Surface Roughness Effects in Elastohydrodynamic Lubrication – A Review with Contributions

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1. Introduction

Modern machine elements are required to work under increasingly severe conditions. Therefore in heavily loaded lubricated contacts the effect of surface topography is now more relevant than say, 40 years ago. Yet, in the year 1977 the 4th Leeds-Lyon Symposium on Tribology was held with the theme "Surface Roughness Effects in Lubrication" ! How much have we learnt since then ?

2. Rapid Methods in micro-EHL

With the use of rapid methods in micro-EHL [1] the work of Venner et al. [2] on waviness amplitude reduction, can be extended to real roughness (e.g. rolling bearing surfaces) as shown in Figure 1, where a similar amplitude reduction curve is obtained as function of the Venner et al. modified ∇ parameter.

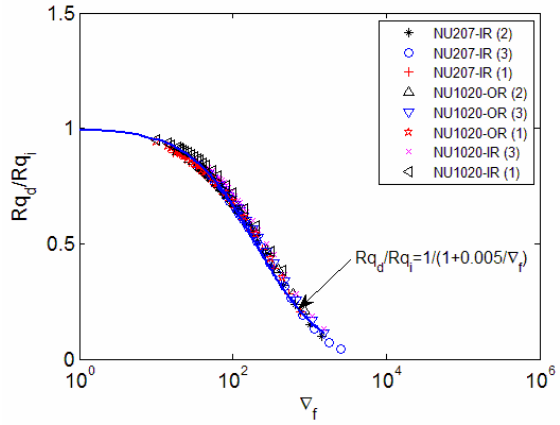

Figure 1. Amplitude reduction curve for rolling bearing real roughness (R_{q_d} / R_{q_i}) as calculated by the rapid method.

3. Material Interaction with Roughness

The micro-EHL rapid methods can be combined with the work of Eshelby [3] to generate solutions where roughness and subsurface material interact in a transient manner. Figure 2 shows an example where roughness has been removed to better show the effect of the inhomogeneities in the EHL pressures and clearances. The results show that inhomogeneities in the material may produce similar effects in EHL pressures and clearances as surface topographical defects (roughness, dents, bumps) would do.

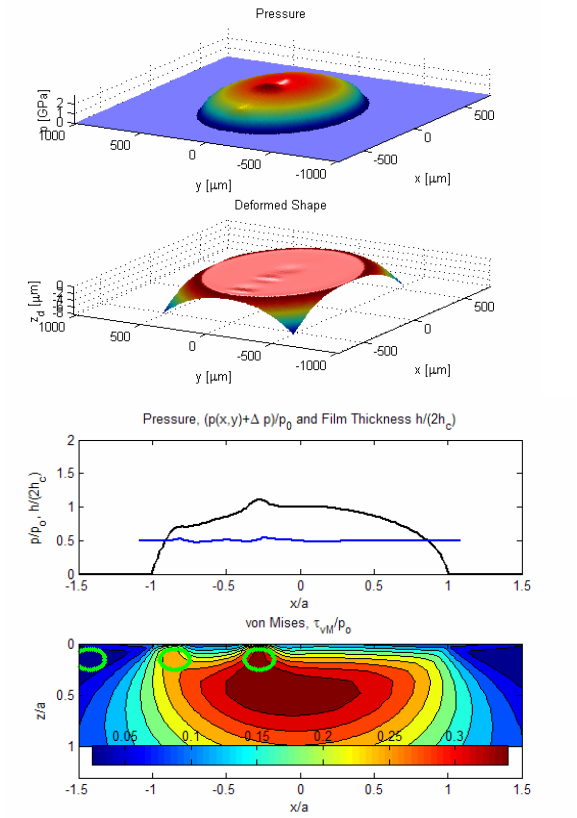

Figure 2. Rapid method solution for pressures, clearances and von Mises stresses for the inhomogeneous lubricated problem of smooth surfaces, ellipsoidal inclusions harder than steel.

4. References

[1] Morales-Espejel, G.E., Lugt, P.M., van Kuilenburg, J., Tripp, J.H., "Effects of Surface Micro-Geometry on the Pressures and Internal Stresses of Pure Rolling EHL Contacts", Tribology Transactions, vol. 46, pp. 260-272, 2003.

[2] Venner, C. H., Couhier, F., Lubrecht, A. A. and Greenwood, J. A., "Amplitude Reduction of Waviness in Transient EHL Line Contacts". Elastohydrodynamics'96, Proceedings of the 23rd Leeds-Lyon Symposium on Tribology (Eds. D. Dowson et al.), 1997, pp. 103-112 (Elsevier, Amsterdam).

[3] Eshelby, J.D., "Elastic Inclusions and Inhomogeneities", Progress in Solid Mechanics, pp. 89-139, Amsterdam North-Holland, 1960.