Thermal Aspects of Debris in EHL Contacts

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1. Introduction

In the last few decades the bearing industry has made significant improvements in the cleanliness of bearing steels, through techniques such as vacuum degassing. This has lead to significant improvements in the fatigue lives of rolling element bearings, since modes of failure, such as spalling, that are initiated around inclusion and impurities are no longer dominant. Surface initiated fatigue is now the main failure mode; with debris contamination being the cause of over 75% of premature rolling element bearings [1]. The prediction of debris behavior in rolling contacts is therefore of significant practical benefit.

In this work, a technique is developed to measure the temperature rise resulting from debris entrainment in an elasto-hydrodynaanmically lubricated (EHL) contact. This is carried out as a means of validating, and providing data for, theoretical simulations. Specifically, the thermo-mechanical particle entrapment model of Nikas et al [2] is tested.

2. Experimental Setup

Experimentally, an EHL contact is produced by loading a steel ball against sapphire disc, located beneath an infrared camera with a microscope lens, as shown in Fig. 1. This setup allows rapid, full-field images of the contact and is sufficiently sensitive to detect temperature rises less than 0.1 °C. Lubricant containing dispersed, solid particles is entrained into the contact. The high acquisition rate allows several successive temperature distributions resulting from the entrainment of a single particle to be captured.

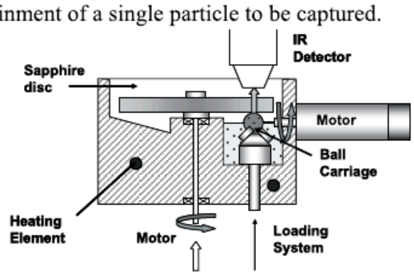

Fig.1 Schematic diagram of experimental setup.

3. Results

Temperature maps have been obtained for both sliding and pure rolling conditions. An example of successive temperature maps for a debris particle is shown in Figs. 2 and 3. As expected, under pure rolling, temperature rises are small, since minimal shearing occurs. Under sliding conditions, the temperature rise generally increases from when the particle is entrapped in the inlet zone, to peak near the contact centre where shearing is a maximum.

Comparison of the measured values with theoretical simulation shows a similar trend in temperature rise as the particle passes through the contact. The magnitude of predicted temperatures is however significantly higher than those measured. Causes of these discrepancies are discussed, and refinement of both the model and the experimental technique are the subject of ongoing work.

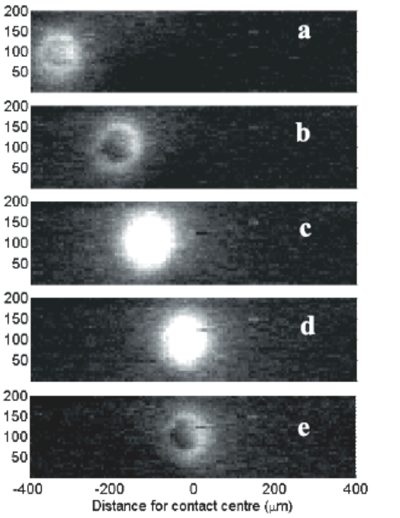

Fig.2 Thermal images of debris particle passing through the contact.

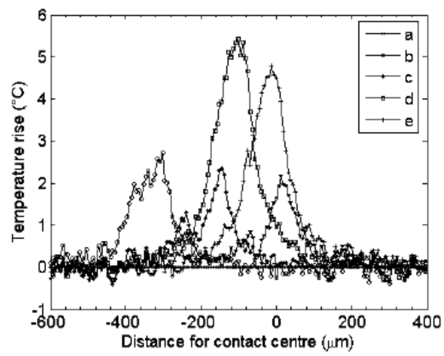

Fig.3 Temperature profiles taken form images in Fig 2.

4. Summary

Successive temperature maps resulting from the entrainment of a single particle have been obtained. These show the different modes of particle deformation as it is entrained through the contact. Particle temperatures are predicted using a thermo-mechanical model, and results are compared.

5. References

[1] Ai, X., (2001), "Effect of debris contamination on the fatigue life of roller bearings", Proc. Instn. Mech. Engrs, 215, pp. 563-575.

[2] Nikas, G., Sayles, R. S., Ioannides, E., (1998), Effects of debris particles in sliding/rolling elastohydrodynamic contacts, Proc. Instn. Mech. Engrs, 212, pp. 333-343.