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

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1. Introduction

Bearings are often used for rotary or reciprocating portions in order to prevent energy loss due to friction. Materials used for the bearings are Fe and Cu alloys\(^{1,2}\). The self-lubrication materials have been proposed as one improving method for lubrication between the bearing components\(^{3,5}\). These materials are metal-based composites containing solid-lubricant particles such as graphite and molybdenum disulfide, and these are usually fabricated by sintering\(^{4}\). 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 centrifugal mixed-powder method (CMPM)\(^{5}\). The CMPM is a casting method in which a combination of centrifugal casting and powder metallurgy\(^{6}\). Moreover, they have reported that it is possible to improve the wear resistance of Cu-based composites containing graphite particles by Ti addition into Cu matrix\(^{7}\). Also aging treatment of Cu/Ti-based composites containing graphite particles has never been carried out\(^{5}\) although the Cu-Ti alloy is age-hardened alloy\(^{8}\).

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

2. Experimental Procedure

Cu/Ti-based composites containing graphite particles were fabricated by the CMPM. At first of all, three kinds of mixed-powders of Cu powder (25 μm), Ti powder (32 μm or less) and graphite powder (50 μm) 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 vacuum furnace, solution treatments of the Cu/Ti-based composites containing graphite particles were performed at 950 °C for 48 h and aging treatments of them were performed at 400 °C for 1 ~ 4 h. Microstructural observations were made by a scanning electron microscope (SEM) for the heat-treated Cu/Ti-based composites. Moreover, micro-Vickers hardness tests were carried out for the composites. Movement type of friction wear test is a linear reciprocating motion. Table 2 shows the condition of the friction wear test. Changes in the coefficient of friction during the test were investigated by calculating the friction factor from the measured friction force.

<table>
<thead>
<tr>
<th>Sample name</th>
<th>Heating temperature (℃)</th>
<th>Weight of mixed-powder (g)</th>
</tr>
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<tbody>
<tr>
<td>Cu-2.5at.%Ti</td>
<td>1250</td>
<td>11.7</td>
</tr>
<tr>
<td>Cu-3.0at.%Ti</td>
<td>1250</td>
<td>11.6</td>
</tr>
<tr>
<td>Cu-5.0at.%Ti</td>
<td>1280</td>
<td>11.5</td>
</tr>
</tbody>
</table>

3. Results and Discussion

Cu/Ti-based composites containing graphite particles are successfully fabricated by the CMPM. Micro-Vickers hardness as a function of aging time is shown in Fig. 1. From this figure,
hardness of the composites becomes maximum by aging treatment at 400 °C for 3 h. Figure 2 is a backscatter electron compositional image of Cu-5.0at.%Ti sample aged at 400 °C for 3 h. From the image, 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, it is considered that bonding strength between matrix and graphite would be improved by formation of TiC. The Cu$_4$Ti phase cannot be observed in Fig. 2, although Cu$_4$Ti phase is usually formed by aging treatment for Cu-Ti alloy. However, since correct age-hardened curves are obtained, very fine Cu$_4$Ti would be formed during aging treatment.

Table 3 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 their mechanical properties.

Table 3 Wear properties of Cu-2.5at.%Ti alloy and Cu-2.5at.%Ti sample

<table>
<thead>
<tr>
<th>Sample name</th>
<th>Frictional coefficient</th>
<th>Cross-sectional area of wear groove [mm$^2$]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cu-2.5at.%Ti alloy</td>
<td>1.06</td>
<td>0.047</td>
</tr>
<tr>
<td>Cu-2.5at.%Ti sample</td>
<td>0.26</td>
<td>0.019</td>
</tr>
<tr>
<td>(containing graphite)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. Conclusions

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°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.

Acknowledgement

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References