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Mapping Internal Composition of Wear Particles using X-Ray Computed Tomography

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During the self-mated rubbing of magnesium, fine powders of aluminum oxide were interposed at the interface. The internal composition of wear particles were mapped by X-ray computed tomography (X-ray CT). Aluminum oxide was detected inside the wear particles exhibiting its layered structure. It means that fine powders of aluminum oxide did not abrade magnesium surface but promoted adhesive wear by assisting the transfer particles to grow larger. The model of adhesive wear is proposed by taking into account the increase in the mechanical strength of transfer particles.

Keywords: X-ray computed tomography, wear mechanisms, magnesium, aluminum oxide

1. Introduction

In adhesive wear of metals, the precursor of wear particle, namely transfer particle, grows at the interface before its ejection to become an independent wear particle. This growth and ejection process is also found in eraser debris formation. From the fact that a series of these processes is enhanced in air, we concluded that the strengthening of transfer particle is caused by the inclusion of impurity such as oxygen and hydrogen in the transfer particle [1]. It was also found that in-situ sputter deposition of metal onto the sliding surface also enhanced the growth process [2]. Therefore, the inclusion of foreign impurities in transfer particles is the key to understand their growth mechanism. X-ray computed tomography has been developed to enable precise analysis of the elemental distribution inside the material. In this study, an attempt was made to map the composition inside wear particles to understand the mechanisms of wear particle formation.

2. Methods

Using Thrust-Washer type wear test rig, fine powders of aluminum oxide were dropped down from the center hole of the washer specimen (magnesium) to the plate specimen (magnesium) at the rate of 0, 1, 2, 3, 5, 10 mg per 100 rotations intermittently. Powders were then pushed out from the interface. The average size of the powder was 1.20 ± 0.3 µm. X-ray computed tomography was phoenix v｜tome｜x L300 type. Elements inside wear particles were identified by the difference of their absorbance.

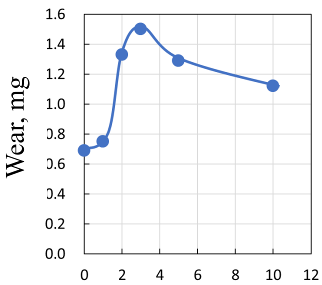

Figure 1: Supply rate of alumina powders

3. Results and Discussion

Figure 1 illustrates the effect of supply rate of alumina powders on wear. When the supply rate was 3 mg/100 cycles, the maximum wear was obtained, which was twice more than that without powders. Table 1 shows the outside view of a single wear particle and the internal distribution of aluminum. The length of black bars underneath the figures at zero degree corresponds to 0.1 mm. The size of wear particle is larger than that of the distribution of aluminum. The observations from various angles demonstrate that the core is sandwiched between magnesium and aluminum oxide powders. These facts mean that the wear particle is wrapped with magnesium and that the core of wear particle is made of a layered structure. The mixed structure of magnesium and alumina could be the cause for the wear increase with the supply of alumina powders to strengthen the mechanical property of transfer particles.

4. References

[1] K. Hiratsuka, Trib. Intern., 28, [5] (1995) pp.279-286.

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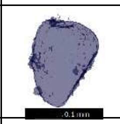
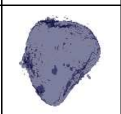
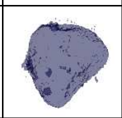
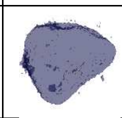
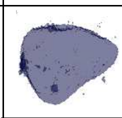
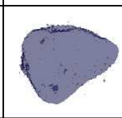
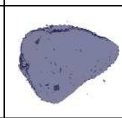
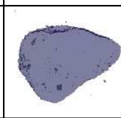
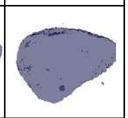
Table 1 : Outside views from various angles and elemental map of aluminum in a single wear particle

Angle of observation, °	0	10	20	30	40	50	60	70	80
Outside view of a wear particle									
Elemental map of aluminum