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A Review of Experimental study of effect of viscosity in roller bearing

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Abstract- In this paper include the summery of Experimental study of effect of viscosity in roller bearing. This work aims to characterize vibration behavior of roller bearings as a function of lubricant viscosity. The applied radial load was 10% of the bearing nominal load. Through root mean square (RMS) analysis of the vibration signals, it was possible to identify specific frequency bands modulated by the change in lubricant viscosity, which was related to change in oil film thickness. Cylindrical roller thrust bearings consist of two flat washers and several cylindrical rollers and have generally very high load carrying capacity. However, these bearings also experience a large amount of relative sliding between the rollers and raceways. Consequently, it was considered that these bearings are not suitable for high speed operation. In applying these bearings, this sliding may be reduced somewhat by dividing a single roller into two in each cage pocket rather than a single integral roller.

Key Word- Lubrication, Roller bearing, Vibration, Viscosity, Lubrication ,Wear; Applied load

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1 -Introduction- A bearing is a machine element that constrains relative motion between moving parts to only the desired motion. The design of the bearing may, for example, provide for free linear movement of the moving part or for free rotation around a fixed axis; or, it may prevent a motion by controlling the vectors of normal forces that bear on the moving parts. Bearings are classified broadly according to the type of operation, the motions allowed, or to the directions of the loads (forces) applied to the parts.

The term "bearing" is derived from the verb "to bear"; a bearing being a machine element that allows one part to bear (i.e., to support) another. The simplest bearings are bearing surfaces, cut or formed into a part, with varying degrees of control over the form, size, roughness and location of the surface. Other bearings are separate devices installed into a machine or machine part. The most sophisticated bearings for the most demanding applications are very precise devices; their manufacture requires some of the highest standards of current technology.

Depending on some aspects, lubrication in mechanical systems can occur in different regimes: full film, mixed or boundary lubrication. Full film lubrication can be further divided into elastic-hydrodynamic lubrication (EHL), which occurs in non-conformal contacts under high pressure,

and hydrodynamic lubrication (HD), occurring under low pressure and usually in conformal contacts .
Among the group of mechanical components operating under EHL condition, there are the rolling bearings. This machine element type is one of those more sensitive for development of faults related to lubrication deficiency. According to technical publications of rolling bearing manufacturers , from the total of faults found in this type of component, 50–80% are related to deficient lubrication, resulting from inadequate lubricant use, lack or excess of lubricant, lubricant aging, and presence of solid or liquid contaminant. In the face of high percentage of rolling bearing failures, the development of techniques for detection and diagnosis of faults in rolling bearings, due to lubrication deficiency, is a fundamental contribution to the preservation of machine precision.

2- There are at least 6 common principles of operation:

- plain bearing, also known by the specific styles: bushing, journal bearing, sleeve bearing, rifle bearing
- rolling-element bearing such as ball bearings and roller bearings
- jewel bearing, in which the load is carried by rolling the axle slightly off-center
- fluid bearing, in which the load is carried by a gas or liquid
- magnetic bearing, in which the load is carried by a magnetic field
- flexure bearing, in which the motion is supported by a load element which bends.

Motions

Common motions permitted by bearings are:

- axial rotation e.g. shaft rotation
- linear motion e.g. drawer
- spherical rotation e.g. ball and socket joint
- hinge motion e.g. door, elbow, knee

Friction-Reducing friction in bearings is often important for efficiency, to reduce wear and to facilitate extended use at high speeds and to avoid overheating and premature failure of the bearing. Essentially, a bearing can reduce friction by virtue of its shape, by its material, or by introducing and containing a fluid between surfaces or by separating the surfaces with an electromagnetic field.

- By shape, gains advantage usually by using spheres or rollers, or by forming flexure bearings.
- By material, exploits the nature of the bearing material used. (An example would be using plastics that have low surface friction.)
- By fluid, exploits the low viscosity of a layer of fluid, such as a lubricant or as a pressurized medium to keep the two solid parts from touching, or by reducing the normal force between them.
- By fields, exploits electromagnetic fields, such as magnetic fields, to keep solid parts from touching.

Combinations of these can even be employed within the same bearing. An example of this is where the cage is made of plastic, and it separates the rollers/balls, which reduce friction by their shape and finish.

Loads-Bearings vary greatly over the size and directions of forces that they can support.Forces can be predominately radial, axial (thrust bearings) or bending moments perpendicular to the main axis.

Speeds-Different bearing types have different operating speed limits. Speed is typically specified as maximum relative surface speeds, often specified ft/s or m/s. Rotational bearings typically describe performance in terms of the product DN where D is the diameter (often in mm) of the bearing and N is the rotation rate in revolutions per minute.

Generally there is considerable speed range overlap between bearing types. Plain bearings typically handle only lower speeds, rolling element bearings are faster, followed by fluid bearings and finally magnetic bearings which are limited ultimately by centripetal force overcoming material strength.

Play-Some applications apply bearing loads from varying directions and accept only limited play or "slop" as the applied load changes. One source of motion is gaps or "play" in the bearing. For example, a 10 mm shaft in a 12 mm hole has 2 mm play.

Allowable play varies greatly depending on the use. As example, a wheelbarrow wheel supports radial and axial loads. Axial loads may be hundreds of Newton’s force left or right, and it is typically acceptable for the wheel to wobble by as much as 10 mm under the varying load. In contrast, a lathe may position a cutting tool to ±0.02 mm using a ball lead screw held by rotating bearings. The bearings support axial loads of thousands of Newton’s in either direction, and must hold the ball lead screw to ±0.002 mm across that range of loads.

Fluid and magnetic bearings can have practically indefinite service lives. In practice, there are fluid bearings supporting high loads in hydroelectric plants that have been in nearly continuous service since about 1900 and which show no signs of wear.

Rolling element bearings

Rolling element bearing life is determined by load, temperature, maintenance, lubrication, material defects, contamination, handling, installation and other factors. These factors can all have a significant effect on bearing life. For example, the service life of bearings in one application was extended dramatically by changing how the bearings were stored before installation and use, as vibrations during storage caused lubricant failure even when the only load on the bearing was its own weight the resulting damage is often false brinelling. Bearing life is statistical: several samples of a given bearing will often exhibit a bell curve of service life, with a few samples showing significantly better or worse life. Bearing life varies because microscopic structure and contamination vary greatly even where macroscopically they seem identical.

Plain bearings

For plain bearings some materials give much longer life than others. Some of the John Harrison clocks still operate after hundreds of years because of the lignum vitae wood employed in their construction, whereas his metal clocks are seldom run due to potential wear.

Flexure bearings

Flexure bearings rely on elastic properties of material. Flexure bearings bend a piece of material repeatedly. Some materials fail after repeated bending, even at low loads, but careful material selection and bearing design can make flexure bearing life indefinite.

Short-life bearings

Although long bearing life is often desirable, it is sometimes not necessary. Harris describes a bearing for a rocket motor oxygen pump that gave several hours life, far in excess of the several tens of minutes life needed.

3- Literature- By research paper, In terms of monitoring of rolling bearing performance, vibration measurements are among the most used techniques. Nowadays, a lot of works on detection of localized defects in rolling bearing elements through vibration analysis can be found in the literature; conversely, references on the detection of lubrication-induced faults are still found to be less. Among these, there is one pointing out that when a rolling bearing is inadequately lubricated, its vibration response is similar to that of a system submitted to a random excitation. In the case of systems with low damping, the predominant components of such response would correspond to the natural frequencies of the rolling bearing. On the other hand, according to Berry, frequency spectra of vibration signals for inadequate lubrication condition are characterized by three or four peaks in the frequency bands from 900 to 1600 Hz, corresponding to natural frequency bands of the rolling bearing. In addition, he affirms that these frequency bands are also seen under adequate lubrication condition; although the vibration magnitudes are much smaller in this case.

Over the past 10–15 years, a variety of new and novel coating materials have been designed and developed that have the purpose of conveying the multifunctional qualities of low friction and low wear to various engineering components and devices. These vary in character from simple monolithic materials to relatively complex nanocomposites . While some success has been demonstrated in relatively simple short duration laboratory based tests, actual performance in many application situations, or in field tests, has often proven disappointing. Automotive engine components have to sustain high wear resistance and low friction under relatively hostile conditions.

Typical of this category of components are those found in automobile transmission and power train components. Of the latter, the cam-cam follower application is one that demands high durability to a combination of sliding and rolling contact fatigue under extreme and cyclic contact pressures (>1.2 GPa). Only limited investigations have been carried out in regard to the development of coated components for this type of application. One concern has been that rolling contact fatigue stresses can stimulate failure along the coating-substrate interface , however, it is unclear how such degradation can be minimized.

Pure rolling motion only takes place in the centre of cylindrical roller thrust bearings. The helical motion of the rollers causes a rising slippage (up to 14%) towards the end of the rollers. If a fully separating lubricating film is missing, sliding wear arises in the fields of positive and negative slippage.

In the centre of the rolling contact the wear is small due to the low sliding ratio. In the fields of large wear, the heights of rolling elements and washers are reduced. Simultaneously, the deformation as well as the pressure decrease. In addition to the pressure, the rate of wear is reduced in these areas, too. As a consequence, the rate of wear in the cylindrical roller thrust bearings is decreasing. Apart from adhesive and abrasive wear, fatigue damage can also arise early in coated bearings. From the moment when fatigue damage first appears, the rate of wear increases rapidly.

This paper presents the friction torque of cylindrical roller thrust bearing which consists of the calculated results for bingham fluid and the experimental ones with greases. At first, the fundamental analysis between cylinder and pl for bingham fluid was investigated, and the velocities of the fluid, shapes of the core and film pressures were obtained.

Friction generated between the meshing teeth is the main source of power loss in a planetary gear. On the other hand, rolling bearing friction is also very important because it can reach about 30% of total power loss occurring within the mechanism. In this sense, understand the friction torque generated within rolling bearings is essential in order to reduce their contribution to the overall power loss. There are four physical friction sources inside a rolling bearing: rolling friction , sliding friction, seal friction and drag losses . The most important ones in the case of windmill applications (high torque and low speed) are the friction occurring in the contact between the rolling elements and raceways (sliding friction) and the friction due to the lubricant flow between the bearing elements (rolling friction). These energy loss mechanisms are highly dependent on the lubricant ability to generate an effective oil film between the rolling elements and the raceways and on the physical properties of the gear oils.

4-Conclusion- Roller bearings are used in order to verify differences in vibration response when lubricated with different viscosity oils. The vibration behavior was studied in two main frequency bands and by using a tribological parameter (l factor). Changes in lubrication regime of roller bearings due to change in oil viscosity grade could be detected by vibration monitoring. In the tests with ISO 32 and ISO 68 viscosity grades, lubrication regime was of full film type. With the ISO 10 grade, lubrication regime was supposed to be very near to that of mixed type. Variations in oil viscosity in roller bearings, caused by either the use of different oils or temperature variation, only affect the bearing vibration in HF band (600–10 000 Hz).

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