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ADVANTAGES AND APPLICATIONS OF SELF-LUBRICATING PLASTIC BEARINGS

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Abstract: *Self-lubricating sliding bearings are widely used in industrial applications and we could assort them in several groups towards manufacturing or lubrication. Some of them, such are oil-retaining porous bearings have been long time studied, but plastic bearings are not enough investigated where we have just some of experimental results. Self-lubricating plastic bearings are produced on polymer basis which is optimized with fiber reinforcement and solid lubricants. They are an ideal solution for machinery that require clean and oil-free operation. Plastic bearings also perform well in dirty environments since there is no oil to attract dust and dirt. Authors of this paper describe main performances and reasons why this kind of bearings are current widely used. A few typical applications of plastic bearings are presented in the paper, taking into account advantages in lubrication, production and maintenance costs in comparison with classical rolling and sliding bearings.*

Keywords: *self-lubricating, plastic sliding bearing, polymers, dry operating.*

1. INTRODUCTION

Most of machine and equipment manufacturers are trying to eliminate or at least to reduce lubrication systems in aim to settle production costs down without sacrificing machine performances. According to significant Bearing Companies investigations, more than 50% of bearing failures are lubrication related (Figure 1). In a study by MIT, USA it was estimated approximately $240 billion is lost annually due to downtime and repairs to equipment damaged by poor lubrication [1].

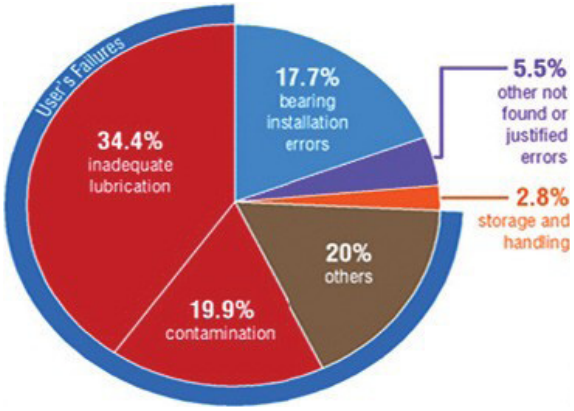

Figure 1. Types of lubricated related bearing failures

By eliminating lubrication from machinery, equipment manufacturers can minimize the costs and risks associated with maintenance for the end user. Because of lubrication problem and costs, which are dominant during the working life, a possible solution is to apply dry running plastic sliding bearing.

Plastic bearings are produced on polymer basis which is optimized with fibre reinforcement and solid lubricants. They are an ideal solution for machinery that requires clean and oil-free operation. Plastic bearings are doing well in dirty environments since there is no oil to attract dust and dirt.

2. PLASTIC BEARING MATERIALS

There are several typical groups of materials for plastic bearings, taking into account their physical-mechanical performances [2]:

- Thermoplastic materials
- Phenol and Epoxy plastic materials
- Elastomers
- Multilayer plastic materials

Thermoplastics and thermoplastic materials are polymers that turn to liquid when heated and turn solid when cooled. They can be repeatedly remelted and remolded, allowing parts and scraps to be reprocessed. In most cases they are also very recyclable. Some thermoplastics contain filler materials such as powders or fibres to provide improved strength and/or stiffness. Products in thermoplastics could also contain solid lubricant fillers such as graphite or molybdenum disulfide. Others contain metal powders or inorganic fillers with ceramics and silicates aimed to improve their mechanical and tribological performances.

Figure 2. igus® lines of plastic bearings made from high performance polymers

Polyethylene (PE), Fluoroplastics (such as PTFE), Polyamide (PA) and Polyoxymethylene (as POM) are common plastic materials from this group and in general, those are using in sliding bearing manufacturing. Detailed performances study of those materials is not aim of this paper [3], but here used to be mentioned just characteristics important for typical applications. If somebody needs plastic bearing for extreme load, than a Homopolymers or Copolymers (POM) with highest strength are recommended. In high environmental temperature conditions of the bearing exploitation Polytetrafluoroethylene (PTFE) is useful with max. working temperature around 200^{o}C. From tribology point of view, materials such PTFE is, has the lowest friction coefficient value (between 0,02 and 0,06 in dry conditions). If we need good wear resistance of the bearing, materials as Polyamide (PA) and POM plastic materials are recommended.

Other plastic materials except above explained group of Thermoplastics are not so common in use, but we could apply them in some special cases. For example, multilayer plastic materials are useful in combination with some metal as a matrix, with different coatings or solid lubricants. Because of current great plastic bearing expansion in wide range of different applications, many companies are exploring and try to on the market with their products. Most of them are sited in Europe or USA and have relatively long tradition, but last years lot of Far East companies are trying to overrun them by low cost products. Some of best known manufacturers of plastic bearings are multinational Company Igus® [4] (Figure 2) with main factories in Germany; famous bearing Company SKF has also some investigations and products in plastics; CSB Bearings [5]; Federal Mogul Germany with Glyco products; AFT Fluorotec (SW Plastics) UK; ISB Italcuscinetti Group Italia [6], etc.

3. ADVANTAGES OF PLASTIC BEARINGS

If we are taking into account proper lubrication delivery as a critical for the operation of ball bearings and most require continued maintenance for re-lubrication, this is a starting reason for thinking about their replacement with plastic bearings. There are also additional parts required to protect ball bearing from contaminants. According to several Institute research, 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 bearing lifetime by 83 percent.

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 some applications where dust and debris are prevalent during operation, seals and wipers may require frequent replacement.

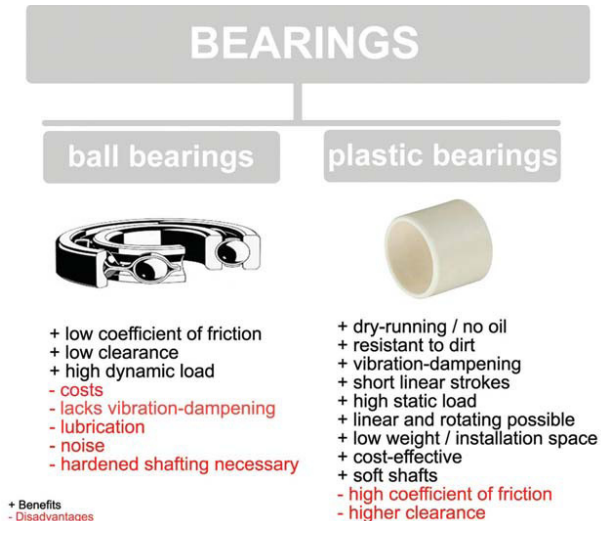

Figure 3. Comparing ball bearings to plastic bearings

4. PLASTIC BEARING APPLICATIONS

Regarding their advantages, plastic bearings are good solution for many applications in machinery that require clean and oil-free operation. They also perform well in dirty environments since there is no oil to attract dust and dirt, like the agricultural industry. Some manufactures creates individual planting row units using walking gauge wheels to deliver a consistent planting depth (Figure 4).

Figure 4. Plastic bearing application in agriculture

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. But 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, or the high salt content in the air caused corrosion and seizure. By replacing all 144 bronze bearings with iglide® selflubricating plastic bearings from igus®, the pick arms lif was increased by 5 to 6 times. The actual bearings cost 70 to 80 percent less than bronze bearings and were more reliable.

Shipbuilding and hydraulic turbine building have accumulated much experience with the use of sliding bearings made of UGET carbon plastic [7]. These include friction units of a driving rudder set of ships of different types and design (supports for rudders and rudder machines) with regard to stabilizers, interceptors, drives for actuators of Kingston valve type, and scupper screens, as well as mast elevating extending devices and mechanisms (Figure 5). Sliding bearings have been previously made of bronze, and shafts have been made of a corrosion resistant material having rather low antifriction characteristics, corrosion resistant steel or titanium alloys. Therefore, in the absence of reliable oil lubrication system there is a danger of seizure of metallic bearings, which may result in the failure of the whole mechanism. UGET carbon plastic containing poly functional epoxy resin and tissue of low module carbon fibre was developed. Bearings made of UGET carbon plastic are successfully used with shafts made of bronze and steels of different hardness and structure.

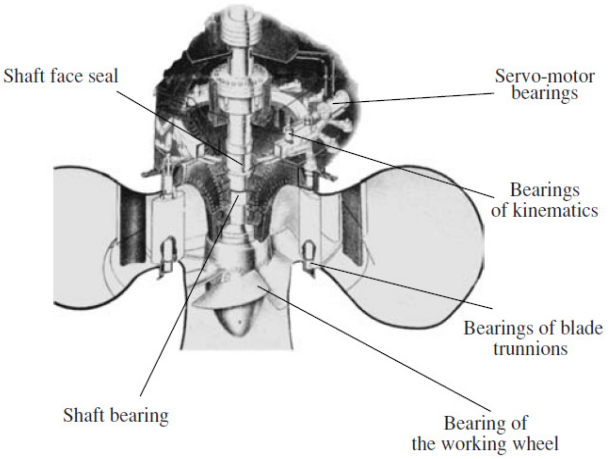

Figure 5. Sliding friction unit of a hydraulic turbine

One manufacturer specializes in vertical, form, fill and seal 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 (Figure 6).

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 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.

Figure 6. Packaging machine with plastic bushings

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 [1]. 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 (Figure 7).

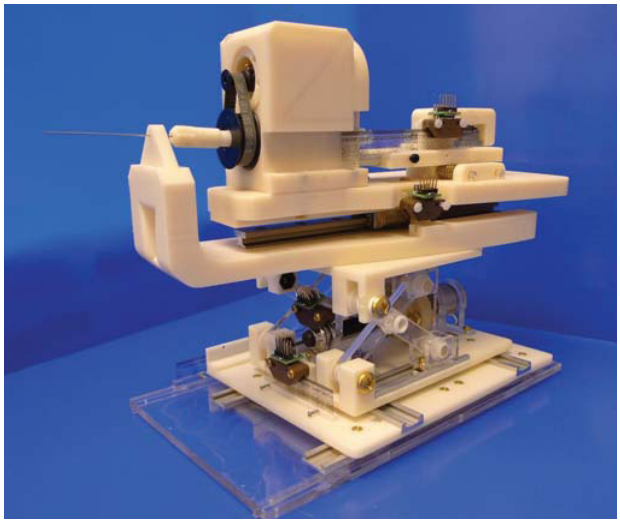

Figure 7. Plastic bearings in magnetic resonance robot

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 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.

CONCLUSION

An actual scientific and practical problem could been solved concerning the development and application of high strength antifriction polymer materials in machine building. According to many researches following by experience in lot of typical applications [8], we could summarize the main benefits of plastic bearings:

- No maintenance
- Oil free, dry-running;
- Corrosion resistant;
- Cost less than ball and other bearings;
- Handle contamination well and often do not require seals or scrapers;
- High damping characteristics for vibrations, ability to reliably work under static or dynamic loads in dry conditions, such also in the presence of many lubricants (water, acids, alkali, oils, hydraulic liquids).
- This kind of bearing can be used on softer shafting, even anodized aluminium, which has excellent corrosion resistance and is usually less expensive and easier to machine than case hardened material or stainless steel.

This paper is just a part of preview and introduction in further researches of plastic bearings subjected to make simpler machine maintenance and better energy efficiency. Because of great expansion and clear explained advantages of plastic bearings application in several branches of industry, not only investigations of new polymer materials, but also deformation behaviour analysis in dry and conditions under different lubricants used to be done.

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