Friction and Wear Behaviors of WC-Co/WC-Co Pairs in Air

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Abstract

To investigate sliding friction and wear behaviors of WC–Co/WC–Co pairs containing different WC grain sizes, the ball-on-disc test in air were carried out, where WC grain sizes a 0.5 μm (F.G.) and 1.5 μm (C.G.). The wear volume of F.G. pin for F.G. pin/C.G. disc is larger than that of F.G. pin for F.G. pin/F.G. disc due to higher friction coefficient, and the surfaces after wear test are richer in oxygen compared to those before test. Furthermore, the wear debris, which is composed of nona-scale grain, after the wear test are remarkably richer in oxygen than to those before test.

Keywords : friction, wear, WC-Co, microstructure

1. Introduction

Development of high-performance micro-devices and micro-machines leads to further enhancement of information, biological, medical, and environmental technologies. Thus, it is essential that more advanced nano- and micro-machining techniques are established. For example, the micro-forging process enables micro-devices to be mass producted at low cost. WC-Co alloys are suitable for dies due to their high stiffness, high strength, high toughness, etc, and it is the wear of dies affects the dimensional accuracy of the forged products.

There have been many reports on the wear properties of WC-Co alloys (e.g. [1]-[3]). In the forging process, the required properties is different for each part, different materials is used for each part. Therefore, it is important to investigate friction and wear properties for different WC-Co pairs to achieve high-performance die.

In this work, sliding friction and wear behaviors of WC–Co/WC–Co pairs containing different WC grain sizes were examined in ball-on-disc geometry in air.

2. Experimental and Results

Two kinds of the cemented carbides were prepared; the WC-10 mass.% Co cemented carbide with the different WC grain sizes of 1.5 μm (C.G.) and 0.5 μm (F.G). Scanning electron micrograph of the cemented carbide is shown in Fig. 1. The sliding friction and wear properties of F.G. pin/ C.G. disc and F.G. pin/ F.G. disc were examined in ball-on-disc geometry in air.

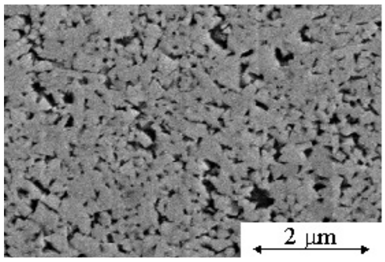

Fig. 1. Scanning electron micrograph of the F.G.

The friction coefficient curves as a function of sliding distance and wear volume after test for F.G. pin/C.G. disc and F.G. pin/F.G. disc are shown in Fig. 2. The initial friction coefficient for F.G. pin/C.G. disc is high value of about 0.8, but can been seen to substantially decrease to about 0.4 to a sliding distance of about 300 m, and then it remains constant. On the other hand, for F.G. pin /F.G. disc, friction coefficient maintains a constant value of about 0.35. The wear volume of F.G. pin for F.G. pin/C.G. disc is larger than that of F.G. pin for F.G. pin/F.G. disc as a consequence of higher friction coefficient.

EDX analysis for C.G. disc before and after wear test are shown in Fig.3. These figures show that the surfaces after wear test are richer in oxygen compared to those before the test. The same trends can be seen in F.G. pin/F.G. disc.

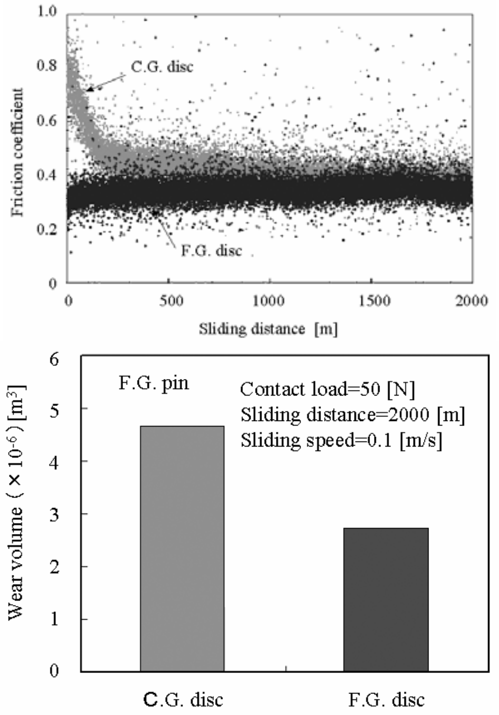

Fig. 2. Friction coefficient curves as a function of sliding distance and wear volume after wear test performed on F.G. pin /C.G. disc and F.G. pin /F.G. disc.

TEM micrograph and diffraction patern for wear debris is shown in Fig. 4. The wear debris is the aggregation of nano-scale grains. The diffraction pattern reveals sharp ring with spots, indicating that the presence of nano-scale grains most probably together with some amorphous material. The same pattern was reported for the other specimens [3], which were concluded to be most likely $CoWO_4$ oxide.

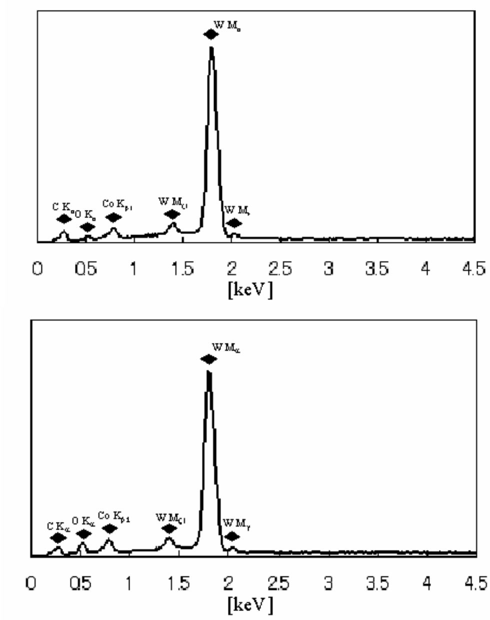

Fig. 3. EDX analysis for C.G. disc before and after wear test.

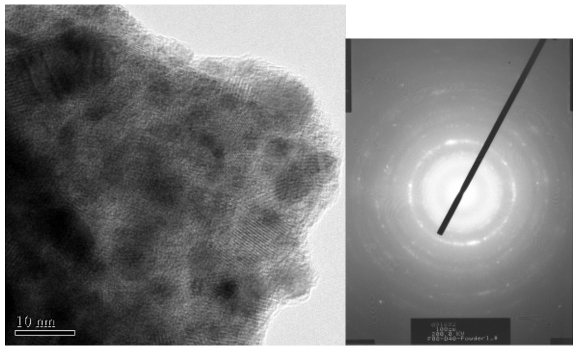

Fig. 4. TEM micrograph and diffraction pattern for wear debris.

3. Summary

In this study, the wear test of F.G. pin/ C.G. disc and F.G. pin/ F.G. disc were examined in ball-on-disc geometry in air. Based on the results, following conclusions could be drawn.

The wear volume of F.G. pin for F.G. pin/C.G. disc is larger than that for F.G. pin/F.G. disc due to higher friction coefficient.

The surfaces of F.G. pin and C.G. disc after wear test are richer in oxygen compared to those before the test.

The wear debris are remarkably richer in oxygen compared to pin and disc before the test. The wear debris is an aggregation of nano-scale grains. The diffraction pattern reveals sharp ring with spots, indicating that the presence of nano-scale grains most probably together with some amorphous material.

4. References

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