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Review on Performance and Tribological of Journal Bearing

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Abstract: The hydrodynamic journal bearing exhibits properties such as low wear, high performance and negligible friction. The current research reviews the existing work on elastic deformation, effect of surface texture and material on performance of journal bearing. These reviews are based on numerical and experimental techniques. Different aspects of journal bearing like damping, eccentricity ratio, clearance and groove geometry are studied by various researchers and presented in the paper.

Key Words: Journal bearing, design optimization

1. INTRODUCTION

Now a days, hydrodynamic journal bearing are in high demand for their excellent properties such as long-term performance, negligible friction and almost zero wear particularly in Diesel engine, centrifugal compressors, pumps, motors, etc. Now a day, hydrodynamic journal bearing are in high demand for their excellent properties such as long-term performance, negligible friction and almost zero wear particularly in Diesel engine, centrifugal compressors, pumps, motors, etc. This type of bearing works on hydrodynamic principle, which involves with the rotation of shaft, creates an oil wedge that supports the shaft and relocates it within the bearing clearances. The shaft spinning within a journal bearing is actually separated from the journal bearing's metal facing by an extremely thin film of continuously supplied oil that prohibits metal to metal contact. In other words the hydrodynamic journal bearing works on hydrodynamic lubrication theory, which is concerned with separation of two surfaces in relative motion.

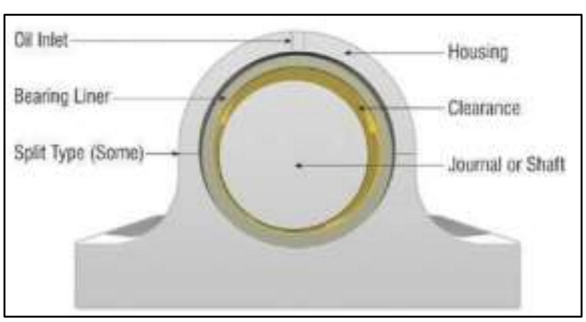

Figure 1: Journal Bearing [2]

Journal or plain bearings consist of a shaft or journal which rotates freely in a supporting metal sleeve or shell as shown in figure 1. There are no rolling elements in these bearings. Their design and construction may be relatively simple, but the theory and operation of these bearings can be complex.

2. LITERATURE REVIEW

Ronen et al. (2001) [2] presented a model to study the potential use of micro surface structure in the form of micro pores to improve tribological properties of reciprocating automotive components. It is shown that surface texturing can efficiently be used to maintain hydrodynamic effects even with nominally parallel surfaces, and that optimum surface texturing may substantially reduce the friction losses in reciprocating automotive components.

Cupillard et al. [3] have presented an analysis of lubricated conformal contact to study the effect of surface texture on bearing friction and load carrying capacity using computational fluid dynamics. The authors have reported that the coefficient of friction can be reduced if a texture of suitable geometry is introduced.

Gertzos et al. [4] have investigated journal bearing performance with a NonNewtonian fluid i.e. Bingham fluid considering the thermal effect.

Huiping Liu et al.[5] studied hydrodynamic journal bearings with elastic insert and found that the elastic deformation of the bearing had a significant influence on the rotor–bearing system, particularly for the polymeric-based materials.

Jaw-Ren Lin et al. [6] numerically calculated oil film pressure by using Fourth Runge-Kutta method and this pressure is utilized to evaluate the load carrying capacity and the friction parameter. A comparison of the results between the Darcy model and Brinkman model is made to show the viscous shear effects provide an increase in the load capacity, as well as a decrease in the friction parameter.

Nabhan et al.[7] solved Navier-Stokes equation with the aid of Simpson rule and calculated the pressures, drags and load carrying capacities by taking binary fluid mixture with different viscosity ratio.

Hassan E. Rasheed [8] theoretically presented the effects of circumferential, axial and combined surface waviness on the performance of the hydrodynamic journal bearings by using Reynolds equation for Newtonian iso viscous lubricant. It was observed that when waviness number is approximately below nine, then circumferential waviness increases the load carrying capacity and decreases the friction variable. But the axial waviness is to always have an opposite effect on the load carrying capacity and friction variable.

S.k.guha [9] analized the effect of isotropic roughness on the steady-state characteristics of hydrodynamic journal bearings terms of load capacity, attitude angle, end leakage flow rate, misalignment moment and friction coefficient are estimated for different values of roughness parameter, eccentricity ratio and degree of misalignment at unit slenderness ratio. Finite difference method is also used to measure steady-state oil film pressures by using Reynolds equation.

Myung-Rae Cho et al.[10] presented the effects of circumferential groove on the minimum oil film thickness in engine bearings and used mobility method for journal locus analysis. It was observed that the circumferential 360° groove only decreases the magnitude while 180° half groove affects the shape and position of the minimum oil film thickness.

Nabarun Biswas and Prasun Chakraborti [11] used physical properties of SAE-50 lubricant for analysis purpose in journal bearing. They involve with six time steps 10, 30, 50, 70, 90, and 110 sec for unsteady analysis and found out that after 110 sec the flow becomes steady. It was also observed that maximum pressure is observed at minimum oil film thickness with increasing value of roughness.

Sep et al.[12] analysed new design of the journal bearing with two-component surface layer and experimentally proved its usefulness in the case, where oil is contaminated by hard particles. In this new design the helical grooves are made on the bearing journal surface that should enable to eliminating contaminants from the frictional contact zone and concluded that if soft material is placed in the immediate vicinity of the grooves it will restrict the hard particles driving into the bearing surface which also decreases sensitivity.

Byoung-Hoo Rho et al. [13] investigated acoustical properties of hydrodynamic journal bearing. The universal Reynolds equation is solved at each step of time using the finite difference method and the nonlinear transient motion of the journal centre is obtained by numerical integration of its acceleration using fourth order Runge-Kutta method.

Byoung-Hoo Rho et al [14] investigated the effects of design parameters on the noise of rotor-bearing system supported by oil lubricated journal bearing. The Reynolds equation for finite width bearing under unsteady condition is applied for calculating pressure. It was observed that the radial clearance, mass eccentricity of the rotor and the width of the bearing considerably affect the A-weighted sound pressure level of the bearing.

Wu et al.[15] studied wall slip problem by parametric quadratic programming method and generalized Reynolds equation with wall slip for two-dimensional flow is applied. It is observed that if limiting shear stress at bearing surface should be more than that at the journal surface, the wall slip avoided.

Nikolakopoulo et al.[16] developed an analytical modal which shows the relationship among the friction force, wear depth and misalignment angles The Reynolds equation is used to calculate the friction force in equilibrium condition and found that friction function dependent on wear and misalignment of the bearing.

Singh et al [17] theoretically performed steady-state thermodynamic analysis of an axial groove bearing by using Reynolds equation, energy equation and heat conduction equation with appropriate boundary conditions in the journal bearing. It was found that the fluid film temperature increases due to frictional heat resulting viscosity and load carrying capacity decreases. It was also observed that groove angle of 360° and groove length (Half of the bearing length) promoted to decrease the maximum temperature and increase the load carrying capacity.

Ron A.J. Van Ostayen [18] presented a mathematical optimization procedure to find the optimal film height distribution for a hydrodynamic bearing. Firstly this methodology is applied for a bearing with constant load and sliding speed. Then subsequently applied for a bearing with periodic load and sliding speed. Slider bearings with different shapes, loads and speeds are analyzed by new heuristic load optimization procedure along with Reynolds equation and found more efficient than general purpose optimization routine.

Andras Z. Szeri [19] modified the structure of lubricant film by using double layer of lubricant into clearance space of bearing surfaces in place of single layer of lubricant. Basic

Reynolds equation was used for composite films under the restrictive assumptions by applying boundary conditions. The low-viscosity lubricant reduced viscous dissipation, while the high-viscosity lubricants maintained the desirable thickness to separate out the bearing surfaces. It was also found that composite-film bearings have considerably lower frictional losses in comparison to other traditional bearings.

Lui et al.[20] designed and fabricated a test rig to investigate the stability nature of the JRHB. It was found that the rolling bearing plays a protective role under IHP condition.

K. M. Panday et al [21] analysis thin film lubricated journal bearing with different L/D ratios such as 0.25, 0.5, 1, 1.5, and 2. It was observed that maximum pressure present at minimum oil film thickness. Also reported that shear stress is reduces on bearing and journal surface with increase in L/D ratio whereas turbulent viscosity of lubricant rises with increase in L/D ratio.

Nacer Tala-Ighil et al [22] developed a numerical model based on finite difference method by using Reynolds equation to study the cylindrical textures shape effect on the performance of hydrodynamic journal bearing. Based on geometric arrangement of textures on the bearing surface, a comparison of considered twenty five cases is conducted. It was found that the minimum oil film thickness increased approximately by 1.8% and friction torque is decreased approximately by 1.0%.

Meybodi et al [23] developed a general methodology, to design the proper bearing in order to eliminate the deviation of final product in extrusion process. Three smooth curved dies with non-symmetric T-shaped sections at different off-centricities have been taken and for each die proper bearing has designed. It was found that the deviation of final product is eliminated to a great extent.

McAllister and Rohde [24] optimized the load-carrying capacity of one-dimensional journal bearings for a given minimum film thickness by using a long bearing approximation, which is inaccurate in most practical design ranges.

Hashimoto [25] presented an optimum study for high speed short journal bearings using successive quadratic programming. For Eccentricity > 0.8 and L/D > 0.3, the short bearing approximation predicts highly unreliable results.

Peeyush vats et al [26] presented thermal analysis of journal bearing by using FEM analysis. Parameters like heat generated, temperature distribution and heat dissipation are studied. From results it is reported that difference between heat dissipated and heat generated in oil film was very large, which causes increase in temperature of the bearing and damaged the bearing pads.

Valeru et al. (2018) [27] improved pour point, oxidation and thermal stability by addition of Polyalphaolefin 4 (PAO 4), Poly (Ethylene co-vinyl acetate) (PPD) and 2, 6 Di-tetra butyl phenol as additives in coconut oil .

Haun et al. (2014) [28] genetically modified soybean oil to improve its oxidative stability by increasing oleic acid content from 20% to 80% and decreasing linoleic acid content from 50% to under 4%. Genetic modification of vegetable oils improves thermal and oxidative stabilities by increasing the oleic acid content whereas increasing proportions of shortchain saturated or long-chain monounsaturated fatty acids improves the cold flow behaviour of oil.

Pathmasiri et al. (2019) [29] found improved pour point of palm oil when blended with castor oil.

Heikal et al. (2016) [30] found improved pour point, viscosity indices and moderate thermal stabilities in jatropha oil when chemically modified through transesterification reaction .

Salimon et al. (2011) [31] got better pour point and higher flash point when castor bean oil is chemically modified to form estolide ester by reacting ricinoleic acid of vegetable oil with saturated fatty acid .

Aelst et al. (2016) [32] partially hydrogenated soybean oil using Pt/ZSM-5 catalyst to improve oxidative stability and cold flow behaviour for biolubricants .

Borugadda and Goud (2014) [33] improved thermal and oxidation stability of castor oil through epoxidation of castor oil forming fatty acid methyl esters of vegetable oil suitable as a biolubricant base stock .

3. CONCLUSION

The existing researches are conducted on improvement of performance of journal bearing. The hydrodynamic effects can be maintained using surface texturing technique. The frictional loss in automotive components can be reduced using optimum surface texturing. The thermal parameters like heat dissipation; temperature on performance of journal bearing is investigated. The bearing pads are damaged due to increase in temperature.

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