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Improvement for Strength of Cu-Ti Based Composites Containing Graphite Particles Fabricated by Centrifugal Mixed-Powder Method

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Centrifugal mixed-powder method (CMPM) is casting process combined of centrifugal casting and powder metallurgy. The CMPM has advantage that solid particles with low wettability for matrix melt can be composed into the matrix. Recently, parts of authors have successfully fabricated Cu-based composites containing graphite particles by using the CMPM. Also, it has been reported that Ti addition into Cu matrix can improve the wear resistance of the Cu-based composites containing graphite particles. However, those Cu/Ti-based composites containing graphite particles are not aged while Cu-Ti alloy is age-hardened alloy. Hence, it is expected that strength of the Cu/Ti-based composites containing graphite particles by the CMPM is further increased by aging treatment. In this study, Cu/Ti-based composites containing graphite particles have been fabricated by the CMPM, and then aging treatment is performed for this composite to improve its strength. The Cu/Ti-based composites containing graphite particles are successfully obtained by the CMPM. Hardness of the composites becomes maximum by aging treatment at 400 ^{o}C for 4 h. Moreover, TiC phase is observed in the aged Cu/Ti-based composites containing graphite particles. From the obtained results, it is found that aging treatment is effective to improve mechanical properties of the Cu/Ti-based composites containing graphite particles.

Keywords: Centrifugal mixed-powder method (CMPM), Centrifugal casting, Composite, Aging, Self-lubrication material, Wear

1. Introduction

Bearings are often used for rotary and reciprocating portions to prevent energy loss due to friction, and materials used for bearings are Fe and Cu alloys. As one of the improvement method for the lubrication between the bearing-parts, self-lubrication materials are proposed [1-3]. The self-lubrication materials are metal-based composites containing solid-lubricant particles such as graphite and molybdenum disulfide. The self-lubrication materials are usually fabricated by sintering [2]. However, since many of the bearing-parts are fabricated by centrifugal casting, processing method of the self-lubrication materials using centrifugal casting is demanded.

Parts of authors have recently developed Cu-based composites containing graphite particles by CMPM [3]. The CMPM is the casting process combined of centrifugal casting and powder metallurgy [4]. Furthermore, they have reported that Ti addition into Cu matrix can improve the wear resistance of the Cu-based composites containing graphite particles [5]. Although it is well known that Cu-Ti alloy is age-hardened alloy [6], aging treatment of the Cu/Ti-based composites containing graphite particles is not carried out [3].

In this study, the Cu/Ti-based composites containing graphite particles have been fabricated by the CMPM, and then aging treatment for this composite is performed. Hence, it is expected that strength of the Cu/Ti-based composites containing graphite particles by the CMPM can be improved by aging treatment.

2. Experimental Procedures

Cu/Ti-based composites containing graphite particles were fabricated by the CMPM. As first step, three kinds of mixed-powders of Cu powder (25 μm), Ti powder (32 μm or less) and graphite powder (50 μm) with different Ti concentration were prepared. Volume fraction of graphite in these mixed-powders was 25 vol.%. After that, the mixed-powder was inserted into mold, and subsequently centrifugal force was induced for the mold after melting Cu ingot. The centrifugal force was 35 *G*. Table 1 shows the casting conditions of the composites. Using the Cu/Ti-based composites containing graphite particles solution treatments were performed at 950 °C for 48 h and

aging treatments were carried out at 400 °C for 1 ~ 4 h using vacuum furnace. Microstructural observations were made by a scanning electron microscope (SEM) for the obtained Cu/Ti-based composites. Moreover, micro-Vickers hardness tests were made for the composites.

Table 1 Casting conditions of sample fabrication.

Sample name	Heating temperature (℃)	Weight of mixed-powder (g)
Cu-2.5at.%Ti	1250	11.7
Cu-3.0at.%Ti	1250	11.6
Cu-5.0at.%Ti	1280	11.5

3. Results and discussion

Cu/Ti-based composites containing graphite particles are successfully fabricated by the CMPM. Hardness as a function of aging time is shown in Fig. 1. From this figure, the composites aged at 400 °C for 3 h has maximum hardness. Figure 2 is a backscatter electron compositional image of Cu-5.0at.%Ti sample aged at 400 °C for 3 h. As can be seen, some TiC phases are observed at interface between Cu/Ti matrix and graphite particle in the aged Cu/Ti-based composite containing graphite particles. Because of this, bonding strength between matrix and graphite would be improved by formation of TiC. Although Cu_4Ti phase is usually formed by aging treatment for Cu-Ti alloy, the Cu_4Ti phase can not be observed in Fig. 2. However, since correct age-hardened curves are obtained, very fine Cu_4Ti would be formed during aging treatment. Table 2 is results of wear tests for Cu-2.5at.%Ti alloy without graphite addition and Cu-2.5at.%Ti sample. It is seen that the Cu-2.5at.%Ti sample has lower frictional coefficient and higher wear resistance. Therefore, aging treatment for the Cu/Ti-based composites containing graphite particles is effective method to improve its mechanical properties.

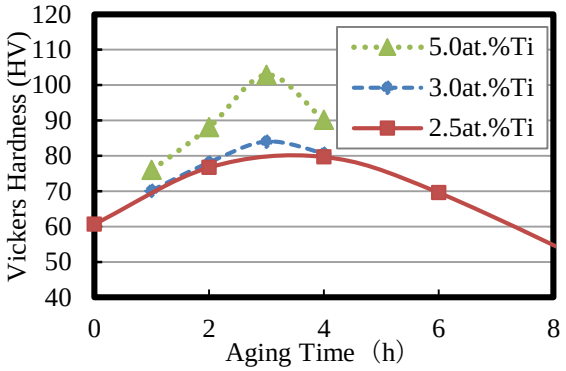

Fig. 1 Vickers hardness of aged Cu/Ti-based composites.

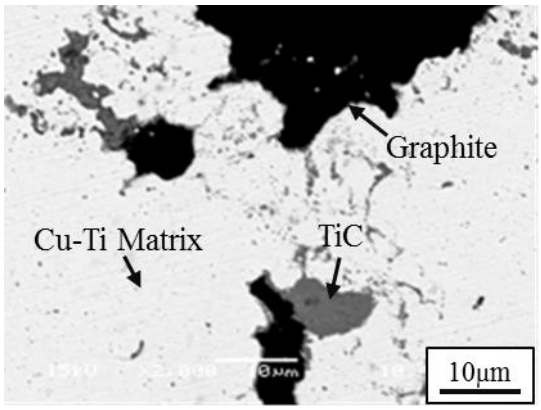

Fig. 2 Microstructures of Cu-5.0at.%Ti sample aged at 400 °C for 3 h fabricated by CMPM.

Table 2 Wear properties of Cu-2.5at.%Ti alloy and Cu-2.5at.%Ti sample

Sample name	Frictional coefficient	Cross-sectional area of wear groove [mm^2]
Cu-2.5at.%Ti alloy (without graphite addition)	1.06	0.047
Cu-2.5at.%Ti sample	0.26	0.019

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