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Performance Analysis of Nano Particle Infused Lubricant in Hydrodynamic Journal Bearing

Shantanu Salunke[1], Mahesh Gaikwad[2]

Lecturer , Mechanical Engineering, JS Polytechnic, Pune, India[1]

Assistant Professor, Mechanical Engineering, JSCOE, Pune, India[2]

Abstract: Influence of Copper Oxide (CuO) and Boron Nitrate (BN) nanoparticle lubricant additive on the load carrying capacity of a journal bearing is studied in this paper. The load carrying capacity of a hydrodynamic journal bearing depends upon the viscosity of the lubricant being used. The dynamic analysis of hydrodynamic solid journal bearing operating with nanoparticle influenced commercial lubricants will be presented in this paper The inclusion of nanoparticles in the lubricant may affect the viscosity of the lubricant which leads to changes in the performance and characteristics of the lubricant. The proposed work is about to obtain pressure distribution in the clearance space of the solid journal bearing. Pressure generation and distribution measurements will be carried out using a Sommerfeld curve. Readings will be taken at a same interval. Pressure measurements will be carried out at a various loads. Same testing procedure will be carried out for conventional bearing.

Keywords: Nanoparticle lubricants, Hydrodynamic journal bearing, Pressure distribution, Load carrying capacity

I. INTRODUCTION

A hydrodynamic journal bearing suggests that the load carrying surfaces of the bearing are separated by a relatively thick film of lubricant; so as to prevent metal to metal surface contact and thus obtain the stability can be explained by the laws of fluid mechanics. The film pressure is created by moving surface itself pulling the lubricant into a wedge-shaped zone at a velocity sufficiently high to create the pressure necessary to separate the surfaces against the load on the bearing. Solid journal bearings are used in heavy machineries to support high loads. The load bearing capacity of hydrodynamic journal bearings get enhanced by addition of nanoparticles because of enhancement of viscosity of lubricant and in turn affect various performance characteristics of hydrodynamic solid journal bearings. In this paper the dynamic and static performance characteristics of solid journal bearing operated under nano lubricants is studied. In conventional solid bearing lubrication is obtained by introducing the lubricant into the load-bearing area at a pressure high enough to separate the surfaces with a relatively thick film of lubricant. In contrast to hydrodynamic lubrication, this kind of lubrication does not require motion of one surface relative to another and applicable when velocities are small or zero, where the frictional resistance is absolute zero. But in most of the engineering practices these are obsolete, because of the extreme conditions under which these are operated. Recent experimental study of tribological properties of lubricating oil with nanoparticle additives was conducted by Wu et al. (2007) [1]. They have obtained viscosities for engine oil (SAE30 LB51153) with nanoparticles like copper oxide, titanium dioxide. It has been found that when nanoparticles of titanium dioxide (TiO_2) are added to the above oil, the viscosity increases ~ 40% higher than that of oil without nanoparticles addition. Inclusion of nanoparticles on the commercial lubricants may enhance the viscosity of lubricant and hence, in turn, load capacity of the bearing. These suspended solid particles increases thickness of lubricants, as a result which affect the various performance characteristics of journal bearing. The existing literature shows that the studies on static and dynamic performance characteristics of rigid and flexible circular journal-bearing operating under nano lubricant are scarce. Therefore in the proposed study the performance characteristics of solid journal bearing operated with nano lubricants i.e. dynamic characteristics in terms of damping coefficients, threshold speed, stiffness coefficients and damped frequency of whirl are computed using finite element method.

Influence of CuO + BN nanoparticle lubricant additive on the load carrying capacity of a journal bearing is studied. Increase in lubricant viscosity due to presence of SiO2 nanoparticles is modelled. Validity of experimental setup in simulating the viscosities of CuO + BN nanoparticle dispersions in engine oil is experimentally verified. The pressure distribution and load carrying capacity are theoretically evaluated using a modified Reynolds equation for various CuO + BN nanoparticle concentrations. Results reveal an increase in load carrying capacity of journal bearing using CuO + BN nanoparticle lubricant additive as compared to plain oils without nanoparticle additive.

II. LITERATURE SURVEY

Binu K.G. et al. [2] studied the influence of shear viscosity variation of engine oil, due to the presence of TiO2 nanoparticle additives at volume fractions ranging from 0.005 to 0.025, on the load carrying capacity of a journal bearing. The presence of TiO2 nanoparticles, even at low concentrations of 0.01 volume fraction is found to increase the load carrying capacity of journal bearings by 40% in comparison to plain engine oil without nanoparticle additives. The DLS particle size analysis reveals that TiO2 nanoparticles of primary size <~100 nm dispersed in engine oil forms aggregates of average size 777 nm, resulting in a particle packing fraction of 7.77. The load carrying capacity of the journal bearing operating on TiO2 based nano lubricant at a constant volume fraction is also found to increase with higher nanoparticle aggregate packing ratios. Simulated results reveal that increasing the particle packing fraction from 7.77 to 10 will lead to a 35 % increase in load carrying capacity for a TiO2 nanoparticle concentration of 0.015 volume fraction. However, further experimental studies are necessary to prove the influence of nanoparticle aggregates on dispersion stability and load carrying capacity. The influence of couple stress effects of nanoparticle additives on the load carrying capacity of journal bearings also needs to be studied.

Sriharsha T.S. et. al. [3] studied that the dynamic analysis of hydrodynamic solid journal bearing operating under nano lubricants is 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 nanoparticle on commercial lubricants may enhance the viscosity of lubricant and in turns changes the performance characteristics. In the proposed work, to obtain pressure distribution in the clearance space of the solid journal bearing, modified Reynolds equation is used. The steady and dynamic behaviour of hydrodynamic journal bearing system have been studied and presented in this paper. The result reveals that lubricant with nano diamond have higher threshold speed which increase with gradual increase in eccentricity ratio whereas damped frequency decreases. The threshold speed and load capacity increases with addition of nano particles at any eccentricity ratio.

Baskar S. et. al. (2014) [4] in this study he stated that, the friction and wear behaviour of journal bearing material (brass) was evaluated and focusing on the effect of nano CuO in the chemically modified rapeseed oil. The bearing material (brass) lubricated with CMRO + 0.5 w. % nano CuO has the lowest friction coefficient of 0.073. The frictional coefficient of bearing material lubricated with CMRO is 0.13 and SAE20W40 is 0.09. The frictional coefficient of CMRO + 0.5 w. % nano CuO is 49 % lesser than CMRO and 18 % lower than SAE20W40. The wear of bearing material lubricated with SAE20W40, CMRO and CMRO + 0.5 w. % nano CuO of 86.77, 136.34 & 82.07 mg. The wear value of bearing material lubricated with CMRO + 0.5 w. % nano CuO has lowest wear and 39 % lesser than CMRO. The wear value of bearing lubricated with CMRO + 0.5 w% nano CuO has 5 % lesser than SAE20W40. It is also possesses superior tribological behaviour in chemically modified rapeseed oil with nano CuO than the other two lubricating oils. The above mentioned discussions are evaluated, it can be stated that among the three lubricating oils, one can contain nano CuO can be preferred for the lubrication purpose in Journal bearing application.

Yathish K et. al. (2014) [5] stated that Load carrying capacity of an oil lubricated two-axial groove journal bearing is simulated by taking into account the viscosity variations in lubricant due to the addition of TiO2 nanoparticles as lubricant additive. Shear viscosities of TiO2 nanoparticle dispersions in oil are measured for various nanoparticle additive concentrations. The viscosity model derived from the experimental viscosities is employed in a modified Reynolds equation to obtain the pressure profiles and load carrying capacity of two-axial groove journal bearing. Results reveal an increase in load carrying capacity of bearings operating on nanoparticle dispersions as compared to plain oil. The presence of 0.01 volume fraction of TiO2 nanoparticles in engine oil was found to increase the load carrying capacity by 38%. However, this increase in load capacity should be experimentally validated. The effect of additive particle size on the bearing performance also needs to be investigated.

III. PROPOSED EXPERIMENTATION PROCEDURE OF BEARING TESTING

CuO + BN nanoparticles are used in this study, CuO + BN based nano lubricant at various volume fractions. The prepared samples should exhibit good dispersion stability. The nano lubricant samples with different CuO + BN volume fractions are then subjected to an experimental analysis to study the Pressure generation and distribution in lubricating film of hydrodynamic bearing with increasing CuO + BN nanoparticle concentrations and load acting on bearing. Pressure generation and distribution measurements will be carried out using a Bearing testing machine. Readings will be taken at an same interval. Pressure measurements will be carried out at a various loads. Same testing procedure will be carried out for conventional bearing.

IV. RESULTS AND DISCUSSION

After investigating the effect of load, speed and bearing texture on the bearing, the profile pressure has been measured, and then it has been compared with each other in terms of the pressure profile generated. It is also identified how the bearing can carry more loads with generating less pressure. The result consists of various graphical representations of the comparison of the base oil along with the varying percentage of the nano particles ranging from 0.1% to 0.3%.

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A. Comparison of Pressure Profile for Base Oil at various RPM

In this case the hydrodynamic pressure distribution in cm of the bearing with base oil lubricant at various RPM obtained from experimental setup is compared.

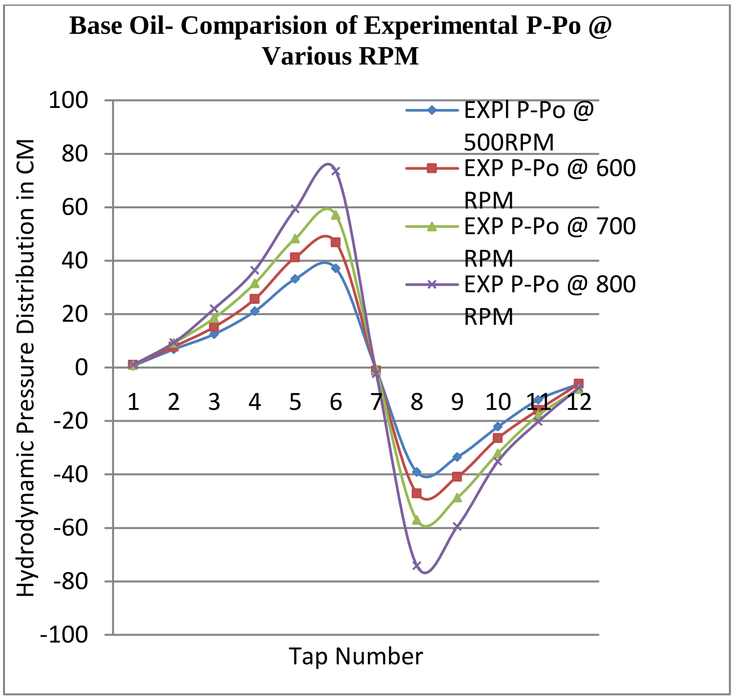

Fig. 1: Comparison of Pressure Profile for Base Oil @ various RPM

B. Comparison of Pressure Profile for Base Oil with 0.1% NF at various RPM

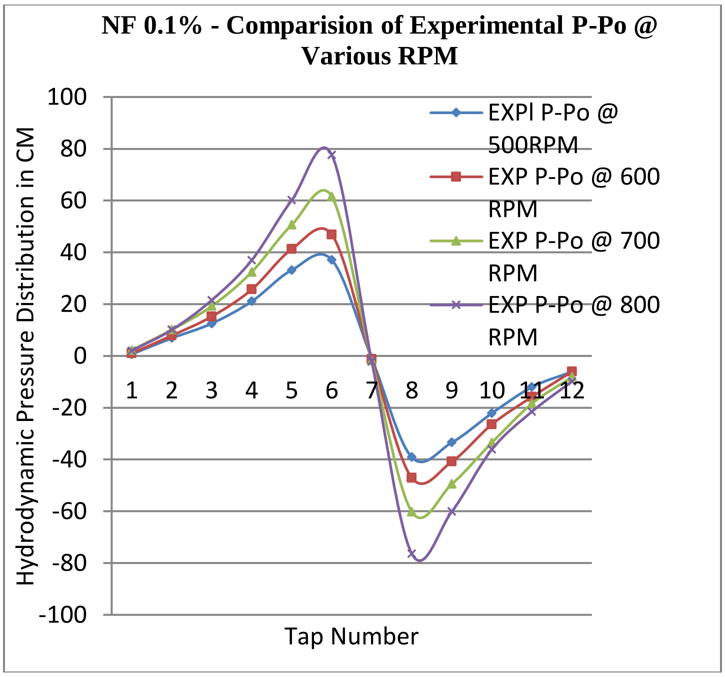

Fig. 2: Comparison of Pressure Profile for Base Oil with 0.1% NF at various RPM

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C. Comparison of Pressure Profile for Base Oil with 0.2% NF at various RPM

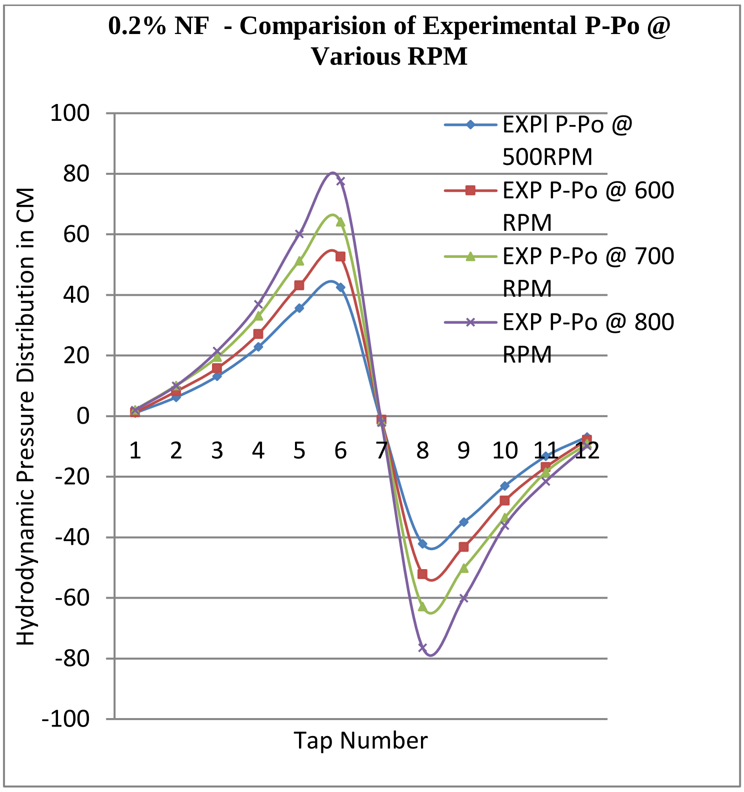

Fig. 3: Comparison of Pressure Profile for Base Oil with 0.2% NF at various RPM

D. Comparison of Pressure Profile for Base Oil with 0.3% NF at various RPM

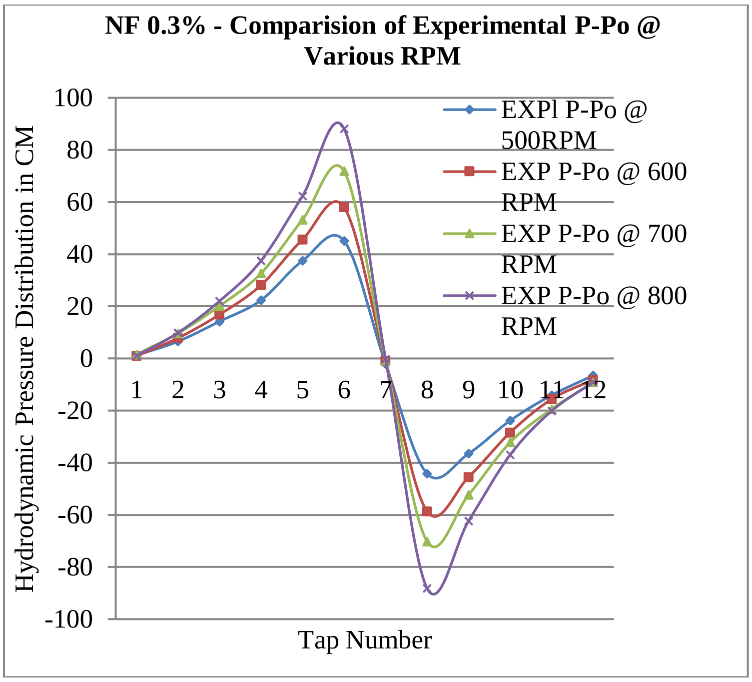

Fig. 3: Comparison of Pressure Profile for Base Oil with 0.3% NF at various RPM

V. CONCLUSION

Experiment shows that the nano particle added lubricant affected the journal bearing performance. It is observed that pressure increases more in nano particle added journal bearing as compared to smooth journal bearing.

— From above figures it can be concluded that nano particle infused bearing can carry more loads and it has the optimum pressure profile as compared to bearing with conventional (SAE 15W40) lubricant.

— With increase of loads at constant speed percentage increase of maximum pressure is more in nano particle journal bearing w.r.t smooth journal.

— With increase in the inclusion of nanoparticles with even small percentage as 0.1% to 0.3% leads to significant increase in the load carrying capacity of the bearing.

— It is concluded that influences of surface nano particle added lubricant are affected by speed variation.

— From the above results for a particular application of higher or lower loading condition, higher or lower speed levels, the optimum shaft context nano particle added lubricant can be applied for the better performance of the Journal bearing for a larger life span.

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