Modelling Wear of Journal Bearings

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Abstract

Journal bearings as the most prominent representative of large-area tribological contacts are main parts in today's machines and draw special attention in internal combustion engines (ICE) or drive chain. Typically they comprise of a steel shaft, a softer multilayer journal bearing shell and the lubricant in between, see Figure 1. The relative motion of the shaft and the journal bearing result in a fluid film gap geometry allowing a hydrodynamic pressure build up separating both surfaces and balancing the external load. In this case the system operates in the fluid friction regime. External influences (e.g. temperature, load and speed) can cause a decrease in film thickness. In cases of film thicknesses in the same magnitude as the combined roughness of the boundary surfaces, the interaction between them leads to solid contact resulting in increased frictional losses and wear. Actual developments aiming to reduce energy consumption and emissions push operation of journal bearings from fluid friction regime into the mixed friction regime making an assessment of wear necessary.

To investigate this topic a numerical model was set up in COMSOL Multiphysics® representing the relevant subsystem of a test rig, a rotationary tribometer TE92HS from Phoenix Tribology in combination with a Journal Bearing Adapter, which is used for friction and wear tests of a close-to-component journal bearing system, see Figure 2. Using a 3D model the Thin-Film Flow of the CFD Module coupled with the Solid Mechanics interface of the Structural Mechanics Module allow solving for the hydrodynamic pressure using the Reynolds equation. This set up allows a time dependent investigation of the hydrodynamic carrying capacity in case of stationary and instationary load. Solid contact is taken into account in terms of an analytical function yielding the solid contact pressure dependent on the fluid film thickness. To investigate the time and spatially resolved wear process a wear law based on Archard's formula is implemented in form of an ODE and solved on the surface of the journal bearing [1]. The gained results include the time and spatial evolution of the wear pattern, see Figure 3. Furthermore the impact of evolving wear on the resulting force equilibrium between external, hydrodynamic and solid contact force is investigated. A comparison between numerical and practical investigation yields good agreement in the case of wear pattern but differs in wear height which can be lead back to the used wear intensity factors.

Reference

J.F. Archard and W. Hirst., Wear of metals under unlubricated conditions, Proceedings of the Royal society of London. Series A, Mathematical and Physical Sciences., Vol. 236, pp. 397-410 (1956).

Figures used in the abstract

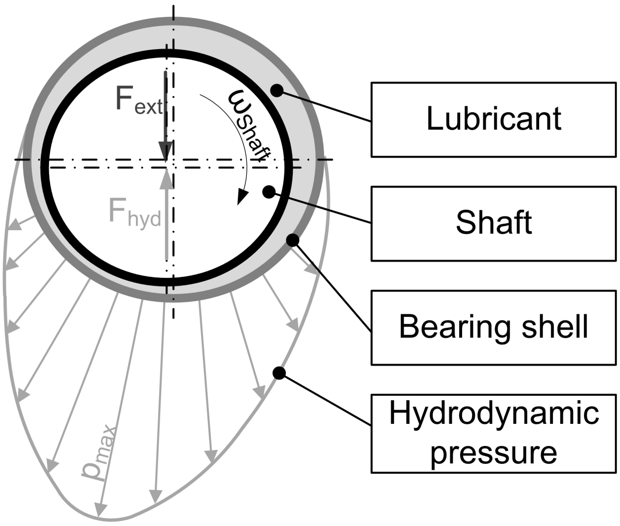

Figure 1: Principle set up of a journal bearing.

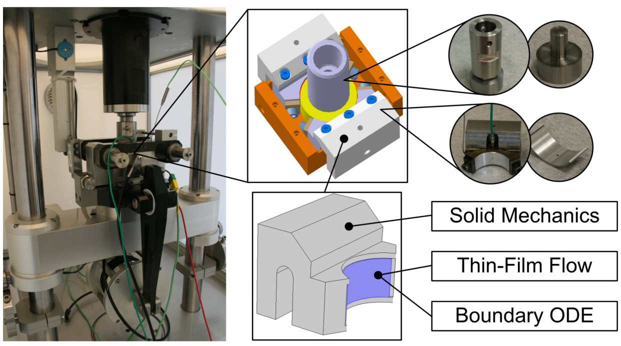

Figure 2: Test set up of the rotationary tribometer TE92HS (Phoenix Tribology) and its COMSOL implementation).

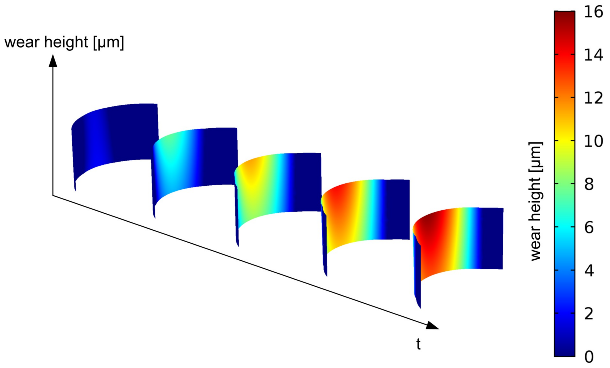

Figure 3: Evolution of wear.