Wear prediction for plain bearings under start-stop conditions

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The aim of this study is to predict the wear in plain bearings caused by start-stop operation. Therefore, the conditions in plain bearings were calculated utilizing transient mixed-elasto-hydrodynamic lubrication simulations. An energetic wear law was adapted to transient conditions and applied on contour as well as asperity scale. For validation of the numerical method, start-stop experiments with varying cycle counts were conducted on a special test rig for plain bearings. For further validation of the proposed method, the wear induced changes of the bearings were subsequently analysed with roundness measurements, laser-scanning microscopy, energy dispersive x-ray spectroscopy and electron backscatter diffraction.

Keywords: plain bearings, elasto-hydrodynamic simulation, wear prediction

1. Introduction

The applicability of oil-lubricated plain bearings in wind turbines, i.e. in gearboxes and as main bearings, is an emerging field of research. These plain bearings are susceptible to wear due to the frequent start-stop procedures of wind turbines. On that account, a reliable prediction of wear-lifetime of a specific plain bearing system during an early stage of the design process is of growing interest. However, in existing methods, the wearing-in of asperities is not taken into account. The primary aim of this study is to develop and validate a method for wear prediction under start-stop conditions from wearing-in to steady-state wear. Furthermore, the near-surface material properties used in simulations are commonly assumed to be constant throughout the lifetime of a bearing. The secondary aim of this study, is to elucidate the near-surface material properties and chemical composition as part of the running-in process.

2. Methods

A coupled mixed elasto-hydrodynamic lubrication and wear simulation method was developed to predict the wear progression during start-stop operation. For validation of the proposed method, the start-stop experiments with varying cycle counts were conducted. Wear induced changes of the bearings were subsequently analysed with roundness measurements, laser-scanning microscopy, energy dispersive x-ray spectroscopy and electron backscatter diffraction.

3. Results

The results of the coupled model for wear prediction under start-stop conditions are summarized in Figs. 1 and 2. In Fig. 1, the evolution of wear volume is displayed.

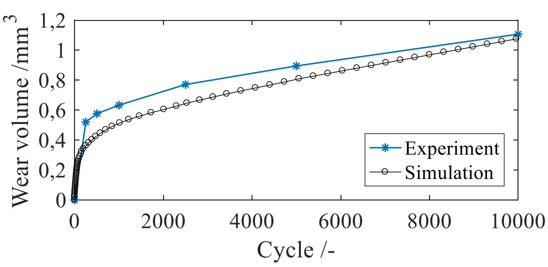

Fig. 1: Comparison between experiment and simulation

Due to wearing-in of the bearing contour and asperities, the wear losses are significantly reduced after a few start-stop cycles. By taking this into account during the wear prediction, a good agreement can be achieved.

The results from roundness measurements and laser-scanning microscopy were used to validate the proposed wear prediction model. The results of the energy dispersive x-ray spectroscopy and electron backscatter diffraction justify the use of constant near-surface material properties throughout the simulations, as minor changes can observed.

For further validation, the transient friction losses during start-stop operation are evaluated. As shown in Fig 2., the predicted friction losses are in agreement with the measured losses.

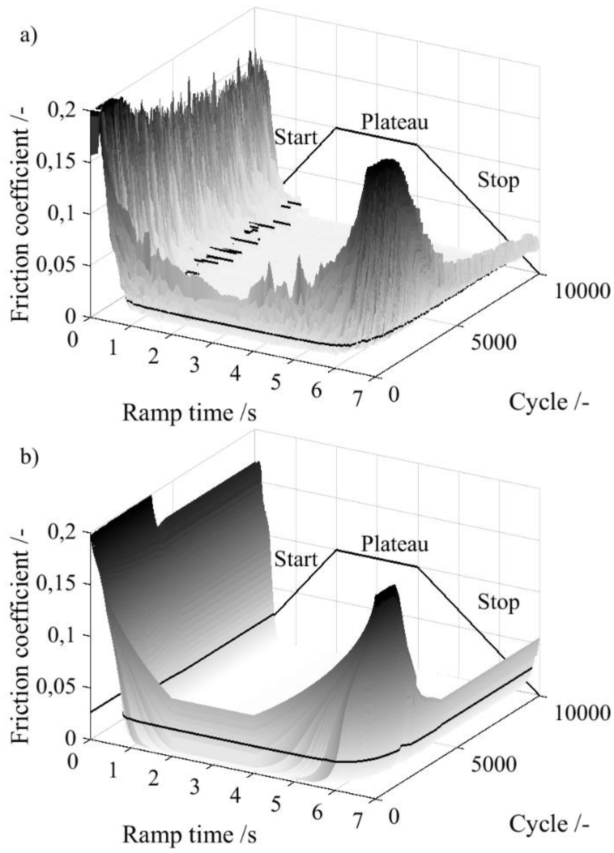

Fig. 2: Comparison between experiment (a) and simulation (b)