Thermal effects of DLC coating on EHL performance at high sliding

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DLC (Diamond-Like Carbon) coatings on steel surfaces are known to reduce friction coefficient in lubricated contacts. In this study, tests are performed in conditions that match as closely as possible a cam/follower contact. Both experimental and numerical results are exploited in order to understand the effects of using DLC coatings on lubricant film thickness and friction coefficient. Finally, conclusions can be drawn on the optimal configuration to both reduce friction and avoid mixed lubrication.

Keywords: engine tribology, TEHL, surface properties, film thickness, friction

1. Introduction

Friction losses in the valvetrain constitute a non-negligible part of the overall energy dissipated in internal combustion engines. This study aims to investigate the effects of using DLC-coated elements on lubricant film thickness and friction coefficient. A barrel-on-disk elliptical contact is the subject of study. Geometry and operating conditions choice reflects as closely as possible a real cam/follower contact.

2. Methods

EHL experiments and numerical simulations are performed with well-defined solid and lubricant properties. Operating conditions correspond to critical moments in the cam/follower cycle.
The experimental apparatus allows measurements of lubricant film thickness (by optical interferometry) and friction coefficient for a barrel-on-disk elliptical contact. Numerical model coupling a Generalized Reynolds equation, load balance, solid mechanics and energy equations is used. Stationary calculations yield lubricant film thickness and friction coefficient.
Tests in Table 1 are repeated for lubricant temperatures of 20 and 75°C and also for different combinations of thermally conducting or insulating surfaces.

Table 1: Test conditions

Entrainment Velocity, U_e (m/s)	1.45	1.22	0.65	0.46
Slide to Roll ratio, SRR	2	3	6	10
Hertzian Pressure, P_h (MPa)	300	400	445	425

3. Results

First, the numerical model needs to be validated by experimental results. Then, both experimental and numerical results are exploited to understand the effect of surfaces thermal conductivity on lubricated contact performance. Figure 1 represents film thickness profile and temperature distribution in the fluid and the solids for coated and uncoated steel surfaces.

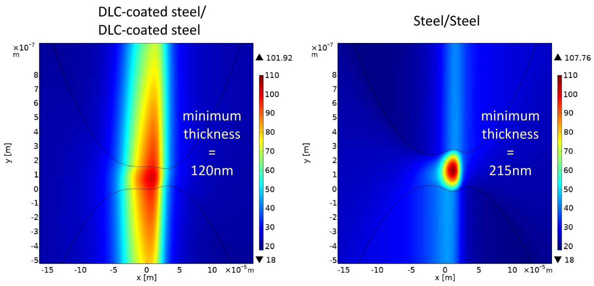

Figure 1: Comparison of temperature distribution and film thickness between coated (left) and uncoated (right) steel. At SRR= 9.49; U_e = 0.458 m/s; P_h= 424 MPa.

4. Discussion

In Figure 1, dimple shape (characteristic of viscosity wedge) disappears when DLC coating is used. Several studies [1, 2] showed improvement in friction coefficient with surfaces with lower thermal conductivity. In the case of the cam/follower contact, sliding is much higher with slide to roll ratio ranging from 2 to 10. In addition, entrainment velocity reaches low values of under 0.5m/s. Even at such velocities, the “viscosity wedge” helps keep a full film separation between two thermally conductive surfaces [3]. As shown in Figure 1, insulating one or both surfaces can disturb this thermal phenomenon and alter lubricant performance. Numerical and experimental results help understanding how film thickness and friction coefficient respond to changes in surface thermal properties. Furthermore, conclusions can be drawn on the optimal configuration to reduce friction while avoiding mixed lubrication.

5. References

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