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OIL FILM BEARING LUBRICATION, MORGOIL®'S LATEST SYSTEMS[1]

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Abstract
The Morgoil bearing lubrication system is a critical part of any rolling mill equipped with oil film bearings. The lubrication system is usually located in an area where it is not highly visible so is not always the first equipment to receive maintenance. Improperly designed or improperly maintained lubrication systems may leak oil, allow roll coolant to ingress, and can cause bearings to fail, adversely affecting mill uptime. A properly maintained system is required to maintain bearing reliability, reduce environmental impact, and reduce lubricant and manpower costs. All these points lead to a more profitable mill.
Key words: Oil film bearings; Lubrication system; Pumps; Heat exchanger.

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1 INTRODUCTION

This paper will discuss the general theory of the systems operation; the function of each major component will be explained for the latest design oil film bearing lubrication systems. The Morgoil lubrication system has evolved combining theoretical design with practical mill experience to provide a highly reliable, low maintenance solution. Morgoil has also experimented with other technical solutions; we discuss some of these solutions and why they are not employed. The Morgoil lubrication system's function is to supply the bearings with the correct quantity of oil, at the correct temperature, and the correct cleanliness.

Also, realizing that existing mills have legacy lubrication systems, methods to improve them will be discussed. Repairs and upgrades to increase system reliability, reduce manpower, reduce lubricant costs, and increase mill uptime will be reviewed. Examples will be given of how utilizing pre-mounted and piped equipment that is custom designed for a specific mill can update systems with very short installation times. This allows mills to gain the improvements of a new lubrication system without the associated costs of long outages.

2 GENERAL THEORY OF OIL FILM BEARING LUBRICATION SYSTEM

Most lubrication systems built for use with oil film bearings control flow thorugh the use of orifices operated at a controlled pressure. In order to understand their operations there are some relationships between pressure, temperature and the bearing nozzles that should be must be described first. The temperature and pressure of the oil and the size of the bearing nozzles directly affect the quantity of oil going to the bearings.

The bearing orifices (nozzles) for the radial and thrust bearings are designed for the length to be > 2.0 times the diameter. This allows for accurate calculation of the flow and for larger orifice diameters to ensure they do not get plugged. This design has the effect of making the flow through the orifice not only dependant on the pressure and the specific gravity the fluid but also its viscosity.

The specific gravity of the lubricant is a constant but the design pressure and the temperature of the oil must be closely maintained to ensure the proper volume of oil is supplied to the bearings.

Supplying the proper amount of oil at the correct temperature to the bearings is not only critical for the proper lubrication of the bearing but also to minimize oil leakage and water ingress. If the quantity of oil going to the mill stand is too great the chock will fill with oil and put undo stress on the sealing system. When the gravity drains no longer have open channel flow the oil backs up in the bearings above the seal level. The oil will either leak out of the bearing or will cause a vacuum to form drawing roll coolant into the chock. If the quantity of oil supplied to the bearing is too little the bearing may be damaged.

In addition to lubricating the bearing, the oil flow also provides the means to effectively remove heat from the bearing and the back-up rolls. This function is naturally tied directly to the inlet temperature of the oil flowing into the bearings. A consistent oil temperature will actually help maintain mill stability. Varying oil temperature will vary the amount of heat being removed from the backup roll and therefore will vary the amount of "roll puff".

3 RESERVOIRS

Morgoil system reservoirs should have four features that help to ensure properly conditioned lubricant is sent out to the bearings.
The most important feature is the floating suction; this ensures that oil is drawn from the top of the tank. The oil on top is in the best condition to lubricate the bearings.
The second and third feature are the large size of the reservoirs and the baffle plate system that separates it into a dirty end and clean end and slows the migration of the returning oil to the floating suction giving it time and inducement to release all three types of contaminants (water, particulate, air). The baffle also helps to mix the oil to help eliminate different temperature oil layers in the tank. The arrangement of the baffles in the tank is critical to obtaining a good result. Properly designed Morgoil tanks have a system of baffles including inclined plates. When purchasing a new system special attention must be paid to this seemingly unimportant aspect of tank design.
The final feature is the tank heaters that maintain the temperature of the oil and heat the offline tank for separating water.
Maintaining the correct temperature in the reservoirs serves two major functions. The temperature in a Morgoil reservoir must be maintained at 45°C to 50°C. This elevated temperature allows the oil to readily separate contaminants and it allows the heat exchanger circuit to control the oil temperature to the mill accurately. An even higher temperature of about 55°C should be maintained when biological contamination is a concern.
Siemens has done extensive testing on tank heater watt density. Tank heaters must be less than 0,6 W/cm2 or the oil will become carbonized. Some suppliers use higher Watt densities and require a pump remains running when the heaters are on. There are problems with this idea; mainly that the high viscosities used in oil film bearing applications do not move uniformly through the tank resulting in hot spots that will damage the oil.
Most oil film bearing lubrication systems are designed with two tanks. The Morgoil standard operating procedure requires the online tank and offline tank be switched weekly. This gives the freshly used oil a chance to separate out water and particulate contamination. After separating out, the water may be readily drained from the bottom of the tank. The offline tank should be heated to 70°C. This facilitates the rapid removal of water from the oil.

4 WATER REMOVAL EQUIPMENT

Morgoil lubrications systems require a means to remove coolant from the oil. The majority of water may be removed by switching tanks and heating the oil, but to achieve the < 2% water requirement water removal equipment will be required.
Many older mills utilized centrifuges for water removal. These machines required a great deal of maintenance, were difficult to run properly and could discharge large quantities of oil into the waste stream if not properly monitored.
New systems utilize vacuum dehydrators. These machines remove water by lowering the pressure on the process fluid thereby lowering the boiling temperature of the water. The steam produced is captured, condensed and discharged from the machine. These machines are low maintenance and effective.

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5 PUMPS

There are generally two system pumps, and in some cases there may be three. Oil film bearing lubrication systems should always have at least one pump running and one pump as an automatic stand-by. The system's electrical controls should automatically start the stand-by pump on loss of system pressure an alarm must sound when the stand-by pump is started.
The relief valves should be considered as an integral part of the pumps. The valves only function is to protect the pumps and system from exceeding the design pressure of the system components. The pump relief valves are not to be used as system pressure control valves; relief valves are not designed for this function and will not maintain pressure properly.
Morgoil currently uses screw type pumps in its systems. These pumps provide a more consistent pressure, less shearing of the oil, and quieter operation. We have experimented with VFD motors on our pumps. This does not work well, as varying the flow through the heat exchanger as the mill speed changes makes proper control of the oil temperature in the heat exchanger imposable.

6 SYSTEM PRESSURE CONTROLS

The amount of oil required by the radial bearings varies with mill speed. The Morgoil bearing is basically a pump: as the mill speed increases the Morgoil bearing will move more oil.
The system back pressure valve is used to maintain system pressure as the flow to the bearings varies due to speed changes. The system back pressure control valve maintains the system pressure by porting varying volumes of oil back to the tank. This maintains a constant system operating pressure supply to the stand pressure control valves.
The function of the stand pressure control valves is to maintain a constant pressure to each mill stand. These valves are adjusted during a mill calibration.
Morgoil utilizes direct piloted control valves, which are valves without expensive electro pneumatic positioners. These valves do not require air to operate. Oil film bearing lubrication systems do not require the high speed pressure corrections the more expensive valves provide. Properly sizing these valves is critical however, and must be done by a competent system designer.
We have experimented with placing the system backpressure control valve before the heat exchanger to save energy. This creates the same problem as the VFD drive on the pumps, the oil temperature cannot be accurately controlled.

7 STRAINERS

Morgoil bearings are very dirt tolerant. Extremely large volumes of contaminants below the 149 µ must build up in a system before they adversely affect the bearings. Normal tank cleanings (annually for hot mills and every two years for cold mills), the floating suction, and make up oil generally keep this from being an issue.

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The Morgoil Bearing business has historically used 100 mesh (149 µ) strainers for our systems. More recently we have specified 200 mesh (74 µ) strainers. The change was made for new systems to extend the period between heat exchanger cleanings. Mills may want to upgrade to finer filtration if they are experiencing rapid degradation of their heat exchanger efficiency due to oil side fouling.

8 SYSTEM TEMPERATURE CONTROL

As described earlier the system temperature control is critical to maintaining the proper flow of oil to the bearings. If the oil becomes too cold the bearings could be starved of flow; if too hot the bearings could be flooded. Flooding the bearings allows the return lines to backup and water to ingress or oil may be lost through the seals.
Morgoil now uses water control ball valves with an electro-pneumatic positioner controlled by an electronic PID loop controller. The added expense of the fast response and finer control is warranted for this application. The PID controller may also have alarm outputs which may be tied into the mills alarm system. The sizing of heat exchangers and water control valves on Morgoil lubrication systems is extremely critical to achieving the maximum ±2°C variation. The water control valve and the heat exchanger cannot be oversized. Special attention must be paid to the minimum and maximum cooling water temperatures to ensure a heat exchanger and control valve(s) combination is supplied to properly maintain the oil temperature.

9 POSSIBLE UPGRADES

Any section of the lube system may be replaced on a pallet or multiple pallets. All pallet type upgrade solutions are specifically designed with pipe orientation, shape and size to fit the mills specific requirements.
Figure 1 is a complete lubrication system may be supplied on multiple pallets. These are complete pre-piped, pre-wired palletized systems. This system was supplied to a North American aluminum rolling mill in two sections. The mill had two slow running stands. Due to no aqueous roll coolant being used a single tank solution was used. This system was mounted on mill floor level and employs a unique pumping solution to bring the oil back to the tank. Morgoil has the perfect mill floor level mounted lubrication system solution.

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Figure 1. Full single tank lube system on two pallets.

Figure 2 is a Morgoil Vacuum Dehydrator with lifting frame. These machines are low maintenance and effective. Most vacuum dehydrators require finer filtration than is found on oil film bearing lubrication systems to operate and are meant to run on low viscosity turbine type oils. Morgoil has a patent pending dehydrator that is extremely dirt tolerant and has been specifically designed to operate on these difficult systems.

Figure 2. Morgoil vacuum dehydrator.

Figure 3 is a heat exchanger pallet. This unit contains all the necessary hardware including a PID controller if required to replace the cooling section of a lubrication system you may now have. A North American steel mill installed this unit. Installation was completed in a 16 hour downturn. We are adding a new system strainer to a pallet like the one shown for a North American customer whom needs to replace the strainer in their system as well as the heat exchanger.

Figure 3. Complete heat exchanger pallet.

Pressure control valves may be supplied pre-piped to facilitate easy and quick of installation. Accurate dimensions of course must be supplied to ensure the equipment fits properly.
Various tank heater replacement schemes can be utilized to replace obsolete reservoir heaters. We have supplied electric heaters mounted in tubes with required plates to replace steam heaters. We have also supplied side stream heating units as complete assemblies with heater vessel, pumps, motors, piping and necessary controls and wiring.

10 CONCLUSION

Oil film bearing issues are not usually caused by a single factor but rather a chain of problems that eventually become too much for the bearing to handle. Proper maintenance of the lubrication system can easily break the chain and save bearings, valuable downtime and labor. Maintaining proper control of the lube oil system will stop oil leaking from the bearing seals and stop roll coolant ingress. The savings on oil consumption alone can justify the cost of properly maintaining the system.
The availability of easily installed pallets containing pre-fabricated lubrication system components will allow mills the opportunity to repair and even upgrade their systems with little or no extra downtime.