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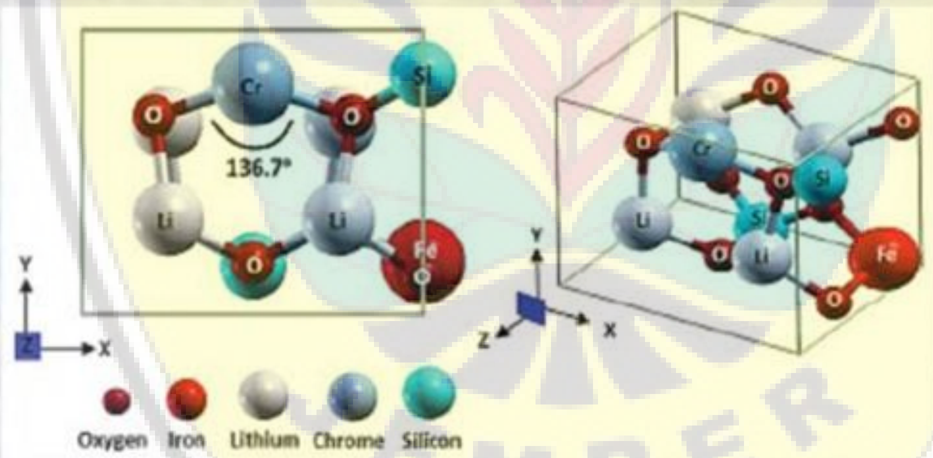

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Effect of Magnesium on Hardness and Microstructure of Metal Matrix Composite Al.6061/$(Al_2O_3)_p$ Produced by Stir Casting Route

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Keywords : aluminum composite, Aluminum alloy,Al_2O_3 ceramic particles, vortex method (stir casting), volume fraction

Abstract. Al.6061/Al_2O_3 metal matrix composites (MMCs) has been fabricated by stir casting. The MMCs were prepared by addition of Al_2O_3 particulates reinfoced with varios Mg content, 8, 10, 15 %wt Mg. Al.6061/Al_2O_3 composites with different Mg contents were successfully fabricated by stirring technique under optimum processing conditions. Effects of Mg content on microstructure and hardness were studied by Scanning Electron Microscopy (SEM)-EDX, SEM-Xray Map, XRD and Rockwell Hardness. The results indicate that Al_2O_3 particles disperse homogeneously in Al matrix and interfacial reaction between Al matrix and Al_2O_3 particles is effectively controlled. Distribution of Al_2O_3 reinforcement and interfacial bonding were improved by adding Mg. Additionally, the hardness of composites were remarkably improved with the Mg. The highest hardness of composites obtained in 15%wt Mg with a value of 55 HRB.

Introduction

Metal matrix composites (MMCs) was first emerged as a distinct technology in an era when improved performance for advanced military systems provided a primary motivation for materials development. In this paradigm, improved affordability and more widespread commercialization followed from the experience gained in the engineering, production and service of these initial military applications [1].

Among the variety of manufacturing processes available for discontinuous metal matrix composites, stir casting is generally accepted as a particularly promising route, and practiced commercially. Its advantages lie in its simplicity, flexibility and applicability to large quantity production. It is also attractive because, in principle, it allows a conventional metal processing route to be used, and hence minimizes the final cost of the product. This liquid metallurgy technique is the most economical of all the available routes for metal matrix composite production, and allows very large sized components to be fabricated [2].

Magnesium is a material which has a hexagonal structure and very lightweight with a specific gravity of about two-thirds of the weight of aluminum. Magnesium has limited ductility, very difficult to deform into a particular shape, hence it is necessary to improve the high temperature deformation properties [3]. The addition of Mg showed a significant effect on the infiltration, as no infiltration occurred with pure Al. This may be due to improving the wettability and decreasing the viscosity of Al melt by the Mg [4].

Furthermore, during the stirring casting of Al composites, the addition of Mg into the aluminum melt also helps to improve the wettability of reinforcement with matrix, increasing interface bonding strength and preventing deleterious interfacial reaction [5].

The purpose of this research is to examine the microstructure and hardness of composite Aluminum alloy Al.6061/Al_2O_3 obtained from stir casting process with different Mg contents. With

Mg content variations, the capability of magnesium to wet Al_2O_3 particles in an aluminum matrix will be observed. The research is divided into two steps ; first, composite making up materials include preparation and second, casting Al.6061/Al_2O_3 stir casting method in order to produce a vortex flow.

Experimental Method

Aluminum alloy (Al.6061 billets) cut to the size (6x3x1) cm and placed in a crucible. Before the stir casting process, ceramic particles with (10, 15) % Vf Al_2O_3 (97.1% purity, spherical shape, average diameter of 63 μm) were heated at 1100 ^oC for 1 hour. Aluminum alloy was heated at a temperature of 800 °C and held for 2 minutes in an aluminum melting conditions. Inert gas (Ar) was flowed into the molten aluminum for 2 minutes afterwards. Al_2O_3 ceramic particles and (8, 10, 15) wt% Mg was added into liquid Al alloys. Mixing was conducted by stirring at a constant speed of 1000 rpm for 2 minutes to produce a perfect vortex flow

Result And Discussion

FESEM-EDX-Xray Map, Manufacture of composite aluminum stir casting method has been difficult, this was due by low levels of wetting between the matrix of aluminum with alumina.

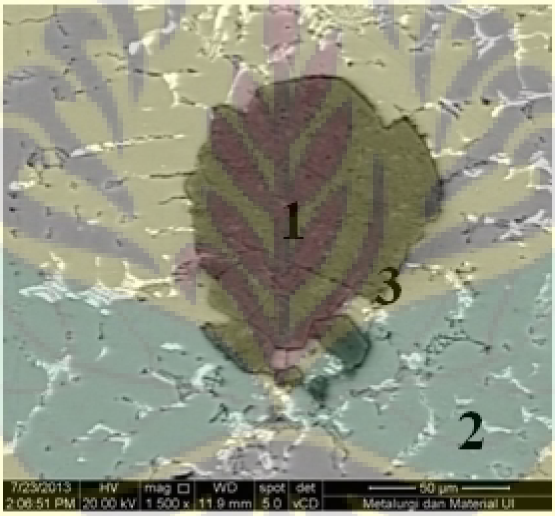
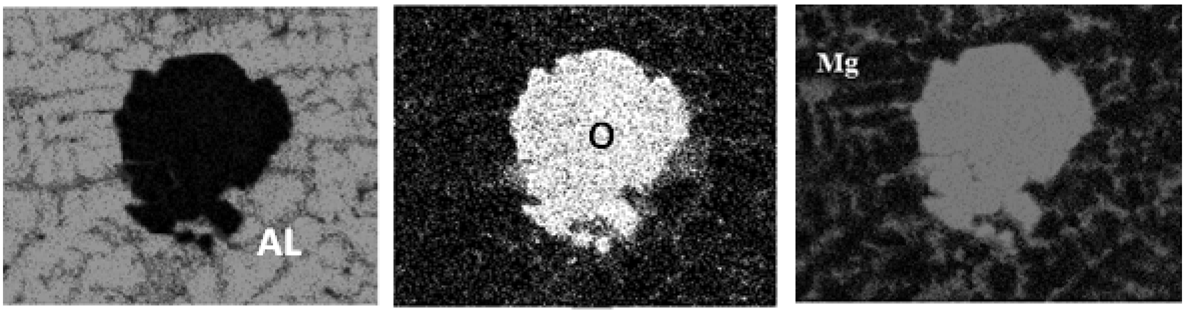


Fig. 1 Composite microstructure.

From Fig. 1, the observations by using FESEM-EDX has revealed the matrix phase, phase reinforcement and phase interphase ($MgAl_2O_4$) that occurs in the composite stir casting.

EDX **Point 1** (O:37.53, Mg:08.04, Al:52.85) can be indicated as an Al_2O_3 particles in the composite reinforcement. It can be concluded from the two dominant elements contained in these phases, namely Al and O. At **point 2** (O:00.28, Mg:05.14, Al:94.33) looks the elemental composition of the matrix alloy (Al-Mg-Si). This is shown by the percentage of aluminum which reached 91.00%. **Point 3** (O:15.07, Mg:27.58, Al:56.99) indicates the formation of $MgAl_2O_4$ phase. Therefore, the phase is an intermediate phase or phase transition closer to the MgO phase in terms of composition [6].

Fig. 1 and Fig. 2 is a mapping of X-rays from the composite to show the distribution of Al, Mg and O at the interface Al-Al_2O_3. Manufacture of aluminum composite with stirring method (stir casting) aims to spread the ceramic particles in the aluminum matrix. Fig. 2, shows the mapping using the X-ray maps showing the distribution of elements in the composite matrix and around Al_2O_3.



(a) (b) (c)

Fig. 2 SEM-X Ray map showing distribution of elements: (a) Al, (b) O, (c) Mg.

In Fig. 2 (a), aluminum were distributed evenly around the Al_2O_3. This indicates that aluminum successfully wetting Al_2O_3. From Fig. 2 (b), it is shown that elements of O wrap Al_2O_3 particles separated from the matrix. In Fig. 2 (c) clearly seen, the surface of Al_2O_3 particles is covered by Mg. It is also can be seen that the addition of alloying elements like a magnesium can active modify the alloy matrix by producing a transition layer between the particles and the matrix. Transition layer covering the ceramic particles have a structure similar to that of the particle and matrix that will be makes it easy occurrence of wetting between reinforcement and matrix composites [7].

X-Ray Diffractometry (XRD)

Fig. 3 shows the presence of a new phase like MgO, $MgAl_2O_4$. The new phase is formed existing as constructive like MgO and $MgAl_2O_4$.

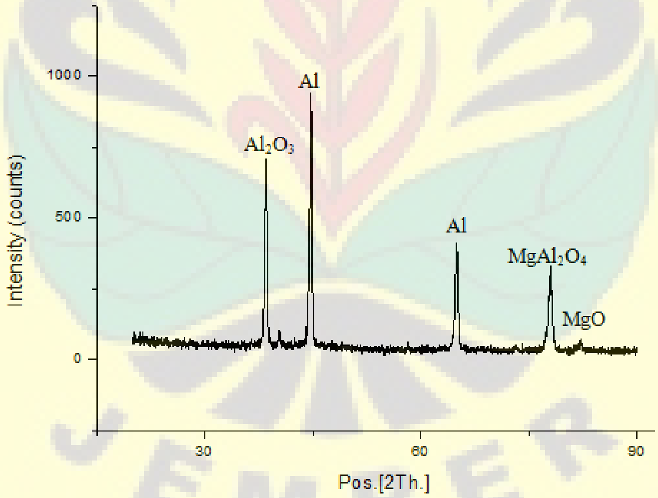


Fig. 3 Diffraction pattern (XRD) composite.

The existence of a constructive phase will improve the quality of the interface bonding layer. The increase temperature up to 600^{o}C of aluminum, will be improve the formation of metal oxide phases such as MgO, Al_2O_3 and $MgAl_2O_4$. Metal oxide phase was formed in the interfacial area of Al-ceramic. As a result of the reaction between the matrix, reinforcement and the surroundings will increase the wetting of the matrix with reinforcement. The main peak of Al (JCPDS.85-1327) at an angle 2θ: 38.15; 44.72; 64.95, and 77.96. Al_2O_3 phase (JCPDS.10-0425) appears at an angle 2θ: 38.15; 64.94 dan 77.96. Phase of MgO (JCPDS.01-077-2364) seen at 2θ angle: 38.27, 44.45 and 64.59, while the phase of spinel ($MgAl_2O_4$) (JCPDS.05-672) seen at 2θ angle: 44.45.

Hardness. Hardness property in general is a function of the bonding strength of aluminum and ceramic materials. From results of the hardness test (Fig. 4), showed increasing hardness with increasing in the percentage of %wt magnesium.

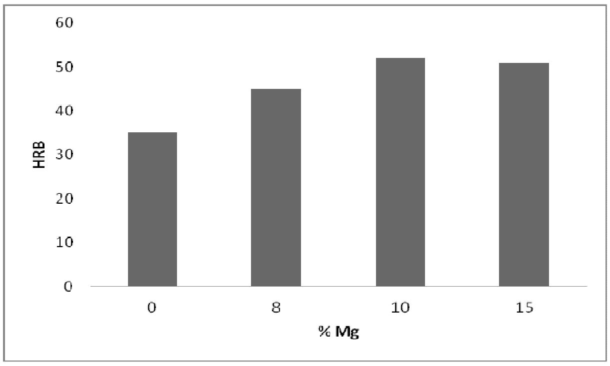


Fig. 4 Hardness composite.

This was due to the increased percentage of magnesium, will be result more Mg oxide formed. With the increasing number of MgO formed on the aluminum surface, it will be change MgO become of spinel ($MgAl_2O_4$). The spinel have not protective layer so that it will be easy for Al_2O_3 particles wetted by the aluminum molten. By comparison, it can be seen that with increasing Mg content, the particles distribution can be further improved because of the better wettability between matrix and reinforcement [5]. The highest hardness was obtained in 15%wt Mg addition with a value of 55 HRB.

Summary

Analysis of microstructure will use the optical microscope and SEM-EDX. Based on the analysis of microstructure can be concluded that with the increasing Vt alumina and wt% magnesium will result in the ceramic particles more easier to wetted by aluminum. And it will improve the mechanical properties of composite aluminum.

The optimum value of 55 HRB hardness (15%Vf Al_2O_3-15%wt Mg). Based on the results of XRD analysis, it can be seen emerging new phase which is the phase of MgO and $MgAl_2O_4$ phase. The presence of $MgAl_2O_4$ phase will be improve the mechanical properties of composite aluminum.

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