years on this machine and still lived in the area. The retired technician's comment was, "After we added dryer section six, we could not keep the oil pressure up on the lubrication system so you told me to shut off all the lower gear nips."

This machine's drive side gearing was designed so it had a lubrication point at the top dryer gear and another at the bottom where the bottom dryer gear and the transfer gears mesh. The mill had shut off the flow to all the lower gear nips. We can only assume their thoughts were that the oil to the top gear would run down to all the other gears. Each gear nip lubrication point should have been getting 1,75 litres per minute of oil.



Fig. 1: Heavy wear on gear teeth

The oil requirements for these 70 new points they added turned out to be 110 litres per minute. When that additional flow was required, the oil system could not supply it at the pressure needed to satisfy the system's pressure requirements. The mill's solution at the time was to take away oil flow going to all the bottom dryer gears. After shutting off approximately 90 litres of oil to those gears the oil system worked again. They could make paper and everyone was happy until the gears began to wear out prematurely (see **figure 1**).

I mention this incident because it is a very good example of paper machine owners planning a machine rebuild without thinking about the effect it may have on the lubrication of the machine. Most problems found during paper machine audits of older machines relate back to how things were built or installed differently at the time the older systems were built. Over the years recommended oil flow rates for many bearings have increased. Also, the requirements for lubrication of the machines gears have changed. Not only did the flow rates increase, but we found mills needed to convert machines to more viscous oils.

Machines that were using ISO 150 oil are mostly using ISO 220 or 320 today. These two things, needing more oil and more viscous oil created requirements for larger drain ports in bearing housings and gear cases as well as the need for larger, better sloped pipes in the oil drain system.

The problems identified during audits are not always related to the equipment. A common problem we still find today in North America is the lack of training for the lubrication technicians who manage the lubrication process around these machines. Many are well trained in working with lubricants, handling them properly, keeping them clean but have little or no training in the systems, the centralized oil circulation and centralized greasing systems that deliver the lubricants to the machines. Many of these people received a week or less of training from the person they replaced. Most do not know how the lubrication delivery systems should be used to maximize their potential.

The majority of the problems found when we began to conduct these audits in 1989 were:

- 1 Poor pressure and temperature control of oil circulation systems.
- 2 Lack of understanding about the damage water and air in the oil can cause.
- 3 Limited knowledge about oil flow rates or grease amounts required in various bearings.
- 4 Little appreciation for or understanding of centralized greasing systems.
- 5 Wide use of substandard filtration.
- 6 Use of sight glasses that did not indicate oil flow rate or indicated incorrect oil flow rates.
- 7 Oil leaks that were causing environmental, safety, and product contamination problems.
- 8 Limited training of people that maintained the lubrication equipment and process.

Within the pulp and paper industry, at least in North America, some things have improved since 1989. Most mills now have a Reliability Manager and staff or at the least an engineer whose primary focus is to investigate problems that lead to repetitive failures. However, while these people are well informed in the use and care of lubricants many still do not understand the equipment



Fig. 2: Old sight glasses for monitoring oil flow on older machines. Sometimes still found during audits, they often leak badly, hence the collection pan. Much better flow monitoring, alarming and trending technology is available today from SKF

that supplies it to their paper and tissue machines.

Once our customers fully understand what a lubrication audit of a paper, tissue, or pulp machine can do for them they are anxious to have one scheduled. The motivation to have one conducted may be related to an upcoming rebuild, it may be because they are having an unusual number of bearings failures, or just because the machine leaks so much oil. We have, in some cases done audits to learn for the customer and report back if his lubrication technicians are doing their jobs around the paper machine correctly. We sometimes use the audit follow up as an opportunity to give the mill's staff training in the systems they have or cover weakness we found.

Normally we schedule our audits so they include at least one day when the paper machine is shut down for at least six to eight hours. We do this because there are often things we cannot safely inspect with it running. A schedule that allows us a day to see the machine running normally prior to a shutdown, see it during a shutdown and then seeing it as it starts back up is very helpful. Most machines can be done in three or four days at the mill if things go well.

We prefer to start an audit by having a kickoff meeting with the customer's key people. This could be a project manager, production manager, maintenance manager, reliability manager, lubrication technicians, reliability engineer, and in some cases the mill manager. Our objectives in this meeting are to see that we understand the customer's goals and expectations from the audit. We use the time to ask key questions to learn what the major problems are in their opinion, what their timing is to fix things and what the mill's future plans for the machine are. In some cases, we have been present in meetings with a team concerned about the rate of bearing failures and learned that those people did not know the engineering manager was investigating the cost to increase the steam pressure in the dryer sections. Higher steam pressure would greatly influence a machine's lubrication needs. The more we know about the present and future situation the better our audit report can help a customer now and in the future.

While we are with these key people we try to get information about the machine speed range, steam pressure, dryer journal insulation and condition of steam pressure control valves. These people should know that infor-

mation, but that is not always the case. Our team has learned we have to be careful who we get this important information from. Some people that should know do not, and they may give us bad information. We also make sure that we are issued a camera pass. Photographs help us days later when we are writing the audit report and need to refresh our memory of what we saw. They are also needed to insert into our report to help our customers understand key points and to see specific things we found.

After the kickoff meeting one of the first steps we take is to understand and verify all the lubrication points on the machine. We collect bearing information and may send that information along with machine speed, roll diameter, oil viscosity, journal insulation, etc. to a team member in the office who will calculate the required oil flows based on the expectations of the audit. It could be we will calculate the needs of the machine as it is at that time and again for what the flow rates will be if the machine is rebuilt in some way.

There is a lot of documented information we hope to gather. We need to get elevation and plan view drawings of the machine as well as any piping drawings that may exist showing the present lubrication piping.



Fig. 3: Example of the internal plate separators found in some new SKF oil reservoirs to improve water and air removal

These are used to document accuracy, looking for places the machine has been modified over the years or was not installed as designed. We look for technical manuals for the existing oil and grease systems, reports on bearing failures, gear inspections, oil sample analysis, oil usage and other documents that might relate to existing or past machine problems. We generally ask for this information to be assembled by the mill before we get on site. However, 50 percent of the time we have to search out this information ourselves. Knowing our way around engineering and maintenance department files has been a big benefit.

We count and gather information on all existing oil flow meters and compare that number to the number of lubrication points we understand the machine has. Sometimes we will find meters shut off, missing or recently added. If we find more active meters than we appear to have bearings and gears, we must find out what those meters service. We inspect the condition and if possible the accuracy of the existing oil flow meters. We look closely at how the flow meters are mounted around the machine and where they are mounted (see **figure 2**). A system can sometimes be improved or made safer

for workers simply by moving the oil flow meters.

It is important to gather information about the existing oil reservoir(s). Normally we do not get to inspect the internals so finding drawings or past inspection reports can be very helpful. If we can, we will open the inspection covers and note the condition of the parts above the oil level. We measure their size so we can calculate the working volume they will hold. If they are old and have no special internal features, we can compare them to the old TAPPI standards that were used for so many years. We now know that those standards can be much improved with new reservoir technology (see **figure 3**).

We inspect and record the make and model of every system component that we can safely reach. This includes oil pumps, motors, filters, heat exchangers, oil heaters, valves, instruments, etc. In some cases, this data will later be discussed with manufacturers to learn about capacity. Pump volume and motor speed and horsepower are critical to understanding the capacity of any system. We are trying to learn the existing capacity of this equipment to see how it compares with the needs of the machine presently and in

the future. We are looking for one or more components that may be the limiting factor in the system. If the pumps and motors can supply 100 litres per minute but the oil filters are only rated for 50, the filters are recognized as a bottleneck in the system.

All system piping, both the supply and drain pipes must be checked. We do not inspect the inside of these pipes but we are interested in any reports the customer may have that cover past internal inspections, system flushing or projects where this piping has been opened and inspected. If we chance to see some of the pipes apart while on site, we try to inspect and document the condition. If the pipes are carbon steel, we can assume that the drain lines may be suspect for internal corrosion and build up that might restrict the oil flow draining back to the reservoir. Stainless steel pipes are recommended in most cases, particularly for the main drain headers. We note the size of the existing pipes and create schematics so we can later do flow calculations to identify areas where the piping is not correctly sized. Supply pipes can sometimes be oversize leading to the oil moving so slow that it cools too much before reaching the lubrication points. We also check the slope of the drain headers. If the pipe



Fig. 4: Example of overly long tubing lengths between flow meters and lubrication points

size is marginal and the slope less than our standard, there is a good chance we will recommend they be replaced or some improvements made.

Tubing is typically used between the oil flow meters and the lubrication points. This is inspected for material of construction, size, and external condition. We inspect for signs of stress corrosion cracking where possible and we check the length of average tubes and how well they are installed (see **figure 4**). The size of the supply tubing is important to understand what the operating pressure of an oil system needs to be. If we have to recommend higher oil flows for a machine we may have to report that the system's operating oil pressure must be increased or the size of the supply tubes might have to be larger, or both of these might have to be done.

We have always considered the bearing housings and drive side gear cases as part of the system that must be looked at and included in our audit. We do this because the

oil drain ports in these parts of the machine have long been undersized and are a limiting factor for oil flow on older machines. As well, the individual drain pipes between these drain ports and the main drain headers were also often under sized. These are something we look at closely.

Most of us that conduct machine lubrication audits for SKF try to reach our own rough conclusions before letting too many people tell us what they think is wrong. However, it is important to ask different people the same questions, to watch for where they agree and disagree and to follow up when there's a difference of opinion. It is also important to watch for signs that people are not sure of their answers. A small nugget of accurate information can be very important in getting our information correct. Much can be learned talking to the right millwright or the person that collects vibration data for example. We have learned to look for knowledgeable people during the audit field work.

For many years SKF has been building its staff of people with practical hands on experience as well as technical knowledge of bearings, gears, piping, paper machine design and assembly. All are necessary to conduct these audits properly. Few people working directly for the paper industry have the opportunity to gain the experience to conduct lubrication audits of paper making machinery. They have not had the chance to gather the knowledge needed of lubrication, lubrication systems and how they should work together to provide reliability.

Customers should not mistake an audit for piping design and drawings. Many times an audit will indicate some new design work and drawings are needed just as the audit may indicate bigger drain pipes are required. While design and drawings of new lubrication systems are something SKF can supply, they are not part of a typical paper machine audit.

The audit report can include SKF recommendations for a multiyear plan to make the necessary improvements over several years

if the customer requests it upfront. This plan gives our experienced opinion of which portions of the project should be done first, second, third and so on. Many customers ask for an audit before asking for their first round of capital funding. After an audit report is issued a customer can easily have an estimate in the $\pm 50\%$ range which is the typical first stage for most pulp and paper company's capital projects to be considered by their board of directors. If they follow the audit by having SKF design/draw the lubrication systems modifications needed, their local contractor can use the drawings to give the mill an accurate cost of labor and materials for the required changes so they can get to the final $\pm 10\%$ number that most capital projects require before getting final approval.

The audit process should be started as early as possible. It may take several weeks to match a time someone from our staff can be at the mill on the same week there will be a short shut down. The actual travel and field work to gather data will take five to seven days. Once back in the office to start our calculations / call equipment manufacturers, etc. and write the report can take four to six weeks. The reports are seldom less than 50 pages and sometimes as much as 100 pages in length as we strive to give the customer as much detail as possible.



Best regards,
Dana Hatton
Applications Engineer
Pulp & Paper
SKF USA Inc.
dana.hatton@skf.com

skf.com

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