ABSTRACT

The surface microgeometry of interacting machine component plays a vital role in controlling the tribological properties (i.e., friction, wear, and lubrication). The distribution of this roughness is generally studied as a Gaussian type when considered in elastohydrodynamic lubrication (EHL) analysis. However, the distribution of surface roughness is governed by the surface finish process of the machine element, which may be different from the Gaussian. Therefore, in the present work, an EHL analysis has been conducted by emphasizing the roughness effect. The digital filter technique is utilized to simulate the surfaces roughness based on the assumed roughness parameters (i.e., ACF and R_q). The EHL analysis of finite line contact is done by incorporating the generated surface roughness profile into the film thickness equation. In contrast, the multigrid technique is utilized to solve the modified Reynolds equation for finding the steady-state distribution of pressure. The elasticity equation has been simultaneously evaluated by the multilevel multi-integration (MLMI) technique. The effect of different rough surfaces, which is produced by different machining processes, has been explored on the distribution of pressure and the overall film thickness of the EHL contact. It is noticed that the surface roughness is useful for supporting more load due to the formation of pressure ripples, but this increase in load capacity is obtained at the cost of film thickness reduction. In addition, the work has been extended to study the effect of surface roughness under moderately heavy to heavy load conditions. Under these operating conditions, it has been found that the interacting surfaces work under the mixed lubrication regime instead of the fully flooded elastohydrodynamic lubrication regime. The mixed lubrication is nothing but the transition from the elastohydrodynamic lubrication to the boundary lubrication and, it has the features of both regimes. Due to the presence of insufficient lubricant within the contact zone, there exist hydrodynamic lubrication as well as asperity contact of surface roughness. In the mixed lubrication problem, the distribution of asperity contact pressure is obtained by using the numerical model presented by Yongqing and Linqing.

Furthermore, the numerical investigation is done for the steady-state performance of elliptical contacts lubricated with micropolar fluids. Eringen's micro-continuum theory is applied to deduce the modified Reynolds equation for micropolar fluids. The numerical solution is achieved under isothermal conditions and considering the exponential variation of viscosity with pressure. The effect of micropolar parameters, i.e., non-dimensional characteristics length, defines the molecular size of the blended additives, and the coupling number measures the coupling between the angular and linear momentum of molecules, and operating parameters are studied. Owing to the analysis, the pronounced effect of the micropolar parameters is observed on the elastohydrodynamic lubrication features of elliptical contacts. Lubricants added with solid additives and coupling between linear and angular momentum improved the overall film thickness and pressure and enhanced the load-carrying capacity. Also, the study is extended to find the coefficients of stiffness and damping of the ball-to-race contact lubricated with micropolar fluids. The first-order perturbation technique is utilized to formulate the hydrodynamic pressure governing static and dynamic equations. After obtaining the steady-state distribution of pressure, the perturbated Reynolds equation is solved in the dynamic condition to obtain the coefficients of stiffness and damping of lubricated contact. The effect of the micropolar parameter on the dynamic characteristics of the ball bearings is studied under various operating conditions. The outcomes showed that the influence of micropolar parameters on coefficients of stiffness and damping is significant.

Keywords: Elastohydrodynamic lubrication, Mixed Lubrication, Finite line contact, Elliptical Contact, Multilevel multi-integration method, Surface roughness, Kurtosis, Skewness, Standard deviation, Micropolar fluid, Stiffness, Damping, Film Thickness.