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Experimental Study on the Friction Effect of Viscosity Index Improver under EHL Contact Condition

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Most studies of elsatohydrodynamic lubrication are oriented only to the measurement of film thickness itself with optical interferometer. In order to exactly investigate the characteristics of a certain lubricant under the condition of additives, especially for traction performance, it is also important to get the information of traction force as well. In this work, we developed the device for measuring friction force of EHL contact condition, which can trace the film thickness over the contact area with optical interferometer. To verify the validity of the measuring system, the friction force and film thickness under EHL condition are measured with the variation of additive ratios of viscosity index improvers.

Keywords: elastohydrodynamic lubrication (EHL), friction force, film thickness, non-Newtonian fluid

1. INTRODUCTION

Many experimental studies for the measurement of EHL film thickness have been performed in many ways. Incident lights and coatings on the glass to make the incident light reflected can decide the measuring range of film thickness. However, measuring film thickness with applied load and speed is not only measurand to investigate the lubricant. To verify the lubricant at normal operating condition where it is usually at high shear rate over $10^5 s^{-1}$. At this speed rate of EHL contact condition, the measurand must hold the information of not only film thickness but also traction force over the contact area. What is more important, most lubricants with a certain additives of long chain polymers have nonlinear characteristics at these speed rates where many mechanical components operate.

In our experimental work, we make the measurement of film thickness of EHL contact condition as well as frictional torque very precisely according to the speed variations. It is found that friction decreases at higher contact speed with lubricant additives of polymeric viscosity index improvers.

2. EXPERIMENTAL APPARATUS

We developed an experimental apparatus for the measurement of EHL film thickness and frictional torque. In order to precisely measure the friction force, the strain gage is attached on the very flexible rod in the torsional direction without bending and the signal from the gage is well transferred to the amplifier by using high quality slip ring. The sliding-rolling contact ratios (SR ratio) are can be selected by adjusting the speed of two motors.

The film thickness is measured by optical interferometer with white incident light as many researches have performed and the measure image of film thickness is digitally converted with Lab format[3].

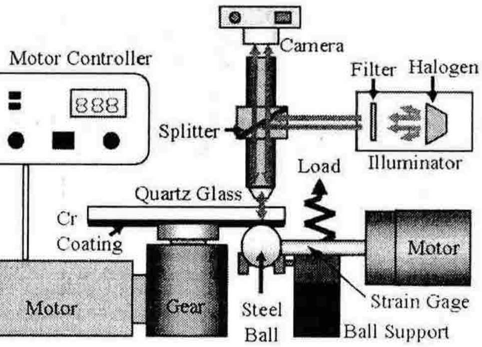

Figure 1 Schematic diagram of EHD film measurement

3. RESULTS

The measured image from the optical interferometer by 35 *mm* camera is shown in Figure2, 3 according to the sliding-rolling ratios. These images are converted into digital format and calibrated with the image of static loading condition with Lab format. The thicknesses along to the sliding direction are computed by image processing method, which gives consistence and objectiveness. Without this image processing method, the interpretation of measured film thickness depends on the observer's experience by lookup table.

The measured friction forces are compared between pure base oil and lubricant with 15% VII additives. The friction force of lubricant with additives has low value as the sliding-rolling ratio increases which means higher contact sliding speed, while the pure base oil has higher values according to the speed.

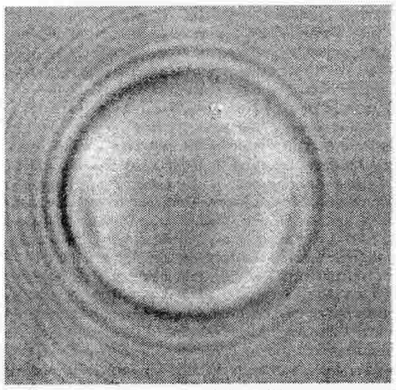

Figure 2 Image from optical interferometer with SR=1.0, U_d=0.048m/s, U_b=0.016m/s F=20N

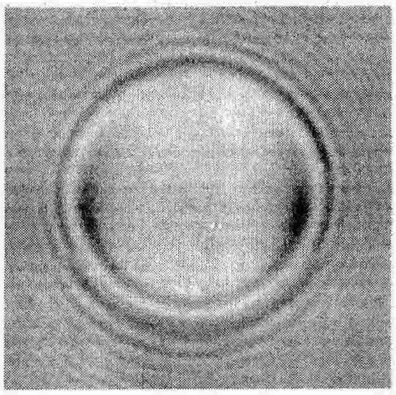

Figure 3 Image from optical interferometer with SR=0.0, U_d=0.016m/s, U_b=0.016m/s, F=20N

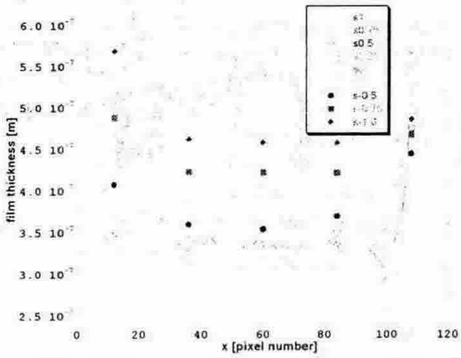

Figure 5 Film thickness variation along the rolling direction according to the sling-rolling ratio under the condition of viscosity index improvers

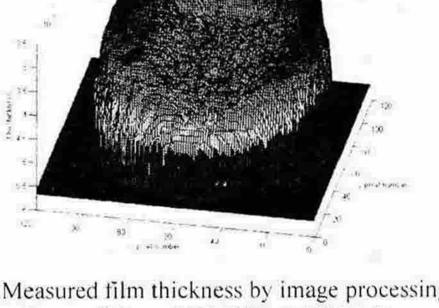

Figure 7 Measured film thickness by image processing under the condition of 15% VII and SR=1.0

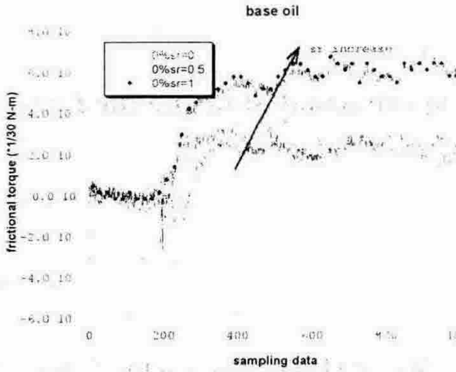

Figure 8 Friction forces according to sliding-rolling variations with base oil

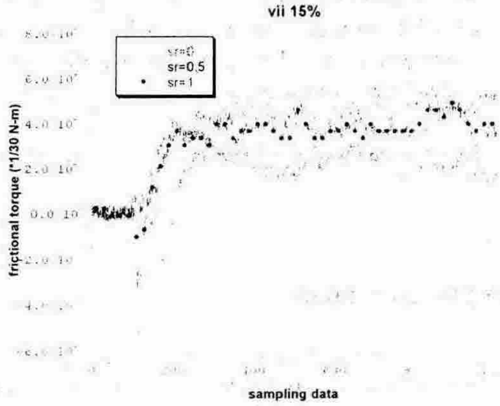

Figure 9 Friction forces according to sliding- sliding-rolling variations with lubricant of 15% VII additive

4. CONCLUION

From the image processing method, we can make the measurement of EHL film thickness down to 200nm over the contact area. With the developed technology, very minute change of film thickness with VII additive can be detected. The frictional forces can be obtained with the film thickness to provide the information of apparent viscosity change at high shear rates.

5. REFERENCES

[1]Gustafsson, L., Hoguland, E. and Marklund, O.," Measuring Lubricant Film Thickness with Image Analysis," Proc. Instn Mech. Engrs J. 208, pp199-205. 1994

[2] Lord, J., Jolkin, A., Larsson, R. and Marklind, O., "A Hybrid Film Thickness Evaluation Scheme on Multi-Channel Interferometry and Contact Mechanics," Trans. Of the ASME, J. of Tribology, Vol. 122, pp.16-22, 2000

[3] Krupka, M. Hartl, J. Čermák and Liška," Elastohydrodynamic lubrication film shape – comparison between experimental and theoretical results" Tribology for Energy Conservation, 1997, Elsevier, Amsterdam

6. ACKNOLEGEMENT

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