The Effect of Polymer Colloids Friction Modifier in Polar Lubricating Oils

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Polymer type friction modifier (PFM) is one promising area for achieving further friction reduction as an adsorbing type FMs compared to conventional low molecular weight FMs. It is assumed that multiple polar units in the molecule enables dense adsorption on the surface, and generate thick oil film under mixed to boundary conditions. Polymer colloids friction modifier which containing oil-insoluble aromatic part is one concept of PFM for reducing friction. It is expected that introduced oil-insoluble part enables stable friction reduction property under polar environment such as ester where the performance of conventional FMs could not be fully activated.

Keywords: friction modifiers, PFM, PCFM, polymer collides friction modifier, ester

1. Introduction

Friction modifiers can be categorized into two types which are an adsorption type that prevents contact of materials which has high shear resistance by adsorbed molecular layer on the surface, and a reactive type that forms tribo-film with low shear resistance on the surface through tribo-chemical reaction. As for the reactive type, an organic molybdenum friction modifier that reduces friction by producing MoS_2 layer on the surface is actively implemented in recent years. Regarding the adsorption type, low molecular weight oil soluble surfactant type chemicals such as glycerol monooleate (GMO) has been widely used for a long time. Typical molecular length of these FMs are around 2 nm but when considering the velocity of 1 m/s of facing surface, share rate will become 10^8 s^{-1} order. This can be translated that when the thickness of the adsorbed layer was 0.5 m, the velocity of facing surface would almost equal to the speed of light, then it will be difficult to resist contact. It is easily assumed that the thicker layer will support the surface better. Polymers which consist of polar and non-polar units has also been studied as friction modifier for decades, and are now forming well known field as polymer type friction modifiers (PFM). It has reported that the polymer colloids friction modifier (PCFM) containing aromatic units which is insoluble in paraffin oils for the purpose of improving the surface supporting capacity of adsorbed polymers with thicker tribo-film has significant friction reduction property[1]. In this study, the impact of polar base oils on the effect of PCFM is evaluated as a fundamental study for implementing PCFM to ester base lubricants.

2. Experiment

Mineral oil and esters are used for evaluating the impact of polarity of base oils (Table 1). Friction reduction property of PCFM, PFM and GMO are compared under sliding rolling conditions with mini traction machine, MTM (Table 2).

Table 1: Base oils

Base oils	Viscosity at 100 ºC
Group III mineral oil	4.2 mm^2/s
Adipate ester	5.4 mm^2/s
Polyol ester	5.6 mm^2/s

Table 2: Friction test parameters

Parameters	Conditions
Load	36 N
Mean rolling speed	0.01 to 3 m/s
Slide-roll ratio	50
Test temperature	80, 100 ºC
Test specimens	Ball: SUJ2 ϕ3/4 inch Plate: SUJ2 ϕ46 x 5 mm

3. Results and Discussions

Friction coefficient at 0.01 m/s are shown in Figure 1 as typical results of this study. Under the tests with mineral oil, the friction coefficient decreased in the order of GMO, PFM and PCFM, from 0.09 to blow 0.05. The results indicates thicker adsorbed molecular layer generate lower friction coefficient. The effect of GMO was not observed in adipate ester while the effect of PCFM were stably observed with mineral oils, adipate and polyol esters. It is assumed that the polymer which contains multiple polar units enables dense adsorption of molecules on the surface, and oil insoluble units enhance the surface supporting capability of the adsorbed layer with generated tribo-film.

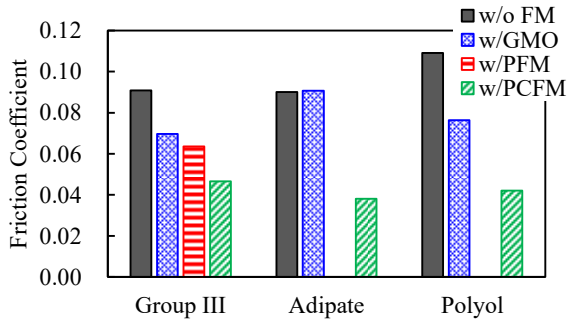

Figure 1: Comparison of friction reduction properties

4. References

[1] Yamamoto, K. et al., "Study on Polymer Colloids as Friction Modifier," STLE Virtual Annual Meeting & Exhibition 2021, 3484985.