EFFECT OF RECIPROCAL SLIDING ON SEVERE-MILD WEAR TRANSITION

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1. INTRODUCTION

It is well known that adhesive wear is strongly dependent on load, sliding velocity, temperature and several other operating parameters. Besides these parameters, test configuration and type of motion also significantly affect the wear mode. For example, severe-mild wear transition is strongly dependent on the orientation of a test rig and the possibility of retention of wear particles on rubbing surface. It has earlier been shown that the retention of mild wear particles is crucial for severe-mild wear transition [1].

In the present paper, the effect of the type of sliding motion (reversal or unidirectional) and waiting time on severe-mild wear transition of iron has been investigated. It has been revealed that reversed sliding in which the direction of sliding changes at the end of each rotation results in earlier transition from severe to mild wear as compared to that in unidirectional sliding. It has also been seen that waiting time in each rotation further accelerates early severe-mild wear transition and results in lower total wear.

2. EXPERIMENTAL WORK

The experiments were conducted by using a pin on disk test apparatus. In this apparatus, a pin specimen was loaded vertically against a horizontal rotating disk. At the end of each rotation, the sliding direction was reversed to achieve circular reciprocating sliding motion. For comparison, experiments were also carried out by using continuous or unidirectional sliding motion. The arrangements for these two tests are shown in Fig. 1. The diameter of the pin was 2 mm. The wear track diameter was kept 6 mm, the smallest possible in the test apparatus in order to enhance the possibility of occurrence of fretting wear. The pin and disk specimens were both made of iron. A load of 5.2 N was applied by means of dead weight. Sliding velocity was varied from 5.5 to 100 mm/s. Sliding distance was 50 m. All the tests were carried out in laboratory air at room temperature. The vertical displacement of pin with respect to disk surface was monitored during the tests in order to detect the severe-mild wear transition.

The disk was stopped for a while at the end of each rotation. This is called “waiting time”. The effect of this waiting time was also studied because it also influences the severe-mild wear transition [2]. The sliding velocity was 50 mm/s and it was kept same in all experiments.

3. RESULTS

The effect of sliding velocity on the disk wear in unidirectional and reciprocal sliding tests is illustrated in Fig. 2. It can be seen that there is hardly any difference in wear during unidirectional and reciprocating conditions at low sliding velocities. However, the reciprocal sliding tests result in significantly lower total wear, particularly at higher sliding velocities, i.e., 50 mm/s and above.

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Fig. 1 Schematic of test procedure
The difference in wear for these two types of sliding motion could be due to rapid severe-mild wear transition. This fact has been confirmed by measurements of the vertical displacement of the pin as well as the examination of the worn surfaces.

Fig. 3 shows the SEM micrographs of the worn surfaces of disk specimens from both types of sliding. The disk worn surface from unidirectional sliding test is very rough indicating that no transition occurred during the initial 50 m of sliding. On the other hand, the disk worn surface from reciprocal sliding test is characterized by plateau formed due to smearing of oxide particles and typical mild wear features.

Fig. 4 shows the effect of “waiting time” on the wear of disk. It is apparent that as the waiting time increases, the wear decreases. This is because the severe-mild wear transition was enhanced by the increase in waiting time at the end of each rotation. The results in Fig. 4 are similar to those seen previously in Fig. 2, as reciprocal sliding results in lower wear as compared that in unidirectional sliding.

4. DISCUSSION
The mechanism of early severe-mild wear transition in reciprocal sliding as compared that in unidirectional sliding may be explained as follows. Usually, during sliding, the transfer particles at the rubbing interface grow large before they are removed or get detached as wear particles [3]. The growth and removal of transfer particles during sliding require some minimum sliding distance. In the case of unidirectional sliding, the transferred fragments continue to grow large (up to some critical size) before these are removed as wear particles. On the other hand, in reciprocal sliding, 18.8 mm is the maximum distance for the pin to slide on the disk during each rotation. Within this sliding distance, the transfer particles are unable to grow large up to the critical size and are ejected from the interface at the reversal point of the reciprocal sliding motion. Owing to this, the growth in size of wear particles is restricted and the wear particles generated during reciprocal sliding are smaller than those generated during unidirectional sliding. The oxidation of these wear particles is also enhanced owing to their small size. The pile up and compaction of these oxide particles on the rubbing surfaces lead to occurrence of mild wear. During waiting time, further oxidation of wear particles continues owing to their exposure to the surrounding air. This is the likely reason for decrease in the wear with increasing waiting time.

In fretting wear, the surface and wear particles are usually oxidized. The reciprocal and small amplitude sliding leads to the generation of small oxidized wear particles as explained above. This also explains as to why the surface and wear particles are easily oxidized in fretting wear process.

5. CONCLUSIONS
A systematic experiment study has been carried out to explain the effect of reciprocal sliding on severe-mild wear transition. It has been shown that the reciprocal sliding promotes severe-mild wear transition and it also results in lower wear. These beneficial effects could be attributed to the generation of relatively smaller oxidized wear particles during reciprocal sliding motion. Increase in the waiting time accelerates the severe-mild wear transition owing to further oxidation of small wear particles during the waiting time.

6. REFERENCES