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A Technical Review on Multi Lobe Journal Bearings

S. Udaya Bhaskar[1], M. Manzoor Hussain[2], Md. Yousuf Ali[3]
[1]*Associate Professor, AHCET, Chevella,*
[2]*Principal, JNTUH CES, Medak,*
[3]*Principal, NSAKCET, Malakpet*

Abstract

Fluid film bearings are machine elements to produce smooth motion between solid surfaces in relative motion and to generate a load support for mechanical components. The lubricant used between the surfaces may be a liquid or gas. Fluid film bearings are designed to support static and dynamic loads, and consequently, their effects on the performance of rotating machinery are of great importance. In the design of high speed rotary machinery, consideration of surface roughness is important to predict the steady state characteristics and stability analysis of the hydrodynamic journal bearings.

1. Introduction

Bearings play a vital role in the performance of rotor bearing system. Though the plain cylindrical journal bearing is generally used in the rotating machinery it does not satisfy the stability requirements of high speed machinery. In such specialized cases plain circular bearings are replaced by non-circular journal bearings. Multilobe journal bearings are widely used to suppress instability under lightly loaded conditions. Bearings with two lobes, three lobes and four lobes are widely used to support the rotating machinery.

2. Literature survey

O. Pinkus [1], [2] and [3] was one of the first study multi lobe bearing, static characteristics of two lobe and three lobe bearings were predicted for different aspect ratios.

Falkenhagen et al. [6] did the analysis of stability characteristics and general transient motion of the finite width three lobe bearings. Reynolds equation was solved by time transient procedure. The linearized stiffness and damping coefficients were computed by evaluating the changes in hydrodynamic forces caused by small perturbation about the steady state position. Threshold speed o stability was determined. The influence of rotor unbalance above and below the stability threshold was investigated.

S.T.N Swamy et al. [9] calculated the stiffness and damping coefficients of finite journal bearings and their application to find the stability prediction. The Reynolds equation is solved using the over relaxation scheme. First the steady state equilibrium performance is calculated next a small change in the eccentricity ratio and attitude angle which is a function of time gives the stiffness and damping coefficients. Characteristic equation is solved using the stiffness and damping coefficients to find the stability curves.

Flack et al. [12] and [13] did an experiment and theoretical investigation of pressure distributions in four lobe bearings. Theoretical pressure disturbances were obtained by using variational approach to solve the Reynolds equation. Both half Sommerfeld and Reynolds boundary conditions were used separately and theoretical results obtained by both conditions were compared with experiment results.

Leader et al. [13] tested a pair of preloaded (factor 0.7 and 0.77) four lobe bearings with simple flexible rotor for the instability threshold analysis. Experiment results were compares with the theoretical results obtained by finite element analysis. In the analysis, half Sommerfeld boundary condition was used for Reynolds equation.

Li et al. [14] determined the linearized stability threshold for multi lobe bearings (elliptical, offset, three-lobe and four-lobe). Reynolds equation was solved by using series solution based on variational principle. Stability of these bearings for different load conditions are discussed. The analysis was done for L/D =0.5 and preload factor of 0.5.

Ghosh et al. [13] studied the stability of a rigid rotor supported on a rough surface journal bearing. By using a first order perturbation method, the time dependent Reynolds equation was linearized and the steady-state and dynamic pressure were obtained. The stability characteristics were evaluated for various roughness heights, eccentricity ratios, and L/D ratios and roughness parameters. By using stochastic models for isotropic roughness.

A. Raj et al. [17] applied the stochastic theory for the analysis of dynamically loaded short rough journal bearing which have striations transverse to the direction of motion. Instead of Gaussian function an approximate polynomial is used to represent the roughness profile. To make the analysis applicable to the real lubrication situations, it is assumed that the standard deviation of the roughness heights and the minimum film thickness are of the same order.

J. Ramesh et al. [22] investigated the stability of a rigid rotor supported by finite oil rough journal bearings with the use of non linear time transient analysis. The effects of the various surfaces roughness parameters composite surface roughness parameters, roughness orientation parameters, variance ratio on the stability is presented in the form of centre trajectories.

H. Hashimoto [25] described an applicability of modified Reynolds equation considering Reynolds equation considering the combined effects of turbulence and surface roughness. In the numerical analysis of modified Reynolds equation, the non-linear simultaneous equations for the turbulence correction coefficients are greatly simplified to save the computational time with a satisfactory accuracy under the assumption that the shear flow is superior to the pressure flow in the lubricant films.

J. Ramesh et al. [26] considered the effect of surface roughness on the stability of submerged oil elliptical journal bearings under unidirectional constant and unidirectional periodic load. The non linear transient simulation taking the oil film history into account has been used to predict the threshold of various parameters, they are composite surface roughness, roughness orientation pattern and variance ratio on stability has been studied.

Ram Turaga et al. [27] considered the surface roughens pattern significantly influence the steady state and dynamic characteristics of hydrodynamic journal bearings. The effect of surface roughness pattern on bearing with different b/d ratios has also been studied. However the influence of surface roughness parameter which is a ratio of half of the total ranges of random film thickness variable to the radial clearance on the performance of hydrodynamic journal bearings.

Cheng et al. [29] analyzed the combined effects of the surface roughness and flow rheology on the linear stability of a rigid rotor supported on the short length journal bearing. The modified equation and the rotor motion equation are linearized about the equilibrium position and the fluid film is modelled as a spring and damping elements. By using the characteristic equation, the instability threshold is then obtained with various surface roughness parameters, flow rheology and eccentricity ratios.

Guha [30] deals with the concept of stochastic process to solve the problem of isotropic steady state characteristics if hydrodynamic journal bearings with finite width, considering two types of misalignment axial and twisting, using a finite difference method, the steady state film pressures are obtained by solving a Reynolds type equation based on the principle of isotropic roughness pattern, with the help of steady state film pressure, the steady state performance characteristics, in terms of the load carrying capacity, attitude angle, leakage flow rate, friction coefficient and misalignment moment of a journal bearing with the slenderness ratio of unity are obtained for various values of isotropic roughness parameter, eccentricity ratio and degree of misalignment.

Cheng-Hsing Hsu et al. [33] theoretically predicted the combined effects of the couple stresses and surface roughness on the lubrication performance of the journal bearing systems. To take account of the pressure of both the surface roughness of the bearings and the couple stresses effects due to the lubricant containing the polar suspensions, the generalized stochastic non-Newtonian lubricant smooth bearing case, the couple stress effects and longitudinal roughness improve the load carrying capacity, and thus decrease the attitude angle and frictional parameters.

3. Conclusion

Surface appreciably effects the lubrication of surfaces if the film thickness is same order as the roughness. By using the first order perturbation method, the time dependent Reynolds equation was linearized and the steady state curves were obtained. The importance of roughness in predicting bearing performance has gained considerable attention in tribology. All previous developments were based on stability analysis of hydrodynamic bearings.

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