Wear mechanisms in oscillating bearings: A semi-analytical method to study radial fretting and false brinelling

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Abstract

Oscillating bearings, unlike conventional bearings used in most applications, operate under small reciprocating motions rather than continuous rotation. Those bearings can be found in industrial applications such as crane slewing bearings or wind turbines pitch bearings (1). These unique operating conditions lead to significant challenges in terms of lubrication. Indeed, oscillating bearings operate under boundary or mixed lubrication regime due the low relative velocity between the contacting surfaces. This limits the establishment of a sufficient lubricant film which can lead to metal-metal contact and wear (2-4). These wear mechanisms are known as false brinelling for lubricated contacts and fretting corrosion for dry contacts (5,6). These wear phenomena can significantly impact the operational lifespan and reliability of oscillating bearings. In addition to lubrication challenges, oscillating bearings are often subjected to high time-varying loads, which contribute to fluctuating normal loads in the contacts. These variations induce relative tangential motions between the contacting surfaces resulting in complex fretting behaviors.
The aim of our work is to propose a fast and efficient calculation method to study fretting mechanisms in oscillating bearings: rotational fretting defined as the relative motion in a reciprocating rolling contact (7), and the radial fretting caused by the relative motion due to a variable normal load (8). To capture these phenomena, a two-step methodology is proposed. First, a bearing calculation code which considers the kinematics (9) and the loading conditions was developed to calculate the micro-slips inside the contact zone, commonly referred as creepages. Then, those creepages are used in a semi-analytical contact model based on the Discrete Convolution and Fast Fourier Transform (DC-FFT) (10). This computationally efficient model is used to calculate the shear stresses inside the contact and to identify the stick vs. slip zones.

Another key aspect of our work is the experimental determination of the coefficient of friction to provide a realistic value reflecting the real operating conditions in terms of materials and lubrication. This experimental campaign was conducted using a fretting sphere-on-flat test rig, where the tangential load was measured during fretting cycles under a constant normal load. The fretting loops obtained from these experiments provided a reliable means to extract the friction coefficient which was used in the numerical simulations to enhance their realism and predictive accuracy.

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By combining advanced numerical techniques with experimental tests, this methodology provides a robust framework for understanding and mitigating fretting-induced wear phenomena in oscillating bearings. This work follows on from several previous studies conducted at the Contact and Structural Mechanics Laboratory (LaMCoS), aimed at developing semi-analytical methods for contact resolution based on DC-FFT (11-13). Future work will focus on integrating the role of wear on the modification of the geometry over fretting cycles.

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