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Fabrication of Fe-Based Self-Lubrication Composite Containing Graphite Particles by Centrifugal Mixed-Powder Method

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As self-lubrication composites, there are metal-based composite containing graphite particles. However, many of the self-lubrication composites have pure Cu or Cu alloy matrix, and investigation of Fe alloy-based self-lubrication composite is few. This is because that Fe alloys can form carbide easily with graphite. In this study, SUS430-based composites containing graphite particles are fabricated by centrifugal mixed-powder method. By using this method, the SUS430-based composites containing graphite particles are successfully obtained. Although very thin carbides are formed at interface between a graphite particle and SUS430 matrix, graphite particles are remained in the SUS430 matrix. Comparing with wear resistance of as-cast SUS430 without graphite particles, the SUS430-based composites have better wear resistance. In addition, frictional coefficient of the SUS430-based composites is much lower than that of the as-cast SUS430. Therefore, the centrifugal mixed-powder method is the effective processing for the fabrication of the SUS430-based composites containing graphite particles.

Keywords: *Self-lubrication composite, Stainless steel, Centrifugal casting, Centrifugal mixed-powder method, Wear.*

1. Introduction

As one of metal-based composites with high wear properties, self-lubrication composite has been proposed [1-3]. The self-lubrication composite contains solid lubrication particles in metallic matrix. Kováčika *et al.* have made Cu-based composite containing graphite particles by sintering process [2]. According to their study, dispersion of the graphite particles in pure Cu matrix decreases frictional coefficient and improves wear resistance. Also, it has been reported that composites fabricated by sintering of graphite particles and Cu alloys matrix powder have high wear resistance [1]. However, strength of these self-lubrication composites is relatively low, because graphite particles with low strength are homogeneously distributed in the matrix. To overcome this problem, parts of authors have recently developed the Cu-based composite containing graphite particles by using centrifugal mixed-powder method [3]. Since the centrifugal mixed-powder method can distribute graphite particles only around the sliding part, this composite has high strength comparing with the Cu-based composite fabricated by sintering process with homogeneously distribution of graphite particles. Hence, if the self-lubrication composite would be applied for bearing, the self-lubrication composite by the centrifugal mixed-powder method is suitable.

Here, considering about materials used for bearing, many of bearings are made from Fe alloy. However, matrix metal of the self-lubrication composites developed in the previous studies is not Fe alloys but Cu or Cu alloys [1-3]. This would be because that Fe alloys easily form carbide with graphite particles. If the composite can be cooled down before formation of carbide, it is expected that Fe alloy-based composites containing graphite particles can be obtained.

In this study, Fe alloy-based composite containing graphite particles is developed by the centrifugal-mixed powder method. For matrix of this composite, SUS430 ferritic stainless steel is used because this stainless steel is stable under high temperature. Using the fabricated Fe-based composites, its wear properties are evaluated.

2. Experimental Procedure

Mixed-powders of SUS430 powder (50-150 μm) and graphite powder (50 μm) were prepared. The prepared mixed-powders were SUS430-35vol.% graphite and SUS430-50vol.%graphite. Using these mixed-powders, SUS430-based composites are fabricated by the centrifugal mixed-powder method. The centrifugal mixed-powder method is the centrifugal casting combined with powder metallurgy [4]. At first, the SUS430-graphirte mixed-powder is inserted into the mold. Then, the mold with the mixed-powder is set into the vacuum centrifugal casting machine and subsequently the SUS430 ingot was melted by melting furnace. After that, the molten SUS430 is poured into the mold by inducing centrifugal force, and the SUS430 powder is melted by heat of the molten SUS430. Finally, SUS430-based composites containing graphite particles are obtained. Details of the casting condition are shown in Table 1. Using fabricated composites, wear tests were carried out under reciprocal movement using ball-on-disc type wear machine. The counter ball was bearing steel (SUJ2) with 5 mm in diameter. Load and sliding distance were 4.9 N and 288 m, respectively. After the wear tests, wear resistance and frictional coefficient were measured. The wear resistances were evaluated by measuring cross-sectional area of worn groove formed on the composites. Also, microstructural observations were performed by using scanning electron microscopy (SEM) and energy dispersive X-ray spectroscopy (EDX).

Table 1 Casting conditions of composites.

Name of composites	Weight		Centrifugal force	Melting temperature
	Mixed -powder	SUS430 ingot		
SUS430-35vol.%Gr	9.5 g	95 g	80 *G*	1600 ℃
SUS430-50vol.%Gr	7.5 g			

3. Results and discussion

Figures 1 (a) and (b) are SEM backscatter compositional images of SUS430-35vol.%Gr and SUS430-50vol.%Gr composites, respectively. As can be seen in Fig. 1, graphite particles are successfully distributed in SUS430 matrix for the both composites. Although very thin carbide is formed at interface between a graphite particle and SUS430 matrix, most part of the graphite particle is un-reacted. Frictional coefficient and cross-sectional area of worn groove for the both composites are presented in Fig. 2. As reference, wear properties of as-cast SUS430 are also shown in this figure. The cross-sectional area of worn groove formed on composite is used to evaluate wear resistance. Larger worn groove means lower wear resistance. Frictional coefficient is decreased by dispersion of graphite particles. In addition, wear resistances of the composites are drastically improved by the addition of graphite particles. From these

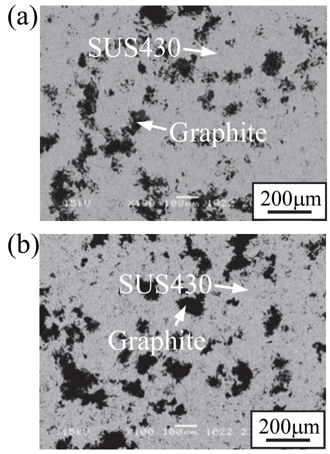

Fig. 1 SEM backscatter compositional images of (a)SUS430-35vol.%Gr and (b)SUS430-50vol.%Gr.

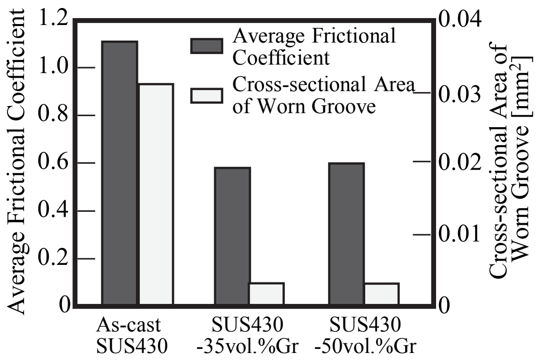

Fig. 2 Wear properties of SUS430-based composites.

results, it is found that the centrifugal mixed-powder method is effective processing of Fe alloy-based composites containing graphite particles.

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