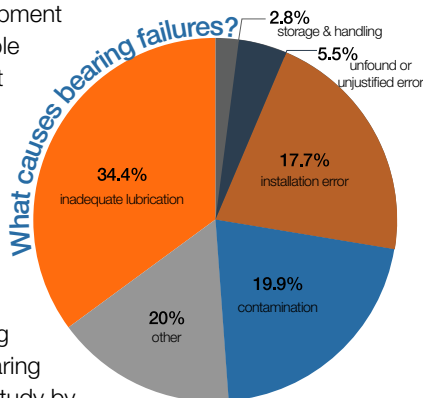


The true cost of bearing lubrication

By Matt Mowry, Product Manager, drylin® linear bearings, igus® Inc.

Introduction

Today, machine and equipment manufacturers are feeling more pressure than ever to reduce costs without sacrificing machine performance, and this balancing act can be difficult to achieve. Original equipment manufacturers (OEMs) often overlook a simple solution that can have a positive, long-term impact on profitability for themselves and their customers: the elimination of bearing lubricant. By eliminating lubrication systems where possible, OEMs can reduce production costs, while at the same time making their equipment more marketable and less expensive to operate for end users.



What are the issues with bearing lubricant? According to a major ball bearing company, 54 percent of bearing failures are lubrication-related (see chart Right). In a study by the Massachusetts Institute of Technology (MIT), it was estimated approximately \$240 billion is lost annually (across US industries) due to downtime and repairs to manufacturing equipment damaged by poor lubrication. Improper bearing lubrication or re-lubrication accounts for up to 50 percent of machine failures. By eliminating lubrication from machinery, OEMs can minimize the costs and risks associated with maintenance for the end user. At the same time, costs related to the proper disposal of oil can be eliminated, and the initial expenditure for ancillary components and processes (grease lines, zerks, manifolds, etc.) can be decreased.

There is a lower cost, easier-to-maintain machine component that eliminates the total cost of bearing lubricants: high performance, dry running plastic bearings.

Re-lubrication maintenance practices fall short due to:

- Lubrication not being properly or consistently administered
 - Lubrication points not being easily accessible
- Maintenance personnel not being properly trained
- Using the incorrect or improper quantity of lubricant

The Hidden Costs of Lubrication

Proper lubrication delivery is critical for the operation of ball bearings, and most require continued maintenance for re-lubrication. The re-lubrication process typically requires scheduled machine downtime, which increases maintenance costs and causes a loss of production time. In addition, re-lubrication maintenance practices often fall short. While some processes are automated, the majority of re-lubrication is performed manually using a grease gun. This seemingly simple task actually involves a number of critical steps to ensure proper lubrication delivery, including correct amount of lube, the right grease gun, proper cleaning, and careful storage and handling conditions, just to name a few. In addition, it is critical to use the same grease for the entire lifespan of a bearing. The Technical Training Division of Life Cycle Engineering conducted a study that found 80 percent of maintenance workers surveyed scored less than 50 percent when it came to the basic technical skills needed to perform their job₂; and “bearing lubrication” was noted first on their list of tasks.

Ancillary components for OEMs

Using lubricated bearings can increase manufacturing complexity and expenses. They often need to be fitted with grease zerks and manifolds, oil lines, and sometimes oil reservoirs and pumps. Not only are there extra costs associated with purchasing these components, there are also manufacturing costs associated with the machining and assembly of the mating parts.

Ancillary components for lubricated bearings

There are also additional parts required to protect them from contaminants. According to McNally Institute, the leading cause of bearing failure is due to contamination of the lubrication by moisture and solid particles. If as little as 0.002 percent water gets mixed into the lubrication system, it increases the probability of failure by 48 percent. Just six percent water can reduce the lifetime by 83 percent₃.

Extra costs for lubricated bearings





Ball bearings require seals to keep oil in and unwanted water and liquids out, as well as wipers / scrapers to keep dust and debris out. Seals only last so long and do not perform well in dirty and dusty environments and can also increase friction in the application. In agricultural machinery and lawn mowers, where dust and debris are prevalent during operation, seals and wipers may require frequent replacement.

Other costs not required for self-lubricating bearings

1. Labor: A major oil company studied the time required to manually lubricate a single grease point. The results showed manual lubrication takes an average of three minutes per point. The average machine has 20 grease points to maintain. This correlates to a total labor cost of \$7,300 annually for maintaining 20 grease points on one machine, every day, seven days per week₄. Another source claims that the average plant employs 2,196 bearings and spends \$60,000 in re-lubrication costs per year; of that \$60,000, \$57,000 is used for labor alone.

2. Downtime: Improper bearing lubrication or relubrication accounts for up to 50% of machine failures. When a bearing fails prematurely, a number of actions may need to be taken. Replacement of the bearings, shafting, and even motor or other parts can be very costly. If the machine needs to be taken offline, expenses can potentially skyrocket. In a six-sigma lead manufacturing guide₅, it was estimated that the average cost for downtime is \$500 per hour, and in some automotive or other high-volume production factories, downtime costs are considerably higher. In addition, unplanned downtime can cause a ripple effect that impacts a plant's production schedule.

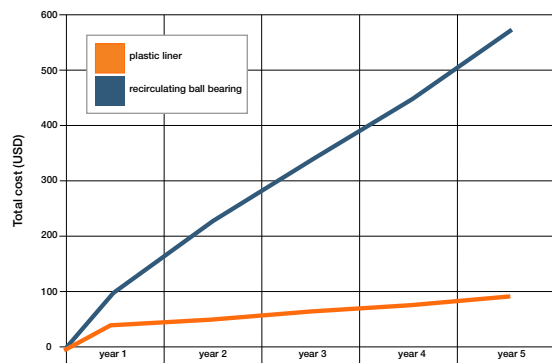
3. Disposal costs: According to Valin₆, proper disposal of lubricants by a process management company can amount to approximately 20 percent of the cost of annual lubricant expenditures. This means if a plant spends \$50,000 per year on lubricants, they will spend approximately \$10,000 in disposal costs. In addition, the cost of the lubrication itself can impact overall expenditures, as it is normally petroleum-based and directly linked to the price of oil.

Ball bearings	VS.	Plastic bearings
 <ul style="list-style-type: none"> + low coefficient of friction + low clearance + high dynamic load - higher cost - requires lubrication - higher noise - hardened shafts necessary 		 <ul style="list-style-type: none"> + no oil required + resistant to dirt + vibration dampening + high static load + linear or rotational movements + low weight + low profile + works with soft shafting - higher coefficient of friction - higher clearance

Self-Lubricating Plastic Bearings

Self-lubricating plastic bearings are made of high-performance polymers and, unlike rolling-element bearings, slide instead of roll. They consist of a base polymer, which is optimized with fiber reinforcement and solid lubricants. The fiber reinforcements increase load carrying capabilities and wear-resistance, and the solid lubricants are transferred from the bearing to the micro-finish of the shaft in order to reduce friction. No external oil or grease is needed for their operation; self-lubricating bearings operate completely dry. They are an ideal solution for applications in labs and food processing machinery that require clean, oil-free operation. Plastic bearings also perform well in dirty environments since there is no oil to attract dust and dirt, like the agricultural industry. They can be used on softer shafting, even anodized aluminum, which has excellent corrosion resistance and is usually less expensive and easier to machine than case-hardened material or stainless steel.

**Plastic bearing liners vs. recirculating ball bearings:
Total cost of replacement parts over 5 years**



Eliminate maintenance costs

Using high-performance, self-lubricating plastic bearings can significantly reduce maintenance costs, as well as reduce unplanned downtime due to bearing failure. OEMs that use self-lubricating plastic bearings are able to deliver a maintenance-free system that increases their end customer's production throughput and the overall marketability of their product. In the event that a self-lubricated bearing does need

replacement, the replacement part (a small, inexpensive plastic sleeve) can be purchased for a fraction of the cost of an entire recirculating ball bearing.

Lower production costs

Plastic bearings do not require the machining and other processes required to install ball bearings. They are less expensive and do not require grease fittings, lines or pumps. Plastic bearings also can be used on less expensive shafting, such as aluminum or cold rolled steel. Some companies offer online calculators to predict bearing lifetime to ensure it is ideal for the application; this eliminates the need for testing, and saves time and errors in material choice.

Benefits of plastic bearings

No maintenance: Once properly installed, plastic bearings don't require any additional maintenance, unlike traditional ball or metal-backed bearing options.

Oil free, dry-running: Engineered plastic bearing materials are a homogeneous blend of a polymer base, strengthening fibers and filaments, and particles of solid lubricant. As friction against a shaft occurs, the particles of lubricant are applied to the shaft, creating a constant coefficient of friction throughout the entire service life of the bearing. Unlike PTFE-lined bearings, plastic plain bearings' self-lubricating properties are present for the full wall-thickness of the bearing.



Lack of oil and grease allows for use in food and medical processing/packaging and other sanitary applications.

Corrosion-resistant: Plastic bearing materials are available to resist a wide range of corrosive media, including water, chemicals, cleaning products, UV rays, and more. Specialized materials are available to stand up to a wide range of harsher media, such as hydrochloric acid, steam/autoclaving, and radiation. This allows for use in wash-down, or even underwater applications.

Lower overall cost than ball bearings: From the initial purchase through the lifetime of a bearing, plastic bearings can represent an overall cost savings greater than 40% when compared to metal bearing options. Eliminating the cost of bearing lubricant as well as the required maintenance costs, partnered with long-running components combined allow for a huge cost reduction for large machinery or plants.



Resistant to contamination; no seals or scrapers required:

Without grease or oil, dirt, dust, and other contaminants are not attracted to a plastic bearing system, eliminating the risk of seizing. Eliminating the need for seals or wipers leads to additional cost savings as well. This makes plastic bearings ideal for sensitive. Clean applications like in biotech or laboratory equipment. This resistance to dirt, dust, and other forms of contamination also make plastic bearings ideal for agriculture or other outdoor or dirty applications.

Ideal for very short-stroke applications, unlike linear ball bearings: Ball bearings require a longer stroke to fully lubricate, and very short strokes can cause ball bearings to slide instead of rolling over the shaft, creating damage. Plastic bearings are able to complete very short strokes, as their coefficient of friction is constant (after an initial start-up phase at the beginning of service life).

Fraction of the weight of metal bearings: Plastic plain bearings weigh approximately one-fifth as much as metal plain bearings, up to one-seventh the weight of some options. Reducing system weight reduces overall drive requirements, and can lead to lower system operation costs and help reduce fuel consumption and/or lowering the inertia of moving parts.

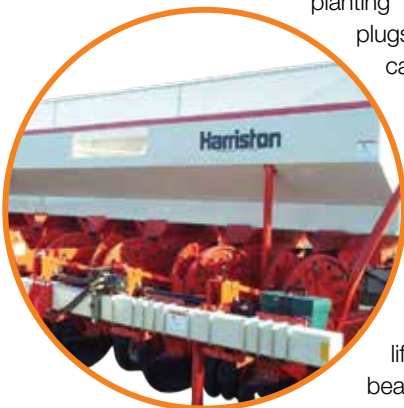
Application parameters not conducive for self-lubricating plastic bearings

- High loads with high speeds: These lead to excessive frictional heat buildup and wear.
- Highly cantilevered loads: Since self-lubricating plastic bearings slide (unlike ball bearings that roll), linear applications with higher coefficients of friction may result in uneven movements for highly cantilevered loads or drive forces.
- Extremely precise applications: Plastic bearings have a higher running clearance than ball bearings, sometimes .001" to .002", and therefore are not ideal for applications needing extreme precision.
- Extreme temperatures: Plastic bearings are not recommended for applications with long-term temperatures >484° F.

Field Applications Using High-Performance Plastic Bearings

Agricultural

A manufacturer of equipment specifically for the farming industry produces 'The Pick Planter', which creates individual planting row units using walking gauge wheels to deliver a consistent planting depth. Oil-impregnated bronze bearings with graphite plugs were used to facilitate this movement until they began causing severe problems. They were even requiring replacement two to three times a season. On the West coast, the bronze bearings were experiencing high wear and premature failure due to the very abrasive conditions caused by high levels of volcanic ash in the soil. On the East coast, the high salt content in the air caused corrosion and seizure. By replacing all 144 bronze bearings with iglide® self-lubricating plastic bearings from igus®, the pick arms' lifespan was increased by 500 to 600 percent. The actual bearings cost 70 to 80 percent less than bronze bearings, and were more reliable.



Packaging

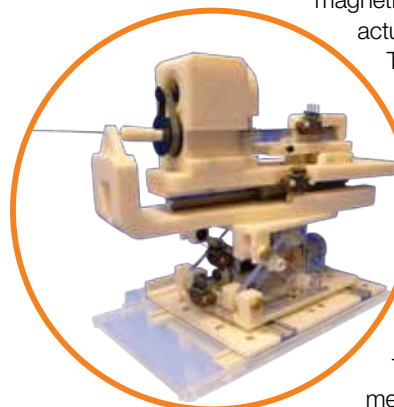
One manufacturer specializes in vertical, form, fill and seal (v/f/f/s) packaging equipment for handling a wide range of products: from green beans to candy to detergent. The machines are capable of reaching up to 160 cycles per minute and withstanding loads up to 15 pounds, while operating at speeds of 750 feet per minute.

The manufacturer had been using metal linear ball bearings. After the metal bearings scored the shafts and leaked grease on some of the machines, the company decided to replace them with self-lubricating drylin® R linear plain bearings. To date, the linear bushings have surpassed the 10-million cycle mark on some of the company's packaging machines with little to no noticeable wear.



Medical

In the quest to improve the way prostate cancer is detected and treated, a team of researchers from the Worcester Polytechnic Institute (WPI) in Massachusetts have developed a specialized magnetic resonance imaging (MRI) compatible piezoelectric actuated robot.



To facilitate different types of motion, the robot uses a drylin linear guide system and iglide plastic self-lubricating plain bearings. The linear guides facilitate translational motion of the positioning module, which provides gross positioning for the robot's needle driver. The needle driver is a vital part of the system, as it enables the rotation and translational movement of the needle cannula: a flexible tube inserted into the patient's body cavity for MRI-guided diagnosis and therapy.

The needle driver has a needle guide sleeve, a collet locking mechanism and passive optical tracking fiducial frame. Two plastic plain bearings are used in the front and rear of the driver to constrain the needle guide. The bearings enable the robot's motor to rotate the needle using the collet mechanism by way of a timing belt. This rotating needle would reduce tissue damage while enhance targeting accuracy. Another 10 plain bearings were used to create a revolute joint, also known as a "pin joint" or "hinge joint", to provide single-axis rotation.

The linear guides chosen are comprised of hard-anodized aluminum rails and carriages and high-performance plastic sliding elements, which do not interfere with the MRI procedure. The linear slides operate without messy lubrication, which is important in a sterile medical environment. They also feature a lower-profile for applications where installation space is an issue. The specific plastic plain bearings used were an ideal choice for the robot, as they are comprised of FDA-compliant polymers specifically designed for applications with contact to food or drugs.

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igus® is certified in accordance with ISO 9001:2015 and ISO/TS 16949:2009 in the field of energy supply systems, cables and harnessing, as well as plastic bearings.



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