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A Comparative Study on Mechanical and Physical Characteristics of Al-SiC and Al-SiC-Egg Composites fabricated by Stir Casting Process

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Abstract: The present work focused on the comparative study of microstructure, mechanical and Physical Characteristics of Al-SiC and Al-SiC-Egg composites fabricated by Stir casting process. Al6061 alloy is used as base matrix in this work. Three type of composite are fabricated. First composite contained only Al6061 alloy. Second Composite contained Al6061+ SiC, in which SiC vary with weight % (10%, 20%, 30%). Third composite contained Al6061+SiC+Egg shell, in which SiC is vary with (10%, 20%, 30%) while egg shell is constant at 5% with each composite respectively. Tensile test, Hardness Test, Density test is performed on the samples obtained by the stir casting process. Tensile strength and hardness of base matrix Al6061 alloy is increased on addition of SiC in base matrix. But on constant addition of egg shell (5 wt %) in each composite, it is found that tensile strength and hardness is slightly higher than the respective composite. Density of (Al+SiC) composite is increasing on increasing of SiC reinforcement wt % into the base matrix because density of SiC is larger than Al6061 alloy. But on addition of egg shell powder in each composite, density of each composite are slightly reduced because egg shell density is lower than both Al6061 and SiC.

Keywords: ***Aluminium composite,; Stir casting; Silicon carbide; Egg Calcite; Tensile Strength; Hardness; Density***

I. INTRODUCTION

Aluminium alloys are broadly employed in aerospace and automobile industries due to their low density and good mechanical properties, better corrosion resistance and wear, low thermal coefficient of expansion as compared to conventional metals and alloys. This composite material have mechanical properties are intermediate between metal matrix alloy and the reinforcements. [1] Due to easy machinability, durable, ductile, malleability, High strength to weight ratio and easy availability, Aluminium is mainly used as nonferrous metal. [2]. The applications of light weight, strong and long lasting aluminium metal matrix composite [3]. Aluminium and its alloys are normally utilized in several of cast and wrought form and in various conditions of heat treatment. Forgings, extrusions, sheets, plate, foils and wire are some of the examples of wrought form while castings are produced by sand casting, pressure and gravity die-castings e.g. Al-Si and Al-Mg alloys [4]. Similar to all composites, aluminium matrix composites are not a single material but a combination of materials whose stiffness, density and thermal and electrical properties can be modified. Composites materials have high stiffness and high strength, low density, elevated temperature stability, high electrical and thermal conductivity, changeable coefficient of thermal expansion, corrosion resistance, enhanced wear resistance etc. The matrix holds the reinforcement to form the desired shape while the reinforcement enhances the overall mechanical characteristics of the matrix. When designed appropriately, the new combined material shows superior strength than each individual material [5-10].

The present work focused on the comparative study of microstructure, mechanical and Physical Characteristics of Al-SiC and Al-SiC-Egg composites fabricated by Stir Casting process. Al6061 alloy is used as base matrix in this work. Three type of composite are fabricated. First composite contained only Al6061 alloy. Second Composite contained Al6061+ SiC, in which SiC vary with weight %

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(10%, 20%, 30%). Third composite contained Al6061+SiC+Egg shell, in which SiC is vary with (10%, 20%, 30%) while egg shell is constant at 5% with each composite respectively.

II. EXPERIMENTATION

A. Materials and Equipment used

The hen egg shell (ES) used in this work is white ES, obtained from household, restaurant and other shop around local area. The ES is firstly washed with water and then sun dried to remove the membranes. The base matrix used is Al6061 alloy. Silicon Carbide powder (SiC) with 46 micron meter is also used as reinforcements. SiC powder is obtained from Kolkata. SiC powder is in figure 1.

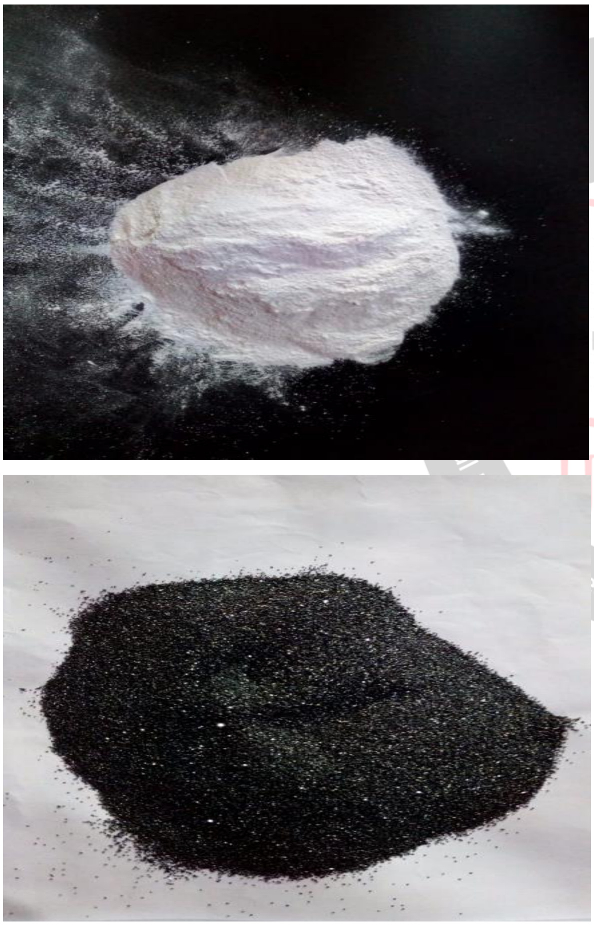

Figure 1: (a) Powder of Egg calcite (b) Powder of Silicon carbide

B. The equipments used in this study included

Ball milling machine, mechanical stirrer, graphite crucible, electrical resistance furnace, brinell hardness testing machine, tensile strength machine (UTM) machine.

C. Methods

C.1 Preparation of Egg shell powder: The egg shell collected is washed thoroughly in water and dried for about 24 hours in sun, the dried egg shell is then ball milled at 240 rpm in ball milling machine. The powdered egg shells is placed on a set of sieves and is vibrated for about 15 minutes and then a fine particulate egg shells powder is collected from the sieves and the size of the egg shell used in the work is 110 micro meter.

C.2 Fabrication of MMC:

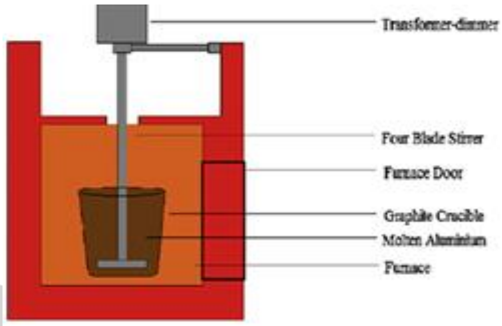

Figure 2 : Schematic diagram of stir casting machine[13]

The experimental setup as shown in Figure 2 consists of the main furnace and parts along with four mild steel stirrer blades. The first method in the experiment is preheating. Here, the empty crucible and the reinforcement powders, namely Silicon carbide and egg shell powders are heated separately to a temperature close to that of the main process temperature. The melting of the aluminium6061 Alloy (95%) ingot is performed in the graphite crucible inside the furnace. Initially, the ingot is preheated for 2–3 h at 550 degree centigrade. At the same time silicon carbide and egg powders are also preheated to 380 degree centigrade in the respective containers. Then, the crucible with aluminium alloy is heated to 830 degree centigrade while the preheated powders are mechanically mixed with each other below their melting points. This metal–matrix with reinforcements is kept into the furnace at the same temperature. The furnace completely melts the pieces of aluminium alloy and the powders of silicon powder and egg shell powder. The stirring apparatus is lowered into the crucible inside the furnace and placed at the required depth. The vigorous automatic stirring of the material takes place for 15 min with 520 rpm of stirring rate, thereby uniformly dispersing the additive powders in the aluminium alloy matrix. The temperature rate of the furnace should be controlled at 830 ± 10 degree C in final mixing process. All the trapped gases

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from the mixture in the crucible are removed by degasser and ensure that the temperature of the mixture in the crucible does not get transferred easily to the atmosphere. This experiment is done repeatedly by varying the compositions of the reinforcement powder. For each composition, a total of 500 g material mix is used for preparing the samples. Apart from the above compositions, the aluminum alloy Al6061 alone is melted and solidified in dies. In this paper, total 7 different composition samples are prepared for tensile strength testing as shown in Figure 3. With same composition 7 different shape samples are also prepared for hardness Testing as shown in figure 4. Sample 1 contains aluminium alloy—100%.Sample 2 contains aluminium alloy-90%, SiC powder-10%.Sample 3 contains aluminium alloy-80%, SiC-20%.Sample 4 contains aluminium alloy-70%, SiC-30%. Sample 5 contains aluminium alloy -85%, SiC-10%, egg shell powder-5%.Sample 6 contains aluminium alloy-75%,SiC-20%,egg shell-5%.Sample 7 contains Aluminium alloy-65%,SiC-30%,egg shell-5%.

Figure 3 : MMC sample for tensile strength testing

Figure 4 : MMC sample for hardness testing

III. RESULTS AND DISCUSSION

A. Effect on Density

The addition of the SiC particles in the Al 6061 powders has increased the density of the composite significantly. The density of the pure Al 6061 powder is found to be 2.7 g/cc. the Density of the composite increased with increasing wt% percentage of SiC powder in the Composite depicted in Figure 5 & 6.The possible reason of increasing the density could be high density of SiC as comparison to Al6061 base alloy. Further density of Al6061-SiC composite is decreased slightly on adding 5 wt% egg shell powder into the composite due to low density of Egg shell powder as comparison to Al-SiC alloy.

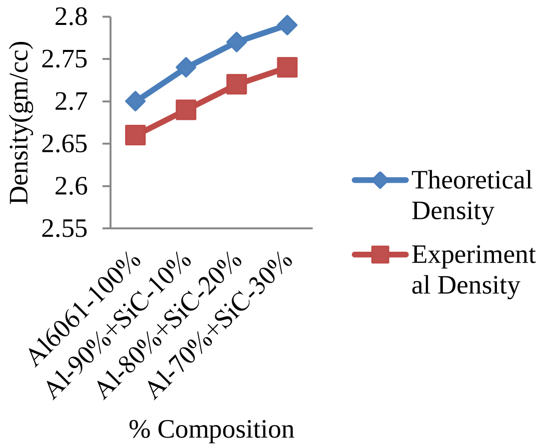

Figure 5 : Variation of Density of Al6061 alloy with its Composition

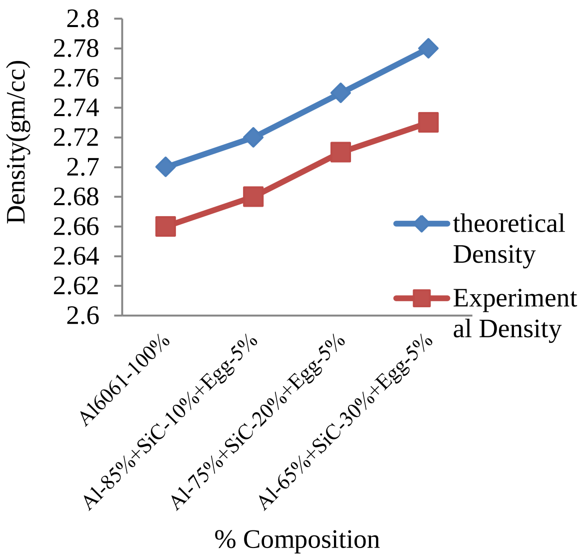

Figure 6 : Variation of density of Al6061 egg calcite SiC composite with composition

B. Hardness Test

The Brinell hardness testing is performed on the seven samples with a load of 500Kgf and the diameter of the steel ball indenter is 10 mm. the impressions made by the steel ball is observed carefully and the diameters of the impressions are used to calculate the hardness value of the samples. The results showed an improvement in the hardness with an increase in the percentage of the SiC powder in the matrix material as illustrated in Figure 7& 8. On addition of egg shell powder in the Al6061-SiC

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composite, hardness is further increased slightly than the composite. The possible reason for improvement of hardness could be proper bonding among Al6061,SiC and Egg shell powder in molten phase.

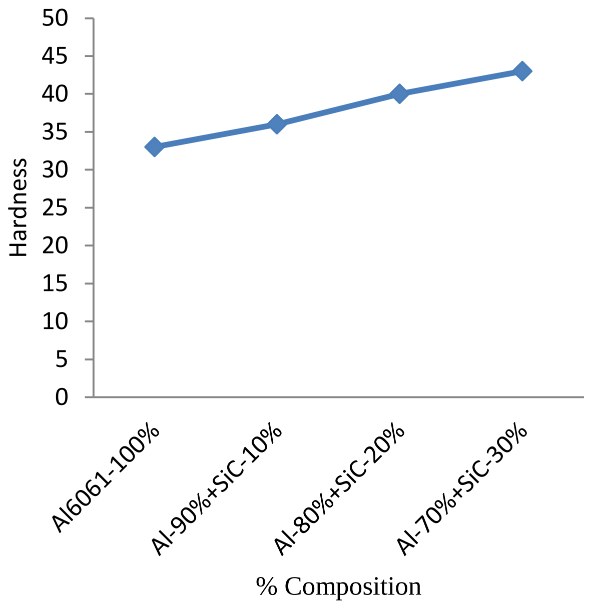

Figure 7 : Variation of Hardness of Al6061-SiC alloy with Composition

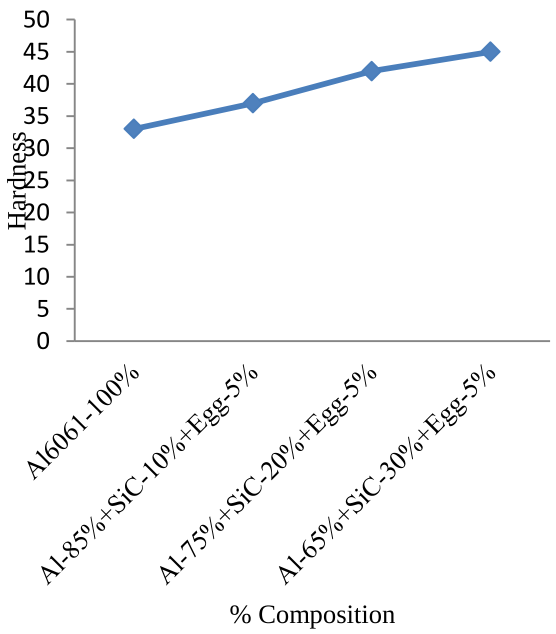

Figure 8 : Variation of density of Al6061 egg calcite SiC composite with composition

C. Tensile Strength

Tensile testing is performed on seven different composition samples on universal testing machine (UTM).The result revealed that tensile strength of Al6061 matrix is increased on addition of SiC powder. Tensile strength increases with increases of wt% of SiC in base matrix as depicted in Figure 9. On addition of constant egg wt% in the composite, tensile strength is further increased shown in Figure 10. The possible reason of increasing the tensile strength could be proper distribution of hard phase of egg shell powder in Al-SiC alloy. Another reason could be strong interfacial bonding among Al-SiC –egg shell.

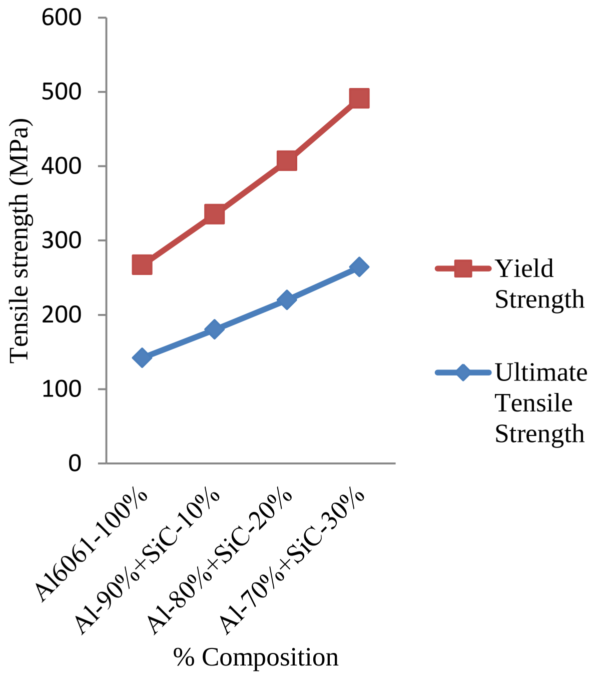

Figure 9 : Variation of Tensile Strength of Al6061-SiC alloy with Composition

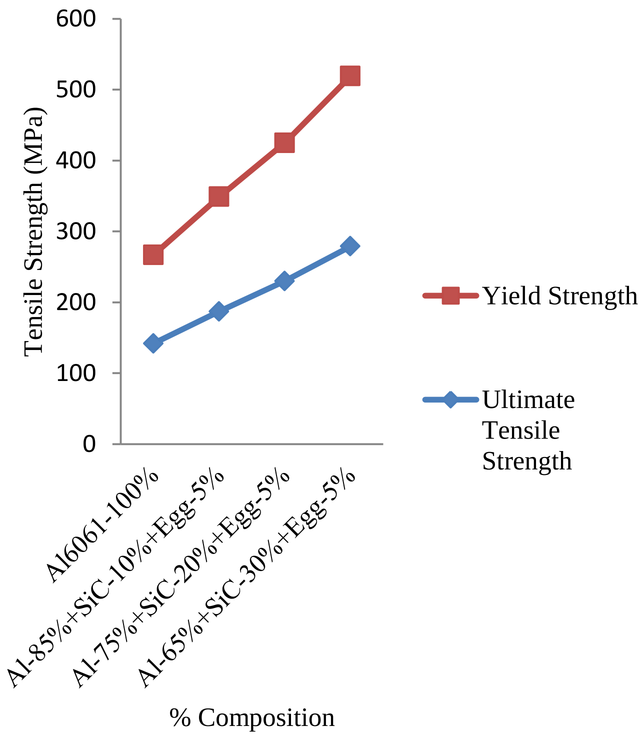

Figure 10 : Variation of Tensile Strength of Al6061 egg calcite SiC

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composite with composition

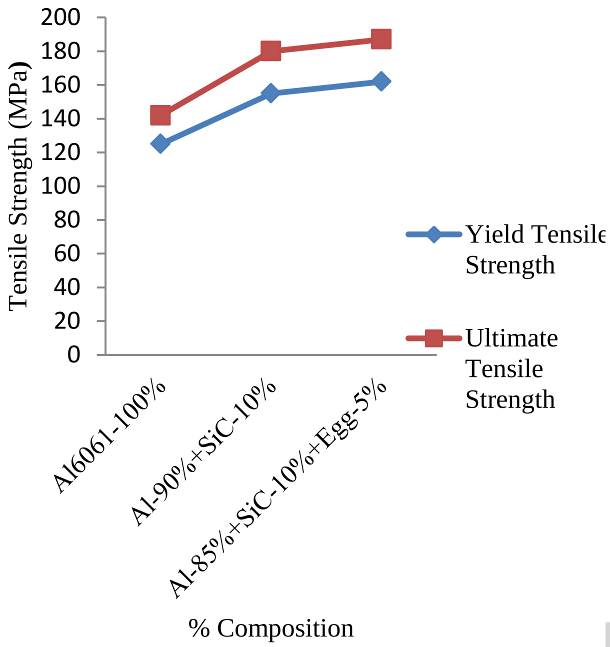

Figure 11: Comparison of Tensile strength of Al6061 alloy and its composite

IV. Conclusion

The current work entitled "A comparative study on microstructure, mechanical and Physical Characteristics of Al-SiC and Al-SiC-Egg composites fabricated by Stir Casting process" has led to the following conclusions:

- The density of Al6061 alloy is increased on addition of 10%, 20% and 30% (wt %) of SiC. It is found that density is slightly continuously increased on increasing of SiC wt % in base alloy Al6061 because density of SiC is higher than the density of Al6061 alloy.Density of Al6061 alloy and SiC are 2.70 and 3.21 respectively.
- The density of Al6061 alloy and SiC composite are decreased on addition of 5 wt% of Egg shell powder with each composite separately because density of egg shell is 2.147 gm/cc which is lower than density of Al6061 and SiC.
- Al6061-SiC composite have shown higher hardness than base alloy Al6061.On increasing of SiC wt% into the base alloy, hardness is increasing slightly.
- But it is found that on addition of egg shell into the composite of Al6061 and SiC, hardness of composite is further increased while density of composite is slightly decreased. This increase in the hardness of the composite is due to the bonding of the hard egg shell phase with the ductile aluminum alloy phase.
- Tensile strength of Al6061-SiC have shown higher than base alloy Al6061 while tensile Strength of Al6061-SiC-Egg shell have shown also higher than Al6061-SiC composite. Tensile strength is increased on increasing of SiC wt% content into the base alloy. Further, on constant addition of egg 5 wt% with each composite, tensile strength is improved than respective composite. The possible reason of increasing the tensile strength is proper distribution of hard phase of egg shell into the Al-SiC alloy and strong interfacial bonding among Al-SiC-Egg shell.

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