Development of a New in situ Friction-Control Method using Electronic Field in Polyelectrolyte Lubricant

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In the present study, we demonstrate a fundamental study of a new method using electronic field at friction test in propylene glycol (PG). As a result of friction test, when +200 V was applied to a SUJ2 ball, the initial friction coefficient was 71 % lower than no bias. On the other hand, when -200 V was applied, there was no reduction in friction. The result clearly shows that the importance of polarity of electrical field, indicating promotion of PG adhesion to the ball surface where severe sliding condition occurs.

Keywords: electronic field, lubricant, boundary lubrication, polyelectrolyte

1. Introduction

In recent years, active friction control techniques were developed for adaptability, multifunctionality, and robustness [1,2]. Many of them used electric field of electric energy (e.g., discharge) to obtain low friction [3,4]. In addition, while electrowetting is considered to be an interesting phenomenon to realize active friction control, there are few researches used it in tribology field. Here, we develop a new in situ friction-control method using electric field at a lubrication condition.

2. Methods

A schematic of the ball-on-disk type tribo-tester is shown in Fig. 1. We used a soda-lime glass plate and a SUJ2 ball with a diameter of 8 mm as test specimens. We dropped 30-µL propylene glycol (PG) on the glass specimen before friction tests. The friction test was conducted at a vertical load of 1 N, sliding speed of 12.6 mm/s, and an electrical bias of 200 V. In order to clarify the effect of the magnitude of bias and polarity, the test was conducted at three levels of applied voltage: 0, +200, and -200 V. The voltages were applied immediately before the start of the friction test and continued to be applied throughout the 3-minute measurement period.

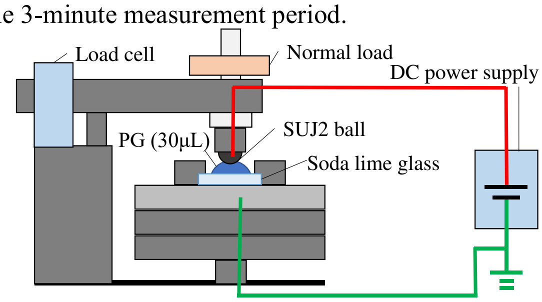

Figure 1: A schematic of pin-on-disk type friction tester.

3. Result and Discussion

When no bias was applied, the average friction coefficient of the initial 0.3 m was 0.085. In the case of +200 V and -200 V, the average friction coefficients of the initial 0.3 m were 0.025 and 0.076, which were 71 % and 11 % lower than no bias condition. These results clearly show the contribution of the electrical field on reduction in friction with PG. On the other hand, in the bias applied conditions, the friction coefficient increased after 0.4-0.5-m sliding.

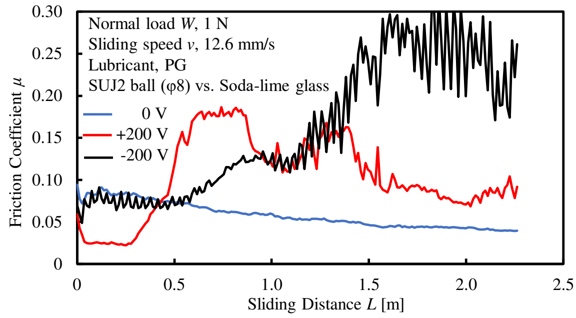

Figure 2: Friction test result.

The friction evolution curves show that the initial friction coefficient is very low (0.025) when +200 V was applied. On the other hand, when -200 V was applied, there was no reduction in friction, indicating the importance of polarity on reducing friction. PG is one of polyelectrolytes. Based on its molecular structure, a hydrogen atom of the hydroxy group is considered to be ionized as H^+. In this case, O^- is formed at the edge of the carbon chain. The body of the carbon chain provides majority of the molecular weight. Thus, for a decrease in friction, the adhesion behavior of minus-charged part should be important. In the present friction condition, the ball has a curvature, and the tip of the ball is in continuous sliding. Therefore, it is considered that the wear state of the ball is more severe than that of the disk. Hence, the friction reduction effect was observed only when positive bias was applied to the ball, providing strong boundary lubrication film.

4. References

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