Relationship between Traction and Molecular Structure of Base Oil in EHL Conditions

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This study proposes the control of traction behaviour in elastohydrodynamic lubrication conditions with changing molecular structure of base lubricant oil. A ball-on-disc type of test rig was used to measure traction and film thickness by white light optical interferometry. Three types of poly-alpha-olefin (PAO) are used, which have almost the same viscosity at the atmospheric pressure and tested temperature. The tested three PAOs have different compositions of oligomers. The relationship between the traction and molecular structure of base oil is discussed in this study.

Keywords: elastohydordynamic, traction, molecular structure, poly-alpha-olefin

1. Introduction

Recently, there is much growing interest in reduction in viscosity of lubricant oil to reduce the friction resistance in hydrodynamic lubrication. As a result, the lubricant film become thinner to cause direct contacts between mating surfaces. There are many ways to overcome problems occurring in severe operating conditions. Normally, various kinds of additives are contained in lubricant oil to function with chemical phenomena to surfaces as the friction modifier and anti-wear additive. Much work has been conducted to investigate lubrication characteristics of additives. On the other hand, research on base oil to control friction has been insufficient. In the current study, we investigate the influence of the molecular structure of base oil on traction behaviour in EHL conditions.

2. Experimental

A ball-on-disk type of test rig is used to measure the traction and film thickness by white light optical interferometry. A point contact area is created between a rotating sapphire disc and a rotating bearing steel ball. The speeds of both the surfaces are controlled by AC servo motors independently. Above the test rig, a microscope is installed to capture optical interferences between the surfaces. On the contact surface of the sapphire disc, a thin chromium layer is deposited to increase the contrast of the interference. The traction and optical interference are measured with changing the slide-to-roll ratio at a constant entrainment speed. For lubricant oil, three kinds of synthetic oil of poly-alpha-olefin (PAO) are used. Table 1 presents compositions of oligomers of PAOs used in this study.

3. Results and discussion

Figure 1 shows the variations in traction coefficient at different slide-to-roll ratios for three kinds of PAOs. The ambient temperature was set to 30°C and load was set to 30 N which produced the maximum Herztian pressure of 0.97 GPa. For the three PAOs, the viscosities are almost the same value of 38 mPas at the atmospheric pressure and ambient temperature while the compositions of oligomers of molecules are different among the oils. The traction coefficient increases with increasing slide-to-roll ratio for the three oil. Clear difference among the oils appears at high slide-to –roll ratios despite almost the same viscosity. In the current study, relationship between the traction behaviour and the molecular structure of base oil is discussed.

Table 1: Composition of oligomers of tested PAOs

<table>
<tr><th>Oligomers</th><th>PAO1</th><th>PAO2</th><th>PAO3</th></tr>
<tr><td>Dimers, %</td><td>2.2</td><td>1.0</td><td>0.0</td></tr>
<tr><td>Trimers, %</td><td>69.9</td><td>73.0</td><td>33.0</td></tr>
<tr><td>Tetramers, %</td><td rowspan="2">26.7</td><td>22.7</td><td>44.7</td></tr>
<tr><td>Pentamers, %</td><td>3.3</td><td>19.1</td></tr>
<tr><td>Heamers, %</td><td>0.0</td><td>0.0</td><td>3.2</td></tr>
<tr><td>Heviers, %</td><td>1.2</td><td>0.0</td><td>0.0</td></tr>
</table>

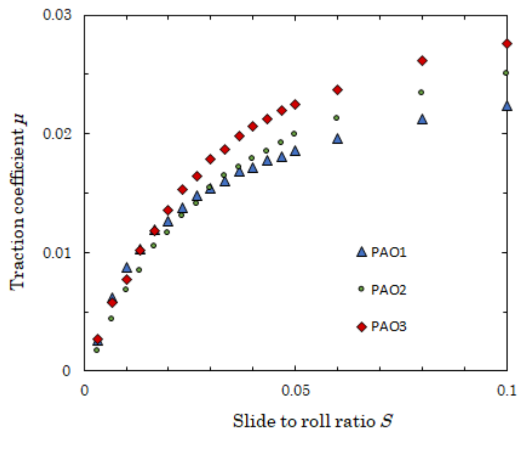

Figure 1: Variations in traction coefficient at different slide-to-roll rations for three kinds of PAOs