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EFFECT OF SOLID CONTAMINATION IN BALL BEARINGS- A REVIEW

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ABSTRACT

This paper presents the study of literature on solid contamination in ball bearing. Review includes experimental, analytical, and numerical and software based analysis. Effect of contamination on the performance of ball bearing due to solid particle of different material is the main study parameter. Most of the researchers study the dynamic behavior of ball bearing. An exhaustive review shows that the viscosity is also a major factor to effect bearing performance at high speed.

Keywords:-ball bearing, solid contamination, materials

INTRODUCTION

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. Due to the relative motion between the bearings in the moving element a considerable amount of energy is lost to overcome frictional resistance. Other bearings are separate devices installed into a machine or machine part [1].

Figure 1-Ball *Bearing*

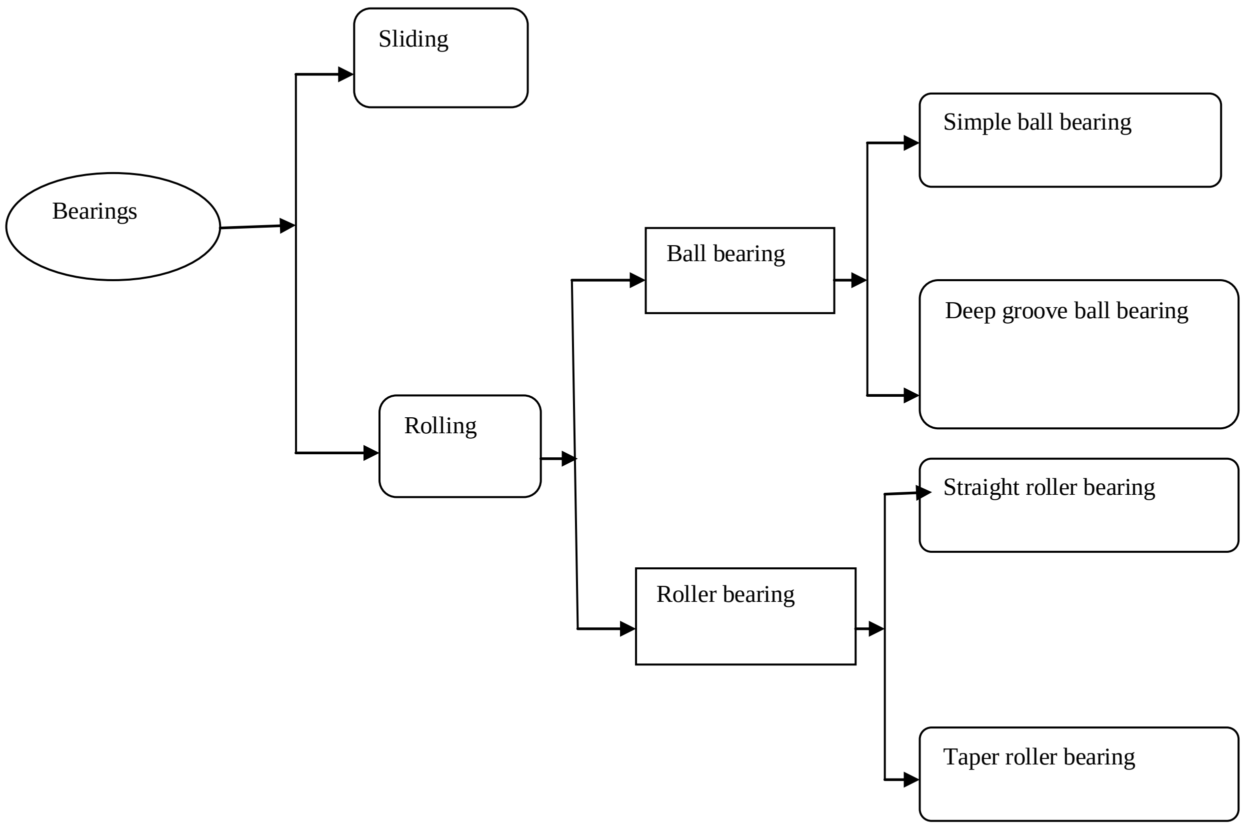
A bearing is a machine element that constrains relative motion between moving parts to only the desired motion. M.M. Maru (2007) aims to characterize vibration behavior of roller bearings as a function of lubricant viscosity. Experimental tests were performed in NU205 roller bearings, lubricated with mineral oil of three different viscosity grades (ISO 10, 32 and 68). The mechanical vibration was determined through the processing and analysis of bearing radial vibration data, obtained from each of the lubrication conditions, during 2 h of test run for temperature stabilization and under several bearing shaft speeds. 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 [2].

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).A relationship between RMS vibration s in EHL regime [3].

values in HF band and l factor was obtained, which was very similar to the standard Steinbeck curve, relating friction coefficient with l factor, found in the literature for system

Types of bearing

Figure- 2 Types of bearing



BALL BEARING

In these bearing steel balls are interposed between the moving element and fixed element. The purpose of a ball bearing is to reduce rotational friction and support radial and axial loads. It achieves this by using at least two races to contain the balls and transmit the loads through the balls as one of the bearing races rotates it causes the balls to rotate as well. Because the balls are rolling they have a much lower coefficient of friction than if two flat surfaces were sliding against each other [5].

Ball bearings tend to have lower load capacity for their size than other kinds of rolling-element bearings due to the smaller contact area between the balls and races. However, they can tolerate some misalignment of the inner and outer races [5].

a) Simple ball bearing

A ball bearing is a small ball, usually metal that is part of one type of bearing it is used to lessen friction between moving parts of a machine.

b) Deep groove ball bearing

Deep groove ball bearings have deep, uninterrupted raceway grooves. These raceway grooves have a close osculation with the balls, enabling the bearings to accommodate radial and axial loads in both directions. Deep groove ball bearings are the most widely used bearing type. Consequently, they are available from SKF in many designs, variants, series and sizes.

Rolling contact bearings

In rolling contact bearings, steel ball or rollers are interposed between the moving element and fixed element .in this bearings shaft or journal is supported rigidly inner race are which rolls over the rolling element. That balls or rollers these rolling elements in turn are supported by the outer race of the bearing.

Ball bearing materials

There are essentially two choices for the material used in ball bearings - chrome steel or stainless steel. Since the material plays a major part in the performance of a bearing in any given application, it is very important that the correct material is used. Note that the specified material applies to the load bearing components only - the rings and the balls. The retainer and the shields (if used) are usually made from a different material and are subject to separate specification.

a) Chrome steel: - This is the standard material used for ball bearing applications where load capacity is the main consideration. The mach inability of this steel is excellent, giving smooth, low noise raceway finishes, together with superior life. Chrome steel material is recommended in applications where corrosion is not a factor.

Table No.1- Standard values of chrome steel

C CARBON	Mn MANGANESE	Si SILICON	P PHOSPHOROUS	S SULPHUR	Cr CHROMIUM	Mo MOLYBDENUM
.95 - 1.1	.15 - .35	Max .5	Max .025	Max .025	1.3 - 1.6	----------

b) STEEL: - These materials have evolved in response to different manufacturing and application needs. It is important to note that the actual material used is generally determined by the manufacturer, and cannot be specified by the user.

Table No.2- Standard values of steel

C CARBON	Si SILICON	Mn MANGANESE	P PHOSPHOROUS	S SULPHUR	Cr CHROMIUM	Mo MOLYBDENUM
6 - .7	Max 1.0	Max 1.0	Max .03	Max .01	12 - 13.5	Max .25

LITERATURE REVIEW

Sujeet K. Sinha (2010) founds that In this paper, we introduce a new class of micro-ball bearing that can be applied between two Si surfaces in relative motion where wear is a problem. Wide channel was created on one Si plate for all the ball bearings to roll within this channel rather than in individual grooves. This type of micro-bearings can be applied as friction reducers to micro- and nano-machines. The tribometer set-up consisted of a top plate (Si wafer), which was connected to a conventional bearing. Tests on the plate with wide channel consistently exceeded 1 million cycles of rotation without failure of the bearing. The main factors affecting the life-cycle are identified as the presence of a wide channel, ball dispersion, and alignment of the Si plates [8]. Micro-ball bearing has been tested with balls rotating between two 15mmdiameter Si plates, with and without a channel on one of the plates.

In total, The surface bearings exhibit extremely low coefficient of friction due to rolling action. The rolling life-cycles exceeding 1 million is consistently obtained when the balls are rotated between two Si plates with one of the plates having a wide channel. Such a channel helps to keep all the balls within the boundaries giving low coefficient of friction throughout the run Tuncay Karacay (2010) founds Vibration measurements and signal analysis is widely used for condition monitoring of ball bearings as their vibration signature reveals important information about the defect development within them [10]. Time domain analysis of vibration signature such as peak-to-peak amplitude, root mean square, Crest factor and kurtosis indicates defects in ball bearings. However, these measures do not specify the position and/or nature of the defects. Each defect produces characteristic vibrations in ball bearings. Hence, examining the vibration spectrum may deliver information on the type of defects. In this paper a test rig is designed and a pair of brand new commercial ball bearings is installed. The bearings run throughout their lifespan under constant speed and loading conditions. Vibration signatures produced are recorded and statistical measures are calculated during the test. When anomalies are detected in the statistical measures, vibration spectra are obtained and examined to determine where the defect is on the running surfaces. At the end of the test, the ball bearings are disassembled in order to take microscopic photos of the defects [12].

Tiago Cousseau et al (2011) founds that thrust ball bearings lubricated with several different greases were tested on a modified Four-Ball Machine, where the Four-Ball arrangement was replaced by a bearing assembly. The friction torque and operating temperatures in a thrust ball bearing were measured during the tests. At the end of each test a grease sample was analyzed through ferrographic techniques in order to quantify and evaluate bearing wear [9]. The experimental results obtained showed that grease formulation had a very significant influence on friction torque and operating temperature. The friction torque depends on the viscosity of the grease base oil, on its nature (mineral, ester, PAO, etc.), on the coefficient of friction in full film conditions, but also on the interaction between grease thickener and base oil, which affected contact replenishment and contact starvation, and thus influenced the friction torque [13]. A qualitative analysis of the results suggests that the base oil properties and the interaction between base-oil and thickener are the predominant factors in the tribological behaviour of a grease lubricated thrust ball bearing.

Chao Jin (2012) founds the operation of a machine tool (MT), the frictions in ball bearings entail sudden and violent heating of the balls which dominants its thermal deformation, and subsequently results in degradation of its accuracy and performance. Modeling of the heat generation in a bearing is a quite difficult job because of the constantly changing characteristics. In this paper, an analytical approach was proposed to calculate the heat generation rate of supporting bearing in a ball–screw system of the MT, with consideration of the operating conditions, such as rotation speed and external loads of the machine tool. The influences of operating conditions to internal load distribution, contact angles and heat generation rate of ball bearings were analyzed. The friction torque due to the applied load and the sliding torque within the contact area were discussed in detail. Experiments were carried out in a high-speed ball–screw system to verify the validity of the presented analytical method. The work described in this paper can be seen as a foundation for the accuracy thermal modeling and thermal dynamic analysis of the ball–screw system in the machine tools [8].

The aim of the paper was to study the heat generation rate of ball bearings with respect to rotational speed and load applied to a feed system. Also, this paper presents an analytical method to calculate heat generation rate of a ball bearing based on careful consideration of load distribution in the internal bearing elements, as well as the changing contact angles of both the inner and outer raceway contacts. Based on an iterative algorithm, it allows one to obtain very quickly the exact angles values to be used in further calculations. Contact forces, pressure, deformation and spin to roll ratios directly do depend on contact angles [6].

Tiago Cousseau et al (2012) found the friction torque and the operating temperatures in a thrust ball bearing were measured for seven different types of greases, including three biodegradable greases having low toxicity. These friction torque tests were performed using a modified Four-Ball machine Rheological evaluations of the lubricating greases were made using a remoter. Bleed oils were extracted from the greases and the dynamic viscosities were measured. In order to compare the performance of the lubricant greases in terms of friction, the grease characteristics were related to experimental results, showing that the interaction between thickener and base oil have strong influences in the bearing friction torque The viscosity of the bleed oil is higher than the viscosity of the base oil in the case of polypropylene thickened greases and the opposite was observed in the case of lithium thickened greases [14].

Carlos M.C.G. Fernandes (2013) Planetary gearboxes used in wind turbines very often have premature bearing and gear failures, some of them related to the lubricants used. Five fully formulated wind turbine gear oils with the same viscosity grade and different formulations were selected and their physical characterization was performed. The lubricant tribological behaviour in a thrust ball bearing was analyzed. A modified Four-Ball Machine was used to assemble the bearings. They were submitted to an axial load and the tests were performed at velocities ranging between 150 and 1500 rpm. Experimental results for the operating temperatures and for the internal friction torque are presented [4]. Above 500 rpm, the total friction torque inside the TBB decreased when the operating speed and temperature increased for the synthetic lubricants (ESTF, ESTR, PAGD and PAOR). The TBBs lubricated with high VI gear oils had an almost constant rolling friction torque for operating speeds equal or above 500 rpm. Above 300 rpm, the rolling torque of the TBB lubricated with mineral oil decreased as the operating speed increased.

CONCLUSION

In rolling bearings, contamination of lubricating oil by solid particles is one of the main reasons for premature bearing failure, So that the effect of lubricant contamination by solid particles on the dynamical behavior of rolling bearings. In order to determine the trends in the amounts of vibration affected by contamination in the oil and by the bearing wear is necessary. The effect of contaminant concentration on vibration was distinct from that of the particle size. The vibration level increased with concentration level, tending to stabilize in a limit. On the other hand, as the particle size increased, the vibration level first increased and then decreased. Particle settling effect was the probable factor for vibration level decrease. In this paper a review of literature has been made to study the effect of contamination on bearing performance.

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