Kuldeep Mistry, The Timken Co., USA, overviews bearing lubrication best practices and ideas for improvement.

BACK TO BEARING BASICS

Introduction

Cement plant operators understand the importance of regular roller and ball bearing lubrication, but the demands of the job often make sticking to a strict schedule difficult. As maintenance downtimes are shortened, and as workforces must become more resourceful, it can be possible that

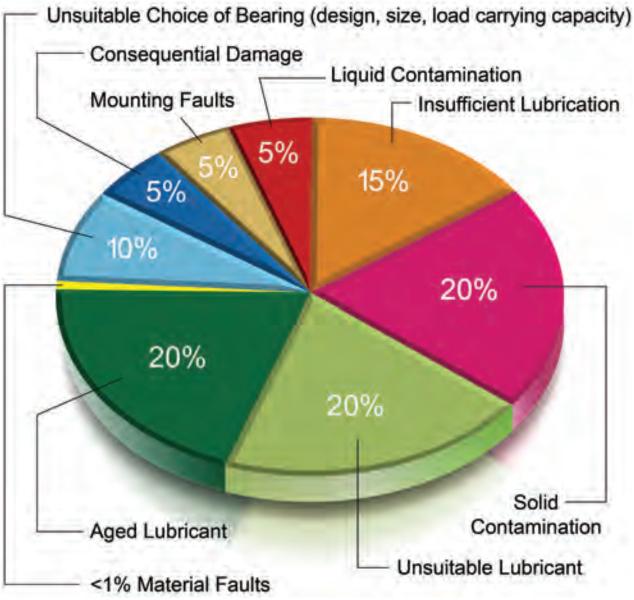

Figure 1. Poor bearing lubrication practices are a bigger problem than most realise.
Note: Reprinted with permission from the August 2009 issue of *Tribology and Lubrication Technology*, the official monthly magazine of the Society of Tribologists and Lubrication Engineers, an international not-for-profit technical society headquartered in Park Ridge, Illinois.

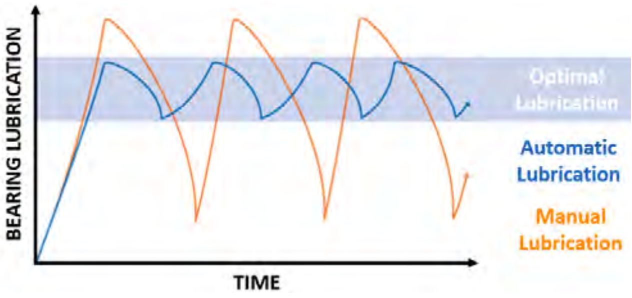

Figure 2. An automatic lubrication system makes it easier to obtain correct, repeatable results.

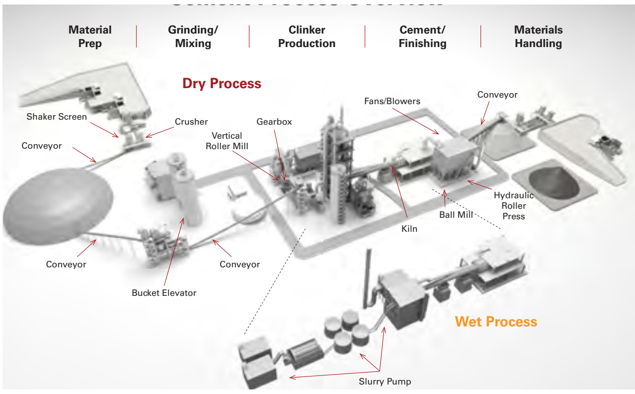

Figure 3. Cement process overview: the vast majority of the equipment in a cement plant can use an automatic lubrication solution.

hard-to-access bearing points are missed during the manual lubrication cycle.

There is often only a small window of opportunity to lubricate bearings in critical equipment without disrupting operations and, depending on the type of machinery, safe access to these bearings can be a concern due to elevated or confined locations, or nearby moving equipment.

Globally, the trend in cement and other industrial markets is to eschew manual lubrication practices in favour of automatic systems. Indeed, lubrication systems are no longer considered optional, but necessary for extending bearing life and avoiding unplanned repairs.

It is important to understand basic considerations for selecting the right lubricant. The manufacturing environment can encompass wet processes, high temperatures during drying, and the constant threat of dust ingress into bearings. These conditions are detrimental to long bearing life and can bring activities to a sudden stop if left unattended. While selecting the correct grease, gear oil, or open gear lubricant is necessary, it is the frequency of bearing lubrication that can make the biggest difference between a smooth operation and a rough ride.

Bearing damage

In the majority of instances, bearing damage is not attributable to contamination or incorrect fitting, but improper lubrication, including unsuitable or insufficient lubrication, as well as aged lubricant (Figure 1).

The importance of using the proper amount of grease for each specific bearing cannot be emphasised enough. Typically, in industrial applications, the bearing cavity should be kept approximately 30 – 50% full and must always follow the manufacturers' exact specifications. Too little grease can result in the bearing being starved of lubrication, leading to excessive heat generation; too much grease can cause the bearing to struggle to push the excess lubricant from the cavity. This churning action can cause a rise in bearing temperature and degrade the chemical properties of the grease, causing the oil to become separated from the thickener. Eventually, the high temperatures can turn the thickener into a burnt crust, leading to premature wear. Further, as grease breaks down, bearing torque can increase because the bearing is forced to work under starved conditions, meaning the processes can become less efficient over time.

Lubricate less but more frequently

The key is to make the lubrication of bearings more accurate and reliable, and in many cases, companies are turning to automatic lubrication systems in order to eliminate the potential for manual error.

As Figure 2 illustrates, applying too much or too little grease at infrequent or irregular intervals puts reliable bearing performance at risk. Instead, the ideal lubrication schedule is to meter out measured amounts of grease more frequently, as an automatic lubrication system is designed to do. Here, there are several options to consider.

Regardless of the method of grease application (manual or mechanical), and in accordance with any manufacturer specifications, the two primary considerations that should determine the selection of a bearing relubrication cycle are operating temperature and sealing efficiency - the less efficient the seals, the greater the grease loss and the more frequently grease must be added.

High operating temperature applications generally require more frequent regreasing, whereas less-than-efficient bearing seals can result in greater grease loss and replenishment costs. The simple rule is that grease should be added any time the amount in the bearing falls below the necessary amount.

Grease should also be replaced at the earliest convenience if its characteristics – mainly oil bleed rate and consistency – have deteriorated through contamination, high temperatures, water or oxidation, thus causing lubricant starvation at the contacts. Consultation of the equipment manufacturer or a lubrication engineer is crucial in the process of optimising the regreasing cycles for any machines.

Automatic systems

As illustrated in Figure 3, automatic lubrication systems can be used on a vast amount of cement plant equipment, from the excavation of raw material, through the manufacturing process, to delivery to the customer. These specialised systems can extend component life significantly by relieving busy technicians of the constant need for lubricating bearings.

It is also important to consider that the bearings used in the cement industry tend to be suited to slower operating processes, but these requirements can change quickly depending on production volume. Thus, it is important to have lubrication systems that can easily cope with rapid increases in demand.

There are two basic types of automatic lubrication systems: single-point (or single-line) lubricators (SPLs) and multipoint (or multi-line) lubricators (MPLs). These tend to comprise a controller, a pump and reservoir, metering valves, supply fittings, and multiple feed lines. Each offers advantages depending on the application and environment particulars.

Single-point lubricators

SPLs automatically dispense the precise amount of clean lubricant to a single point over a pre-set schedule. Many of these electromechanical units are programmable, allowing operators to specify the optimal amount of lubricant flow over a period of days, weeks, months or years. This is advantageous for maintaining a constant pressure and lubricant flow in environments with fluctuating ambient temperatures that can impact the rate at which grease is consumed or deteriorated. There are also gas-powered units that can deliver dependable service in difficult locations, or to locations where there is no ready supply of electricity.

Table 1. The National Lubricating Grease Institute (NLGI) classification of grease consistency

NLGI number	ASTM D217 (tenths of a mm)	Appearance	Consistency of food analogue
6	85 – 115	Very hard	Cheddar cheese
5	130 – 160	Hard	Smooth pâté
4	175 – 205	Very firm	Frozen yoghurt
3	220 – 250	Firm	Vegetable shortening
2	265 – 295	Normal	Peanut butter
1	310 – 340	Soft	Tomato paste
0	355 – 385	Very soft	Brown mustard
00	400 – 430	Semi-fluid	Apple sauce
000	445 – 475	Fluid	Cooking oil

Besides bearings, these direct-mount systems, which tend to be equipped with replaceable canisters or cartridges, can be used periodically to apply grease to chains, guideways, and other industrial equipment components. The units can be set to release grease over variable amounts of time to suit the application and bearing size. A manufacturer will have any brackets, clamps, brushes, fittings, or hose extensions needed to ease installation and provide a range of mounting options.

Many SPLs can also be mounted remotely, typically using a $^1/_4$ in. pipe or $^3/_8$ in. hose or tubing, when installation guidelines are closely followed. The distance a lubricator can be mounted will be dependent upon the model chosen and the specific discharge setting. Many units can be remotely mounted up to 10 ft, regardless of discharge setting.

In cement plants, it can be beneficial to install SPLs on conveyors, bucket elevators, fans and blowers, pumps, and electric motors for several reasons, including the following:

- The creation of a self-contained actuation unit for lubricating remote bearings using power or pneumatic amenities.
- The elimination of the need to manually access unsafe lubrication points, regardless of whether they are inaccessible, at height, or adjacent to rotating elements with limited guarding.

Figure 4. There is often only a small window of opportunity to lubricate bearings in critical equipment without disrupting operations.

Table 2. Application specifics versus base-oil recommendation	
Application details	**Base oil**
High speeds	Low viscosity
High temperatures	High viscosity with extreme pressure additive/solid lubricants
Low speeds, high loads	High viscosity

- The avoidance of irregular and/or infrequent maintenance practices.
- The establishment of relatively simple lubrication requirements.

Multipoint lubricators

For a centralised lubrication solution, there are multipoint systems that can deliver grease to many lubrication points simultaneously.

Many of these lubricators feature integrated keypads with LED displays, making setup fast and convenient for the user. The in-built system flexibility with regards to run and delay times provided by today's units allows operators to make adjustments, even while the equipment is in motion. The option also exists to use relay controllers to interface with the machine PLC, providing the user with optimal control over the system, as well as real-time feedback on pump flow level and grease flow.

Given the rigors of most cement plants, a rugged unit that will withstand shock and vibration is necessary. One place that a multipoint solution is often found is on a series of ball mills, each with multiple pinion-and-trunnion bearing lubrication points over long distances. Similarly, these systems can support multiple machines within the packaging area of the plant.

MPLs have also proven successful on commercial vehicles, due to the multitudes of different lubrication points.

Centralised systems

A screening plant in the UK invested more than US$3.1 million for the manufacture of various products, from railway ballasts to fine granite particles. A lubrication solution was needed for the plant's 12 screens, which each had eight lubrication points: four pedestal bearings, which required 70 g of grease, and four pod bearing assemblies, which required 15 g of grease every 50 hr.

A centralised lubrication system was designed and installed to feed grease to all 96 bearings to aid in the protection of the plant's main assets. At US$40 000, the cost of the automatic system represented just 1% of the total project cost.

In other terms, the cost of the system was equivalent to the cost of a single downtime incident at the plant, including manpower and materials. Furthermore, there was no risk factor for technicians to lubricate bearings while screens are running.

Lubricant considerations for cement equipment

Grease

More bearings are lubricated with grease than with oil, and grease lubrication is simpler, more economical and can provide sealing to bearings, thus keeping out contaminants and resisting water ingress.

Grease is a lubricant made up of approximately 15% thickener and 80% base oil, with the addition of oxidation inhibitors, as well as specific additives and polymers, to provide anticorrosion capabilities, wear and water resistance, extreme pressure endurance, and high film strength properties. It can be applied to a bearing in one of two ways: the bearing can be prepacked with grease, or pressurised grease can be injected into the bearing.

Regardless of the delivery method, the successful use of bearing grease depends on the physical and chemical properties of the lubricant, as well as application and environmental conditions.

Selection

Grease must be carefully selected for its consistency, base-oil viscosity, dropping point, oxidation stability, and extreme pressure performance, as well as for its corrosion, oil separation, and water resistance properties. Grease thickening or thinning, the separation of oil, or oxidisation should be avoided. The dropping point (a measure of the cohesiveness of the oil and thickener of a grease, or the temperature at which the grease turns from semi-solid to liquid state) should be 38˚C higher than the operating temperature.

As the choice of grease for a specific bearing under certain service conditions can be difficult to make, operators should consult a lubricant expert or equipment maker before selection.

Consistency

Greases vary in consistency from fluid (akin to cooking oil) to very hard (akin to cheddar cheese).

Consistency is measured by a penetrometer, in which a standard-weighted cone is dropped into the grease using ASTM D217 method. The distance the cone penetrates, measured in tenths of a millimeter during a specified time, is the penetration number (Table 1).

Grease consistency is not fixed, but rather it changes when sheared or mechanically worked. In the laboratory, this working is accomplished by forcing a perforated plate up and down through a closed container of grease. However, this does not compare with the violent shearing action that takes place in a bearing, nor the oxidation induced at higher temperatures. Thus, any data collected in a laboratory does not necessarily correlate with the actual performance.

Many different types of grease are successfully used for the different types of equipment found within a cement plant. Often a grease with an NLGI grade of 2 or lower is desired.

Types

Identifying the optimal grease requires a good understanding of each specific application, particularly the operating load, speed, temperature, and ambient conditions. There is no universal anti-friction bearing grease; each has limiting properties and characteristics.

As noted above, bearing grease comprises a base-oil, a thickening agent, and additives. Specific base-oils are designed to handle certain applications and environments (Table 2).

Thickening agents within grease manage the bleed-rate by releasing or retaining the base-oil. Some grease thickeners are incompatible with certain thickeners and additives, resulting in undesirable softening or hardening of the grease. This may cause poor lubrication conditions that can shorten the life of components.

Most machines found in cement plants use a mill grease or one formulated for construction. These greases generally offer high-temperature properties, and so are suitable for operating temperatures from -18˚C to 190˚C. In addition, a mill grease will provide enhanced resistance to water washout, high load carrying capabilities, high base-oil viscosity, and protection against both rust and corrosion.

Moreover, many construction and off-highway greases provide strong resistance to extreme pressures caused by shock loading, which is common in crushers and screens.

Kilns and crushers

Kilns and crushers can be especially troublesome when it comes to achieving long bearing life. As such, it is important to note that rotary kilns operate under slow speeds, high loads, and high temperatures, due to process heat. This creates challenges for bearings, open gears and gearboxes. It is quite common to use an extreme-pressure gear oil when operating on a circulation system to manage both heat transfer and filtration. Synthetic lubricants (gear oil or sprayable grease), with essential low frictional characteristics and a high viscosity index, are applicable here.

Crushers operate under extreme shock loads, vibrations, dust, and other difficult environmental conditions, resulting in numerous bearing failures. Conventional greases are not suitable; a heavy-duty bearing grease with tackifier additives, extreme working stability, extreme pressure characteristics, and good sealing capabilities is a must.

Increasing bearing life

The cement plant will never be the ideal operating environment for bearings, but with strict adherence to a regular lubrication schedule, there is nothing stopping plant operators from preventing the one problem that causes the most frequent bearing damage.

Monitoring each lubrication point in a plant, and determining if the bearing life is optimal is the first step in prevention. If there is room for optimisation, the solution might be an automatic lubrication system or, in other cases, a grease that is better formulated for the unique requirements.


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