The Effect Of Sic And Addition Mg Volume Fraction On Characteristics Al6061-Sic Composite

Sumarji, Salahuddin Junus, Rahma Rei Sakura, Mochamad Asrofi, Ahmad Wafi

Abstract: Aluminium matrix composite is one of composite materials that has good mechanical properties and widely used in industry. The addition of Mg and SiC components increased the hardness number of the composite. While, the aluminium 6061 alloy is an alloy with the possibility of small shrinkage defects and better liquidity levels that affect the weldability and cast ability due to the silicon content of the alloy. (1) In this study the addition of Mg serves to increase the value of hardness, wetting ability of the matrix and reinforcement. (2) This study analyzed the addition of 3%, 5% 8% Mg and 8% SiC. The tests were done by hardness test, tensile test, microstructure observation, SEM, and XRD. (3) The highest hardness number was 87.67 HRB with the addition of 8% Mg while the highest tensile strength was 174.26 MPa with the addition of 5% Mg. (4) From the results of the study showed that the addition of Mg improves the mechanical properties of Al6061/SiC composites.

Keywords: Metal Matrix Composite, Stir Casting, Wettability, Mechanical Properties, Hardness Test, Aluminium.

1 Introduction

Aluminium is a type of metal that has mechanical properties, namely corrosion resistance and good conductor of electricity [1]. Al6061 alloys have good mechanical properties and have good corrosion resistance properties, but if the levels of silicon are high it will cause the alloy to become brittle [2]. Metal Matrix Composite (MMC) is a material formed by combining two or more materials to get new material that has better mechanical properties. MMC consists of matrix and reinforcement, MMC matrix typically soft metals such as aluminium, and reinforcements use micro to nano sized ceramics such as SiC, Al_2O_3, etc. Metal matrix composites have their own advantages over other types of composites [3] for example: better thermal expansion and wear resistance, good shear and compressive strength, non-flammable, does not absorb moisture, resistant to high temperature and good stress and strain transfer. The addition of filler materials as reinforcement to the composite manufacturing process is one way to improve the properties of the composite. SiC (Silicon Carbide) and Al_2O_3 (Alumina) particles are the most widely used reinforcing materials in the MMC (Metal Matrix Composite) production process. The advantage of SiC as a reinforcing material able to increase hardness, tensile strength, density and wear resistance of materials [4].

Table 1. *Chemical composition of SiC [2]*

Powder Type	C (%)	Si (%)
SiC	21.87	78.13

The importance of adding Mg as a wetting agent because the presence of free silicon on the SiC surface which able to reduce the contact angle between the alloy and the substrate. SiC and aluminium have an active role in chemical reactions that produce positive effects on silicon at the contact angle. Wettability is the ability of a liquid which used to wet the entire surface of a solid, so that the matrix able to wet the SiC particles and improve the mechanical properties [5]. Magnesium has excellent specific strength and rigidity, good dimensional stability, high wetting capacity and high recycling capability [6]. Therefore, researchers conducted studies based on Al-SiC metal composites with Mg as wettability agents. The novelty in this study in the form of the object, because according to the best our knowledge there is no research about it. In this study, the composite samples were tested using tensile, hardness, X-Ray Diffraction (XRD), microstructure and Scanning Electron Microscopy (SEM).

2 Experimental Procedure

2.1 Materials and Methods

Before conducting the experiment, we have done to prepare the specimen in accordance with variations in the addition of Mg 3%, 5%, and 8% with 8% SiC, respectively. The following steps were taken in this study, first: melting the composite from Al6061/SiC heated at 750 °C (inserted alternately after Al6061 melts then Mg was inserted until it melts and then incorporating SiC particles that have been heated first), after that, it was inserted and melted, then the stirring process was carried out at a speed of 450 rpm for 300 seconds, then pouring the cast into the mold where the mold has been heated until the mold temperature reaches 250 °C. After that, the metal was allowed to harden (wait for ± 30 minutes) metal was released from the mold. Then, it was prepared specimens to observe scanning electron microscopy (SEM), x-ray diffraction (XRD), hardness value according to American Standard Testing Materials (ASTM) E10 using Rockwell Hardness Tester, ASTM E8 standard using Zwick / Roell Z 100 Tensile Testing tool for tensile test, and ASTM E407-7 using Microscope Olympus BX41M for microstructure observation, respectively.

3 Results and Discussions

In this study, Al6061/SiC composite material with the addition of Mg fraction volume will use the stir casting method and will be tested specimens which include hardness tests, tensile tests, microstructure observations, SEM observations, and XRD observations. From the results of this study, it was

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expected that there will be an increase in the mechanical properties of the Al6061/SiC composites.

3.1 Hardness Test Results

In Figure 1, hardness testing on Al6061 specimens added 8% Mg and 8% SiC showed the highest hardness value while Al6061 without any addition showed the lowest hardness value, because in addition Mg could improve wettability and SiC was able to reduce grain boundaries on composites.

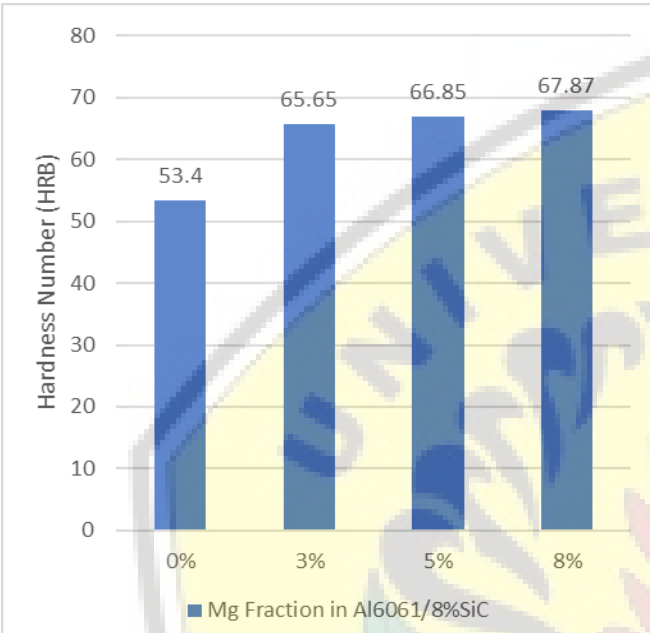

Figure 1. *Hardness test results of Al6061/SiC + Mg composite*

Hardness value of Al6061 without any addition was 53.4 HRB, addition of 3% Mg and 8% SiC by 65.65 HRB, addition of 5% Mg and 8% SiC by 66.85 HRB, addition by 8% Mg and 8% SiC by 67.87 HRB. Where optimum hardness is achieved in Al6061 composites added with 8% Mg and 8% SiC. SiC as reinforced will increase hardness value of composite Al6061/SiC. This is in accordance with research by Inegbenebor et. al. [7] the advantages of SiC as a reinforcing material can increase the value of resistance, tensile strength, density, and wear resistance. In the research of Rahman and Rashed [8] the addition of Mg as wettability increases the hardness value of Metal Matrix Composite. This lower hardness value is caused by several things, including the presence of porosity due to gas that can be trapped during melting to pouring, shrinkage during solidification and poor interface between the amplifier and the matrix.

3.2 Tensile Test Results

In Figure 2, the optimum tensile strength testing of Al6061/SiC tensile strength or it can be said that the average tensile strength value above Al6061 is achieved on Al6061/SiC composites with the addition of 5% Mg of 174.26 MPa, and the lowest average tensile strength found on Al6061/SiC composites with the addition of 8% Mg which is equal to 131.61 MPa as can be seen in Figure 2.

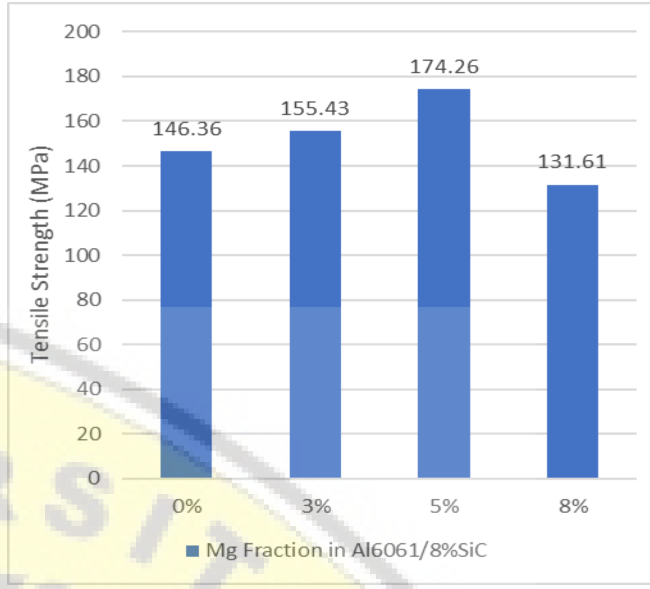

Figure 2. *Tensile strength of Al6061/SiC + Mg composite*

In this study, tensile curve showed the addition of Mg on Al6061 reinforced SiC will increase and decrease the tensile strength of the tensile strength of Al6061 material without any addition, which is 146.36 MPa. This can be seen in Al6061/SiC composites with the addition of 8% Mg of 131.61 MPa. This low tensile strength value can be caused by several things, including the presence of porosity, the unfavorable interface between SiC particles and aluminum matrix, and the presence of impurities entering due to fabrication. Porosity can also be caused by molds that have poor gating systems, causing shrinkage and the amount of trapped gas. Impurities that enter when stirring takes place can be a point of stress concentration in the material, so that the place will be the place where the failure begins and the tensile strength decreases [9].

3.3 Microscope Observation

Microstructure observations can show conditions that show the characteristics of the mechanical properties of Al6061/SiC composites by observing the visible elements, so that they can be used as the main support for evidence of increasing alloy properties.

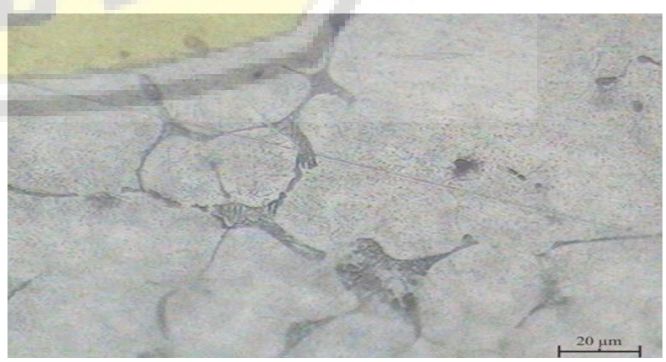

Figure 3. *Microstructure of Al6061/SiC+5%Mg*

In Figure 3 it can be observed that the magnesium content in Al6061/SiC composites can affect the microstructure. The grain size, grain boundaries and formed phases vary. With the addition of magnesium alloys making grain sizes smoother, adding magnesium will also reduce grain size. The refined grain size makes the material hard [10]. However, the addition of SiC and Mg does not rule out the absence of porosity in the composite.

3.4 SEM Observation

SEM observation aims to determine the presence of elements and predict phases in Al6061/SiC composites. Morphological observations using SEM were carried out on Al6061/SiC composite samples which added Mg as a Wetting Agent by 5%, namely structures with optimum hardness values in this study. In Figure 4, there are several phases identified that appear in SEM observations on Al6061/SiC composites plus 5% Mg, these phases are the dominant matrix as composites, micro-SiC reinforces are dispersed as unit particles or form clusters in regions Al matrix, namely spinel phase (AlMgO), Magnesium Oxide (MgO) phase formed around the SiC micro interface as a bonding product between Magnesium and SiC micro powders, the SiO2 phase formed due to the high melting point of SiC and the lack of heating at SiC makes a reaction with Oxygen, Magnesium and MnSi are formed around the content of one of the Al6061 matrix contents with additional material. The addition of Mg affects the formation of the interface layer which increases the strength between the matrix and the reinforce that affects the metal oxide phase such as MgO and $MgAl_2O_4$ with the presence of oxygen quantity during the synthesis of the environment and the oxide layer on the highly reactive Al and Mg surfaces will facilitate the formation of MgO [11].

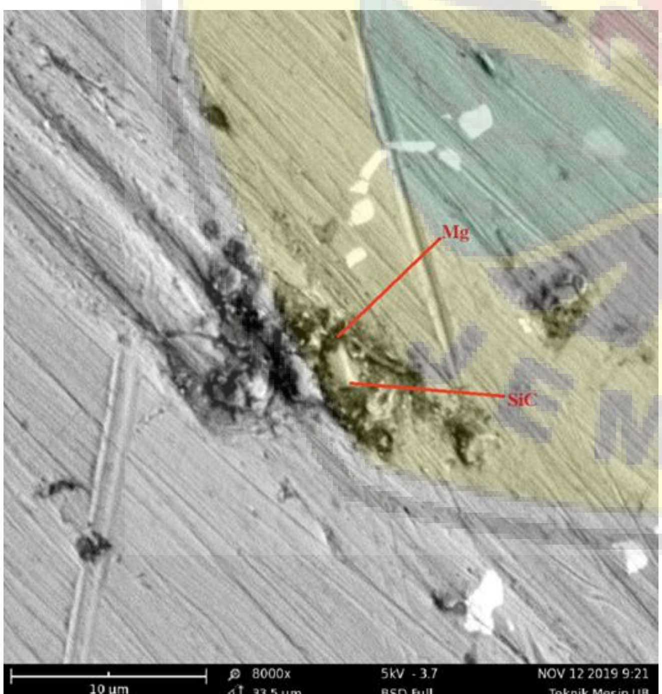

Figure 4. SEM Observation of Al6061/SiC+5%Mg

3.5 XRD Observation

The XRD observation aims to identify the compounds formed in Al6061/SiC composites, the specimens identified are specimens with the addition of 5% Mg. Figure 5 shows the presence of a new phase formed on Al6061/SiC composites with the addition of 5% Mg.

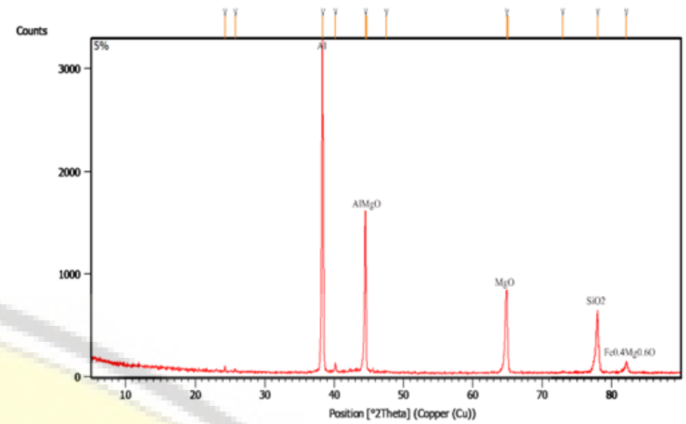

Figure 5. *XRD pattern of Al6061/SiC+5%Mg*

These phases are constructive phases where this constructive phase will improve the quality of interface bonding layers such as AlMgO (40-0903) which is seen at an angle of 2θ: 18.94; 32.43; 46.87. MgO (JCPDS 01-077-2364) which can be seen at an angle of 2θ: 26.71; 40,75; 55.93; 48.66. SiO2 (JCPDS 33-1161 and 85-1330) can be seen at an angle of 2θ: 11.39; 79.15; 86.24. Fe0.4Mg0.6O (JCPDS 4-829) seen at an angle of 2θ: 40.19; 40.53; 82.63.

4 Conclusions

The effect of Magnesium and SiC addition on Al6061/SiC composites influences the hardness of Al6061/SiC composites, where the highest hardness is found with the addition of 8% Mg and 8% SiC with hardness value of 67,875 HRB. Effect of Magnesium and SiC addition on Al6061/SiC composites influences the tensile properties of Al6061 / SiC composites, where the highest average UTS is found by adding 5% Mg and 8% SiC with a hardness value of 174.26 MPa. From the results of observations of microstructure found changes in particle shape along with the addition of variations in Mg. With the addition of Mg microstructure changes were found to be getting smaller or finer on Al6061/SiC composites. From the XRD observations, it is found that the number of constructive phases formed by the reaction of the matrix and other particle enhancers along with the addition of Mg variation where the constructive phase will improve the quality of the interface bond layer. Low test values are caused by several things, including the presence of porosity due to gas trapped during melting to pouring, shrinkage during solidification and poor interface between the amplifier and the matrix. Porosity can also occur due to the composite manufacturing process where air outside the melt, especially on the surface, is trapped when stirring is carried out.

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