Enhancing the Mechanical Properties of Metal Matrix Composite by Reinforcing Aluminium 6063 with Sic & Graphite

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***Abstract*—Aluminum metal matrix composites (AMMC) are becoming progressively very important materials in manufacturing industries and are generally preferred due to their enhanced mechanical properties like high strength, hardness, wear resistance, corrosion resistance, fatigue strength, compressive strength etc. These are very much widely used in applications of automobile, marine, aircraft industries because of their high temperature resistance and superior strength to weight ratio. This paper attempts to view the enhancement of mechanical properties by the combination of Aluminum 6063 (Al6063) reinforced with Silicon Carbide 2% (SiC) and Graphite are fabricated by stir casting technique. The specimens are prepared with aluminum with 2% Silicon carbide and Graphite (1%, 2% and 3%). Tests have been conducted on these composites to evaluate how the tensile strength, microhardness, flexural strength, compressive strength and microstructures of the materials affect. It is observed that the above properties are found to be more improved in at 2%graphite.**

Keywords—Aluminum Metal Matrix Composites (AMMC), Silicon Carbide, Graphite, Stir Casting Technique.

I. INTRODUCTION

Aluminum is the third most abundant element after oxygen and silicon in the earth's crust. Its abundance and its properties like corrosion resistance, electrical and thermal conductivity, recyclability etc. are the significant factors considered for its diverse applications. Properties like High Tensile strength, Compressive Strength, Micro-hardness, Flexural strength are essential in a material. To achieve these properties various aluminum composites are being prepared [1]. Composite materials are those that are formed by the combination of two or more materials to achieve properties that are superior to those of its constituents. Aluminum composites have been used in recent times in aerospace and automotive industries because of their high temperature resistance and superior strength to weight ratio [2]. Metal matrix composites (MMCs) are metals reinforced with other metal, non-metals, ceramic or organic compounds. They are made by dispersing the reinforcements in the metal matrix [3]. The most commonly used reinforcements are Silicon Carbide (SiC) and Aluminum Oxide (Al_2O_3) [4]. Research on materials over the past several decades has produced some advanced materials with properties superior to conventional materials, one of these being Hybrid Metal Matrix Composites (HMCs) which possess high specific strength, toughness, impact strength and low sensitivity to temperature changes [5]. Aluminum hybrid composites are a new generation of metal matrix composites that have the potential of satisfying the recent demands of advanced engineering applications. These demands are met because of improved mechanical properties, amenability to conventional processing technique and possibility of reducing production cost of aluminum hybrid composites [6]. The addition of the reinforcement enhances the mechanical properties of aluminum-based composites, when compared to the matrix alloy. However, addition of any hard reinforcement to aluminum reduces the corrosion resistance, electrical conductivity and surface finish, etc. Bagasse ash (BA) is rich in SiC, which helps to increasing the strength of aluminum such as high hardness, low coefficient of thermal expansion, high wear resistant and good mechanical properties including high strength, thermal conductivity, etc. Graphite is considered as the most important constituent for solid lubrication of the ceramic reinforcement composites [7].

In the present work attempt has been made to study the influence of Graphite / SiC addition on the mechanical behavior of 6063 Aluminum alloy. Graphite is one of the two natural crystalline allotropic forms of carbon. Graphite possesses the properties such as high tensile strength, low density, low friction and wear resistance, and high thermal conductivity and electrical conductivity, and is highly refractory and chemically inert. Silicon carbide (SiC), also known as carborundum is a semiconductor containing silicon and graphite. SiC reinforcement increases the tensile strength, hardness, density and wear resistance of Al and its alloys. The particulate MMC are extensively used for tribological applications due to excellent wear resistance during sliding as well as its ability to withstand high stress and their ability to carry heavier loads. In this study stir casting is used as it is accepted as a particularly promising route, currently can be practiced commercially. Its advantages lie in its simplicity, flexibility and applicability to large quantity production and it allows a conventional metal processing route to be used, and hence minimizes the final cost of the product. In general, the solidification synthesis of metal matrix composites involves producing a melt of the selected matrix material followed by the introduction of a reinforcement material into the melt. To obtain a suitable dispersion the stir casting method is used. The mechanical properties – tensile strength, compressive strength, flexural strength and micro hardness of Aluminium6063 keeping 2%SiC as constant and adding Graphite by varying its weight % by 1%, 2% and 3% in this work.

II. EXPERIMENTAL PROCEDURE

The crucible is filled with 600 grams of aluminum 6063 pieces and is melted at 700 degrees centigrade in furnace. After melting it is stirred with a magnetic stirrer with the help of blades attached to the supporting stand. The temperature at which the stirrer is maintained is also around 700 degrees centigrade and is also used as a pre-heating equipment. For mixing, the other powders, they are packed form of small packets in aluminum foil in compliance with the percentage of the given mineral, silicon carbide (2%), and other compound Graphite powder (1%) each packet separately. In stir casting equipment the speed of stirrer is maintained at 600rpm for 10min as shown in figure 1. slight amounts of Magnesium is also used as it enhances the flowability. The molten metal is poured into cylindrical dies as seen in figure 2 and after a couple of minutes the whole solid composite extracted from it. It is then followed by the cooling of the composites with air as medium. The cylindrical rods obtained as seen in figure 3 are machined and standard test specimens are prepared which are required for tensile, compressive, flexural, micro-hardness and micro-structural tests.

Table 1: Al6063 Composition

Element	Weight %
Si	0.63
Fe	0.83
Mn	0.069
Mg	0.38
Zn	0.16
Ti	0.029
Cr	0.017
Ni	0.011
Al	Balance

Fig.1 Stir casting

Fig.2 Cylindrical Die

Fig.3 Castings

Fig 4. Tensile test specimens (length =57mm, diameter at ends= 12mm and diameter at center =8mm).

Fig 5. Compressive strength test specimens (Length = 20mm, Diameter = 10mm)

Fig 6. Flexural test specimens

Fig 7. Instron Universal Testing machine

The Instron universal testing machine seen in figure 7 was used to test the ultimate tensile strength, compressive strength and flexural strength of the specimens.

Microhardness:

The micro hardness of the samples at their cross sections was measured using a calibrated Vickers micro indentation hardness indenter as seen in figure 8. It was done under a test load of 300 grams, dwell time 15s, indenter speed of 60µm/sec, and the angle between two faces is maintained as 1360.The hardness number is determined by the load applied over the surface area of the indentation. The reported values are averages of 6 measurements.

Fig. Vicker hardness testing machine

Microstructures: Basic activities that are performed before evaluating of the microstructures of the Specimens are sectioning, cleaning, mounting, grinding, polishing, optical microscopy and image analysis.

Fig.9 Microstructure Analysis

III. RESULTS AND DISCUSSION

The microstructures obtained are as shown in figures 10,11,12 and 13.

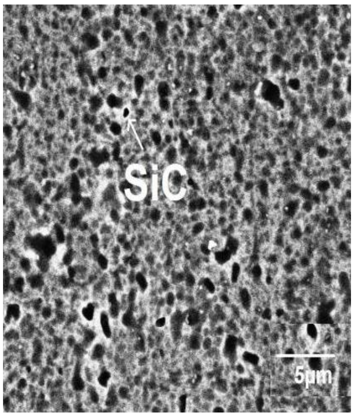

Fig 10. Al6063 with 2% SiC

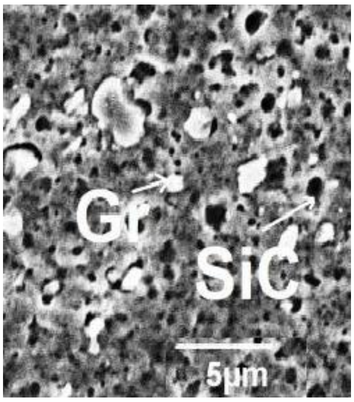

Fig11. Al 6063 with 2% Si C& 1%Graphite

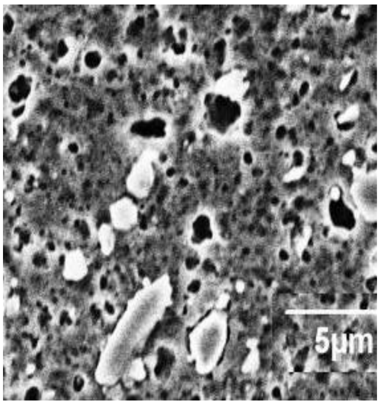

Fig12. Al6063 with 2% SiC&2 % graphite

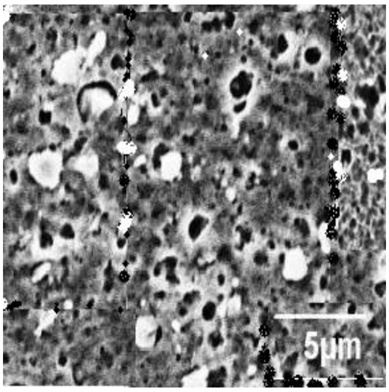

Fig13. Al6063 with 2% SiC 3% graphite

Optical micrographs showed reasonably uniform distribution of SiC particles and graphite. Homogenous dispersion of SiC and graphite particles in the Al matrix shows an increasing trend in the samples prepared by applying stir casting technique.

Ultimate Tensile Strength: From the graphite Ultimate tensile strength (MPa) shows an increasing trend up to 2 weight % graphite and it decreased when the graphite content was increased to 3 weight%. The ultimate tensile strength was observed to be maximum at 2 weight % graphite as seen in figure 14.

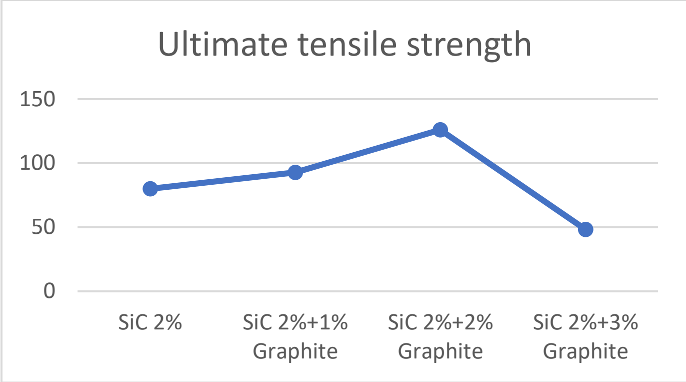

Fig14. Tensile test

Compressive strength: It has decreased when weight% of graphite was added to Al 6063+2weight% SiC. , But when the graphite content was increased to 2 weight % the compressive strength has improved significantly. However, the compressive strength has decreased when graphite content was increased to 3 weight % as seen in figure 15

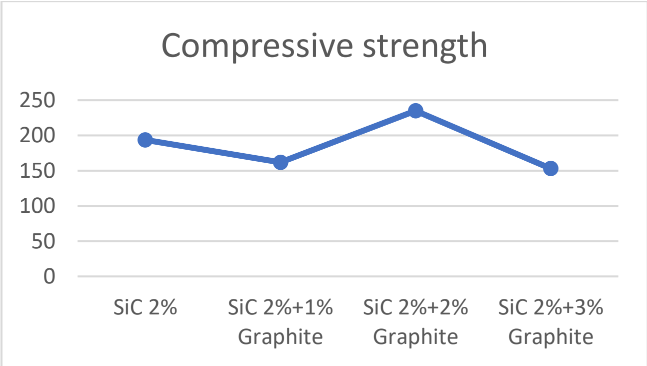

Fig 15. Compression test

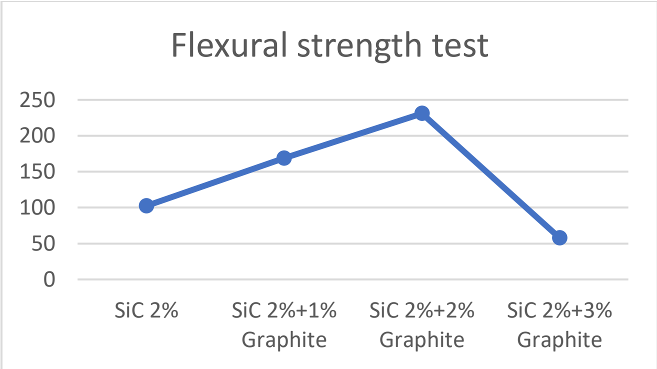

Fig 17. Flexural strength test

IV. CONCLUSIONS

1. Tensile strength has been increased with the percentage of 57.5% in comparison with no graphite, but tensile strength has been decreased at 3% of graphite.

2. Compressive strength has increased by 21.4% with the percentage increase in graphite upto (2%) but tensile strength has been decreased at 3% of graphite.

3. Flexural strength has been increased significantly by 125.3% at 2 weight % graphite but tensile strength has been decreased at 3 weight% of graphite.

4. Vickers Hardness Value has been increased with the percentage increase in graphite up to (2%) but tensile strength has been decreased at 3% of graphite, keeping 2% SiC as constant. The Vickers hardness number has increased from 42 (0 weight% graphite) to 55.9 (2 weight% graphite).

5. The decrease in the strength and hardness of AMMC with increase of graphite content may be attributed to increase in porosity as the graphite content increases. So it would not be beneficial to reinforce AMMC with more graphite content.

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