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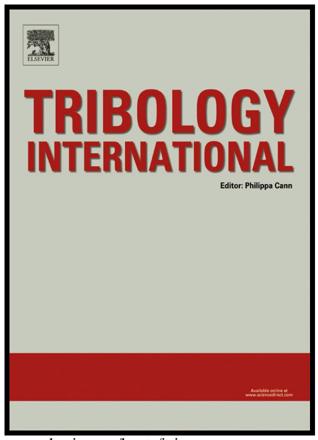

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Modelling and Analysis of Elastic and Thermal Deformations of a Hybrid Journal Bearing

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Abstract

The continuous demand for higher power density leads to a very challenging operational environment for sliding bearings regarding pressures and deformations. Understanding of the deformation behavior of heavily loaded bearings becomes even more pronounced when modern hybrid multilayer designs are considered. The aim of this study is to develop a numerical, multi-physical model for the evaluation of journal bearing performance. Hydrodynamics were based on the Reynolds equation and deformations were calculated using the integrated finite element method. Elastic and thermal deformations have a significant effect on bearing performance and those deformations can be adjusted with properties of polymer layer. The design of hybrid bearings is delicate and their properties must be tailored according to the operating conditions.
Keywords: Hydrodynamic lubrication, Deformation, Journal bearing, Polymer hybrid bearing

1. INTRODUCTION

A hydrodynamic sliding bearing is a very commonly used type of bearing in heavy industry. It is based on a hydrodynamic lubrication film which forms as a result of the relative movement and shape of the gap between the sliding surfaces. In case of a journal bearing, a narrowing gap forms between the bearing and the shaft as they are eccentrically located relative to each other due to external forces. An analytical solution to hydrodynamic lubrication of journal bearings can be found by assuming simple steady state operational conditions and bearing geometry conditions. For more complex cases, a numerical solution of Reynolds equation is needed in order to take into account, for example, dynamic operation conditions, thermal effects, shaft misalignment and out-of-round bearing geometries. In modern heavy machinery with continuously increasing demand of higher output (power density), elastic and thermal deformation of bearing surfaces and housings need also to be considered.

The interest in compliant liners has increased in recent years and several studies have shown that more uniform pressure distribution with reduced maximum pressure can be achieved with bearings utilizing compliant polymer layer, where the thickness of the elastic layer is in the range of 0.5-2mm and commonly used materials with different strengthening materials are Polytetrafluoroethylene (PTFE), Polyether ether ketone (PEEK) or Polyamide-imide (PAI), depending on the operational conditions. In this case it is obvious that a relatively high elastic deformation takes place in the compliant lining with relatively low hydrodynamic pressure. For example: Kuznetsov et al. [1] developed a model to investigate the effect of a polymer liner compliance on the bearing characteristics. They used a simple plane strain hypothesis for the calculation of elastic deformations. Thermal deformation was based on the solution of the energy equation and the hydrodynamic pressure on the solution of Reynolds equation. They concluded that compared to a standard bronze bearing, polymer hybrid bearings with a 2mm PTFE liner has higher load carrying capacity, more even oil film pressure distribution with up to 40% lower maximum pressure, similar or slightly higher maximum oil film temperature, more favorable (pocket shape) oil film distribution, increased minimum oil film thickness at the bearing midplane and slightly lower at the bearing edges and similar or higher power loss depending on operating conditions. Thomsen and Klit [2] studied the effect of polymer layer on large scale dynamically loaded bearings. Their hydrodynamics model was also based on Reynolds equation. Thermal response is calculated by a constant viscosity method and the equivalent temperature rise. Elastic deformation of the polymer liner is considered using the Winkler/column compliance method and thermal deformation is not considered. They concluded that the eccentricity increases slightly with the compliant layers but the maximum pressure decreases significantly. Thomsen and Klit [3] later improved their model by introducing finite element model for the calculation of deformations and two dimensional energy equation