Multiphysics Modeling of Spring-Supported Thrust Bearings for Hydropower Applications

F. Xavier Borràs[1], Andreas Almqvist[1], Jan Ukosaari[2]

[1]Luleå University of Technology, Luleå, Sweden
[2]Vattenfall Research and Development, Luleå, Sweden

Abstract

Spring-supported thrust bearings are used in huge rotor dynamic machines, generally to support the shafts from the biggest hydropower generators. For example, this type of bearings can be found in the turbines of the Three Gorges Dam (China) and in the biggest turbines in Sweden and Germany. Typically, the bearing supports axial load of about 2000 tones rotating at 100 rpm over a 50 micrometer thick lubricant film. Mechanical contact between the pad and the collar cause damage to the bearing and possibly also the shaft and must under all circumstances be avoided. Any attempt of modifying any aspect of this type of thrust bearing implies huge investment and is always associated with some risks. The goal of the present work is to predict the performance of spring-supported thrust bearings by combining existing theories and to incorporate them in a COMSOL Multiphysics model. Only one pad is considered when studying thrust bearings. It is assumed that the behavior of this pad can be applied to the rest of them. The Reynolds equation is adopted to govern the fluid flow and it is solved considering elastic deformation and thermal expansion of both the pad and the collar. The effect of the springs mattress placed underneath the pad is also taken into account. The final result is compound of 3 coupled models with 7 physics schematically depicted in Figure 1. The most complex stage turned out to be achieving convergence for the Reynolds equation defined in the Lubricant Shell interface. The output of this physics is the pressure profile in the gap between pad and collar (Figure 2). When working with the Lubricant Shell physics, the main parameter is the gap definition. For the present thrust bearing application, the gap description needs to be coupled with the deformation fields from both the Solid Mechanics physics defined in the pad and collar models (Figure 3). The bearing running temperatures are obtained from the Heat Transfer interface. These temperatures temperature distribution are used to estimate the thermal expansion in both solids. The result of this study is a thermoelastohydrodynamic model (TEHD) taking into accounts the main variables affecting the behavior of spring-supported thrust bearings. This model predicts the pressure within the lubricant, acting on the pad and collar (Figure 2), the fluid film thickness (Figure 4) and the temperature distribution on the entire assembly. The deformation of the pad (Figure 3) and the collar due to the pressure applied and the thermal expansion are also outputs. The model obtained is generic and can be easily adapted to other spring-supported thrust bearings. With the model it is possible to carry out experiments predicting the bearing performance when varying the external load, varying the angular velocity of the shaft, testing different lubricants, testing different compound materials or shapes, experimenting with different spring patterns, varying the oil bath temperature, etc. Hopefully, the usage of this model during design process of spring-supported thrust bearings can help avoid dangerous and expensive mistakes.

Figures used in the abstract

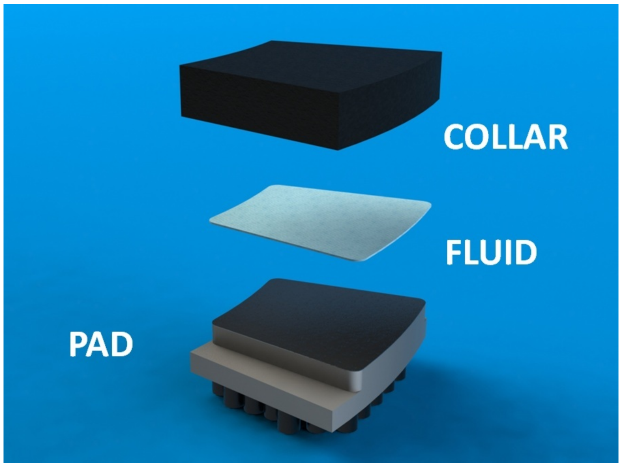

Figure 1: Assembly Scheme.

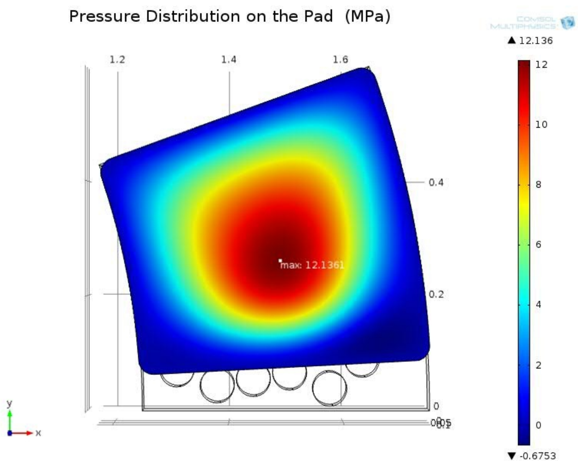

Figure 2: Pressure Distribution on the Gap.

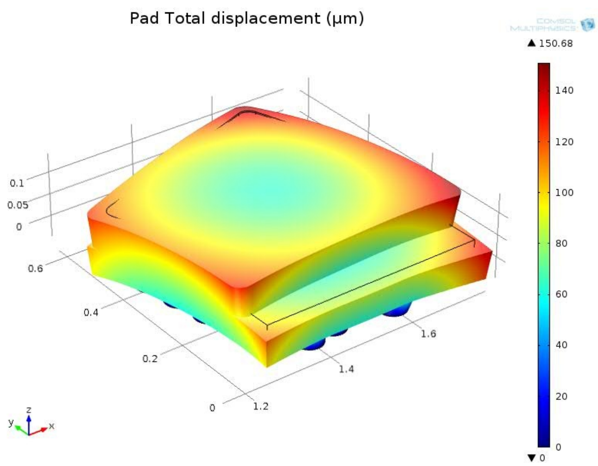

Figure 3: Pad Deformation.

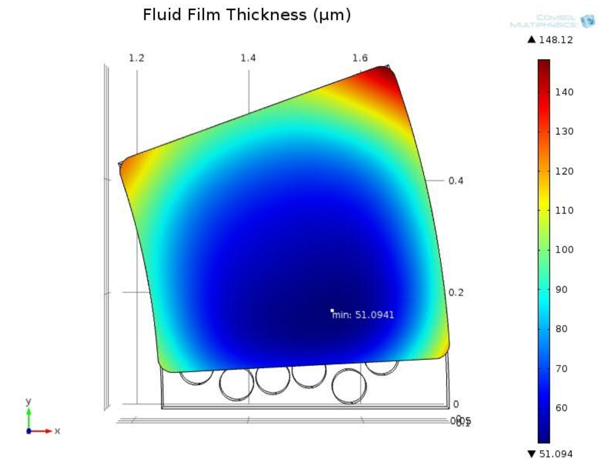

Figure 4: Fluid Film Thickness.