Optimizing Oil Sump Bearing Lubrication in Process Pumps

Widely used, it's easy, inexpensive and reliable.

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Anti-friction bearings in process pumps often, by design, utilize oil sump lubricated technology. As simple as this method is, there are many critical elements that will degrade the overall performance of the lubricant, resulting in premature component failure. Specification of lubricant type, bearing housing configuration, maintenance methods and condition monitoring are all key elements to consider for improved reliability of horizontal pumps used in pulp & paper, refining and chemical operations.

For many years, it was an accepted condition that oil used in oil sump bearing lubrication should be changed on a regular basis to prevent high levels of contamination that could lead to premature bearing failure and contribute to downtime. Frequently, the indicators used to determine change intervals were based on visual elements of the oil, such as color. Too often, though, relying on these indicators meant that damaging levels of contamination had already become present by the time the oil was changed.

Lubrication Protection

Understanding how oil sump lubrication fails is critical to learning how to protect it. As shown in Figure 1, there are several ways that the quality of the oil can

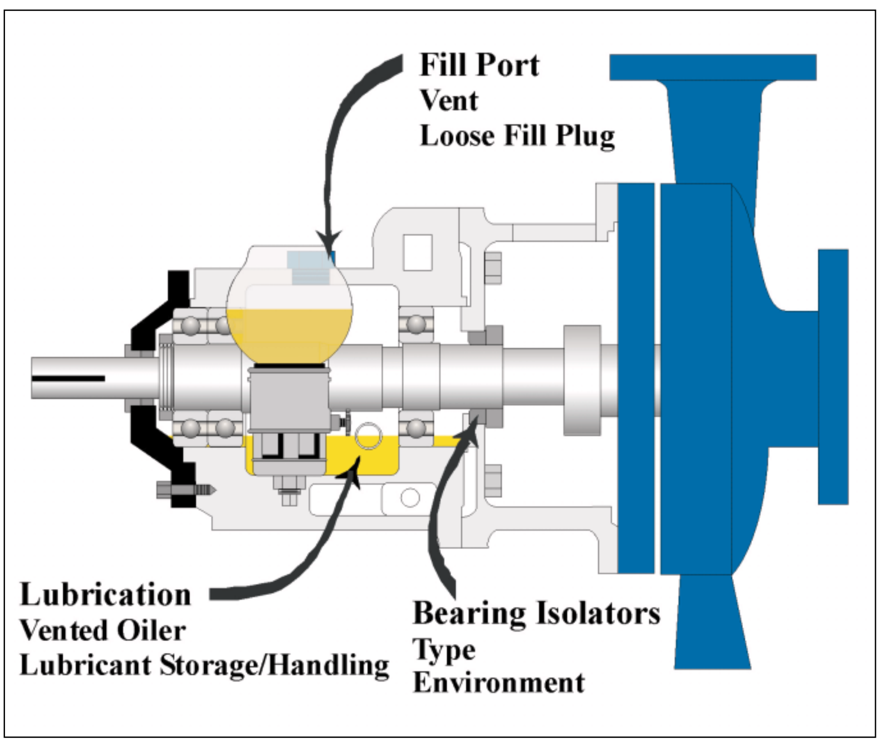

Figure 1. Contamination ingression sources

be affected. The most common causes of equipment failure due to poor lubrication are:

- Contamination
- Degradation
- Oil starvation
- Excessive lubrication
- Mixing incompatible fluids

These can be controlled through the proper understanding and application of methods, procedures and products designed to protect oil sump lubrication. Items to be considered in improving lubrication effectiveness include:

1. Closed system design involving bearing housing isolators (seals), lubrication dispensers, pressure controls (expansion chambers) and view ports.
2. Low-cost monitoring devices and products that provide visual indication of lubricant condition, contamination, and quantity.
3. Improved maintenance procedures and methods.

Although it has long been acceptable to maintain the quality of lubrication in bearing housings through regular change intervals, field tests have shown that minimizing the potential for contamination ingression through restriction of the venting capacity of the bearing housing can greatly reduce the frequency of these changes. Operating modes can be a significant contributor to pressure differentials leading to contamination of equipment lubrication. Frequent start-ups and shutdowns can create a pressure differential between equipment and the surrounding environment. The contamination ingression problems caused by these operating modes can be minimized by limiting the potential for air exchange between the equipment and the surrounding environment, with the use of closed loop (non-vented) lubricating systems and proper seal (bearing isolator) selection.

Furthermore, since damaging contamination levels occur long before visible confirmation, it is imperative that sampling and analysis of bearing housing lubrication be utilized to determine actual levels of contamination before damage can occur. Low cost monitoring devices, like that in Photo 1, are effective in minimizing guesswork about oil sampling and change intervals. Field tests have confirmed that as much as 85% of all sampling and change intervals are done either before it is required or after damage has occurred.

Photo 1. Oil contamination monitor

Types of Lubrication Contamination

There are four major elements of contamination:

- Particles
- Moisture
- Heat
- Air Entrainment

Particle contamination, possibly the most well known form of lubricant contamination, is considered the cause of wear of component parts, silting and surface fatigue. In a study by the National Research Council of Canada on the effects of particle contamination, nearly 85% of contaminant wear of components and surfaces was particle-induced. To make matters worse, particle contamination can create more particles—*more wear*. Lower particle counts significantly extend the life expectancy of equipment. For example, by reducing contamination levels from ISO 21/18 to ISO 14/11, life of a 50-gpm pump could be extended by a factor of seven.

Water contamination of oil can cause several problems relative to oil contamination or degradation. This represents a significant recent change in perception as to acceptable water levels, and is based on evidence that mineral-based oils have been known to lose their corrosion resistance at 200 ppm of water. Zinc additives in the lubricant can fall out of solution, and lubricity, along with the lubricant's ability to become a solid under pressure, are lessened. Metal fatigue, cracking and spalling begin to occur in the bearing. Visible water, or "free water"

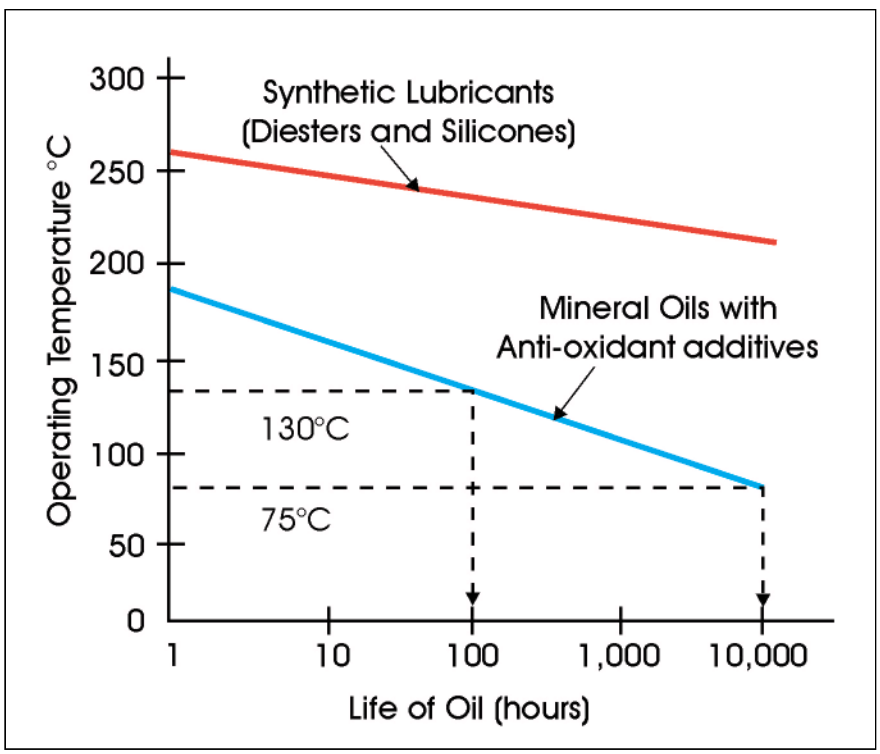

Figure 2. Useful life vs. temperature

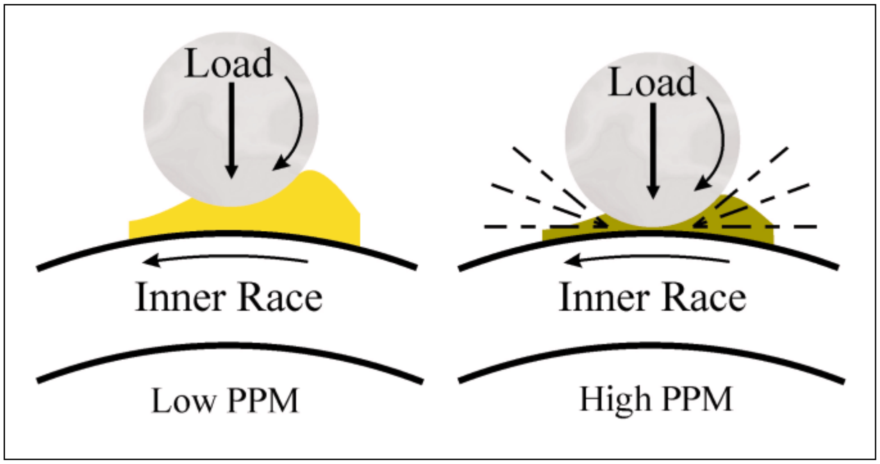

Figure 3. Excessive moisture contamination may allow contact

begins to occur in some mineral-based oils between 400 and 500 ppm. By the time water becomes visible, damage is already occurring in the oil and on the surfaces of the equipment and components.

Heat from elevated operating temperatures is a major contributor of oil oxidation. Combining heat with air, particulate and water contamination sets off a chain reaction of oxidation. Additives are affected first, followed by the base stock, which leads to machine and component surface wear and fatigue. For every 10°F of oil operating temperature, the oxidation rate doubles. Oil operating at 75°C will last 100 times longer than at 130°C (Figure 2).

Air Entrainment is the primary source of oxygen in the oxidation failure of oil. New oil contains approximately 10% air at atmospheric pressure. Splash-lubricated gearboxes, bearing housings utilizing flinger rings or slingers, and compressors are all aeration-prone applications. Excessive aeration has a negative effect on acid number (AN), oil color, film strength and viscosity. In addition, air entrainment can lead to accelerated surface corrosion, higher operating temperatures and oil varnishing.

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Oil Degradation

Primary causes of oil degradation are high heat, air entrainment and mixing of incompatible fluids. Increased viscosity (thickening) is one of the results of this degradation. Viscosity is the single most important property of a lubricant. To more completely understand the significance of viscosity, it is necessary to understand how a lubricant works. The primary function of a lubricant is to reduce friction and wear. In order to perform this function, a protective oil film is required. The three basic oil film conditions are:

1. Full Film—denotes the presence of enough lubricant to ensure complete separation of the moving surfaces; also known as hydrodynamic full film.
2. Elastohydrodynamic (EHD)—hydrodynamic film formed by applied pressure or load; predominantly found in rolling element bearings.

3. Boundary Layer—sometimes referred to as thin film lubrication; usually the result of insufficient lubricant supply—although lubrication is present, there is not enough to prevent metal-to-metal contact.

In rolling element bearings, for instance, the load on a roller causes it to move toward a stationary element, or raceway. This load produces a pressure area that elastically deforms, creating the "Hertzian" contact area. Such pressure can reach 200,000 PSI—compressing the lubricant into a thin film. The viscosity of the oil increases where this fluid film acts as a solid and allows the ball to roll without metal-to-metal contact. When the viscosity is "wrong," the lubricant's load carrying ability is negatively affected (Figure 3). Additionally, if the oil degrades to a point where it is too thick to penetrate between these surfaces, the oil supply may not be adequate to prevent sacrificial contact. (See "Boundary Layer").

Back to Basics

Oil sump continues to be one of the most basic and widely used forms of bearing lubrication in horizontal pumps. Although simple in design, the effectiveness of lubrication can be severely reduced, without consideration for oil selection, handling and storage, seal types, lubricant selection, quantity and condition monitoring. Based on the information in this article, this form of equipment lubrication can be easy to use, low cost, and most importantly, reliable. ■

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