Speed-Dependent Friction Characteristic of ZnDTP Having Linear Hydrocarbon Moiety

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1. Introduction

Zinc dialkyldithiophosphate (ZnDTP) is thermally decomposed and reacts with metal atoms on the nascent surface during friction, resulting in formation of a tribofilm on the metal substrate. Since hydrocarbon moieties of ZnDTP are one of influencing factors for the thermal decomposition, followed by formation of the tribofilm, the moieties are possibly related to the tribological properties such as an antiwear performance or a load-bearing function. On the other hand, previous studies by the authors demonstrated that ZnDTP with primary alkyl chain showed lower friction than that with secondary one did [1]. Of particular interest is that ZnDTP with linear alkyl chain groups showed sliding speed dependency of friction. There is a possibility that the linear hydrocarbon moieties could exhibit load-carrying function like as a fatty acid. In this study, a friction characteristic of ZnDTP having different primary alkyl chain was investigated in order to make it clear that the hydrocarbon moiety of ZnDTP has a load-carrying capability.

2. Experimental procedure

Friction measurements were carried out using a laboratory-made cylinder-on-disk tribometer. Both the disk and the cylinder specimens were parts of commercially available bearings made of heat-treated high-carbon chromium-bearing steel corresponding to AISI51200 steel. After a sample lubricating oil was heated at 100 °C, a dead weight was added to the upper disk against the lower cylinder. For a run-in trial, the upper disk was continuously rotated against the stationary lower cylinder at a constant speed. After the run-in, the friction-speed measurement was conducted, by changing the sliding speeds at four measuring positions in a stepwise fashion from 8.5 cm/s to 5.0 μm/s. Polyalphaolefin (PAO) was used for an additive-free base oil to prepare sample lubricating oils for the friction measurements. Several kinds of ZnDTPs having different primary alkyl chain were used and listed in Table 1. Each ZnDTP was added to the base oil at a phosphorus concentration of 0.1 mass%.

3. Results and discussion

Figure 1 shows plots of friction coefficient against sliding speed, obtained from several kinds of ZnDTPs having different primary alkyl chain. For comparison of friction characteristics among all ZnDTPs tested, there were significant differences among ZnDTPs with a decrease in sliding speed. It is also found from Fig. 1 that ZnDTPs having linear alkyl chain such as nC18 exhibited reduction in friction with decreasing in the speed while ZnDTP with shorter or blanched alkyl chain showed an increase in friction. This means that ZnDTPs having linear alkyl chain showed stronger speed dependency of friction and thus that linear hydrocarbon moieties of ZnDTP can act similarly as adsorbed film of linear fatty acid to reduce friction in a low speed region.

Table 1 ZnDTPs having different primary alkyl chain

CODE	Primary alkyl chain
nC4	$CH_3CH_2CH_2CH_2-$
nC8	$CH_3(CH_2)_7-$
isoC8	$CH_3(CH_2)_3CH(CH_2CH_3)CH_2-$
nC12	$CH_3(CH_2)_{11}-$
nC18	$CH_3(CH_2)_{17}-$
isoC18	$CH_3CH_2CH(CH_2)_5$ / $CH_3CH_2CH(CH_2)_3$ $CH(CH_3)CH_2-$

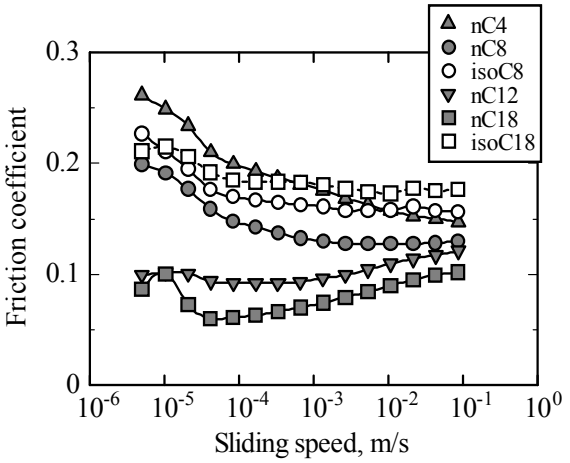

Figure 1 Friction coefficient vs. sliding speed for sample lubrication oils of each ZnDTPs having different hydrocarbon moieties

4. References

[1] Aoki, S., Suzuki, A. and Masuko, M., "Comparison of Sliding Speed Dependency of Friction between Steel Surfaces Lubricated with Several ZnDTPs with Different Hydrocarbon Moieties," Proc. I. Mech. Eng. Part J. J. Eng. Tribol., 220, 4, 2006, 343-351.