Tribological Behavior of Electro-pressure Sintered Cobalt-Iron, Cobalt-Nickel, and Cobalt-Iron-Nickel Compacts

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Abstract

Dry sliding wear behavior of electro-pressure sintered Co-Fe, Co-Ni and Co-Fe-Ni compacts was investigated. Pin-on-disk wear tests were performed on the sintered compacts disk specimens against alumina (Al2O3) and silica (SiO2) ball counterparts at various loads ranging from 3N to 12N. Two sliding speeds of 0.1m/sec and 0.2m/sec and a fixed sliding distance of 1,000m were employed. Worn surfaces and cross sections of them were examined by a scanning electron microscopy, and wear mechanism of the compacts was investigated. Effects of the oxide layer that was formed on wearing surface of the compacts on the wear were also studied.

Keywords : tribology, sliding wear, Co-Fe, Co-Ni, Co-Fe-Ni, compact

1. Introduction

Cobalt has been widely employed as the metal bond for a diamond-impregnated sawblade segment, which is normally used for a stone sawing. Traditionally, Co has been regarded as the best bod materials, since it has a superb diamond-holding capability and exhibits proper wear rate to achieve an optimum stone sawing [1]. However, the Co powder is expensive and the price- variation range is large. Therefore, it has been an active research field to develop substitutes for the Co. Powders based on Fe and Cu have ben developed, however their performance has not, so far, come up to that of the Co.

Wear characteristics of the metal bond are very complicated. The bond experiences three-body abrasive wear and erosion by the stone debris as well as sliding wear due to the direct contact with the cut [2]. Therefore, it is very important to characterize the wear behavior of the bond to improve the prfomance of the diamond -impregnated sawblade segment. The present research was performed with the aim of investigating the sliding wear characteristics of the electro-pressure sintered Co-Fe, Co-Ni and Co-Fe-Ni compacts.

2. Experimental and Results

Co, Fe, Ni elemental powders with the average size less than 10μm were used to fabricate disk specimens for the wear test. The powders were mixed by predetermined ratios, and hot pressed to make disk specimens with a diameter and thickness of 30mm and 7mm, respectively. The content of the Fe and Ni powders were varied from 20 to 80 wt. %. Dry sliding wear tests of the disk specimens against Al_2O_3 and SiO_2 beads were carried out in the air at room temperature using a pin-on-disk wear tester with a sliding speed of 0.1m/sec. Applied wear loads were varied from 3N to 12N, and sliding distance was fixed as 1000m. Worn surfaces, their cross sections, and wear debris of the disk specimens were examined by an SEM (scanning electron microscope) to invstigate the wear mechanism.

The Co-Fe compacts showed little difference in wear rates when they are tested against the two counterpart materials, Al_2O_3 and SiO_2 beads. For both counterpart materials, the wear rate of the Co-Fe compact varied inversely with the hardness of the compact if the Co content were high. The wear rate of the Co-Fe compacts with high Fe content was affected by an oxide layer formation on the wearing surface. The 60Co-40Fe and 40Co-60Fe specimens exhibited the highest wear rate, which was explained by the brttile FeCo superlattice formation in the specimen with the composition.

Unlike the Co-Fe, the wear characteristics of the Co-Ni compacts varied significantly depending on the counterpart material. When the Co-Ni compacts wear agaist the Al_2O_3 bead, the wear rate increased with the increase of the Ni content up to 40%. If the Ni content exceeds 60%, the wear rate decreased with the formation of oxide layer on the wearing surface. However, when the Co-Ni compacts were worn against the SiO_2 bead, the oxide layer was not formed, and the wear rate showed the typical behavior that the rate decreases with the increase of the specimen hardness.

The wear rate of the Co-Fe-Ni compacts, if the Fe content were high, was significantly influenced by the oxide layer formed on the wearing surface. When the oxide layer controls the wear, the wear rate of the compacts was

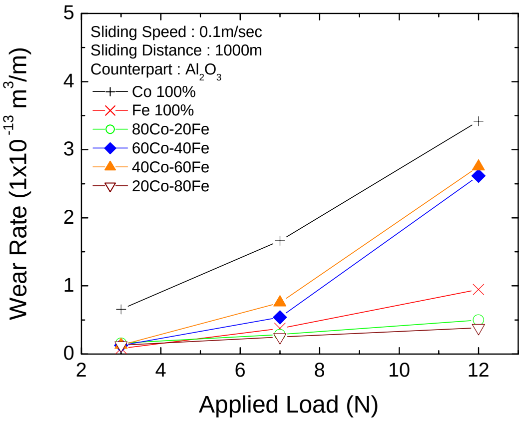
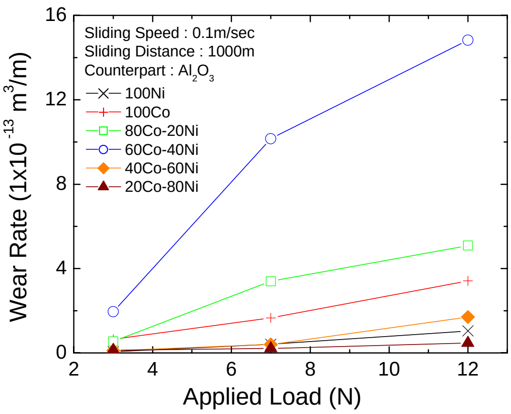
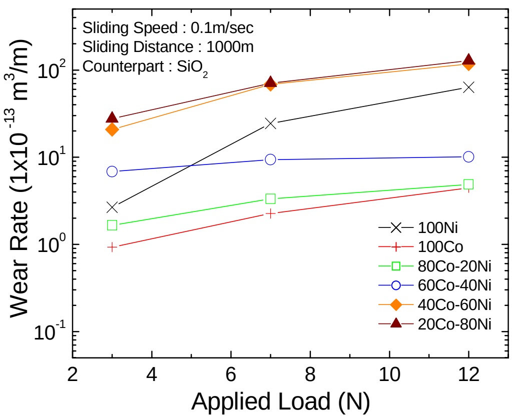


Fig. 1. Variation of wear rates of the Co-Fe compacts against alumina.



(a)



(b)

Fig. 2. Variation of wear rates of the Co-Ni compacts against alumina (a) and silica (b).

independent of the counterpart material. During the wear of the Co-Fe-Ni compacts with high Ni content, the oxide layer was formed only against the alumina. When worn against the silica, the wear rate of the specimen with Ni content higher than 30% increased abruptly.

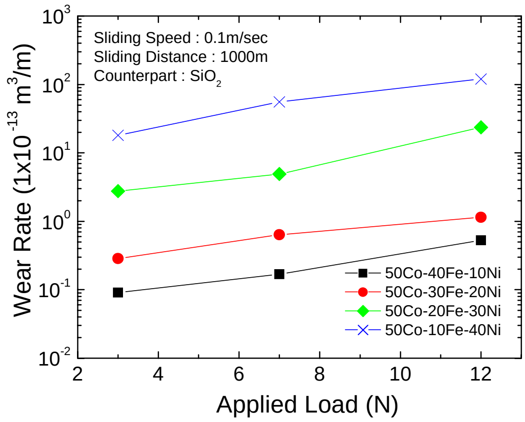


Fig. 3. Variation of wear rates of the Co-Fe-Ni compacts against silica.

3. Summary

Dry sliding wear behavior of electro-pressure sintered Co-Fe, Co-Ni and Co-Fe-Ni compacts was investigated. Pin-on-disk wear tests were performed on the sintered Co-Fe, Co-Ni and Co-Fe-Ni disk specimens against alumina (Al_2O_3) and silica (SiO_2) ball counterparts at various loads ranging from 3N to 12N. A constant sliding speed of 0.1m/sec was employed. Wear rate was calculated by dividing the weight loss measured after the test by specific gravity and sliding distance. Worn surfaces and cross sections of them were examined by a scanning electron microscopy, and wear mechanism of the compacts was investigated. Wear characteristics of the compacts were discussed as a function of composition of the compacts. Relationship between the wear rate and mechancial properties of the compact was explored, and effects of the oxide layer that was formed on wearing surface of the compacts on the wear were also studied.

4. References

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