PREDICTING BEARING FAILURES AND MEASURING LUBRICATION FILM
THICKNESS IN YOUR PLANTS ROTATING EQUIPMENT

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ABSTRACT

Typically there are two options of maintenance concerning bearings, one is to lubricate them the other is to change them. Monitoring bearing condition is critical to insure reliability. The equipment in water and wastewater plants is an asset that must be managed and prolonging its life will insure a positive contribution to your plants operating efficiency. By incorporating a condition-monitoring program that involves monitoring both equipment condition and bearing lubrication film thickness, issues such as secondary damage, spills and excessive operating costs are avoided.

The following paper will identify some of the condition-monitoring methods used today. Factors that affect the quality of the film thickness will be discussed followed by real life case studies. The case studies will present issues that are common in all industries including water and wastewater plants followed by solutions.

KEYWORDS
Bearing, failure, lubrication, shock pulse, predictive maintenance, vibration, reliability, film thickness

INTRODUCTION

There are several ways to monitor and measure the severity of bearing problems. Ultrasonic, temperature, vibration analysis, and shock pulse are just a few of the methods used today to detect both bearing lubrication film thickness and bearing condition. Most lubrication practices are often performed on a time basis, which can result in over lubrication causing premature bearing failure.

In many of these monitoring techniques the information regarding the bearing lubrication condition is provided after the problem has developed. The key here is to adopt a balanced combination of technologies and methods to develop a good predictive maintenance program with the goal of maximizing reliability. Since lubrication is the first line of defense for prolonging bearing life it is imperative that the lubrication film thickness between the rolling elements and the raceways be measured and monitored. Lubrication is the vital element in all rolling element bearings.
With all of this said, what about the lubrication film thickness in a rolling element bearing after it is installed but before it’s turned on? This is where many bearings start premature failure. As indicated in the chart below and relative to the L10 formula for bearing life, “load” is a commanding factor. The lube pump is turned on and there is no apparent measured vibration alarm. There is no need for oil analysis yet because the machine is new or rebuilt with new and clean lubricant. So, what’s the problem? You may have zero or very little lubrication film thickness between the rolling elements and the raceways of the bearing. If the shaft fit and/or housing fits are too tight or the bearing is slightly cocked or not seated properly your internal clearance within the bearing will be reduced. If there is a slight alignment problem and/or overhung load from over tensioned belts your internal clearance will be reduced. If you are using a super precision bearing i.e. a spindle bearing with very little clearance built in, your film thickness will be reduced. And, the most common installation fault that I have seen in the field is the installation and set up of the tapered bore, double-row spherical roller bearings using a split tapered adapter. The tapered adapter is used as a wedge device to hold the inner race of the bearing onto the shaft. All bearing manufactures have recommended clearances for applying this type of bearing. This type of bearing in a pillow block housing is very common on larger fan applications and is a very popular style for many other applications. If the tapered sleeve (adapter) is drawn up too far by over tightening the spanner nut (a very common practice) the internal clearance of the bearing will be removed thus reducing the lubrication film thickness.

There has always been much discussion and debate regarding the question of how much, how often and what kind of lubricant should be used in rolling element bearings and to many it still remains a mystery. The following chart indicates the many parameters related to the lubrication film thickness and film quality in a rolling element bearing.

Sealed bearings will lose their lubrication film thickness over time. Knowing how much lubricant is left in a sealed bearing can make the difference between productive uptime and
unscheduled downtime. Knowing if lubricant is getting into the bearing will allow maintenance to maximize bearing life by optimizing oil film thickness and unscheduled downtime can be prevented.

Differentiating between bearing surface damage and lubrication film thickness, as a bearing fault is measurable. Knowing the difference is valuable knowledge. The following case studies will relate to equipment (electric motors, pumps, blowers etc.) that is found in all types of industry including water and wastewater plants

CASE STUDY 1: (Computer microchip plant)
Scruber for cleaning contaminated water before dispersing into the waste water system. Four small 3/4 hp motors with integral “C” face mounted impeller pumps plumbed with PVC piping. All four motors were running at the same time. After demonstrating the shock pulse method for monitoring bearings at this printed circuit manufacturing plant we were asked to look at a small water scrubber. The screaming sound of a bad bearing could be heard but they could not pinpoint which bearing was making the noise. Was it the drive end or opposite drive end of which motor? After a quick check the bearing was identified and it’s condition was determined. Related to shock pulse readings the bearing condition was in the RED and the fault was surface damage with the dBm at 57. The recommended dBm number for changing the bearing is 55. This was a 6204.2RS sealed bearing (a sealed for life bearing). Cost about $9.00.

During the night the bearing froze up and tripped the motor leaving three operating motors. They lost 25% of the capacity of the system to clean water. The next day (before the repair could
be made) the EPA inspector showed up. Water was still being dumped into the waste water system. Due to the decreased capacity and after the treated water was tested it did not meet the cleaned requirements. The fine was $32,000.00 Unfortunately they knew which bearing was bad. They also knew how bad it was. If predictive maintenance was a part of normal operating procedure this downtime including spillage of un-treated water and subsequent fine could have been prevented.

CASE STUDY 2: (Food processing plant)
The equipment was a 700 hp ABB electric motor driving a fan for dehydrating milk. ABB Motors have long recommended the use of shock pulse to measure their motor bearings. Many ABB motors are equipped at the factory with adapters for quick-connect measurements.

A new ABB motor was installed at a food processing plant and failed within the warranty period. The bearing froze up and twisted the shaft. There was no lubrication in the bearing. After careful review the records showed that the maintenance personnel in the plant had indeed greased the bearing according to the recommended schedule. The bearing and seal cap were removed from the end-bell of the drive end for inspection. It was found that a machining error was made during manufacture and the grease pathway from the grease fitting to the bearing lubrication notch did not line up. Grease could not get into the bearing. Even though the lubrication schedule was being adhered to, the bearing was not being monitored so no one could tell if lubricant was actually getting into the bearing. Production was interrupted so a new motor was taken from inventory to replace the damaged motor. Before installing the new motor a test run was performed. While the motor was running a shock pulse measurement was taken while lubricant (grease) was applied to the grease fitting. Without disassembling the motor or causing an intrusive action it was determined that the grease pathway was in the correct place and lubricant was truly getting into the bearing. ABB honored the warranty. The damaged motor was repaired and stored as a spare and the new motor is still running today. They have since installed an on-line system to monitor this motor. The on-line system feeds into a PLC that is set to trigger an alarm if a lube problem or fault develops in the motor.
The photo below shows a vertical electric motor driving an edger in a sawmill. The vertical pump is a very common application in water/wastewater plants.

Standard electric motors that are mounted in the vertical position must have special consideration related to lubrication. In most cases ball bearings are used in place of thrust bearings to reduce cost. The ball bearing in a horizontal motor is supporting an overhung load in the radial direction. If the motor is mounted in the vertical position the bearing will see more thrust loads and also the lubricant will run out through the opening of an open or shielded bearing. A sealed bearing will hold the lubricant reservoir in the lower half of the bearing because the bearing is lying on its side in this application. This position will also force the balls of a ball bearing to one side of the raceway thus placing them all in a more loaded situation in both the radial and thrust directions. Load affects the lubrication film thickness. Normally a motor mounted in this position will need lubricating more often than what is recommended.
CONCLUSION

The ability to measure the lubrication film thickness including bearing condition is paramount. Better asset management and machine reliability can be obtained by measuring the film thickness as soon as the machine is turned on. This will prolong bearing and machine life.

Lubrication film thickness in rolling element bearings is critical. It can be measured to detect and troubleshoot for proper lubrication amounts (over/under), the right kind of lubricant for the right job, to detect installation faults and even to pinpoint the lack of film thickness if there is a compatibility and/or contamination problem.

Knowing the film thickness of lubrication in rolling element bearings, even a sealed bearing, is information worth measuring. Lubricant should only be applied to rolling element bearings due to demand requirements. Measuring the bearing film thickness before you lubricate will insure that there is truly a lubrication requirement.

Now maintenance can maximize bearing life by optimizing oil film thickness and preventing unscheduled failures. Knowing the lubrication film thickness including bearing condition is instrumental in best asset management practices.