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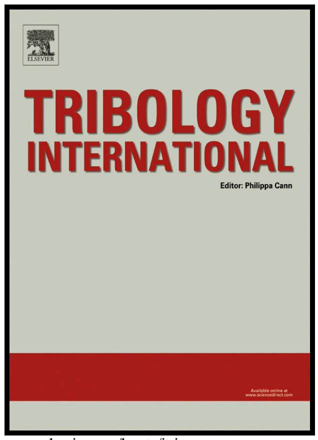

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Wear simulation in non-lubricated and mixed lubricated contacts taking into account the microscale roughness

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Abstract

Wear is a phenomenon that occurs in every technical system and represents the limiting factor in the operational durability. Therefore, it is very important to predict the amount of wear for a tribological system in a reliable manner. In this investigation, different journal bearing materials are investigated in focus of wear behavior in combination with a shaft of steel. The aim of this investigation is to simulate sliding wear on two rough surface profiles in a non-lubricated and mixed-lubricated regime, taking into account the real surface topography of the bearing and the shaft. The whole numerical investigation is taking place at the microscopic level and is modelled with the finite elements software Abaqus (Dessault Simulia) in combination with the programming language Python for applying wear on the rough surfaces. All investigations for the mixed-lubricated regime are based on the lubrication model of Lorentz [1] and taking into account the new add-ons described in [2].

INTroduction

For a question of CO_2 reduction, new innovative operating strategies like the start-stop system have been implemented in the automobile industry for reducing fuel consumption and exhaust emissions. Such new strategies provide new demands on machine components in lubricated regimes like wet clutches, journal bearings or piston rings. In this work, the focus is on hydrodynamic journal bearings which are subjected to a running-in phase and several start-up phases. At any time during these operations, mixed lubrication occurs and causes wear.

To investigate journal bearings under mixed lubricated conditions with numerical approaches holistically, it is necessary to consider the friction behaviour as well as the wear mechanism occurring under these conditions.

This paper reports a new approach for modelling wear on the microscopic scale, taking into account real surface roughness of measured journal bearings. The whole numerical approach is based on the finite elements method and was modelled with Abaqus and new modules were developed for the wear calculation at the rough surface topology.

There are similar works concerning wear approaches with the finite element method on non-lubricated regimes. A summary is given in the next section about the different approaches and their limitations for modelling wear on both surfaces in mixed lubricated regimes. In the third section, a summary is given about the different models for the wear mechanism for applying wear. In the fourth section, the results for different wear and friction coefficients are shown, taking into account the mesh density and different mixed lubricated conditions.

STATE OF THE ART

For modelling wear with the finite element method, there is often used the incremental wear law by Archard [3]. The macroscopic wear coefficient defines the volume loss per load of a tribological system, at a constant load and sliding distance. Khader [4] used this approach for modelling wear in silicon nitride rolls undergoing rolling-sliding contact under dry conditions. The surfaces were ideally smooth and the experiments were conducted on a twin-disc tribometer. The results have shown that there was an acceptable accuracy. The simulations were carried out with Abaqus and the subroutine UMESHMOTION. With this routine, the surface nodes could be moved by using the adaptive mesh method in Abaqus for applying local wear depths. With this subroutine, wear could be modelled on one surface and is only applicable with implicit analysis methods. In the same way, Bhattacharya [5] modelled wear in an artificial cervical disc in a non-lubricated regime. Ali [6] did the same investigation by the example of hip implant devices. Ismail [7] investigated the running-in phase of a rolling contact of a rigid hemisphere on a rough surface. Above a certain load, a significant change in surface topology is observed. He made the observation, that the running-in of rolling contacts takes place within the first few cycles. Argatov [8] indicated that the contact pressure is very important in determining the end of the running-in phase. His approach is a combination of the theory of elasticity in conjunction with Archard's law. Hegadekatte [9] developed a further method, predicting wear in rolling-sliding contacts. With the Global Incremental Wear Model (GIWM) he determined the pin wear on a pin-on-disc tribometer. For this approach he used the wear law by Sarkar [10]. Sarkar extended Archard's wear law by relating the friction coefficient to the volume of material loss. Chmiel [11] created a Python script for applying wear on a rocket sled track. With this code, he could also apply wear in an explicit calculation method in Abaqus.