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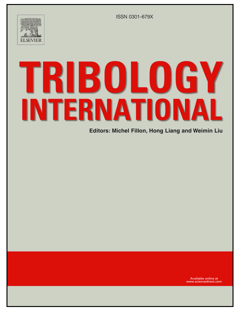

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The effects of surface roughness on the transient characteristics of hydrodynamic cylindrical bearings during startup

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Abstract

The effect of surface roughness on the transient characteristics of the hydrodynamic cylindrical bearing during startup is studied. A mixed lubrication model considering both asperity contact and hydrodynamic fluid flow is solved. The asperity contact pressure is obtained by the Greenwood-Williamson (GW) contact model. The hydrodynamic pressure is calculated by modified average Reynolds equation with finite element method (FEM). The transient movement of the journal center, the transient average film thickness, the hydrodynamic pressure and the contact pressure are presented for different surface roughnesses. The contact time and contact zone in different types of surface roughness are obtained. The influences of the standard deviation of asperity height (σ) and rough surface patterns on these parameters are analyzed. The results show that the surface roughness has an important influence on the transient characteristics of the bearing during the initial period of startup.

Keywords: hydrodynamic bearing, mixed lubrication, surface roughness, surface pattern, startup

1 Introduction

For the hydrodynamic bearings without auxiliary support system, the mixed lubrication is critical for frequent startup operation in overload conditions. The minimum film thickness of the bearings during early startup is on the same level as the asperity height of the rough surfaces [1]. Asperity contact of the shaft and bearing surface can be generated [2, 3], leading to serious wear of the bearing surface, power loss, and seizures [4]. Under the mixed lubrication, both the asperity contact pressure and the hydrodynamic pressure are influenced by the asperity height and surface roughness pattern [5]. Therefore, the effects of surface roughness on the startup characteristics of the hydrodynamic cylindrical bearings must be understood.

Christensen et al. [6] numerically presented the effects of surface roughness on the hydrodynamic behavior of the journal bearing. They found that generally the surface roughness had slight impacts on the carrying capacity of journal bearings. However, when the eccentricity ratio closed to the hydrodynamic limit, the structure and statistical properties of surface roughness had a strong impact on the carrying capacity of the bearings. The rough surface in transverse orientation could enhance the carrying capacity, but the one in longitudinal orientation would decrease the carrying capacity.

Patir and Cheng [7, 8] developed an average Reynolds equation considering the effects of the directional patterns of surface roughness. Based on this model, Wang et al. [9-11] built a mixed-THED model to analyze the conformal contact between the rough surfaces for the journal bearings. They concluded that the asperity contact/sliding friction and the viscous friction could be evaluated using the roughness-relate friction correction factor and the shear stress factor of the average Reynolds equation [7, 8]. Sander et al. [12] analyzed the effect of surface roughness on the dynamic properties of the journal bearing running from hydrodynamic lubrication to mixed lubrication. They found that comparing to the rough surface of a new bearing, a run-in rough surface could decrease both maximum contact pressure and contact area. Dobrica et al. [13, 14] proposed a numerical method of