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Effect of Micro-Dimples for Keeping Stable Sliding under Surface-to-Surface Contact Configuration

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In this study, the tribological effect of micro-dimples for keeping stable sliding was investigated. The friction tests with steel-based specimens were carried out repeatedly and change of surface profile was also measured after each test. As a result, it is suggested that even under severe condition, surface profile was maintained and friction coefficient was kept stable by the effect of dimple.

Keywords (from 3 to 5 max): tribology, micro-dimple, surface texturing, stable sliding, running-in

1. Introduction

Reducing energy losses due to friction between piston and cylinder in internal combustion engines is one of the most important subjects. Applying surface texturing to a cylinder liner is expected to be an effective way to reduce friction. Many researchers showed that fabrication of micro-dimples on the sliding surfaces is effective for friction reduction. However, the reports on its quantitative effectiveness for keeping stable sliding is still limited. Therefore, the repeated sliding tests under surface-to-surface contact configuration without/with micro-dimples were conducted in the study.

2. Experiment

2.1. Specimens

To conduct sliding tests under surface-to-surface contact, a ring-on-disk friction tester was developed. The upper ring specimens made of AISI 440C stainless steel were rotated and slid on the lower flat disk specimens made of AISI 52100 steel. A lot of micro-dimples were fabricated on the lower disk surface by laser manufacturing. Constant dimple depth was varied between 3 and 10 µm for each disk, while keeping dimple diameter of 50 µm and area ratio of 10 %.

2.2. Experimental conditions

Repeated friction tests were conducted by the ring-on-disk friction tester. The experimental conditions are shown in Table 1. Rotational speed of ring specimen was varied between 100 rpm and 600 rpm over 15 minutes. After finishing the test, wear particles on the specimen surface were removed by ultrasonic cleaning and the next test was conducted after setting the specimens again. Change of surface profile was also measured after each test by a step profiler and a white light interferometer.

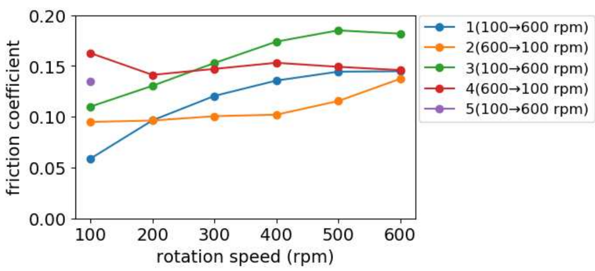
Table 1: Experimental conditions

Lubricant	PAO-30, 50µl
Load	30 N (0.16 MPa)
Sliding speed	100 rpm to 600 rpm (0.05 m/s to 0.33 m/s)

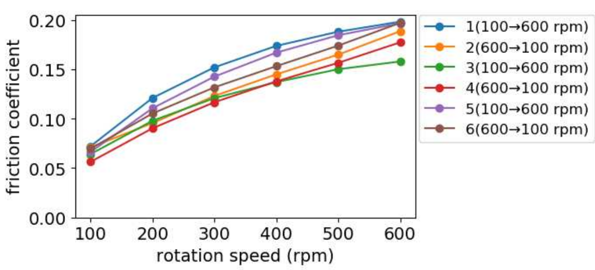
3. Results

Figure 1 shows the results of friction tests using the disk specimen without/with micro-dimples. In Figure 1(a), repeated tests caused high friction coefficient gradually in the running-in process and the test was finally stopped at the 5th round because a rapid increase of friction coefficient with vibration of large amplitude was observed. On the other hand, the test by the disk with micro-dimples kept stable friction coefficient over 6 repetitions as shown in Figure 1(b).

Analysis of surface profile showed that the disk with micro-dimples did not change extensively even after the repeated tests, while the disk without micro-dimples worn and became rough after the tests.



(a) Without micro-dimples



(b) With micro-dimples

Figure 1: Transition of friction coefficients during the repeated friction tests.

4. Discussion

In friction tests by the specimen without micro-dimples, the coupled actions of two and three-body abrasion due to the lack of lubricant caused increase of surface roughness, and then finally brought high friction coefficient. On the other hand, by the specimen with micro-dimples, dimple contributed as a lubricant reservoir and suppressed the stuck of wear particles in the contact area. Therefore, surface roughness was maintained to be small and friction coefficient was kept stable even under severe condition.