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Severe-mild wear transition at different relative humidity rates

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ABSTRACT – Severe-mild wear forms transition in self-mated sliding of pure Fe was studied in normal atmospheric air and the influence of relative humidity (RH) rates was discussed. The period of the severe wear form before the transition was not recognized in high RH rate environment while that had certain length in low RH rate. The influence of RH rate in atmospheric air on the transition was discussed with consideration on adsorbed water layer on the metallic surface.

1. INTRODUCTION

The terms severe and mild might firstly be used for the forms of wear by Archard and Hirst in 1956 [1] as “they exhibit two forms of wear, one mild, the other severe.” Some of metallic materials are known to show severe-mild wear transition and initial period with severe wear form is also recognized as running-in period which usually results in much wear amount of newly produced machines. This is why studying the mechanism of the transition is practically important. The transition should be studied based on understanding of the adhesive wear mechanisms and the influences of environmental gases. One of the most convincing physical models of adhesive wear is a mutual transfer model proposed by Sasada and Norose [2]. As for influences of environmental gases, one of the authors of this research found that the severe-mild wear transition in dry sliding of some metallic materials is strongly influenced by RH rate in atmospheric air [3]. Water is one of the most influential gaseous species in atmospheric gas on tribological properties and it was found that even ppm to ppb level trace water can dominate tribological properties of materials [4-6]. In this paper, influence of RH rate on severe-mild wear transition is studied.

2. EXPERIMENTAL PROCEDURES

Figure 1 shows a schematic drawing of a pin-on-disk apparatus used in this study. To avoid partial contact of specimens during experiments due to the misalignment of specimens, a pin which has spherical head with radius of 4 mm was used. Pure Fe was selected for material of both disk and pin because pure Fe shows severe-mild wear transition in low and high RH [3]. The surface of pin and disk to be tested were polished using a 3 µm diamond slurry, and the typical surface roughness of the specimens was 0.005 µm Ra. Both of the specimens were twice cleaned ultrasonically using a mixture of acetone and hexane for 10 minutes each, and then they were set in the apparatus. Diameter of sliding track on the disk was 20 mm. Table 1 sets out the experimental conditions of the sliding test in this study. The sliding tests were conducted in air with room temperature and controlled RH at 4 or 81%.

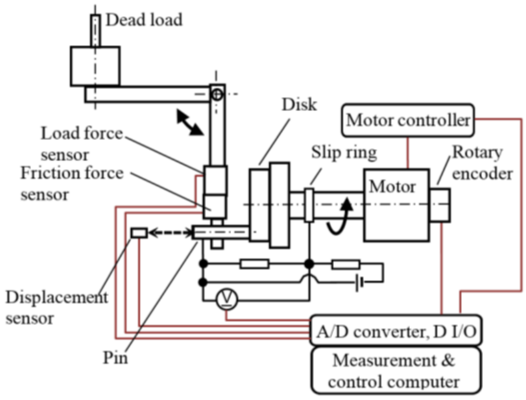

Figure 1 Pin-on-disk apparatus.

Table 1 Experimental conditions.

Sliding speed	0.0628 m/s
Load	10 N
Sliding distance	628 m (10,000 disk rotations)
Lubricant	None
Atmosphere	Normal air with RH 4 or 81 %, room temperature

3. RESULTS AND DISCUSSION

Figures 2 and 3 show chronological changes of coefficient of friction and pin displacement perpendicular to the sliding surface, respectively. For RH 4%, severe-mild wear transition took place at around 3,500 rotations of disk. At the transition point, a wear rate suddenly reduced and a coefficient of friction also reduced slightly and became stable at around 0.7.

On the other hand, for RH 81%, both of a wear rate and coefficient of friction showed small values from the beginning of the sliding, in other words, it was difficult to detect severe wear form even in early stage of sliding for RH 81%. Table 2 shows specific wear rates of pin and disk in both RH rates. All of these wear rates showed good agreement with data obtained for same material by similar experimental conditions in the previous study [3]. Wear rates for RH 4% are larger than those for RH 81% because the period of mild wear form for RH 4% was shorter than that for RH 81%. The slope of data curve in Fig. 3 can be regarded as kind of a wear rate and slopes of both RH rates shows similar values in mild wear period. However, their coefficients of friction are very different even in the mild wear period and "mild wear" appeared in high and low RH rates should be recognized as different phenomena.

Severe wear form observed in RH 4% showed typical adhesive wear mechanisms which gave serious damage on the sliding surface [7] in an early stage of sliding. The damaged layer formed oxide layer on the sliding surface before severe-mild transition. On the other hand, sliding surface of RH 81% did not have severe damage due to adhesive wear mechanism and thick adsorbed water layer [8] was supposed to contribute for the transition to the mild wear form. Different types of mild wear form observed for different RH rates in this study should be attributed to different mixture ratio of contributions of oxide layer formation and the thickness of adsorbed water layer.

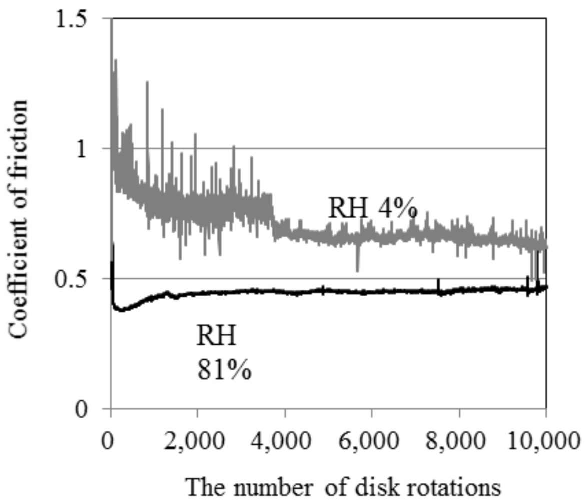

Figure 2 Chronological change of coefficient of friction.

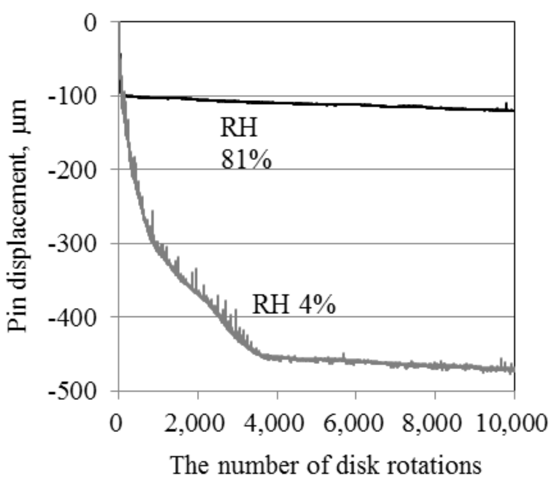

Figure 3 Chronological change of pin displacement perpendicular to the sliding surface.

Table 2 Specific wear rates (mm^2/N).

	Pin	Disk
RH 4%	4.6×10^{-7}	7.5×10^{-7}
RH 81%	2.9×10^{-8}	2.2×10^{-8}

4. CONCLUSIONS

Different types of mild wear form were recognized for dry sliding of pure Fe in normal air with different RH; 4% and 81%. Oxide layer formation and the thickness of adsorbed water layer are supposed as major parameters which governs the establishment of mild wear form.

5. ACKNOWLEDGEMENT

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