Effects of thermal deformations on textured thrust bearings optimally designed by isothermal and THD calculation methods

Anastassios Charitopoulos[a,b *], Michel Fillon[a], Christos I. Papadopoulos[b]
*anastasios.charitopoulos@univ-poitiers.fr
[a] Institut Pprime, CNRS-University of Poitiers-ISAE-ENSMA, Dpt GMSC, Futuroscope Chasseneuil, France
[b] School of Naval Architecture and Marine Engineering, NTUA, Zografos, Greece

KEYWORDS
Modelling in tribology, Artificial surface texturing, Fluid lubrication, Parallel surface thrust bearings.

ABSTRACT

In the present work, two numerical optimisation problems have been setup and solved, aiming at evaluating the optimal texture geometry of a sector pad thrust bearing with rectangular dimples. In the first optimisation problem, isothermal lubricant flow has been considered, whereas in second one, a THD modeling approach has been followed. The resulting optimal geometrical configurations have been evaluated with the use of a thermoelastohydrodynamic (TEHD) model, in order to quantify the effects of thermal deformations on the tribological characteristics of the textured bearing. After the TEHD evaluation, four optimal designs have been selected, and a sensitivity analysis has been performed, varying the independent geometric parameters around their optimal values, in order to identify their proximity to a local optimum.

1. INTRODUCTION

Many studies have been conducted aiming at optimising texture design and evaluating the effects of texturing on the tribological characteristics of thrust bearings. In most of the studies, the conclusion drawn was that, for each application, the optimal texture parameters differ (in terms of texture region, shape, depth), thus individual studies need to be performed on a per-case basis [1]. On the other hand, the optimised textured parameters have shown to improve the performance characteristics of the bearings in a narrow range of operating conditions, but both computational [2] and experimental studies [3] have pointed out that, for high values of specific pressure, the positive effect of textures decreases dramatically, whereas, in some conditions, even a parallel thrust bearing exhibits better tribological characteristics than a partially textured thrust bearing optimised for different operating conditions [3]. At high values of specific pressure, mechanical and/or thermal deformations of the bearing geometry become significant, therefore more advanced modelling procedures are required, in order to evaluate the optimal texture geometry of the bearings.

2. METHODOLOGY

To CFD models of a textured thrust bearing (isothermal and THD) have been generated, following modeling techniques proposed in the recent literature [1-2]. Two different optimisation problems have been solved, one for each model. Two sets of optimal parameters have been selected from each optimisation process. The four sets of optimal parameters, obtained from the isothermal and THD optimisations, have been evaluated by a TEHD model. A parametric analysis has been performed for each set, in a range near the optimal parameter values, in order to identify if this set can be characterised as optimal for operation under a thermoelastohydrodynamic regime.

The ThermoElastoHydroDynamic (TEHD) model has been generated utilising a commercial code (Ansys CFX and Ansys Mechanical). A two-way FSI modelling approach has been utilised for the fluid-pad interface. The CFX and FE solvers exchange data for the domain interface (Fluid-Pad). Temperature and pressure field data are transferred from the CFD to the FE solver, and mesh displacement and heat flux of the interface from the FE to the CFD solver. The bearing pad geometry is able to deform due to (a) the temperature gradient, and (b) pressure generated within the thin lubricant film. In the present simulations, lubricant properties and operating parameters are considered to be the same as those in [3].

The bearing geometry is characterised by a parallel sector pad configuration, consisting of 8 pads with 24 rectangular dimples on each pad, being 4 and 6 in the radial and circumferential directions, respectively. The optimisation parameters for both problems are: (a) textured length (as a percentage of the pad length), (b) texture depth, and (c) textured width (as percentage of the pad width). The runner is made of steel and the slider of bronze, both characterized by a thickness of 20 mm.

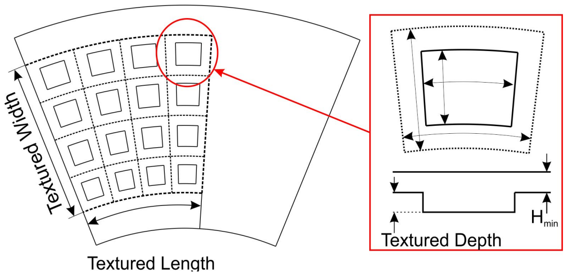

Fig1. Texture geometric parameters.

3. REFERENCES

[1] Gropper D., Wang L., Harvey T., 2015, 'Hydrodynamic lubrication of textured surfaces: A review of modeling techniques and key findings', Tribology International, Vol 94, pp 509-529.

[2] Papadopoulos C., Kaiktsis L., Fillon M., 2013, "Computational Fluid Dynamics Thermohydrodynamic Analysis of Three-Dimensional Sector-Pad Thrust Bearings With Rectangular Dimples", ASME Turbo Expo 2013: Turbine Technical Conference and Exposition, Vol 7B, pp 30-40.

[3] Henry Y., Bouyer J., Fillon M., 2014, "An experimental analysis of the hydrodynamic contribution of textured thrust bearings during steady-state operation: A comparison with the untextured parallel surface configuration", Journal of Engineering Tribology, Vol 229, pp 362-375.