Investigating the impact of surface roughness on the EHL film thickness by using a homogenization technique

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1. Introduction

Common engineering non-conforming contacts, such as the ones that occur in gears, roller bearings and cams, operate under elasto-hydrodynamic lubrication (EHL) conditions. Since the breakdown of a continuous lubricant film leads to adhesion and severe distress of the surfaces, a proper evaluation of the film thickness is crucial in any engineering design.

Several formulae for the central and minimum film thickness are available in literature, cf. that by Dowson and Higginson for line contacts or its counterpart for point contacts [1], [2]. These representations are based on a power law regression to the numerical solutions of the classical EHL problem for smooth contacts. However, in many practical engineering applications, the film thickness predicted by these formulae is comparable with the height of surfaces asperities. Therefore, the performance of the lubricated contact depends on both the macroscopic geometry of the contact itself and on the microscopic length scales of the roughness.

More recently, an effective approach to tackle the problem fully rationally was introduced, which adopts a homogenization technique [3] [4], [5]. The homogenization process leads to a hierarchical but coupled system of equations which allow to study the macroscopic behavior of a lubricated contact (i) subject to a given micro structure, (ii) without resorting to the explicit resolution of the micro scale, i.e the roughness, on the macro scale.

Interpreted as a rigorous (i.e. asymptotic) method, homogenization provides proper means for the description of the lubrication mechanism for largely arbitrary roughness patterns. Most important, it allows to overcome the limits of semi-rational approaches, notably the statistical one by Patir and Cheng; see [6]. Finally, the solution of the homogenized problem can be obtained with a considerably less computational effort than the one required by a fully deterministic approach.

2. Numerical simulation

An attempt has been made to rigorously study the effect of surface roughness on non-conformal concentrated contacts under the action of elasto-hydrodynamic lubrication. Here the most intriguing phenomena of interest include the impact of transversal and oblique roughness on the EHL film thickness i.e., due to grinding marks produced by machining process on engineering surfaces. This investigation may prove to be of interest from both a designer's and a theoretician's point of view.

Amongst others, first numerical results allow for assessing the deviations of the typical "horseshoe-type" homogenized distributions of the contact pressure as well as the height of the lubricated gap from those referring to smooth contact surfaces; see figure 1.

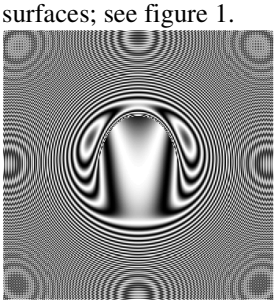

Figure 1 Simulated pseudo-interferometry of a point contact involving surfaces

3. References

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