ANALYSIS OF ELASTOHYDRODYNAMIC CIRCULAR AND NON-CIRCULAR JOURNAL BEARINGS WITH MICROPOLAR LUBRICANTS

ABSTRACT

The subject of elastohydrodynamic lubrication, during the initial stages of its development, conventionally included the lubricated point and line contacts. However, recently the area of elastohydrodynamic lubrication has been widened to encompass the lubricated surface contact problems such as slider and journal bearings. Though bearings are generally designed using the data developed with the assumption that their surfaces are rigid, bearings carrying heavy loads need analysis and design, which take into account their elastic deformation. The bearing deformations may quite often have magnitudes of the order of the film thickness, thus affecting the clearance space geometry of the bearing to an extent such that the actual performance characteristics may become significantly different from those computed with rigid bearing assumption.

Modern large capacity turbogenerators running usually at 3000 to 4000 rpm and producing power in the range of 500 MW to 1400 MW require large hydrodynamic bearings to support heavy rotor loads. In future, these bearings may even operate at higher speeds. In high speed applications where bearing stiffness and stability are major considerations, non circular bearing configurations give better dynamic performance of journal bearing systems and also reduce the power loss and increase the oil flow as compared to those of plain journal bearings.

To enhance certain characteristics of the lubricants various additives i.e. solids or liquids in the form of small particles are added to the lubricant. These additives along with contaminants form a dilute suspension of solid particles in the oil. These suspended solid particles produce thickening of lubricating oil, which in turn affect various performance characteristics of journal bearings. So it

is felt that there is a need to compute the static and dynamic characteristics of elastohydrodynamic journal bearings operating with micropolar lubricants.

This thesis is concerned with the analysis of circular and noncircular (two lobe and three lobe) journal bearings taking deformability of the bearings liner and variation of viscosity due to the presence of various additives in the lubricant. A survey of literature shows that a few investigations have been carried out on circular bearings operating with micropolar lubricants. Literatures are available on static analysis of such bearings, but literature on dynamic analysis is scarce. Literature survey also shows that no work has been carried out on EHD analysis of circular and non circular bearings operating with micropolar lubricants. So it is felt that there is a need to compute static and dynamic characteristics of elastohydodynamic journal bearings operating with micropolar lubricants.

In the present analysis a two dimensional modified Reynold's equation was derived from Navierstoke's equation and Fick's mass transfer equation and this modified Reynold's equation and three dimensional elasticity equations were used to compute the pressure distribution of the flow field and deformation of the bearing liner respectively. The solutions of the lubricant flow and elasticity equations were obtained using finite element method and a direct iteration scheme.

Based on the normalization of the governing equations, a non dimensional deformation coefficient ($\overline{\psi}$), as a function of runner speed, geometry of the lubricated contact, viscosity of the lubricant, modulus of elasticity and the thickness of the bearing linear, giving the measure of the bearing flexibility is defined. The effects of these variables (in terms of various values of deformation coefficient) on the pressure distribution, bearing deformation and on the performance characteristics of the journal bearing are studied.

In the work carried out, the static and dynamic characteristics of rigid or deformable and circular or non-circular (two lobe or three lobe) bearings have been studied. The static characteristics in terms of load capacity, attitude angle, end leakage and frictional force and dynamic characteristics in terms of stiffness

coefficients, damping coefficients, threshold speed and damped frequency of whirl have been determined for different values of eccentricity ratios and volume concentrations of additives for circular bearings, two lobe bearings and three lobe bearings. In the case of rigid circular and non-circular bearings, static and dynamic characteristics are obtained for different values of eccentricity ratios and wide range of volume concentration of additives. These characteristics are also evaluated for different values of mass transfer rate of additives in the fluid. For flexible bearings operating with Newtonian and micropolar fluids these performance characteristics are obtained for various eccentricity ratios and deformation coefficients.

The results of the study show that the effect of bearing deformation on the performance characteristics of the hydrodynamic bearings is quite appreciable when either the deformation coefficient or eccentricity ratio becomes large. The variation of viscosity with volume concentration and mass transfer rate of additives also introduces significant changes in the performance characteristics.