MICROSTRUCTURE, HARDNESS AND TENSILE PROPERTIES OF Al7%Si0.35%Mg ALUMINUM ALLOY

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ABSTRACT

In this work, the effects of composition on the microstructure, tensile and hardness properties of modified A356 aluminum alloy had been investigated. The alloy was produced by stir casting. Microstructures of the samples were investigated using the optical microscopy. The results showed that the modification of Al-7%Si-0.35%Mg decreased hardness values of the alloy. Also, the ultimate tensile strength (UTS) and elongation values decreased from 230 to 182MPa and 6% to 3.8% respectively.

Keywords: A356 aluminium alloy, Hardness, Microstructure, Tensile property.

I INTRODUCTION

Aluminum alloys are widely used in automobile and aerospace industries due to low densities, excellent cast ability, good mechanical properties such as: hardness, ultimate tensile strength and weld-ability as well as high wear resistance and corrosion resistance[1].

In these alloys, Mg is added into Al-Si alloys as a key alloying element in order to induce aging hardening behavior by the precipitation of Mg_2Si [2].A356 (Al-7%Si-0.35%Mg)aluminum alloy is a very commonly Si containing Alalloy used as the matrix in MMCs. It is characterized by: low cost, ease of handing, good strength and ductility and resistance to atmospheric corrosion. Hard particles such as Al_2O_3 and SiC are commonly used as reinforcement phases in the composites. The application of Al_2O_3 or SiC particle reinforced aluminum alloy matrix composites in the automotive and aircraft industries is gradually increasing for pistons, cylinder heads, connecting rods etc.,[3-6].

Further improvements in the strength and ductility of the alloy are frequently accomplished through the addition of elements that modify the eutectic silicon phase compounds. The inter-metallic β-Al_5FeSi phase that forms during solidification of aluminum alloy is detrimental to the mechanical properties because it is brittle and exists as thin plates [7].

Sharp edges of these platelets act as stress concentration sites, which facilitate crack initiation and thus decrease the ductility of the castings. It has been reported that the nature, composition and structure of iron rich intermetallic compounds can be modified with addition of Sr and Mn[8]. Reinforcement is good choice to modify the eutectic Si phase in Aluminum alloy [9]. In this work, the effects of reinforcement addition on the microstructure, tensile and hardness properties of modified A356 alloy have been studied.

II EXPERIMENTAL PROCEDURE

ThechemicalcompositionofaluminumalloystudiedinthisworkisgiveninTable1.

Table 1 Composition of modified A356 alloy (mass fraction, %)

Si	Mg	Fe	B	Sn	Zr	Ti	Al
3.15	0.49	0.91	0.0002	0.002	0.008	0.024	Balance

Samples of the metal matrix composites were prepared by stir casting route. The amounts of the matrix material and the reinforcements were determined using the weight percentage. The melting was carried out in a resistance furnace. The reinforcement particles were also preheated to before adding aluminum matrix. The aluminum material was melt into 750 °C. They were then slightly cooled to below the liquids, to maintain the slurry in the semi-solid state. This procedure had been adopted while stir casting aluminum composites with single reinforcement. The preheated reinforcement was added Zr in various percentage like 0%, 0.25%, and 0.5% along with A356. The composite slurry was then reheated to a fully liquid state and mechanical mixing was carried out for about 10–15 min at an average mixing speed of 150–300 rpm. The final temperature was controlled to be within 800°C±10°C.Themelting material can be transformed to the die.Quantitative data on the microstructure were determined using an optical microscope equipped with an image analysis system.

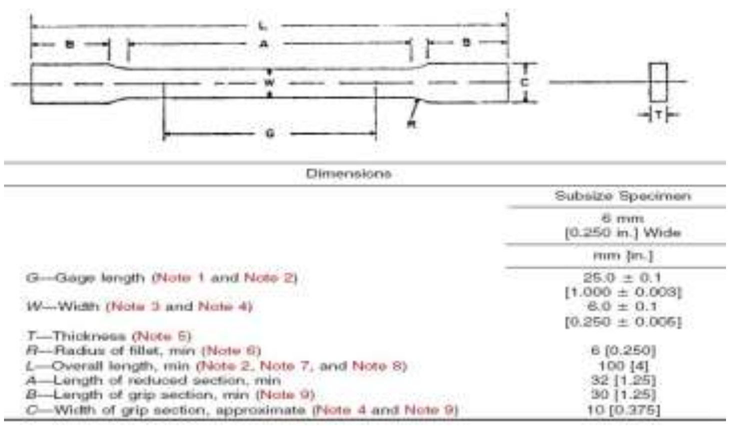

Figure 1 Size of tensile Specimen

Tensile test bars were machined, according to ASTME8m-13aa sub-size specimen is shown in Fig. 1and the test was performed on a computer controlled tension machine. Four tensile specimens of each alloy were tested and the average value obtained. Hardness tests were carried out Rockwell hardness machine (Model TRSD-N, Load: 100, indicator: 1/16" ball).First, surface finish was completed and five measurements were taken randomly in each sample and averaged to obtain the hardness value of the specimen.

III RESULTSANDDISCUSSION

3.1 Microstructures

A microstructural examination of the modified A356 was carried out to conform the microstructure. A cross section of the sample revealed that microstructure consists of interdendritic network of eutectic silicon particles (mostly rounded, less angular) and Mg_2Si particles distributed in a matrix of aluminum solid solution throughout structure is shown in Fig. 2.

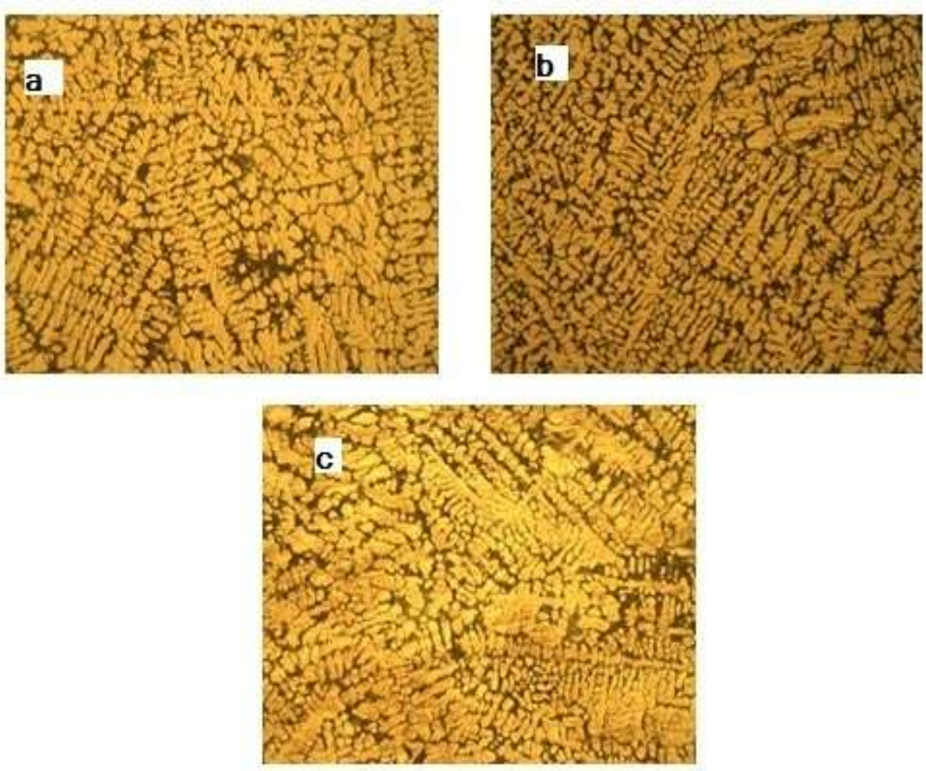

Figure 2 Microstructures of the modified A356 type aluminum alloys(a) reinforcement-free, (b) 0.25 wt% reinforcement and (c) 0.5 wt% reinforcement

3.2 Hardness

The results of hardness tests are shown in Figure 3.It can be seen that the initial hardness of the unmodified alloy was 60HRB that decreased to 43 HRB after addition of 0.5 % reinforcement. According to the microstructure modification of β intermetallic, hardness should increase with the rise of reinforcement contents. But the results indicate that hardness obviously declines. Because hardness appears to be much sensitive to the porosity volume fraction [10] and the most important material property factor that influences the hardness is the porosity [1],the increase of the porosity amount would result in the decrease of the hardness of the samples. As mentioned before, with increasing of reinforcement content, the amount of the porosity increased.

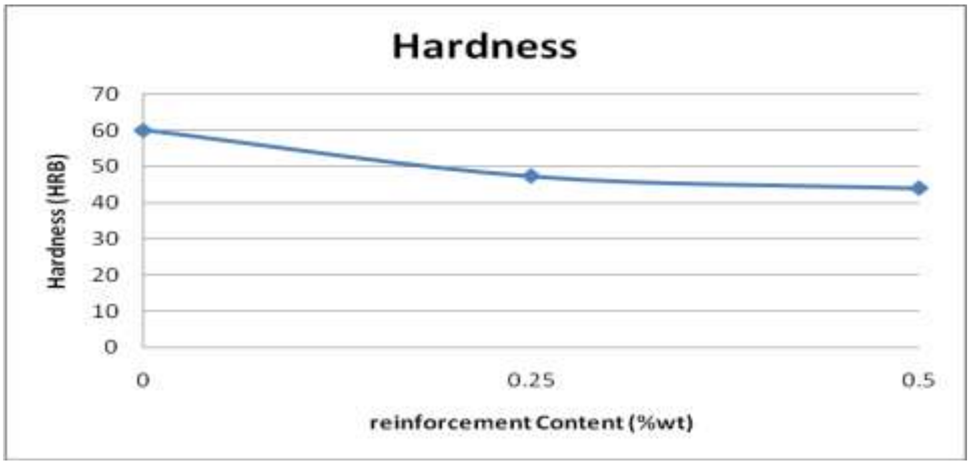

Figure 3Hardness of modified A356 type aluminum alloys

3.3 Tensile properties

The average ultimate tensile strength (UTS) and elongation values of alloys with and without reinforcement additions are illustrated in Fig. 4. It is evident that reinforcement additions reduced both UTS and elongation values of the samples. UTS isdeceased form 230 to 182MPa and elongation percentage is reduced from 6% to 3.8%. Among the reinforcement containing A356 aluminum alloys, which addition of 0.5 % exhibits the reduced UTS and elongation; High reinforcement content have lower UTS and elongation, in comparison with modified alloys with lower reinforcement content (0.25%). This can be attributed to the amount of porosity. As it can be seen form Figure 4. When the amount of reinforcement is increased the level of porosity is so high that the negative effective of reinforcement on the porosity prevails the positive effect on the modification of secondary phases.

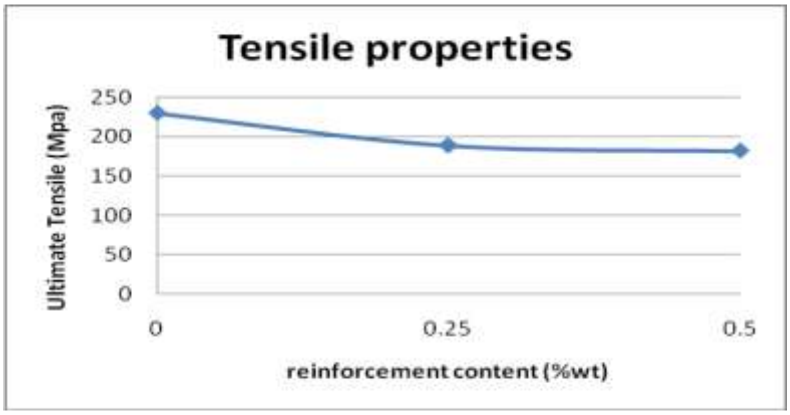

Figure4Ultimate tensile strength of modified A356 type aluminum alloys

IV CONCLUSIONS

The influences of reinforcement on the microstructure and mechanical properties of modified A356 aluminum alloys were investigated. The following conclusions were drawn:

1. Adding 0.25%-0.5% reinforcement to the aluminum alloy decreased the hardness values of the alloys.
2. In presence of 0.25%-0.5% reinforcement UTS and elongation of the A356 aluminum alloys were decreases. The reinforcement-containing A356 aluminum alloys, specimens with addition of 0.5% reinforcement exhibit the poor mechanical properties.

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