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Wear Behavior of Carbon Fiber Reinforced Aluminum Alloy Composite

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Effects of the reinforcement with Pitch-based carbon fiber on the wear characteristic of aluminum alloy have been investigated. The composites were fabricated by squeeze casting. Wear tests were carried out under dry sliding conditions using pin-on-disk method. Wear loss of the aluminum alloy was greatly reduced by the fiber reinforcement. The friction coefficient during the wear test of the composite was stable compare to that of the unreinforced alloy and the roughness values of the worn surface of the alloy became smaller by the reinforcement. These results indicate that the carbon fiber acted as a solid lubricant on the worn surface.

Keywords: *Aluminum, Carbon Fiber, Composite, Squeeze Casting, Wear.*

1. Introduction

Reinforcing with non-metallic fiber has been proposed to improve the properties of aluminum alloy. Carbon fiber was widely used as the reinforcement because it has a high strength, rigidity, low density and low thermal expansion. Pitch-based carbon fiber is one of the most attractive materials as the reinforcement because its thermal conductivity is higher than that of the PAN-based carbon fiber [1]. Although the properties of the carbon fiber reinforced aluminum alloy are widely studied [2-3], PAN-based carbon fibers were used as the reinforcement in these reports. No research has been found on the wear characteristics of the composites reinforced with the pitch-based carbon fibers. In the present study, aluminum alloy composites reinforced with pitch-based carbon fibers were fabricated by the squeeze casting, and then the effects of the fiber reinforcement on the wear characteristics of the aluminum alloy were discussed.

2. Experimental procedure

2.1 Materials

The JIS-AC8A aluminum alloy (Al-12Si-1Mg -1Cu-1Ni) was used as the matrix metal. Short pitch-based carbon fiber was used as a reinforcement. In order to fabricate the fibrous preform, the carbon fibers are mixed with water, an inorganic binder (silica sol) and an organic binder (PVA) and then pressed in the mold, followed by drying at 458 K for 2 h. The fiber volume fraction in the preform was 30 vol%. The composite was fabricated by the squeeze casting. The mold was firstly preheated with the preform at 673 K, the molten AC8A alloy (973 K) was then poured into the mold and quickly pressed by a plunger (40 MPa for 1 min) to be infiltrated into the preform. Figure 1 is the optical micrograph of the composite, showing that fibers are randomly oriented.

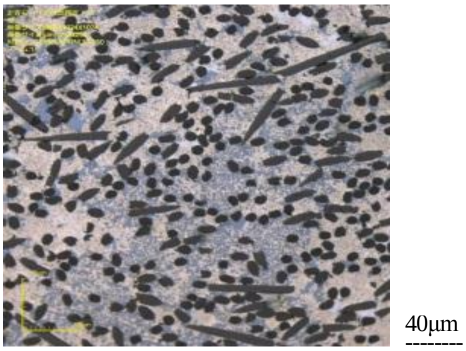

Fig. 1 Optical micrograph of the composite.

2.2 Wear test

The composites were subjected to wear test by the pin-on-disk method. AC8A alloy was used as a comparative material. Aluminum and composite were cut into the pin specimen (φ5×15 mm). High carbon chromium bearing steel material (JIS-SUJ2) (hardness: 188 Hv) is processed into a disk shape for the counterface. Wear tests were carried out under a contact load of 19.6 N and at the sliding velocity (υ) of 0.3 m/s and 3.0 m/s. The mass loss and the coefficient of friction (μ) during the wear test were also measured. Subsequently, the worn surfaces of the pin specimen and the counterface were observed using microscope and the roughness values (center line average roughness, R_a) of the worn surfaces of the specimens were measured.

3. Results and discussion

Figure 2 shows the relationship between the sliding distance and the amount of wear loss of the composite and unreinforced AC8A alloy (pin specimens). By reinforcing the alloy with the carbon fibers, wear loss of the AC8A alloy was greatly reduced.

The coefficient of friction of the specimens (μ) during the wear test is shown in Fig. 3. Error bars represent the range between the maximum and minimum values. The range was getting smaller by reinforcing with the carbon fibers, indicating the change in μ for the composite was small throughout the wear test.

Figure 4 shows the optical micrographs of the worn surfaces of the counterface after the wear test. When υ was 0.3 m/s, worn marks became unclear by the fiber reinforcement. When υ was 3.0 m/s, the adhesion of the aluminum on the surface seems to be slightly decreased by the fiber reinforcement.

Figure 5 shows the surface roughness values (R_a) of the disk specimens after the wear test. The average values and the range values was slightly decreased by the fiber reinforcement at every sliding velocity.

At a low υ, the wear loss, the change in the coefficient of friction during test and the surface roughness of the AC8A alloy and the counterface decreased by the reinforcement. These facts indicate that the carbon fibers act as a solid lubricant on the worn surfaces thus preventing the adhesion of the matrix on the counterface. At a high υ, although the change in the coefficient of friction of the AC8A alloy decreased by the reinforcement, the surface roughness of the AC8A alloy and the wear loss of the counterface did not significantly change by the reinforcement. This is probably due to the fact that the AC8A alloy melted by the heat that were produced by the friction on the surface thus welded and covered on the worn surface of the counterface.

4. Conclusions

The wear loss of the AC8A alloy was greatly reduced by the carbon fiber-reinforcement. Although the reinforcement had no effect on the average values of coefficient of friction, the range in the values during the wear test decreased by the fiber reinforcement. These results was probably due to the carbon fibers which act as a solid lubricant on the worn surface.

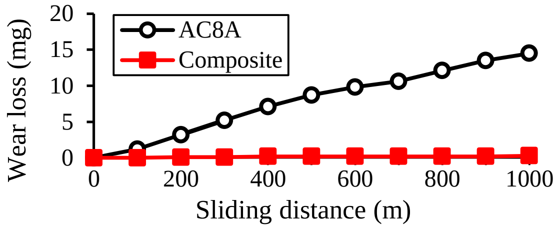

Fig. 2 Relationship between sliding distance and wear loss of AC8A alloy and composite.

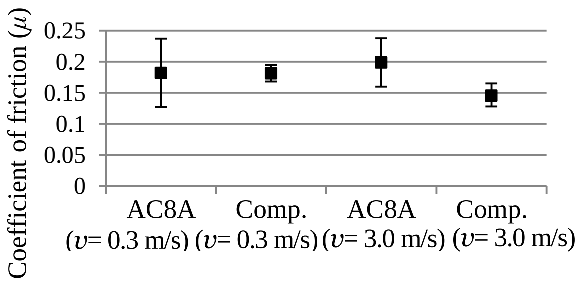

Fig. 3 Coefficient of friction of AC8A alloy and composite under wear test.

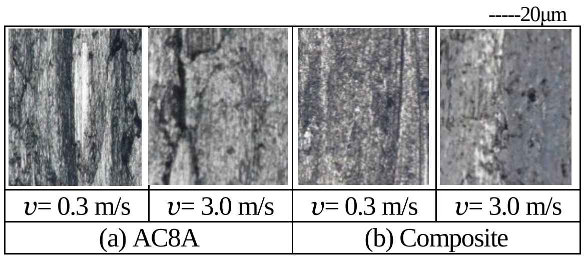

Fig. 4 Worn surfaces of the disk specimens after wear test.

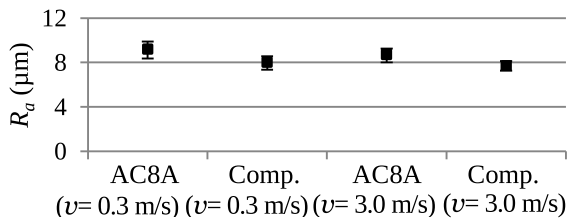

Fig. 5 Surface roughness of disk specimens after wear test.

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