Gap and Shear Rate Dependence of Viscoelasticity of Lubricants with Polymer Additives Sheared in Nano Gaps

CATEGORY OR KEYWORDS

Lubricants, Rheology, Polymer additives, Nano gaps

AUTHORS AND INSTITUTIONS

Shintaro Itoh[1], Ryosuke Aoki [1], Kenji Fukuzawa[1], Hedong Zhang[2], Naoki Azuma[1], Yasushi Onumata[3]

[1]Department of Micro-Nano Mechanical Science and Engineering, Nagoya University, JAPAN

[2]Department of Complex Systems Science, Nagoya University, JAPAN

[3]JXTG Nippon Oil & Energy Corporation, JAPAN

INTRODUCTION

To reduce fuel consumption of cars, it is effective to reduce friction loss by lowering viscosity of engine oil and transmission oil [1]. On the other hand, this leads to a decrease in load capacity, which means that the sliding gap narrows and wear and seizing easily occur. Therefore, there is a need for a lubricant design that does not break the oil film even in a minute gap while achieving a reduction in the viscosity of the lubricating oil. It was reported that polymer additives that have been used as a viscosity index improver form an adsorption layer on solid surface and contribute to the reduction of friction force and the improvement of wear resistance in the boundary lubrication regime [2-3]. The sliding gap when such an adsorption film exhibits lubricity must be on the order of nanometers, which is about the same as the thickness of the adsorption layer. It is known that liquids and polymer melts confined in nano gaps have unique mechanical properties that are completely different from those in the bulk state. In this study, we aimed to quantify the viscoelastic properties specific to the adsorption layer of polymer additives sheared in the nano gaps.

MATERIALS AND METHODS

The fiber wobbling method (FWM) was used to quantify the viscoelasticity of polyalphaolefin (PAO) with polymer additives which is sheared at gaps of nanometer order. FWM is the original methods (Fig. 1) that can measure the dynamic viscoelasticity of lubricant sheared under the precisely controlled nano gaps [4].

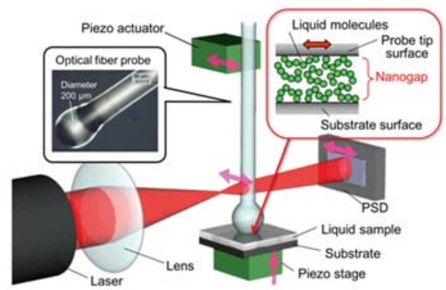

Fig. 1 Schematic diagram of fiber wobbling method.

RESULTS AND DISCUSSION

When the polymer was added, we observed the prominent increase of viscosity and elasticity specific to nano gaps. We considered these mechanical properties were caused by the adsorption layer of the polymer on the solid surface. In addition, we found that shear thinning was more apparent in the nano gap than that in the bulk state (Fig. 2). We expect these results are fundamental and important knowledge in the advanced lubrication design achieved by polymer additives.

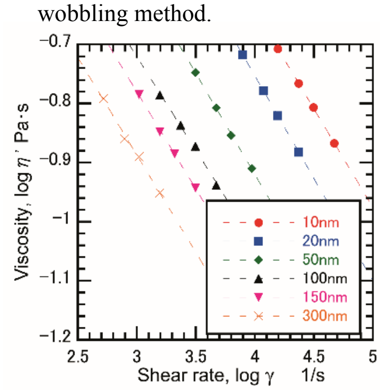

Fig. 2 Shear rate dependence of viscosity at nano gaps measured with PAO containing 2.5 wt% of polyisobutylene.

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