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Abstract—The aim of this project is experimental analysis of Hydrodynamic journal bearing with Nano particle added lubricating oil. The dynamic analysis of hydrodynamic solid journal bearing operating under nano lubricants will be presented in this paper. The load carrying capacity of solid journal bearing mainly depends upon the viscosity of the Lubricant being used. The addition of nano particles on commercial lubricants may enhance the viscosity of lubricant and in turn changes the performance characteristics. In the proposed work is about to obtain pressure distribution in the clearance space of the solid journal bearing.

Key words: Hydrodynamic Journal Bearing, Nanoparticle Lubricant

I. INTRODUCTION

The current trend of modern industry is to use machineries rotating at high speed and carrying heavy loads. In such applications hydrodynamic bearings are widely used. When a bearing operates at high speed, the heat generated due to large shear rates in the lubricant film raises its temperature, which lowers the viscosity of the lubricant and in turn affects the performance of journal bearing. Addition of nanoparticles in the lubricant may enhance the viscosity of the lubricant and in turn changes the static and dynamic performance characteristics of the bearing. Therefore, a thermo hydrodynamic analysis is necessary to predict the performance characteristics of the journal bearing operating under nanolubricants (lubricants, which contain nanoparticles). Solid journal bearings are used in heavy machineries to support high loads. The load bearing capacity of hydrodynamic journal bearing get enhanced by addition of nano particle because of enhancement of viscosity of lubricant and in turn affect various performance characteristics of hydrodynamic solid journal bearings. The use of nanoparticles as lubricant additive has been a major subject of research in the past decade. Various metals and metal oxide nanoparticles have been studied as lubricant additives in thin film lubrication. Recent experimental study of Static and Dynamic Performance Characteristics of THD Journal Bearing Operating under Lubricants Containing Nanoparticles conducted by Sreedhar Babu Kalakada (2012). They have obtained Furthermore viscous case addition of nanoparticles increase the load capacity of journal bearing at any eccentricity ratio, and this increase is significant at high values of the eccentricity ratio. For example, 0.5% weight concentration of nanoparticles increases the load capacity by 14.45% (CuO), 13.98% (CeO₂) and 12.53% (Al₂O₃) on thermoviscous case when bearing operates at ε=0.9. The friction force of bearing increases with the increase in concentration of nanoparticles for both isoviscous and thermoviscous cases. Addition of nanoparticles on the commercial lubricants may enhance the viscosity of lubricants and hence, in turn, load capacity of bearing. Hydrodynamic journal bearings are extensively used in high speed rotating machinery. When a bearing rotates at high speed and heavy load, the heat generated due to large shear rates in the lubricant film raises its temperature which lowers the viscosity of the lubricant and in turn affects the performance of journal bearing. A thermo hydrodynamic analysis is therefore necessary to predict the performance characteristics of the bearing.

II. LITERATURE REVIEW

Following are some of the important reviews of different researches and scientists.

Sreedhar Babu Kalakada et al. Studied the static and dynamic performance characteristics of journal bearing in terms of load capacity, attitude angle, end leakage, frictional force, threshold speed and damped frequency are presented when the bearing operating under lubricants, which contain nanoparticles and viscosity of these lubricants varies with temperature. The nanoparticles used for the present work are copper oxide (CuO), cerium oxide (CeO₂) and aluminum oxide (Al₂O₃). The modified Reynolds and energy equations are used to obtain pressure and temperature distribution across the lubricant film and these equations are solved by using the finite element method and a direct iteration scheme. The static and dynamic performance characteristics of journal bearing are computed for various values of eccentricity ratios for isoviscous and thermoviscous lubricants. The computed results show that in isoviscous case, addition of nanoparticles does not change performance characteristics considerably but in thermoviscous case, changes are significant. In isoviscous case increase of weight concentration of nanoparticles does not change the performance characteristics of bearing especially at low values of eccentricity ratios. For thermoviscous case addition of nanoparticles increase the load capacity of journal bearing at any eccentricity ratio, and this increase is significant at high values of the eccentricity ratio. For example, 0.5% weight concentration of nanoparticles increases the load capacity by 14.45% (CuO), 13.98% (CeO₂) and 12.53% (Al₂O₃) on thermoviscous case when bearing operates at ε=0.9. The friction force of bearing increases with the increase in concentration of nanoparticles for both isoviscous and thermoviscous cases. At any eccentricity ratio, both end leakage and attitude angle decreases with the increase in concentration of nanoparticles in both isoviscous and thermoviscous cases, and these decreases are considerable for thermoviscous case and at higher eccentricity ratios. The stability parameters in terms of threshold speed increases by the addition of nanoparticles at any eccentricity ratio and the damped frequency decreases with addition of nanoparticles. This indicates that at any eccentricity ratio when the thermo hydrodynamic bearing operates under lubricants, which contain nanoparticles, the
stability higher than that obtained without addition of nanoparticles, and load capacity increases with addition of nano particles at any eccentricity ratio.

M Zare Mehrjardi et al. studied the steady-state and stability performance characteristics of circular and noncircular two-, three-, and four-lobe journal bearings with micropolar fluids are presented. For this purpose, lubricating oil containing additives and contaminants is modeled as micropolar fluid. The modified Reynolds equation in dynamical state is obtained using the micropolar lubrication theory, and it is solved by finite element method. The bearing performance characteristics in terms of load carrying capacity, whirl frequency ratio, and critical mass parameter of journal are determined for different values of design parameters such as eccentricity and aspect ratio, preload factor, and micropolarity characteristics of lubricant in terms of material characteristic length and coupling number. Results show that in the case of noncircular bearings, the critical mass to load carrying capacity ratio decreases with increasing of preload factor, so for a constant vertical external load, the stability performance of rotating system can be improved by replacing the circular journal bearing with similar noncircular types. The results compared with Newtonian fluids indicate that micro polar lubricant exhibits better steady state and dynamic performance. Also, results reveal that upgrading the micropolarity characteristics of lubricant causes increase in critical mass, load carrying capacity but decrease in whirl frequency ratio. It is also observed that the effect of micropolar fluids is more pronounced at high coupling numbers. In the case of noncircular bearings, the ratio of critical mass parameter to load carrying capacity decreases with increasing of preload factor. For a constant vertical resultant load, the stability performance of rotating system can be improved by replacing the circular journal bearing by a noncircular type.

K. Prabhakaran Nair et al. studied the effect of deformation of the bearing liner on the static and dynamic performance characteristics of an elliptical (two lobe) journal bearing operating with micropolar lubricant is presented. Lubricating oil containing additives and contaminants is modelled as micropolar fluid. A generalized form of Reynold’s equation is derived from the fluid flow and diffusion equations. Finite element technique is used to solve the modified Reynold’s equation governing the flow of micropolar lubricant in the clearance space of the journal bearing and the three-dimensional elasticity equations governing the displacement field in the bearing shell. The static and dynamic characteristics of the bearing are computed for a wide range of deformation coefficient which takes into account the flexibility of the bearing liner. The increase in volume concentration of additives in the lubricant produces significant effects in the performance characteristics of the bearing especially when the bearing operates at higher eccentricity ratio. For any eccentricity ratio and deformation coefficient, load carrying capacity of a circular journal bearing increases with increase in volume of concentration of additives. For a rigid bearing (ε = 0) when volume concentration (cr) increases from 0.0 to 0.4, there is approximately 60% increase of load capacity at eccentricity ratio ε = 0.8. The end leakage is independent of volume concentration of additives when the mass transfer ratio is zero. The attitude angle and frictional force increase with increase in mass transfer rate at any value of volume concentration of additives and eccentricity ratio. The static performance characteristics: load capacity, end leakage, attitude angle and frictional force decrease when the bearing liner flexibility increases and these changes are significant especially when the flexible bearing operates at high eccentricity ratio.

B. S. Shenoy et al. studied the effect of CuO, TiO2 and nano-diamond nanoparticles additives in APF-SF engine oil, on static characteristics of an externally adjustable fluid-film bearing. Modified form of Reynolds equation is solved numerically for various simulated operating conditions. Static characteristics evaluated are in terms of load carrying capacity, end leakages and friction. This study predicts that, a bearing having negative radial and negative tilt adjustment, and operating with API-SF engine oil blended particularly with TiO2 nanoparticle, result in better load capacity. This study predicts that the bearing having negative radial and negative tilt adjustment and operating with API-SF engine oil added especially with TiO2 nanoparticles, result in approximately 23% and 35%
higher load carrying capacity than that obtained for API-SF engine oil without nanoparticle additives.

Shen et al. discussed the tribological properties of oils with added diamond Nano-particles within average diameter of 5–6 nm. They found that the spherical diamond nano-particles in base oil exhibit a viscosity-increasing effect and form a thicker film than that in the pure base oil. The friction coefficient decreased with sliding distance. He studied the rheological behaviour and tribological performance of a nano-diamond-dispersed oil. The Bingham plastic model was recommended for this Nano-diamond dispersed oil. They used aluminium alloy and steel to study the tribological performance and found that the Nano-diamond particles made the wear tracks of aluminium alloy smoother by polishing the contact asperities and thus increasing the friction and wear. However, for carbon steel pairs, this additive reduced the friction force and the wear but made the wear tracks rougher.

Hershberger et al. pointed out that most theories on the initiation of scuffing have been based on the assumption of the occurrence of adhesion between sliding surfaces. Since diamond nano-particles can reduce the sliding friction coefficient and wear, it is useful to study the anti-scuffing performance of nanodiamond dispersed oil. The aim of our study is to experimentally investigate the anti-scuffing performance of Nano diamond dispersed oil. Lubricating oil containing diamond particles with various concentrations was used in our study to evaluate the tribological performances and scuffing resistance. In order to simulate the scuffing of the piston ring and cylinder wall pair in an engine, the experiments were conducted on a Falex wear test machine with a three-block-on-ring configuration operating at different conditions. The contact behaviour between a block and rings similar to that of the piston ring and cylinder wall pair. Friction coefficient, electrical contact resistance, and oil temperature were measured to evaluate the effects of operating conditions and nano-diamond additive concentration on the tribological performances including scuffing resistance, mean friction coefficient, wear loss, friction energy, and friction power.

Chou and Lee et al. studied the rheological behaviour and tribological performance of Nano diamond-dispersed oil. The Bingham plastic model was recommended for this Nano-diamond-dispersed oil. They used aluminium alloy and steel to study the tribological performance and found that the nano-diamond particles made the wear tracks of aluminum alloy smoother by polishing the contact asperities and thus increasing the friction and wear. However, for carbon steel pairs, this additive reduced the friction force and the wear but made the wear tracks rougher.

Wang-Long Li et al. studied The static performance of finite journal bearings lubricated with non-Newtonian poruer law fluids is analyzed by using a control volume method with an 1-Irod algorithm to solve the average Reynolds equation and determine the cavitations region accurately. The results show that the flow behaviour index of power law fluids has an insigniJicant affect on the load ratios, side Iroru ratios and cavitations regions, while it signJicantlyaffects load capacities and side flow rates. Furthermore, the 4fact.4 of film thickness ratios, pressure flow factors, shear flow factors, slenderness ratios, eccentricities and inlet pressures on the variations of cavitations regions are also discussed.

III. LAYOUT OF EXPERIMENTAL SYSTEM

Figure shows schematic layout of experimental system. The adsorption cooling system consists of an oil receiver, measurement Board, oil tank, journal bearing, dead weight and connecting pipes. For this system SAE 15 W 50 is used to measure pressure distribution and load carrying capacity. The structure of the system is very simple.

![Fig. 1: Layout of Experimental System](image)

The major objective of lubrication of journal bearings is to induce and maintain a film of lubricant between the journal and the bearing. The purpose of this film of lubricant is to keep the two surfaces separate at all times and thus prevent metal to metal or dry contact which otherwise will create bearing failure. Hydrodynamic lubrication is the most common method of lubrication of journal bearings. In this method, as the shaft rotates it will, due to the load applied to it (as well as its own weight), take a slightly eccentric position relative to the bearing. The eccentric rotation of the shaft in the bearing acts some-what like a rotary pump and generates a relatively high hydrodynamic pressure in the con-verging zone. The hydrodynamic pressure for a properly designed bearing is responsible for supporting the shaft without allowing it to come in contact with the bearing.

IV. CONCLUSION

From literature survey it can be say that it is a novel method for evaluating the load carrying capacity of journal bearings operating on lubricants containing nanoparticle additives. The load carrying capacity of solid journal bearing mainly depends upon viscosity of lubricating oil. When lubricating oil is supplied to bearing then heat generated and viscosity decreases and load carrying capacity decreases. The addition of nanoparticle on commercial lubricants may enhance the viscosity and load carrying capacity increases.

REFERENCES


