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PREDICTION OF SOFT EHL FILM THICKNESS WITH GREASE

Soft EHL film thickness was measured by optical interferometry. The film thickness with greases is larger than that with their base oil alone and, difference among the sample greases are found due to their different thickeners. The possibility of prediction of the film thickness with grease is investigated on the basis of their rheology.

The apparent viscosity of the sample greases listed in table 1 was determined using a cone-on-plate rheometer. The cone was driven at stepwise increaseing shear rate from 100 to 40000s^{-1}. The results are plotted in Fig.1, in which the viscosity of the base oil is shown by the broken line. A rheology model after Bauer is employed:

$$\tau = \tau_y + k_1\dot{\gamma} + k_2\dot{\gamma}^n , \qquad \eta = \tau / \dot{\gamma} \qquad (1)$$

where τ is the shear stress, $\dot{\gamma}$ is the shear rate, τ_y, k_1, k_2 and n are the rheological parameters. The viscosity of the base oil is reasonably used for the parameter k_1, and if the other rheological parameters are chosen to give the best fit, the curves in Fig. 1 agree with the experimental results with sufficient accuracy

At lower shear rates, the apparent viscosity decreases with increasing shear rate generally in a similar way, and the order of the apparent viscosity of the sample greases are B>C>A. However, the gradient of the curves are slightly different and, at high shear rates, the order changes into C>A>B.

The left side of rheological curves in Fig.1 shows the behavior of a plastic solid with a yield stress, and right side shows the behavior of Newtonian fluid, represented by the first and second terms in Eq.(1), and non-Newtonian behavior is by the third team, respectively.

Based on the rheological properties of greases, the prediction of the film thickness H_g in soft EHL contact is

Table 1 Sample greases

Sample grease	A	B	C
Base oil Viscosity @25°C, mPa·s	PAO 49.5		
Thickener Concentration, mass%	Li-St 12	Li-OHSt 9.5	Urea 11
Penetration (60w)	296	297	294
Additive	None		

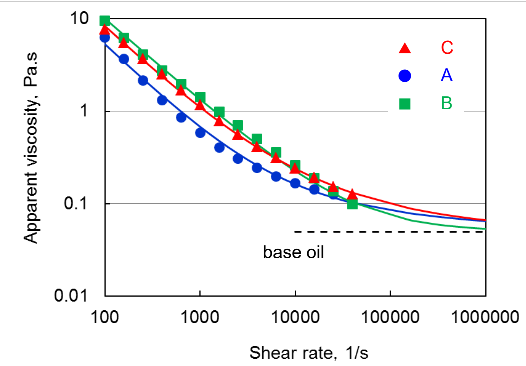

Fig.1 Apparent viscosity of sample greases

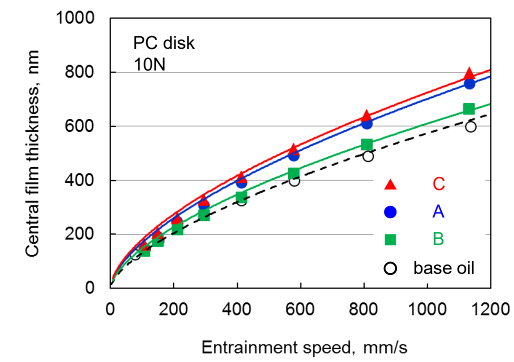

Fig.2 Film thickness with different grease

$$H_g / H_{oil} = \left(1 + m^n M\right)^{0.64} \qquad (2)$$

where H_{oil} is the film thickness for base oil, M is the ratio of non-Newtonian effect to Newtonian effect, and m is a modifying coefficient changing from 1 to 1/n.

The curves in Fig.2 represent the central film thickness predicted with Eq.(2) for the sample greases. The prediction agrees well with the experimental results as a whole, though the predicted thicknesses are a little larger at lower speeds. The prediction procedure for hard EHL point contact is also proposed in present work.

Kochi, Ichimura, Yoshihara, Dong and Kimura: Film thickness and Traction in Soft EHL with Grease, Tribology Online, **12**, 4(2017), 171.