Parametric Analysis on Effect of Hydrodynamic Lubrication of Journal Bearing with Different Characteristics of Oil

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Abstract

A number of analytical and numerical approaches are available for the analysis of journal bearing under different mechanism of wear, fatigue and crush during service conditions. The present work deals with the variation of different parameters like coefficient of friction, bearing modulus, flow variable with respect to the bearing characteristics number (S). With the help of above parameters, the effect of eccentricity for journal and bearing on the design aspects can easily be encountered. The results revealed that the bearing parts should have appropriate clearance, pressure distribution and a range of eccentricity ratio should be maintained for proper operation of journal bearing apparatus. Furthermore, deep numerical analysis of the complete experimentation suggests the need of evaluating the above design parameters in detail. The article also aims also to provide the efficient way to perform the experiment taking in consideration of calibration and accuracy of the system.

Keywords: Bearing Characteristics Number, Coefficient of Friction, Bearing Modulus and Flow Variable

INTRODUCTION

Journal bearings designed with reasonable slippage surface tended to lower friction and increase bearing capacity. On square bearings with combined surface slip illustrated the accomplishment of good performance of high carrying load, low friction and low temperature rise. It is still insufficient to derive criteria needed for designing practical boundary slip surface for journal bearings. While designing of hydrodynamic journal bearings, the eccentricity of the shaft within the bearing shell and the resulting minimum film thickness are essential target values of the bearing calculation. The eccentricity of the shaft depends on the hydrodynamic pressure development in the plain bearing. The variables are summarized in the Sommerfeld number, which is important for the plain bearing calculation. The selected bearing parameter is a too low eccentricity, unwanted vibrations may occur during operation and the frictional losses of the bearing are higher than necessary.

LITERATURE REVIEW

Illner et al (2015), In this literature the development of an analytical model for calculating the minimum oil film thickness and the transition speed, are taken for elastic bearing deformations. The focus of the development was on generalizing an existing model to include any relative eccentricities and width/diameter ratios. They influence the different bearing types; geometry-related load-carrying capacity increases as well as load-carrying capacity reductions in the calculation model. Different calculations method are used to demonstrate the comparison of transition speed and it represents a feasible solution for the quick determination of the transition point into mixed lubrication in journal bearings.

Hui Zhang et al (2014), In this literature the development of a numerical model to study the tribological behavior for high speed and water lubricated journal bearings with different boundary slip arrangements. The influences of slip and its possible mechanism are analyzed and discussed from the view point of volumetric flow rate conservation. Bearings with combined slip/no-slip surface arrangement on sleeve have been proved to reduce frictional force and to enhance also load bearing capacity. When the start angle θ1=0 and the end angle θ2=140 it reaches its

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maximum load bearing capacity and the cause for the increase in load bearing capacity of the bearings with slip/no-slip region it may be the change of volumetric flow rate .Further-more, Bearings with higher rotational speed tend to result in larger slip length and subsequently lead to more significant increase in bearing capacity and reduction in friction. Such improvement of load bearing capacity and friction becomes more significant for the slip/no-slip combined journal bearings.

Nikhil Sharma et al (2014), In this literature an experimental observation of unexpectedly low-angular-extent solutions in a journal bearing with a relatively large clearance ratio and demonstrate the theoretical feasibility of such solutions using a relatively simple model. The assumptions about boundary conditions are the pressure-bearing films in journal bearings. Since oil inertia is neglected in the Reynolds equation, only relative velocities between the journal and the bearing determine the oil pressures. A Fourier sine series has been used in the axial direction, to obtain a set of decoupled ODEs. Under these simplifications, we have obtained four separate solution families and we have also studied stability under two limiting conditions: viscosity dominated and inertia dominated. These four computed solution families gives a stable solution branch that involves high eccentricities and low angular extents, with pressure profiles Thus, the plausibility of such solutions has been established in this preliminary work, and future work may lead to a more thorough physical understanding of such solutions.

Xiuli Zhang et al (2015) In this literature an efficient method for determining the stiffness coefficients of hydrodynamic plain journal bearings lubricated by water and relationships between the stiffness coefficients and the load for bearings with different relative clearances, different length-to- diameter ratios and different rotational speeds are obtained. Load carrying capacities and attitude angles are obtained to determine their relation to the eccentricity ratio under a certain structure. Large numbers of CFD analyses are performed to find the influence of relative clearance, length-to-diameter ratio, diameter and rotational speed on the stiffness coefficients. The stiffness coefficients of a hydrodynamic water-lubricated bearing 80 mm in diameter are on the order of 107–109 N/m. For a constant eccentricity ratio, the load carrying capacity is proportional to square of diameter and rotational speed and inversely proportional to square of relative clearance while the stiffness coefficients are proportional to diameter and rotational speeds and inversely proportional to cube of relative clearance. Finally, a method is provided for determining the stiffness coefficient ratio of such bearings.

Methodology

The journal bearing experiment incorporates a shaft rotating within a circular sleeve. The journal and bearing have relative rotational velocities with respect to each other and the amount of eccentricity adjusts itself until the pressure generated in the converging lubricating film balances the external loads. The pressure generated, and, hence, the load capacity of the journal bearing depends on the journal eccentricity, the relative angular velocity, the effective viscosity of the fluid lubricant and the journal bearing geometry and clearance. To perform the experiment over journal bearing apparatus the following procedure has been adopted. Firstly, sufficient oil is being filled in the oil supply tank, so that a continuous flow of oil is being managed inside the bearing. Then the pressure gauge in the vertical column is maintained at 0^o and adjusts the pointer on torque arm to match with the stationary pointer fitted on the frame. And after that motor is being started, a constant speed is maintained, developing pressure head. The pressure head changes with the alteration in weight and its distance. The weight and distance providing a balanced torque is being noted as the readings. The pressure distribution across the bearing is being procured by the angular pipes given at the surface of the apparatus oriented at an angle of 30^0. For different speed and different weight of the torque arm apparatus the readings are been noted. The lubricating oil used is SAE 40. The society of automotive engineers (SAE) has recommended the usage of oil with different properties based on the requirement. The SAE 40 is used because of medium ranged viscosity, and due to maximum usage of this oil in automobiles.

Abbreviations and Acronyms

μ	=	coefficient of friction
h_0	=	minimum oil film thickness.
e	=	eccentricity of journal

Results and Discussion

Figures and Tables

N	*Load*	*Distance*	*W*	*€ Eccentricity ratio*	*Y Max Pressure angle*	*Pb Bearing Pressure*	*S*	*μ*	*Bearing modulus*	*Q/rcNL Flow variable*
300	250	0.105	45.51	0.037	87.29	18204	3.60	0.22	1.42	0.23
400	250	0.125	45.51	0.028	87.96	18204	4.81	0.29	2.53	0.23
500	250	0.139	45.51	0.022	88.37	18204	6.01	0.36	3.95	0.23
600	500	0.083	47.97	0.020	88.57	19188	6.84	0.41	5.12	0.24
800	500	0.105	47.97	0.015	88.92	19188	9.12	0.55	9.10	0.24
1000	500	0.013	47.97	0.012	89.14	19188	11.40	0.68	14.22	0.24

The Petroff's equation produces the reasonable estimates of coefficients of friction of lightly loaded bearing. The cofficient of friction given by

$$f = 2\pi^2 \frac{\mu N r}{pc}$$

The Somerfield number is a dimensionless quantity used in hydrodynamic lubrication analysis and given by

$$S = \left(\frac{r}{c}\right)^2 \frac{\mu N}{P}$$

The behavior of the journal bearing apparatus should only be analyzed by the variation of Somerfield number with respect to different parameters. Figure 3.1 shows the variation of somerfeild number with respect to coefficient of friction (μ). The graph shows the corresponding increase in μ with increase in somerfeild number (S). The plot also shows the perfect hydrodynamic lubrication in comparison to graphs of Mckee brothers [1]. The minimum value of bearing characteristic number is coming to be 3.60 and the respective coefficient of friction is 0.22. This minimum value is also the design criteria for the journal bearing experiment and thus it can be characterized as the design zone. Due to increase in fluid friction the temperature generation takes place. This rise in temperature leads to decrease in viscosity and results in unsafe design. Therefore, it is observed that, bearing characteristic number controls the design of journal bearing and it is dependent of design parameters like, operating conditions (temperature, speed and load), geometrical parameters (length and diameter) and viscosity of the lubricant.

Figure 2.1.

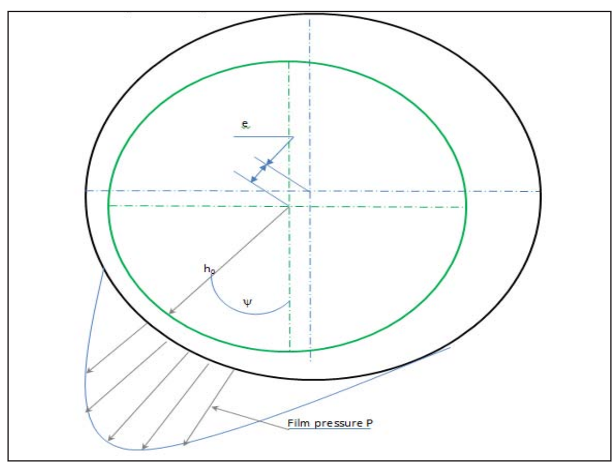

Figure 2.2.

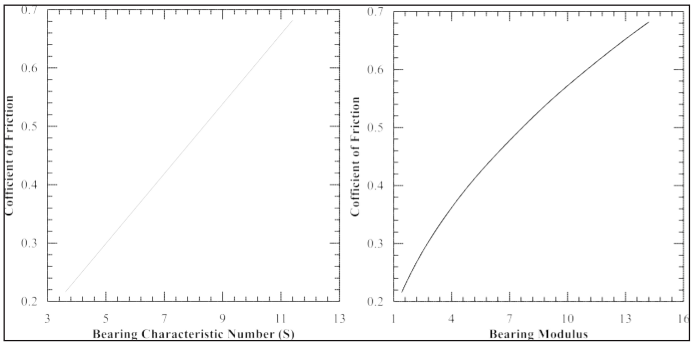

Figure 3.1. **Bearing Characteristic Number vs Coefficient of Friction and Bearing Modulus**

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