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Modeling of the Wear Particles Formation in Mixed Lubricated Sliding Line Contacts

CATEGORY: WEAR

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INTRODUCTION

Wear is the gradual removal of surface material through generation of wear particles. The influence of wear particles generated during sliding is not only limited to wear process itself as for example in the transition from the more severe "running-in" mode to the mild wear regime [1,2] but can also have a severe impact on a complete system. For example the oxidation of grease thickener and base oil was found to be accelerated by the wear debris [3,4] and regarding artificial joints an autoimmune reaction of the body is significantly dependent on the size of the formed wear fragments, when the artificial joint replacement is used [5,6]. In addition, the wear particles also may have environmental effect [7]. Hence, development of models for predicting the size and shape of wear particles is necessary for optimization in these systems.

In this work, the formulation of a model capable of predicting the wear particles formation in mixed lubrication is considered. A BEM contact model was combined with a particle removal model. For the contact simulations, a half-space-based contact algorithm was joined with a numerical elastohydrodynamic lubrication solver through the load-sharing concept.

MODEL AND SIMULATIONS

The considered wear particles formation model is based on the critical von Mises stress and it is therefore required to calculate the contact pressure, which in turn is determined by the load carried by the surfaces contacts. In mixed lubrication, the applied normal load is partly carried by the hydrodynamic film (generated due to presence of the lubricant) and only partly by the surfaces contacts. The load-sharing concept based approach is used to find the corresponding values of hydrodynamic and contact loads. The details of the algorithm can be found in reference [8]. The subsurface and von Mises stresses are calculated using a half-space approximation. For a volume to form a wear particle two criteria need to be met: 1) the von Mises stress exceeds a critical value 2) the volume is exposed to the surface. The details of the wear model can be found in reference [9]. A schematic diagram of the algorithm is shown in **Fig. 1**.

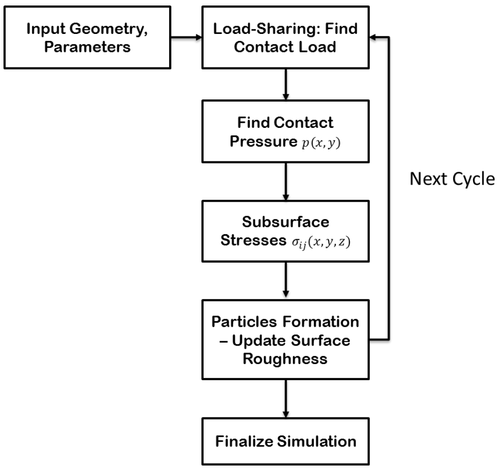

Fig. 1. The algorithm for particles simulation.

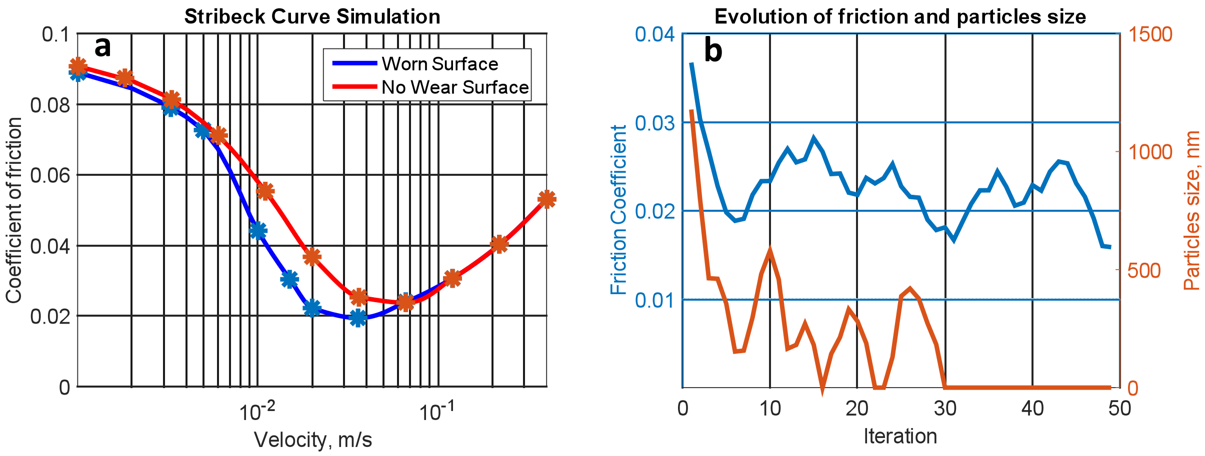

Fig. 2. Examples showing (a) the effect of wear on friction and (b) evolution of the coefficient of friction and wear particles size at a speed of 0.02/s.

The Stribeck curve simulation was performed to find the friction coefficient in mixed lubrication with and without surface roughness evolution due to the generation of wear particles. In the case where wear is taken into account, at each sliding velocity the calculations were performed until the friction coefficient was stabilized. Results are shown in **Fig. 2**. Clearly, the wear process results in the decrease of the friction due to surface evolution. In the beginning, large wear particles are formed, but their size decays rapidly and wear particles stop forming, indicating that only elastic deformation is present in the system after an initial period. These effects can be summarized as the running-in effects.

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KEYWORDS

Wear particles, running-in, mixed lubrication, simulation