Air Foil Bearings - a Modeling Approach

M. Bezemer-Krijnen[1], Y.H. Wijnant[1], A. de Boer[1]

[1]University of Twente, Enschede, The Netherlands

Abstract

Introduction:
A first generation air foil bearing (AFB, Figure 1) consists of two foils, a bump foil and a top foil. When rotating at high speeds; an air film is formed which will lower the friction forces between the journal and the top foil. The goal of the research described in this abstract is to develop a model to predict the characteristics of an AFB, such that the bearing can be designed for best performance.

Use of COMSOL Multiphysics®:
The circular geometry of the bearing is described by a flat plate representing the top foil. The flow in the thin air film between top foil and journal is described by the Reynolds equation for thin fluid films, which is predefined in COMSOL Multiphysics® (Lubrication Shell interface, CFD module). The inlet and outlet of this fluid film are coupled to simulate the circular geometry. The thickness of the air film depends on the clearance, eccentricity and elastic deformations of the bump structure [1].

The bump structure is modeled with a series of nonlinear springs for which the stiffness depends on the position of the bump w.r.t. the welded end (see Figure 1) [2]. This is modeled in COMSOL Multiphysics® by a spring foundation, linked to the top foil. The stiffness of the springs is described as function of the deformation and position of the springs (Figure 2).

Results:
A series of simulations is performed to find the parameters which are most important for the performance of the AFB, here the load capacity of the bearing. The fluid pressure (Figure 3), the Von Mises stress and the deformations of the top foil are used to compare the simulations. The most important parameters are the friction between the foils and the housing and the thickness and Young's modulus of the foils.

The load capacity of the AFB can be determined by computing the forces acting on the journal for a certain eccentricity and orientation of the welded end. The load capacity depends heavily on the eccentricity and should be optimised per situation. In general it seems that the load capacity is largest when the welded end is positioned around 120 degrees from the top position of the AFB (φ in Figure 1).

Conclusion: The developed model combines analytical descriptions with FEM to find more

accurate results and a faster computational time. A limitation of the model is that it simulates the stationary situation. The dynamic behaviour of an AFB is not described. Experiments are needed to validate this numerical model. However, it is expected that this model gives guidelines and is a simple method to design new AFBs.

Reference

1. H.Heshmat, et al, Analysis of Gas Lubricated Compliant Thrust Bearings, Journal of Lubrication Technology, vol. 105, pp. 638–646 (1983)

2. I.Iordanoff, Analysis of an Aerodynamic Compliant Foil Thrust Bearing: Method for a Rapid Design, Journal of Tribology, vol. 121, pp. 816–822, (1999)

Figures used in the abstract

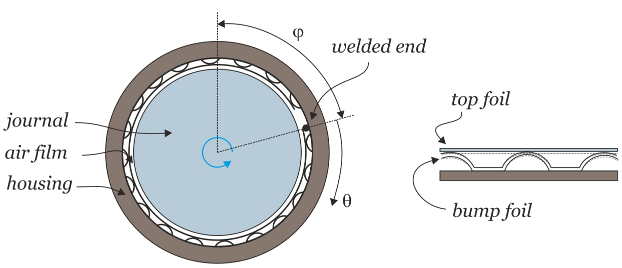

Figure 1: Schematic design of a first generation air foil bearing

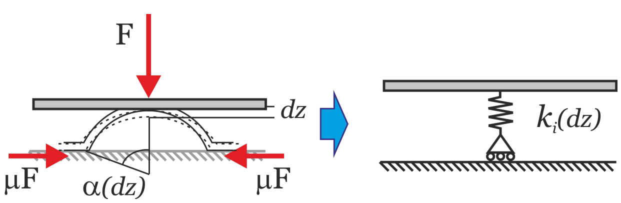

Figure 2: Model of bump structure

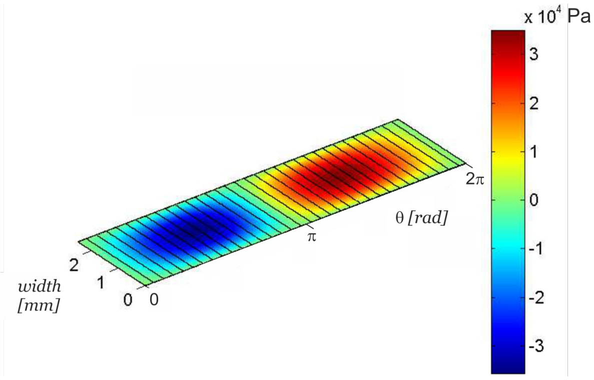

Figure 3: Difference in fluid pressure between total pressure in thin air film and ambient pressure, for φ=0