Study on mechanical properties of Metal Matrix Composites (MMCs) Al-Cu-Mg/SiC\textsubscript{p} with Powder Metallurgy

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Abstract. The synthesis of aluminum (Al) alloys, Al-Cu-Mg from mixture powder 88.4 wt% Al; 3.8 wt% Cu and 1.8 wt% Mg the adding 6.0 wt% up to 7.0 wt% of SiCp on Al-Cu-Mg. After mixing the sample has been prepared by hot pressing process at a temperature of 350°C. After pressing sample has prepared by sintering one hour at a temperature 500°C and aging 16 hours. Al-Cu-Mg/ SiCp alloys samples has been investigated. The structure analysis were examined by X-Ray Diffractometer (XRD) and scanning electron microscope (SEM-EDX). The hardness was measured by hardness Vickers method. According to the results, it can be assumed that the 7 wt% of SiCp content is prefer content to get better quality of hardness Vickers of Al-Cu-Mg alloys.

1. Introduction
Research on aluminum-based metal matrix composites (MMCs) continues to be developed because this material is a strategic material, besides being a basic ingredient in aerospace technology (airplanes, rockets), it is also used as a base material in designing automotive spare parts for pistons. Aluminum matrix is chosen, because aluminum has the advantage of being light weight, corrosion resistant, easily fabricated or casting, has a low melting point, low strength but alloying can increase strength [1–6]. The addition of copper (Cu) and magnesium (Mg) elements was chosen because this element is able to dissolve very significantly and has the effect of substantial strength in the hardening process given to aluminum. The reinforce (filler) is used silicon carbide (SiC), a crystalline compound that has the highest mechanical properties and has a high melting point. Other properties are insoluble in water and other solvents, also easy to bind and do not cause oxidation to aluminum metals [7,8]. It should be noted that the composite made from aluminum matrix with SiC powder reinforcement is difficult to obtain with conventional melting based methods due to the poor wettability between Al liquid and SiC. In addition, this method usually leads to unwanted reactions between SiC and Al liquid, which results in fragile phases of Al4C3 and Si [9–11]. Then powder metallurgy (P/M) technique is a problem solving technique by mixing and high-energy milling to produce composites with fine microstructure of solid component powder before pressing, reducing temperature and holding time to reduce interface reaction [12–14]). In this paper, the results of the matrix Al-Cu-Mg in powder phase are reported mixed with silicon carbide (SiC) [15,16].
2. Method
Preparation of Al-Cu-Mg/SiC$_p$ Metal Matrix Composites (MMCs) with a matrix composition of 3.8 wt% Cu, 1.8 wt% Mg and the rest Al, with SiC fillers varied (6.0; 6.5 and 7.0) wt%. Matrix Al-Cu-Mg powder milling by vibrator ball mill (VBM), after mixing the sample has been prepared by hot pressing process at a temperature of 350 °C. After pressing sample has prepared by sintering one hour at a temperature 500°C and aging 16 hours on 190 °C. Al-Cu-Mg/SiC alloys samples has been investigated. The structure analysis was examined by X-Ray Diffractometer (XRD) and scanning electron microscope (SEM-EDX). The hardness was measured by hardness Vickers method.

3. Results and discussion
Phase composition of Al-Cu-Mg alloys were examined by XRD, the result is shown in Fig. 1. It shows for of composition 7.0 wt % of SiC$_p$ that the main phases of aluminum (Al) and no second phase.

![Figure 1. XRD pattern of Al-Cu-Mg/SiC alloy with SiC 7.0 wt %.

This indicates that SiC has entered into Al-Cu-Mg structure to form Al-Cu-Mg/SiC alloy was formed by pressing process. According Figure 1 Al-Cu-Mg/SiC (7.0) wt% aluminum forming phase the phase is dominant with peak intensities in (111), (002), (022), and (113). The minor phase of Al$_2$CuMg originates from precipitate atoms which diffuse into Al matrix during sintering process. However, at cooling process, the precipitate atoms move back to the grain boundary and the composite surface [1,11]. Therefore, it can be understood that there is no other new phase forms in Al-Cu-Mg composite.

Microstructure testing using SEM / EDX Jeol jsm 6510LA machine with a magnification of 2000 times. According of the SEM observations (Figure 2) it can be seen that the surface of the Al-Cu-Mg with 7.0 wt% SiC$_p$ surface appears ruder when compared with the Al-Cu-Mg with 6.5 wt% SiC$_p$ and the Al-Cu-Mg with 6.0 wt% SiC$_p$ samples. From the EDX results it was found that the SiC$_p$ 7.0 wt% SiC$_p$ phase composition was detected, but in the sample with SiC$_p$ 6.5 wt% and 6.0 wt% the SiC$_p$ phase was not detected. It can be seen from the XRD test that the SiC$_p$ content increases, there is a tendency to increase SiC$_p$ and Mg, Cu bonds to form the Al$_2$CuMg phase, SiC$_p$ and Mg bond to form the Mg$_2$Si phase, making the sample grains bigger and appear coarser (1,6). In addition, the EDX results also indicate the presence of oxygen (O$_2$) in each sample, it is possible for the oxygen element to enter the sample during the pressing and cooling process.
Figure 2. Microstructural SEM-EDX samples of Al-Cu-Mg / SiCp 6.0 wt%.

Figure 3. Microstructural SEM-EDX samples of Al-Cu-Mg / SiCp 6.5 wt%.

Figure 4. Microstructural SEM-EDX samples of Al-Cu-Mg / SiCp 7.0 wt%.
The Vickers’ micro hardness results are summarized in Fig. 5. Al-Cu-Mg alloy with SiCp 7.0 wt % had the highest average value at 48.1 kg/mm², and Al-Cu-Mg alloy with SiCp 6.0 wt % had the lowest micro hardness of 37.4 kg/mm². The micro hardness increased due to the addition of the SiCp on matrix of Al-Cu-Mg. This proves that filler SiCp in a matrix of Al-Cu-Mg widened surface touch ears, so it will bind to the ears of the more powerful. In addition to the effect of SiCp contents influences micro hardness.

**Figure 5.** The Vickers’ micro hardness of Al-Cu-Mg with various SiC_p contents.

4. Conclusion

Based on the results of testing indicated SiC_p content increases, there is a tendency to increase SiC_p and Mg, Cu bonds to form the Al_2CuMg phase, SiC_p and Mg bond to form the Mg_2Si phase, this phenomenon making the sample grains bigger and appear coarser. Besides that, the increased of SiC_p on Al-Cu-Mg hardness Vickers’ values tend to increase. In addition to the effect of SiC_p contents influences micro hardness.

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