Techni-Tips 102
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Lubrication of Open Gears: Grinding & Pulverizing Mills

Introduction

In many mining, electric utility and industrial plants, metallic and nonmetallic minerals are pulverized or ground so they can be used as solid fuels or ingredients in products. For example, coal as a solid fuel requires some processing before its latent energy can be fully exploited. At a coal-fired power plant, the coal is pulverized in a mill, then fed into a boiler and used as fuel to heat water and generate steam to drive the turbine. Likewise, limestone must be ground to a fine size so it can be used to manufacture various types of cement or made into a slurry for use in scrubbers at power plants.

Various types of mills are used to grind coal, limestone and other materials. Most of these mills are driven by large pinion and girth gears, which operate in high load conditions. These mills often are critical to a plant's operation and cannot afford to be down except for scheduled maintenance. Therefore, lubrication of these gears with the most advanced lubricant available is crucial in assuring continuous operation of the mills and protecting the expensive gears.

Lubrication Engineers developed its high-performance Pyroshield® line of open gear lubricants specifically for applications subject to extreme conditions such as extreme pressure, shock loading and the high contact point temperatures experienced during boundary lubrication. These lubricants are:

- Pyroshield® Syn Hvy Open Gear Lubricant (9000)
- Pyroshield® Syn XHvy Open Gear Lubricant (9011)
- Pyroshield® Syn Open Gear Grease (5180)

LE formulated its Pyroshield lubricants with its proprietary wear-reducing additive Almasol®, along with a unique combination of EP additives, to ensure outstanding load-carrying ability. Asphaltic lubricants have a Timken OK load of only 20 to 35 pounds as compared to 90 pounds for Pyroshield 9000, 90 pounds for Pyroshield 5180, and 95 pounds for Pyroshield 9011. Plants around the world that have switched from asphaltics to one of LE's Pyroshield lubricants have eliminated the problems with their previous gear lubricant and obtained additional benefits.

Types of Mills

Although a variety of manufacturers make grinding and pulverizing mills, the design and principle of operation are very similar. Each manufacturer tends to concentrate on a specific industry or mineral. The major mill manufacturers and their areas of concentration are listed below.

Manufacturers

- Denver – *metallic & nonmetallic minerals*
- F.L. Smidth – *cement, metallic minerals, mines*
- Foster Wheeler – *coal-fired power plants*
- Fuller-Taylor – *cement, nonmetallic minerals*
- KHD – *mines*
- Metso Minerals
  - formerly Allis Chalmers – *cement, glass sand, metallic & nonmetallic minerals*
  - formerly MPSI/Koppers – *metallic minerals*
  - formerly Riley Stoker/KVS – *coal-fired power plants*
- Outotec (Nordberg) – *cement, metallic & nonmetallic minerals, mines*
- Polysius – *cement, mines*

These mills are referred to by different names, depending on the industry or the type of medium used to crush or pulverize the mineral. Names include SAG, AG, ball, rod, tube,

and pebble, all of which are grinding mills. No matter what the name, the principle of operation is the same. A large rotating horizontal cylinder is filled with a crushing medium and the material to be ground or pulverized. In the case of a ball mill, as the cylinder rotates, steel balls tumble and crush the mineral. Rod mills have steel rods as the crushing medium. Other crushing media can be used, such as rocks in pebble mills and ceramic balls in ore processing. In semi-autogenous (SAG) mills and AG (autogenous) mills, both of which are popular in mineral processing, larger rocks are used to crush themselves with the tumbling action of the turning mill.

These types of mills can be found in practically every industry where there is a requirement to crush or grind a mineral. Particular industries and corresponding minerals are below.

Industries

- Battery manufacturers – *lead*
- Cement – *limestone*
- Coal-fired power plants – *coal, limestone*
- Glass sand producers – *quartz*
- Nonmetallic minerals/mines – *phosphate, perlite, mica, talc, etc.*
- Ore processing/mines – *copper, uranium, iron, gold, molybdenum, zinc*
- Paint (small mills) – *pigments*
- Refractories – *fireclay*
- Sugar – *sugar beets*

Mill Gears

In most units, rotation of the large cylinder is affected by a large open gear train that consists of spur, single helical or herringbone gears. The size of the bull gear will usually range from 1.8 to 12.2 meters (6 to 40 feet) in diameter. The pinion gear normally varies from 1/2 to 3/4 meter (1-1/2 to 2-1/2 feet) in diameter. Although various drive configurations exist, the pinion is usually driven by an electric motor through a gear reducer. Pinion speeds range from 15 to 250 rpm, and bull gear speeds are approximately 20 rpm, depending upon the inside radius of the rotating drum.

Because of the heavy loads in the cylinder that must be rotated, gear protection is extremely important. Replacement costs for pinions range from $11,000 to $50,000. The cost of bull gears are as high as $500,000, and can require up to one year lead time for replacement. In most cases, these mills operate continuously, and the loss of their production time is even more expensive than the replacement costs. For example, if a ball mill or SAG mill is out of operation for one hour at a Chilean Copper Mine, it costs the mine $200,000 or $300,000 USD, respectively.

With proper installation, careful maintenance and proper lubrication, users can expect long, trouble-free gear mill life.

Lubrication

Asphaltic Problems

Historically, asphaltic products had been used in these types of applications, serving more as “cushioning compounds,” than lubricants. Some unleaded asphaltic-based lubes are considered cancer-causing because they contain polycyclic aromatic hydrocarbons (PAHs), which are considered potential carcinogens by the International Association for Research on Cancer (IARC).

Asphaltic products remaining in the bottom of the drums and in the drip pans pose possible health hazards and must be disposed of at an approved hazardous waste disposal site. Approximately 75% of the product remains to be disposed of after use at a cost per pound that depends on the proximity of the disposal site. This is both inconvenient and costly.

In addition to health and disposal concerns, users of asphaltics have been plagued with housekeeping problems. The sticky black asphaltic product also builds up in the gear tooth roots. Because of this, plants experience problems such as worn pinions due to misalignment, pinion bearing failure, breakage of pinion pedestal bolts, and disintegration of the pedestal concrete foundation.

Most users of asphaltic materials have remained so because of a lack of knowledge of alternatives. Molybdenum-based fluid

grease lubricants have offered some improvements. However, they usually result in increased consumption. No product has approached the capabilities of LE's Pyroshield products. Superior lubricants are necessary to protect mill gears from damage and excessive wear. The advanced technology of LE's Pyroshield 9000, 9011 and 5180 lubricants versus conventional asphaltic cushioning compounds and moly fluid greases does just that.

Conversion to Pyroshield

Mill gears are closely shrouded, loosely shrouded or unshrouded. In closely shrouded gear systems on ball mills, LE recommends Pyroshield 9000 or 9011 to enable the small amount of used lubricant to flow out of the shroud and be collected in a container. When there is loose or nonexistent gear shrouding or when product buildup is not a concern, LE's nonmelting Pyroshield 5180 can be recommended.

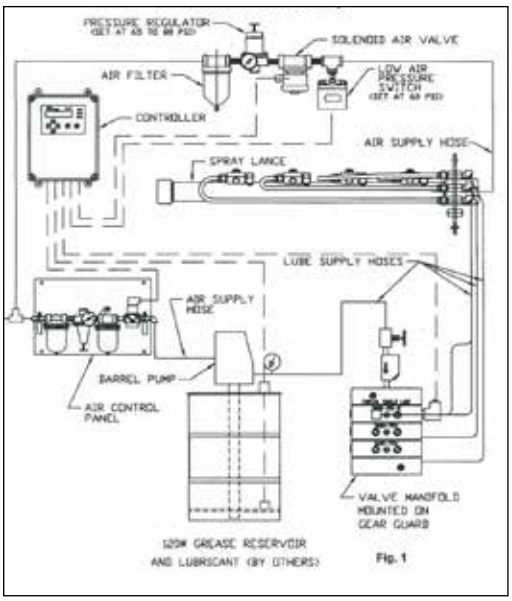
During asphaltic-to-Pyroshield lubricant conversions, LE consultants have recorded before and after pinion operating temperatures. On the larger mills with external heat sources, such as in coal pulverizers where hot primary air – up to 371°C (700°F) – circulates through the mill, pinion temperatures with asphaltic lubricants in service reach 99-104°C (210-220°F). Pinion temperatures with any of the Pyroshield lubricants in service typically run 8-14°C (15-25°F) cooler. Depending on load, mills without external sources of heat generally have pinion temperature of 41-82°C (105-180°F) with asphaltics in service. Pinion temperatures typically decrease with Pyroshield lubricants by 3-6°C (5-10°F).

Automatic Lubrication Systems

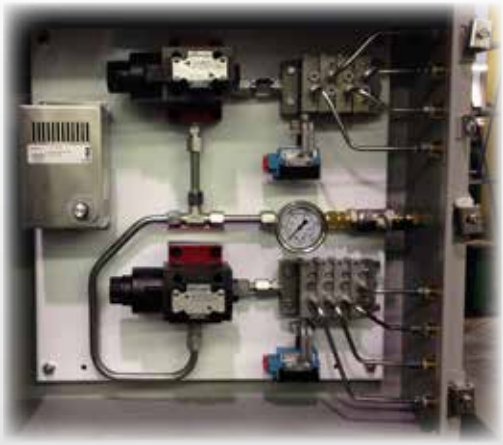
In open gear lubrication, it is critical to get the right quantity of the right lubricant at the right time to the right spot. An automatic spray-type lubrication system is used for lubricating the gear train and does just that. Bijur Delimon, Farval, Lincoln and Trabon are the most commonly used. In these systems, air is used to pump and carry the lubricant to the gears. Although there are variations of these systems, the basic design and principles are the same.

Automatic lubrication systems use an air-operated pumping unit that feeds the system directly from the drum of lubricant. Typically, these systems are designed to operate with 60- to 100-psi air, which is critical to ensure adequate lubrication to the mill gears. An electronic timer controls the frequency of spraying and is fully adjustable for various cycles. The systems usually contain a warning device to indicate when the equipment is malfunctioning, such as during an air supply failure or lack of lubricant. The amount of lubricant supplied to the mill gears is determined by the timing, as well as by the measuring valve size and adjustment.

Cold can be a factor. It is important that the lubricant can be pumped and sprayed at the lowest expected temperatures throughout the year. While Pyroshield 9000, 9011 and 5180 each provides the protection required by these mill gears, the correct one must be used at lower temperatures if drum heaters are not part of the lubrication system. If the temperature to which the lubricant and lubrication system are exposed is less than 13°C (55°F), Pyroshield 9011 is the lubricant to use. Above this temperature, any of the Pyroshield lubricants will work.



Above: *This Bijur Delimon Singline model is a typical automatic spray lubricating system, with pump close to valve panel.* ***Below:*** *A Bijur Delimon system "in a box" for customer demonstrations.*



Farval reports that asphaltic products can harden in the lube lines and valves, which can cause lubricant starvation. If this situation is not detected before damage occurs, catastrophic failure can result. The close tolerance of lubrication system internal components – in particular the pistons in the reversing valve and metering pistons – are subject to abrasive wear due to the asphaltic and molybdenum-

based compounds. Also, these components must handle four to seven times more volume than when using Pyroshield. Thus, wear-related failures occur much sooner with their use.

Because lubrication system malfunction is widespread with the use of asphaltics, and an occasional occurrence even with Pyroshield lubricants, the margin of safety provided by the lubricant is very important to operators. Operators have reported that when lube system malfunction occurs with an asphaltic in service, temperatures begin to rise dramatically within an hour and in some cases fires break out. All of the Pyroshield lubricants have been tested to determine the margin of safety they provide. These results have shown that Pyroshield lubricants provide up to two eight-hour-shift margins of safety before pinion temperatures rise.

Lubricant Comparison: Asphaltic vs. Pyroshield

Problems with Asphaltic & Molybdenum-Based Products

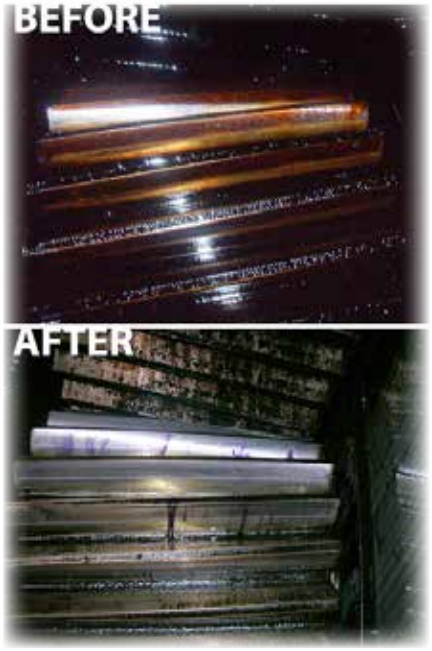
- Health, safety and disposal problems
- Sticky black products create housekeeping problems, requiring drip pans and extra labor to keep clean
- Buildup in tooth roots causing alignment and bearing problems
- Gear wear, with low or no margin of safety
- Lubrication system malfunctioning
- Non draining, leading to buildup in shrouds

Benefits of Pyroshield Lubricants

- No disposal problems.
- Lower consumption. A much smaller amount (compared to asphaltics) is required, due to superior lubricating ability.
- No buildup of lubricant.
- Translucent lube film for ease of inspection
- Lower cost in use
- Lower pinion temperatures mean less friction and wear, which in turn gives longer gear life and a greater lubrication margin of safety to protect gears. “Healing” of moderate gear damage has also been observed.
- No lubrication system malfunctions caused by the lubricant. In fact, a lubrication system was purposely shut off for two eight-hour shifts with no gear temperature rise. This confirms the extra protection of Pyroshield lubricants even when the lubrication system has mechanical problems.
- High viscosity meets or exceeds all relevant manufacturers’ specifications for open gear applications, unlike some competitor products. Pyroshield’s viscosity and film strength are superior to many competitive open gear products.
- Even with its high viscosity, it still has excellent pumpability for automatic lubrication systems.

The benefits listed above have been experienced with all types of mills operating in various industries. Previous lubricant products used include: Whitmore Surtac, Petron Gearshield, Molub-Alloy 907B and 957, Mobiltac, Exxon Surret, Texaco Crater, Fuchs and Kluber.

Note: No lubricant can overcome weak foundations, poor gear alignment, undetected vibrations, poor maintenance and an inadequate lubrication system. Any of these problems will add extra loads of unknown magnitude on top of the designed gear load and need to be addressed separately to prevent gear damage.



Mill gears shown before and after conversion from asphaltic to Pyroshield lubricant.

Summary

Mill open gears are subject to heavy- and shock-load conditions and require lubricants that will provide the protection necessary to ensure the long gear life that users expect while eliminating health hazards, disposal problems, housekeeping problems and minimizing lubrication system malfunctions. All of this has been proven to be accomplished through the use of Pyroshield 9000, 9011 and 5180 high-performance lubricants from Lubrication Engineers.

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