Abstract

With the increasing demand of high functional characteristics to low weight ratio of machinery, it becomes necessary to improve the present design of the individual components. Bearing is a vital component in majority of machine elements. The most widely used is the ball bearing due to its universal motion and less frictional characteristics. Because of non-conformal contact in a ball bearing and application of heavy load on a small area the surfaces deform elastically. The elastic deformation is of the same order of magnitude of the lubricant film thickness. A theory that provides solution of hydrodynamic equation with elastic deformation equation simultaneously is called elastohydrodynamic lubrication (EHL).

Although the steady state analysis of EHL point contacts for ball bearing is well understood, little information is available as far as dynamics of lubricated ball bearing is concerned. Present work provides engineers with the tools that enable them to predict the dynamic performance of lubricated ball bearings efficiently. A theoretical procedure for finding the stiffness and damping coefficients of lubricated ball bearing has been given and solved numerically using finite difference method (FDM). Linear perturbation method is used to derive the dynamic perturbed pressures from the solution of classical Reynolds equation. Then the stiffness and damping coefficients are found using dynamic perturbed pressures.

The theory of predicting stiffness and damping has been modified considering the surface roughness effect in elastohydrodynamic lubrication. It is found that rough surface gives better load carrying capacity as well as stiffness and damping capabilities. Later, a non-Newtonian thermo-EHL analysis is performed, in which it is observed that isothermal Newtonian theory is good enough in comparison to the time consuming three dimensional non-Newtonian thermo-EHL analysis because of insignificant change in the results. The theories have been modified in an attempt to improve the characteristics by means of couple stress fluids. These lubricants are special type of fluids where base oil is blended with high polymer additives. It is observed that couple stress fluids gives a better

load carrying capacity, stiffness and damping capabilities, and less power loss due to viscous friction. It may be desired to consider the case of mixed lubrication with high load on ball bearing in the presence of surface roughness, where a part of load is carried by asperities in direct contact. Hence, mixed lubrication analysis has been carried out. The results show that the contact load increases with increasing surface roughness, indicating more asperities are in direct contact between the two mating surfaces.

The linear and nonlinear structural vibration characteristics of these bearings have also been studied in the present work. Linear vibration is carried out on a rotor bearing system numerically using finite element method (FEM). The bearings have been modelled using the developed stiffness and damping coefficients. The results obtained have been compared with those of rotor supported on plain journal bearing and dry contact ball bearing. It is found that the response of a lubricated ball bearing is in between those of the plain journal bearing and dry contact ball bearing. Nonlinear structural vibration of the bearing is studied by solving simultaneously the equations of motion of each individual component. This analysis quantitatively shows the vibrational characteristics for each ball as well as inner and outer races of the bearing. Two characteristic frequencies are identified in the vibration signal of individual components and are referred to as natural frequencies. The damping is very much helpful in reducing the high frequency vibration components of the bearing.