Maintaining Proper Quantity/Quality Lubrication in Horizontal Process Pumps

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Proper lubrication in a process pump is critical to component's function and longevity. Key points to obtaining proper lubrication: 1) lubrication fundamentals 2) how the pump is designed for providing lubricant to the bearing and 3) and surrounding environment. Some basic lubrication fundamentals, types of lubricant, and different methods currently used for providing lubrication to the bearing will be covered. Importance of maintaining the critical elements of lubrication quality and quantity and different means of accomplishing this will also be introduced.

Lubrication Fundamentals

Anti friction bearings in process pumps can either be grease, mineral oil, or synthetic oil lubricated. The primary purpose of oil, or the oil constituent of grease, is to separate the roller elements and raceway contact surfaces, lubricate the sliding surfaces within the bearings, and provide corrosion protection and cooling.

Viscosity is the single most important property of a lubricant. Use of the correct viscosity lubricant for the speed and loads ensures the development of a full oil film between rotating parts. When the incorrect viscosity is used the load carrying ability of the lubricant is negatively affected. The oil degrades to a point where it is too thick to penetrate between the surfaces and the oil supply may not be adequate to prevent sacrificial contact. Viscosity is influenced by load, temperature, water, contaminants, and chemical changes.

Oil in process pumps are typically an ISO grade 32, 46, 68, or 100. These numbers relate to the Kinematic viscosity in centistokes. The oil is usually hydrocarbon oil, although synthetic oils are sometimes used for specific lubrication applications. The viscosity of synthetic oil is less sensitive to temperature changes, and more widely used when temperature fluctuations exist. If temperature also exceeds 100° C (212 °F), a synthetic is recommended as the oxidation rate of mineral oil accelerates faster at higher temperatures.

Methods of Lubrication

The most common types of methods for lubricating rolling element bearings in horizontal process pumps are:

- Grease
- Oil Splash (Direct Contact, Rings, or Flingers)
- Pure oil mist

- Purge oil mist

Grease
The use of grease is primarily limited to lower horsepower pumps where the parameters are in the size and speed range of rolling element bearings. Grease is usually lithium, with a normal viscosity of 100 centistokes and typically has a maximum operating temperature of 121°C (250 °F), but limited to a service temperature of 93°C (200 °F). To prevent the loss of grease, shielded bearings may be used. Shielded bearings may be limited to a maximum operating temperature of 52°C (125 °F).

Oil Splash
The most common form of bearing lubrication is direct contact. As the shaft rotates the rolling elements in the bearing make contact with a level of oil. Since it is critical that an effective oil film be maintained between the rolling element and the race of the bearing, only enough contact between the bearing and the surface of the oil as necessary to provide the bearing with lubricant is required. If the level of lubricant is too high or too low excessive heat will be generated accelerating the degradation of the oil and shortening the life of the bearing.

Oil rings are one option with oil splash lubrication. In cases where speed or loads are factors the oil is not in contact with bearings due to elevated temperatures experienced. Oil rings make contact with the oil and provides splash type lubrication without direct bearing contact. Proper level is important in a splash type as well. If the oil level is too high the ring will become submerged reducing its ability to splash oil to the bearings. If the level is too low the ring may not be able to pick up enough oil to satisfactorily lubricate the bearings.

Flinger discs are another option with oil splash lubrication. They are primarily made of steel and attach directly to the shaft. Flingers are designed to pick up the oil and splash it throughout the bearing housing. The oil level is normally such that the bearing is in contact with the oil.

Oil Misting Pure
The basic concept of the oil mist lubrication system is dispersion of an oil aerosol into the bearing housing. Air atomizes the oil into particle sizes of one to three microns. Airflow transports these small oil particles through a piping system into the pump housing which flows through bearings. It is a centralized type of low pressure lubrication system. In pure mist lubrication the oil/air mist is fed under pressure to the housing. There is no reservoir of oil in the housing and oil rings are not used.

Oil Misting Purge
In purge mist lubrication utilizes the same principles of pure mist, but a reservoir of oil in the housing exists. A slinger/flinger disc or oil rings can also be used to provide splash lubrication.

Quantity of Lubrication

The most critical elements of lubrication are quality and quantity. Without one the other is significantly affected. Having the proper quantity of poor quality oil is no better than having an insufficient quantity of high quality oil. Having the proper quantity of oil may even be more important than maintaining the quality of the oil. Oil sump lubrication does not require that a specific level be maintained for proper bearing load only that oil levels do not reach critically low or high points. (Figure 1)

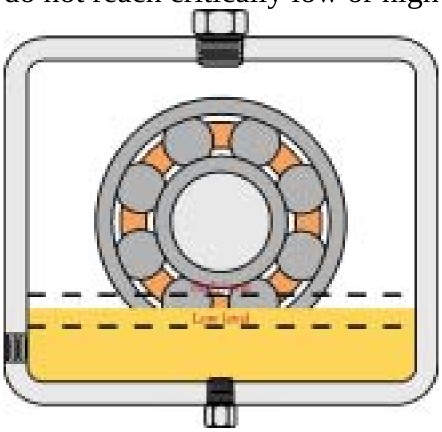

Figure 1.Typical oil level conditions

Low Level
In a low level operating condition the bearing will not receive enough lubricant necessary for proper film strength - a precursor to surface contact, skidding, and possible catastrophic failure. Without enough oil to prevent friction, thermal runaway can happen quickly to a steel bearing. As the temperature of the bearing increases, the ball and race both expand which creates and even tighter fit. This increases the temperature even more, and the cycle continues to a rapid, catastrophic failure. A less obvious cause of oil starvation is high viscosity - as a result of oxidation or degradation, or improper oil selection. If the oil is too thick it cannot penetrate the small clearances of a rolling element bearing, particularly at higher speeds.

High Level
In a high level operating condition churning of the lubricant will occur, accelerating the oxidation rate due to excessive air and elevated temperatures. It is a common mistake to believe that more is better - especially when it comes to oil sump lubrication. Too much oil can affect the operation of oil rings, flingers, and direct bearing contact. Another result of high lubricant levels is leaking seals.

Quality of Lubrication

The quality of lubrication is affected by degradation and contamination. Although contamination is widely recognized for its effect on the quality of oil, degradation can be just as damaging to equipment. The leading causes of contamination are particulate, moisture, incompatible fluids, and air entrainment. The leading causes of degradation are oxidation, heat, and use.

Particle contamination is the most well known form of lubricant contamination. This form is considered the cause of wear of component parts, silting and surface fatigue. Particle contamination can occur from ingress from the surroundings, improper cleaning of the bearing housing during maintenance cycles, or corrosion products from the high water content in the oil. Lower particle counts significantly extend the life expectancy of equipment. A common method used to quantify particulate cleanliness is the ISO 4406:1999 codes. The standard provides a three part code to represent the number of particles per milliliter (ml) of fluid greater than or equal to 4 µm, 6 µm, and 14 µm respectively. It is recommended to contact the equipment manufacturer on oil cleanliness levels and to test new oil for establishing a base line.

Water contamination of oil can cause several problems relative to oil degradation. Since each type of oil has its own safe level of water before damage can occur, the common practice of measuring parts-per-million (PPM) is not conclusive. There are significant differences between oils, beginning with mineral and synthetic bases. Additive packages, commonly referred to as ad-pacs, can also make a difference in how much water an oil can hold before phase separation occurs – and free water forms. Temperature also plays a major role in how much water oil can hold. Damaging levels of free water begin to occur in some mineral based oils between 400 and 500 ppm at 60°C (140°F). Free water may form at 200 ppm at 52°C (125°F) in the same oil. The oil supplier can supply the saturation point for a given temperature to aid in determining a set point for effective lubrication maintenance. By the time water becomes visible, damage is already occurring to both the oil and the surfaces of the equipment and components.

Elevated operating temperatures are a major contributor of oil oxidation. Combined with air, particulate and water contamination, the chain reaction of oil oxidation begins. Additives are affected first, followed by the base stock, which leads to machine and component surface wear and fatigue. For every -8°C (18°F) increase in oil operating temperature, the oxidation rate doubles. Oil operating at 75°C (167°F) will last 100 times longer than at 130°C (266°F).

Air Entrainment is a primary source of oxygen in the oxidation failure of oil. New oil can contain as much as 10 percent air at atmospheric pressure. Splash type bearing housings utilizing flinger rings or slingers 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.

General Practices

There are numerous means available for ensuring proper quality and quantity of lubrication is maintained on process pumps. Using one or many in combination may be the correct solution. Understanding the pumps' components as well as the surrounding environment is critical for applying the correct and most economical lubrication management system.

Improving Quantity
Maintaining the proper quantity of lubricant is perhaps the easiest means of increasing lubrication life and effectiveness. Consult with your equipment manufacturer for recommended oil levels, optimum lubricating equipment, and preferred practices. A general guideline is to maintain minimal contact with the lubricating element. Rolling element bearings should not be submerged more than one-half the diameter of the rolling element (ball) at the deepest point of submersion in static condition. Oil rings are more dependent on the shaft speed relative to the depth of submersion, but a good rule-of-thumb to use is to use 3/8" at the deepest point. Flinger disks are less susceptible to problems of over-lubrication since they are attached directly to the rotating shaft.

One of the most widely used methods of maintaining the proper level lubricant in a bearing housing is the constant level oiler. (Figure 2) The constant level oiler replenishes oil lost by leakage through seals, vents, and various connections and plugs in the bearing housing. Once the proper level has been set replacing the oil in the reservoir is the only required maintenance. View ports (bullseyes) can also be used to verify proper oil level.

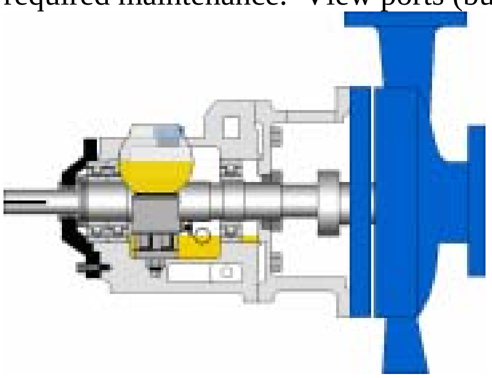

Figure 2.Cross section of typical pump with constant level oiler

Improving Quality- Contamination
Housing components including oilers, seals, and vents, when specified properly can be very effective in preventing contamination. For many years constant level oilers were used to maintain oil levels. Most of these were vented to the surrounding atmosphere, which can lead to contamination ingression to the housing sump. By switching to a non-vented oiler and removing vent plugs ingression can be significantly reduced.

Bearing isolators are used to prevent lubricant leakage and contaminant ingress. Labyrinth type bearing isolators are the most widely used on horizontal pumps. Bearing isolators allow increase pressure created by normal pump operation to vent through the seal and proven to be very effective at reducing contamination ingression. The rotor and stator are not in contact, which allows for the venting to occur while preventing wear – prolonging the life of the seal.

Lip seals can also be very good at preventing contamination, however being a contacting type design, eventual wear to the seal allows for contamination ingression and oil leakages. Lip seals need to be replaced more frequently than do bearing isolators or face seals. Face seals are used to prevent damage to bearings due to contamination and lubricant leakage. Face seals are characterized by optically flat stationary and rotating faces loaded together by magnetic force or springs.

Improving Quality – Degradation
The life of a lubricant is significantly reduced when exposed to high operating temperature conditions. As mentioned previously, the oxidation rate of oil doubles every -8°C (18°F). This can be significant when considering pump operating temperatures are frequently near, or above, 60°C (140 °F). By simply lowering the operating temperature of the oil to 50°C (122°F), a 50 percent reduction in the rate of oxidation would be realized – doubling the effective life of the oil. The most basic methods to reduce (or maintain) lower oil operating temperatures are:

- Use the correct viscosity oil. Too high or too low will raise the temperature of the oil.
- Use quality oil.
- Use the right amount of oil. Maintain proper oil levels – too much or not enough will increase the temperature of the oil.
- Keep the oil clean. Contaminated oil operates at a higher temperature than clean oil.

Improving Quality – Moisture
Pressure differential between the equipment housing and surrounding atmosphere is a leading cause of moisture ingression. Equipment operation where housing temperature fluctuations occur during frequent on/off running conditions, process fluid temperature changes, outdoor use, and air flow over the equipment create this atmospheric exchange as pressure is equalized. When moisture is introduced into the housing, the oil absorbs it at a variable rate depending on temperature, type of oil, and lubricant agitation. Another common source of water ingression is when wash downs occur near the pump.

To eliminate water ingression a closed system type constant level oiler should be used and the vent plugs replaced with a plug. (Figure 3) Consideration of the type of seal installed is required when converting to a closed type system. As discussed above, certain types of seals are better at preventing ingression but still vent to the outside to accommodate the pressure differential. Some seals are not capable of handling the pressures due to equalization and would require an expansion chamber.

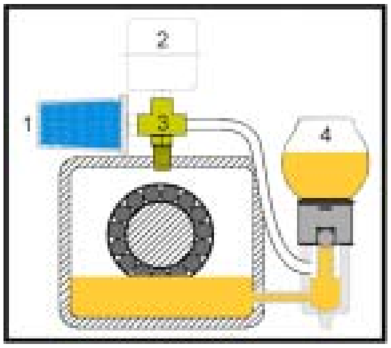

Figure 3.Closed system oiler, expansion chamber, and desiccant dryer

If moisture/water is a known problem, there are various products commercially available to aid in the removal. Desiccant type dryers remove moisture over a period of time indicated by a change in color when maximum absorption has occurred. Filtration is another way of removing water from the oil. Proper storage of oil and proper dispensing containers will also decrease the possibility of water or other contaminants from entering into the bearing housing.

General Recommendations

The importance of proper lubrication in process pumps is well known, but achieving it is not always easy. The best recommendation is to eliminate known causes of poor quantity and quality of oil caused by improper level, contamination, and water ingression. Installing a closed system constant level oiler, replacing all vent plugs with standard plugs, and using reliable seals are a good start.

Establishing an Oil Monitoring system is another positive step to achieving proper lubrication. Performing routine oil analysis and trending the results are one method used to determine quality of oil. Using condition monitoring devices are another method. There are numerous commercially available devices that provide: moisture/water levels, viscosity levels, vibration analysis, etc. Using one or both methods to determine when oil changes are required based more on need than routine are beneficial.

Steps to effective lubrication:

- Evaluate current lubrication methods
- Set target cleanliness levels
- Identify sources of contamination & degradation
- Take specific actions to achieve targets
- Analyze lubricant health frequently
- Distribute the results - raise visibility