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Structural Analysis of Traction Oil under Dynamic High Pressure

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Introduction

The microscopic structure of lubricants has received much attention recently because of its great influence on the tribological properties of the sliding surface under lubrication conditions. As is well known, the structure of a conventional lubricating oil transforms into a quasi-solid structure under high pressure, as occurs in continuously variable transmission mechanics, for example. Past studies have focused mainly on the macro-characteristics of lubricants under high pressure, such as their viscosity and bulk modulus. Nevertheless, some studies have revealed that the tribological properties largely depend on the molecular structure of the oil. Several simulation studies using molecular dynamics techniques have investigated the molecular structure of lubricating oil under high pressure. Such studies indicate the obvious growing attention being paid to the microscopic behavior of lubricating oils.

X-ray diffraction (XRD) is traditionally used for obtaining information about the microscopic structure of materials, even amorphous and liquid ones. We have now used XRD to analyze the structure of lubricating oils, focusing especially on their microscopic behavior under dynamic high pressure generated by a specially-designed apparatus with two rotating cylinders.

Sample Oil

We used a pure base oil DM2H of the traction oil TDF32 (produced by Idemitsu Kosan, Co., Ltd.) as a sample oil for the analysis.

Experimental Setup

The experimental setup with an apparatus with two rotating cylinders to dynamically pressurize the sample oil is shown in Figure 1. We set the apparatus in the beam path in BL-18C in the Photon Factory. Monochromatic X-ray was entered to the contact point of two cylinders through the collimator with its hole diameter of 60 μm. The averaged rotating speed was 5.12 m/s, and the averaged Hertz pressure was 1.5 GPa.

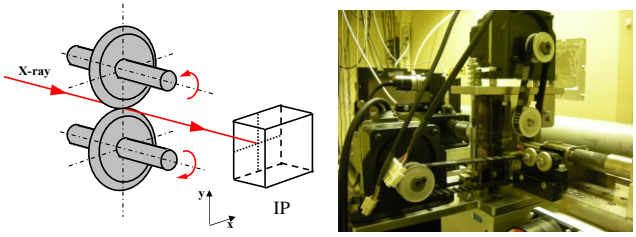

Fig. 1 Experimental setup with two cylinders apparatus

Experimental Procedure and Results

We adjusted the beam path on the correct contact position of two cylinders first with using a photodiode sensor. After the adjustment, we obtained the scattering intensity profiles at five points; at 50, 100, 200, 300, 500 μm far from the contact position of two cylinders. The obtained profiles are shown in Figure 2. We can see that all profiles have no sharp peaks. It means that the oil did not transit to solid phase from liquid phase against our previous expectation.

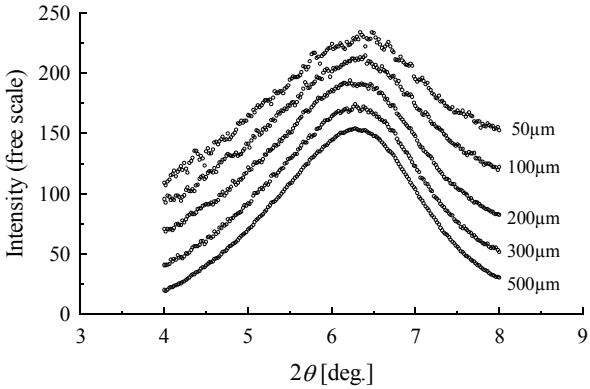

Fig. 2 Scattering intensity profiles from traction oil under EHL

Conclusion

The phase transition of traction oil was not observed from the change in X-ray diffraction profiles even under high pressure as 1.5 GPa. The reason why may be due to the velocity effect under dynamic pressure condition.

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