WEAR CHARACTERISTICS OF METALS USING DISK ON DISK TYPE WEAR TEST RIG

K. Hiratsuka*1 and T. Yoshida*2

*1 Department of Mechanical Science and Engineering, Chiba Institute of Technology, 2-17-1 Tsudanuma, Narashino, Chiba 275-8588, Japan

*2 Nihon Kosakuyu Co. Ltd., Japan 5-29-14, Shiba, Minato-ku, Tokyo 108-0014, Japan

1. INTRODUCTION

Wear of metals is influenced by many factors such as material, surrounding atmosphere and sliding conditions. Besides these factors, type of the wear test also has a significant effect on wear results. For example, when pin on disk test rig is used, wear of disk is usually more than that of pin[1]. This is because the contact time of each specimen is asymmetric. In this case, the transfer particle at the tip of the pin protects pin against wear. So the wear of dissimilar metals depends on the pin-disk combination. In order to fully characterize the adhesive wear, we have developed a disk on disk type test rig[2]. In this rig, the circumferential surfaces of the two identical disks are in sliding contact thereby resulting in a symmetrical contact. In this paper, the wear characteristics of ten different metals sliding against emery paper as well as against themselves have been presented along with the wear of 43 dissimilar metal combinations.

2. EXPERIMENTAL PROCEDURE

Two disks rotate to slide in the opposite direction with the same sliding speed (200mm/s) as shown in Fig.1. This results in a relative interfacial sliding speed of 400mm/s. A load of 10N was applied between disks by dead weight.

Ten different metals (Al, Zn, Ag, Cu, Nb, Fe, Ni, Zr, Ti, Mo) were rubbed against themselves, other metals and emery paper (#100) which was pasted on to one of the disk’s circumferential surface. All tests were conducted in laboratory air at room temperature.

3. RESULTS

Fig.2 shows the wear coefficient of metals when they were rubbed against emery paper. Wear coefficient is calculated from the wear volume divided by load and sliding distance and multiplied by hardness. It is apparent that the wear coefficient is constant as a function of Vickers hardness, meaning that the wear volume is in inversely proportional to the hardness of metals. So in this case, the wear mode was abrasive.

In similar metal combinations, the wear of both specimens showed the same wear rate. This is because the rubbing system is symmetrical. As shown in Fig.3, the wear depends on the oxidation activity and crystal structure; i.e., hexagonal closed packed metals such as Ti, Zr and Zn and low oxidation activity metal such as Ag show relatively low wear coefficient.

In dissimilar metal combinations, the wear modes are classified into four categories as follows:

1) Single side wear (wear observed in only one disk)
   1-1) High wear rate (SWH)
   1-2) Low wear rate (SWL)

2) Both sides wear (wear observed in both the disks)
   2-1) High wear rate (BWH)
   2-2) Low wear rate (BWL)

The wear modes are governed by the factors depicted in Fig.5 from the points of view of relative hardness, oxidation activity, mutual solubility and crystal structure. Each wear mode is determined as follows:
1) When a metal is much softer than the mating metal, only the soft one is worn out. The amount of wear is determined by the oxidation activity of softer metal.

2) When the hardness is not different, and when the mutual solubility is low, it shows extremely low wear. When the mutual solubility is not low, it shows relatively high wear.

4. DISCUSSION
From the results presented above, it has been shown that disk on disk type wear test rig is most suitable to understand the wear characteristics of metals because of its symmetrical contact. The wear results are not influenced by the contact configuration and geometry of the specimens, which usually affect the wear. The effect of material properties can be extracted as the determining factor of wear.

5. CONCLUSIONS
Using disk on disk wear test rig, abrasive and adhesive wear of metals were studied. Abrasive wear of metals are inversely proportional to the hardness of metals. Adhesive wear of similar metals depends on the crystal structure and oxidation activity. Adhesive wear of dissimilar metals depends on the hardness difference, oxidation activity, mutual solubility and whether it is rubbed against Ti or Zr.

6. REFERENCES

Fig. 2 Effect of Vickers hardness on abrasive wear of metals
Sliding Distance; 94.2mm (one rotation)

Fig. 3 Effect of Vickers hardness on adhesive wear of metals
Similar metal combinations, Sliding Distance; 1500m

Fig. 4 Wear coefficient of dissimilar metal combinations
Sliding Distance; 1500m