Starved Lubrication: Contribution of Laser Surface Micro-Texturing

Florian Brémond[1)*], Denis Mazuyer[2)] Philippe Maurin-Perrier[1)], Juliette Cayer-Barrioz[2)]
[1)] IREIS, rue Benoît Fourneyron, CS 42077, F-42162 Andrézieux-Bouthéon cedex, France
[*]Corresponding author: fbremond.ireis@hef.fr
[2)] Laboratoire de Tribologie et Dynamique des Systèmes, UMR5513 CNRS, Ecole centrale de Lyon,
36 avenue Guy de Collongue, F-69134 Ecully cedex, France

ABSTRACT

To prevent the occurrence of wear and the increase in friction in case of lubricant starvation between two surfaces in contact, this study demonstrates experimentally the possibility to create oil feeding in the high pressure zone, by controlling the micro-topography of the surfaces. Thanks to a femtosecond laser, micro-cavities are generated on the surface and locally increase the lubricant film thickness.

1. Introduction

The ability of a fluid to separate two surfaces in contact under severe mechanical conditions is outstanding. However, the persistence of this protective film will be challenged in case of inadequate contact feeding in lubricant, that is to say when starvation occurs. Although various experimental [1,2] and numerical [3] studies have focused on starvation and replenishment mechanisms under stationary conditions, only little work has taken into account transient conditions.

The goal of this paper is to evaluate the contribution of a laser micro-textured surface to maintain a lubricating film and to prevent wear. We also analyze the onset of partial starvation based on an effective feeding volume in the convergent zone. The consumption of this volume leads to severe starvation regime.

2. Experimental

In this context, starvation mechanisms in elastohydrodynamic regime were experimentally investigated in pure rolling, in rolling/sliding and also reciprocating conditions for fluid viscosity ranging from 50 to 3000 mPa.s. Thanks to a ball/disk tribometer [4] with an optical interferometric system, the convergent, contact and outlet zones are simultaneously visualized (see Figure 1), and the film thickness distribution and the friction force in the high pressure zone under controlled contact kinematics are measured.

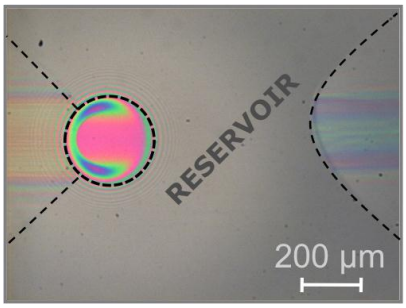

Fig.1 EHL contact. The air/lubricant meniscus is clearly visible in the inlet zone. The flow direction goes from right to left.

Occurrence of starvation will be discussed in terms of film thickness, location of the air/lubricant meniscus and friction.

3. Results and discussion

Severe starvation occurs when an effective volume of lubricant in the convergent zone is consumed: the film thickness decreases and the friction force simultaneously increases. We show that starvation process is function of two time scales. For short time, inferior to 1s, the film thickness and the location L_M of the air/lubricant meniscus are correlated as shown in Figure 2. For longer times, few hundreds of s, a progressive diminution of the film thickness down to few nanometers in the contact zone results from the lubricant deficit induced by the ratio leakage/flow rates. This decrease of the film thickness causes the occurrence of wear in the contact. In presence of a laser micro-textured surface, the shearing of the lubricant entrapped in the micro-geometries is able to provide a local increase of the film thickness, protecting the mating parts. The ability to diminish wear is governed by the density and the depth of micro-texturing.

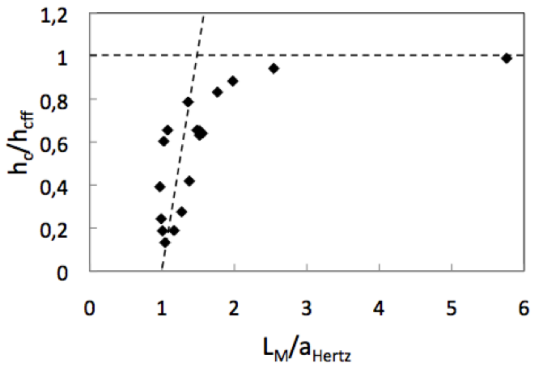

Fig.2 Correlation between the central film thickness h_c and the location of the air/lubricant meniscus L_M.

4. References

[1] Chiu, Y.P., "An analysis and prediction of lubricant film starvation in rolling contact system", ASLE transactions, vol. 17, 22 – 35, 1974.

[2] Guangteng, G. and Can, P.M.E. and Spikes, H.A., "A study of parched lubrication", Wear, vol. 153, 91 – 105, 1992.

[3] Chevalier, F. and Lubrecht, A.A and Cann, P.M.E and Dalmaz, G., “The evolution of lubricant film defects in the starved regime”, Proceedings of the 24th Leeds-Lyon Symposioum of Tribology, vol. 34, Tribology series, 233-242, 1998.

[4] Bou-Chakra, E. et al., “A non-Newtonian model based on Ree–Eyring theory and surface effect to predict friction in elastohydrodynamic lubrication”, Tribology International, 43, 9, 2010, 1674-1682.