7th World Tribology Congress, WTC 2022
July 10-15, 2022, Lyon, France

Computational investigation of the pressure build-up mechanism in parallel-surface fixed-pad thrust bearings

Anastasios Charitopoulos[1),2)]*, Michel Fillon[1)] and Christos Papadopoulos[2)]

[1)]Institut Pprime, CNRS-University of Poitiers-ISAE-ENSMA, Dpt GMSC, Futuroscope Chasseneuil, France.
[2)]School of Naval Architecture and Marine Engineering, National Technical University of Athens, Zografou 15780, Greece.
*Corresponding author: ancharitopoulos@gmail.com

In the present work, the pressure build-up mechanism of the fixed-pad parallel thrust bearing is investigated. The different theories proposed in the scientific literature have been evaluated. To this end, a CFD-based thermoelastohydrodynamic (TEHD) model has been generated, accounting for all the physical phenomena of the lubricant, of the solid domains and of their interaction. The importance of each physical phenomenon has been quantified, and a final modelling approach has been proposed, for accurately evaluating the performance of a parallel surface thrust bearing. Furthermore, the generated model has been validated against literature experimental results.

Keywords: Parallel Surface Thrust Bearings; Thermal Deformations; TEHD; CFD.

1. Introduction

In 1946, Fogg [1] published his experiments about the load carrying capacity (LCC) of the fixed-pad parallel surface thrust bearing. The ability of such a bearing to support load could not be explained by the classical lubrication theory; thus, he introduced the theory of the thermal wedge. In the discussion of the publication, Swift introduced the idea that thermal deformation of the stator could be the reason for the observed LCC. Since then, additional theories have been formulated and published; in his Thesis, Ettles [2] presented the predominant ones, namely: the thermal wedge, the viscosity wedge, the leading edge ram pressure effect, the macro roughness effect, the chamfer of the leading edge, and the thermal deformation of the bearing. In the present work, the importance of each theory has been quantified and a final modelling approach has been proposed, for accurately evaluating the performance of a fixed-pad parallel surface thrust bearing, by means of a 3D CFD-based thermoelastohydrodynamic (TEHD) model. Finally, the model has been validated against previously obtained experimental results [3].

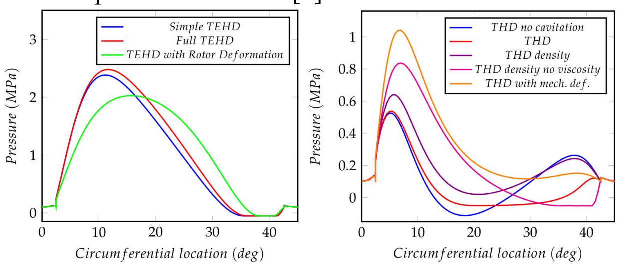

Figure 1: Pressure profiles of a parallel surface thrust bearing for the different generated models.

2. Methodology

The TEHD model generated in the present work, is a coupled model, utilizing a CFD solver (ANSYS CFX) and a FE solver (ANSYS Mechanical). The lubricant viscosity, density, heat capacity, and thermal conductivity have been considered temperature dependent. The Rayleigh-Plesset equation has been utilised for cavitation modelling. Conjugate heat transfer has been calculated in both solid domains (stator and rotor), and the stator mechanical and thermal deformations have been taken into account, while the rotor is considered undeformed.

3. Discussion

After detailed investigation, it is concluded that the main pressure build-up mechanism of the fixed-pad parallel thrust bearing is the thermal deformation of the stator geometry. Moreover, the ram pressure effect, the macro roughness, the mechanical deformation, and the thermal wedge, have minor contributions to the LCC of the parallel surface bearing.

A good correlation of the computational results with the experimental of Henry[3] has been observed (Fig.2). Furthermore, the inclusion of rotor deformation in the calculation model adds to the accuracy of the results, leading to a more accurate temperature distribution evaluation, and a better approximation of tribological characteristics of the parallel surface thrust bearing.

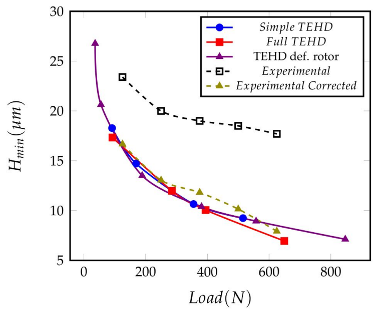

Figure 2: TEHD results: Experimental H_{min} correction

4. References

[1] A. Fogg. “Fluid Film Lubrication of Parallel Thrust Surfaces”. In: Proceedings of the Institution of Mechanical Engineers 155.1 (1946), pp. 49–67. DOI: 10.1243/PIME_PROC_1946_155_011_02.

[2] C.M. Ettles. “Hydrodynamic thrust bearing study”. PhD thesis. Imperial College, 1965.

[3] Y. Henry, J. Bouyer, and M. Fillon. “An experimental analysis of the hydrodynamic contribution of textured thrust bearings during steady-state operation:A comparison with the untextured parallel surface configuration”. In: Proceedings of the Institution of Mechanical Engineers, Part J: Journal of Engineering Tribology 229.4 (2015), pp. 362–375. DOI: 10.1177/1350650114537484.