Comparative Study of Performance of Hydrodynamic Journal Bearing with a Bio-Lubricant and ISOVG 100- A Review Paper

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Abstract: Journal bearing is a mechanical component that provides support to shafts in rotating machinery such as turbines in hydro power plants, rotor of ships, turbine of thermal power station etc. It works on the principle of hydrodynamic lubrication in which a thin film of lubricant is used to provide support to the shafts in rotating machineries. So the perfect function of journal bearing majorly depends on selection of proper lubricant. In the current scenario The majority of industries use petroleum oil as a lubricant in journal bearing due to this concentration of petroleum oil in earth crust decreasing rapidly and the wastage of petroleum oil causes hazardous impact on the environment. In this review paper different types of bio lubricants were examined such as castor oil, soybean oil, jatropha oil etc. to find a best alternative which was replaced by petroleum oil such as ISO VG 100.

***Keywords*:** Journal bearing, Pressure distribution, castor oil, soybean oil, ISO VG 100.

1. INTRODUCTION

A bearing is a machine element which supports or guides a moving element permitting its relative motion. When there is a relative motion between two machine parts, one of which supports others. The supporting member is called Bearing. Due to the relative motion between two elements, friction occurs, and there is loss of energy. To minimize the loss of energy, lubricants are used between the contact surface of the bearing and moving elements.

1.1 PRINCIPLE OF JOURNAL BEARING

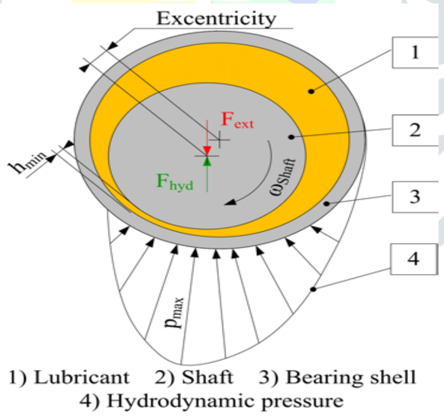

Figure 1: schematic diagram of working of journal bearing

The journal bearing works on the principle of hydrodynamic lubrication which states that a thick film of lubricant is generated between the load carrying shaft and the bearing surface to prevent metal to metal contact between them. Here the pressure to support the shaft is generated by a centrifugal force of rotating fluid so there will be no external pressure required to support the shaft. Figure 1 illustrates the working of journal bearing in which at initial position when the shaft is steady there will be metal to metal contact between shaft and bearing surface. When the shaft starts rotating with high speed the lubricant which is in contact with the shaft surface will also rotate and generate a thick film of lubricant which induces centrifugal force and lifts the shaft.

1.2 LUBRICANTS

The lubricant must be able to allow the motion of the moving part. Its presence avoids the metal-to-metal contact. The surface of metals is not plain, but is irregular with peaks and valleys. When two metals in relative movement are in contact, there is a severe friction effect between both surfaces, resulting in noise, losses and damage.

2. LITERATURE REVIEW

To gain the knowledge of Hydrodynamic Journal Bearing, its working principle and to get acquainted with the behaviour of the journal bearing under the application of the load the following literature has been carried out.

In this research paper they study and compare the friction forces and friction coefficient of jatropha oil with petroleum oil such as XT 46 and 20W40 for different L/D ratios with the help of journal bearing tester. And they conclude that they got maximum pressure distribution for jatropha bio-oil as compared to XT 46 and 20W40, So it is beneficial to use. The main point where bio lubricants are ahead is their biodegradability which acts as a non pollutant for the environment. Jatropha works on low operating temperatures generates high torque but power loss is high, this is because of high viscosity. The viscosity of the jatropha reduces very rapidly as L/D ratio increases, so jatropha can be used for high L/D ratio journal bearings. Jatropha Bio-lubricant shows the intermediate hydrodynamic behavior for pressure and load carrying capacity as that of the 20W40 and Turbinol XT 46. Jatropha oil shows several good characteristics high viscosity and increased load carrying capacity hence can be used as alternative bio-lubricant for journal bearing application. (P.A.Narwade 2017)

In this research paper they carried out a tribological study of popular synthetic lubricant ISO VG 32, 46, 68 and SAE-40 oil with Jatropha oil. Tribological properties of Jatropha were computed experimentally and the performance of hydrodynamic journal bearing using Jatropha Bio-lubricant is theoretically investigated and validated analytically by using CFD Software. The theoretical results for maximum pressure at different eccentricity ratio and journal speed have been evaluated .They conclude that Jatropha Biolubricant gives the intermediate hydrodynamic behavior for pressure and load carrying capacity as that of the ISO VG 32 and ISO VG 46. Both theoretical and analytical results show enhancement in maximum Pressure and load carrying capacity of the Jatropha bio-lubricant rises with increase in journal speed and eccentricity ratio. Jatropha oil shows several good characteristics high viscosity and increased load carrying capacity hence can be used as alternative bio-lubricant for journal bearing application. (S. Khasbage 2016)

In this research paper they analyzed the pressure distribution on hydrodynamic journal bearing under different lubricants for various loading conditions and various operating parameters. Journal bearing test rig (JBTR) is used to test the 40 mm diameter and 40 mm long bearing. The vegetable oils such as rapeseed oil and soya bean oil were tested under the different operating conditions in the JBTR and the results are compared with the SAE20W40. They conclude that at all operating conditions of 300N and 450N, 1500 rpm and 1750rpm it is observed that pressure variation in rapeseed oil is same as that of SAE 20W 40 with a variation of 10 to 20%. At same operating conditions the pressure distribution plot is found to be similar with a very minimum variation even in the pressure range for rapeseed oil. At operating conditions of 300N and 450N, 1500 rpm and 1750 rpm the pressure distribution plot is found to be not similar and a maximum variation of 50 to 75% in the pressure range for soya bean oil. Soybean oil seems to be very low in viscosity leading to higher heat generation. The oil film thickness formed by soya bean oil was very much low, leading to some metal-to-metal contact in between the journal and shaft. Therefore it is concluded that soya bean oil as a raw vegetable oil is not suitable for the lubrication purpose in journal bearing. (Sriram 2012)

In this research paper three types of lubricants such as mineral oil, a synthetic oil and a bio-based (AWS-100 SAE-10W40 SAE-30) are used in order to examine their effects on the tribological behavior of journal bearings. Lubricants are experimentally and analytically examined for several configurations of load and journal rotational velocity. The friction forces and the hydrodynamic friction coefficients are calculated and compared. And they conclude that the use of the synthetic lubricant yields the best possible performance among the three lubricants examined in this work. These benefits in terms of friction coefficient are significant. The bio-lubricant also exhibits a decrease of the friction coefficient in comparison to the SAE-30 oil. The performance benefits though for both the synthetic SAE-10W40 and the ISO AWS-100 bio-lubricant depend on the specific operating conditions of the journal bearing. Also they conclude that the effect of temperature on the performance of the bio-lubricant may prove to be significant. (bompos 2015)

In this research paper tribological performance of crude Nigeria-based castor oil has been investigated and compared with 20W-50 high quality crankcase oil, to see its suitability as base oil for lubricating oils in indigenous vehicle and power plants engines. The experiment was conducted using a four ball tester. The results showed that unrefined castor oil has superior friction reduction and load bearing capability in an unformulated form than the commercial oil; can compete favorably with the commercial oil in wear protection when formulated with suitable antiwear agent, hence can be a good alternative base stock for crankcase oils suitable for Nigeria serviced vehicles, and plants engines from tribological, environmental, and non-food competitive points of view. (B. Bongfaa 2015)

In this paper performance characteristics of a hydrodynamic journal bearing lubricated with a Bingham fluid are derived by three-dimensional computational fluid dynamics (3-D CFD) analysis. The FLUENT software package was used to calculate the hydrodynamic balance of the journal using ‘‘dynamic mesh’’ technique. The results obtained from the developed 3-D CFD model are found to be in very good agreement with experimental and analytical data. They conclude that the volume of a core occupies is greater for a larger value of L/D and T0 for a specific relative eccentricity. A core is formed at a specific relative eccentricity and adheres to the bearing surface at the inlet side. The core moves to the outlet side for greater values of relative eccentricity. At a high value of relative eccentricity, a core is formed and adheres to a small region of the journal. As the value of eccentricity increases, the solid on the bearing separates into two or three parts and a floating core between these parts is observed. The load carrying capacity, the film pressure, and the frictional force of a Bingham solid are larger than those of a Newtonian fluid and they increase as the yield stress increases. (N.U. Manojkumar 2008)

In this paper they study the performance characteristics of the journal bearing experimentally having different geometries operating with commercial Mobil grade lubricants that are used in power plants. Three grades of Mobil lubricants (DTE 24, DTE 25, and DTE 26) have been considered during the study. TiO2 nanoparticle additives have also been considered during the study as a lubricant additive to examine the performance of journal bearings. The dynamic characteristics such as stiffness and damping properties of journal bearings are represented in this paper. An experimental test rig is developed to accommodate any geometrical type of bearing. An elliptical journal bearing shows the superior performance than that of a plain bearing. The obtained experimental results are in a very good agreement with theoretical results for pressure and temperature profile. And they also conclude that the performance characteristic is improved using TiO2 nanoparticle additives in the lubricating oils for both plain and elliptical journal bearings. After addition of TiO2 nanoparticle additives, the pressure distribution increases upto 87.79 %, 187.12 % and 364.34 % in an elliptical bearing as compared to a plain bearing when operating with Mobil DTE 24, Mobil DTE 25 and Mobil DTE 26 respectively. At the same time, the temperature rise in an elliptical bearing operating with Mobil DTE 24, Mobil DTE 25 and Mobil DTE 26 containing TiO2 nanoparticle reduces upto 73.60 %, 68.18 % and 70.26 % respectively. (Pattiwar 2019)

In this research paper they present development of wear in plain hydrodynamic journal bearings under repeated cycles of starting and stopping by experimentally. The wear which occurred caused easily discernible but localized changes in diametric clearance, .surface finish, and roundness of the bearing's bore and these changes were measured after various numbers of operating cycles had been completed. They Studied of the location, within the bearings of the wear which arose, showed that it was caused entirely by the sliding which occurred during starting and that no significant contribution to the wearing process was made during stopping. It was also observed that, once an initial rapid phase of wearing was completed, the surface finish of the hardened steel shaft was reproduced in the regions of the bearing surface which continued to be worn. (M.O A. Mokhtar 2008)

3. CASTOR OIL

Figure 2 : castor beans

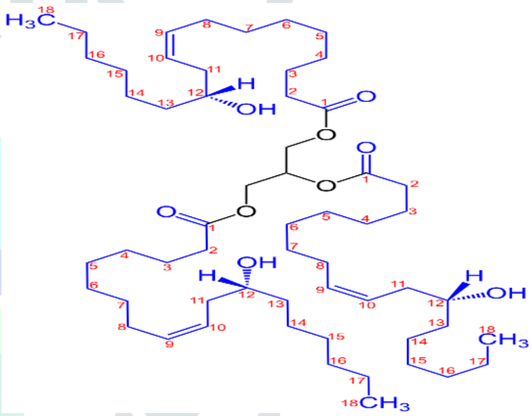

Figure 3 : chemical composition of castor oil

Castor oil is a vegetable oil derived from castor beans shown in figure 2. It is mainly used in soaps, paints, dyes, inks, waxes etc. castor oil is an colorless having boiling point 313°C and kinematic viscosity is 238.1 centi-stock. The main source of castor oil is a ricinoleic acid. The chemical structure of castor oil is shown in figure 3 it shows that at 12 no. of carbon there will be a hydroxyl group showing a major sign of being a lubricant. If it's pure form of castor oil is used as a lubricant. Due to high viscosity it resists the flow of oil inside the bearing and causes problems such as high heat generation and friction losses etc. so pure form of castor oil is not suitable as a use of lubricant.

4. SOYBEAN OIL

Figure 4 : Beans of soybean

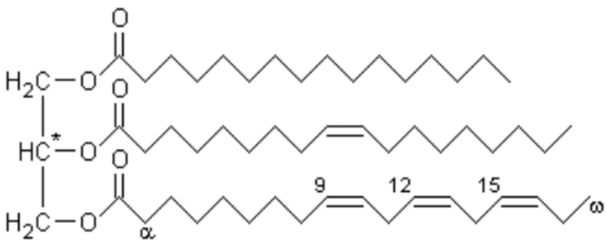

Figure 5: chemical structure of soybean oil

It is a vegetable oil derived from beans of soybean shown in figure 4. Soybean oil mainly used in oil paints, food, drying oil etc. the chemical structure of soybean oil is shown in figure 5 which states that soybean oil is a part of an ester group. The kinematic viscosity of soybean oil is 31.6 centi-stock. Due to its low viscosity if the pure form of soybean oil is used as journal bearing lubricant then there will be a chance of metal to metal contact between the shaft and journal.

5. ISO VG 100

ISO VG 100 is a petroleum based lubricant highly used in the journal bearing. Here ISO VG means international standard organization viscosity grade and 100 is a viscosity index of the oil.

6. CONCLUSION

Here author examine properties of bio-lubricant such as castor oil and soybean oil and compare with petroleum oil ISO VG 100 and from research it conclude that the pure form of castor oil is not suitable as a lubricant because its high viscosity and a pure form of soybean is also not suitable as a lubricant due to its low viscosity. But the mixture of castor oil and soybean oil gives nearly the same viscosity as ISO VG 100. So there is an emerging need for an experimentally and analytically investigation of different concentration mixture of castor oil and soybean oil in a journal bearing test rig for different loading conditions and compared with ISO VG 100.

7. REFERENCES

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