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Studying the Mechanical properties of Aluminum 6063 reinforced with Silicon Carbide and Mica

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Abstract: ***Metal matrix composites (MMC) are the metals added with other metals, ceramics or organic components etc. MMCs are used to enhance the properties of the base metal like stiffness, strength, conductivity etc. Aluminum and its alloys have been given more priority as base metal in metal matrix composite because of their remarkable properties. Al MMC's are extensively used in automotive, aerospace and other various fields. This paper attempts to view the improvement of the mechanical properties by the unification of Aluminum 6063 (Al6063) reinforced with Silicon Carbide (SiC) and Mica composites processed through stir casting method. The specimens are prepared with aluminum varying with Silicon carbide by weight percent of (12%, 13% ,and 14%) and mica (2%). Experiments have been conducted on these composites to evaluate how the tensile strength, microhardness, flexural strength, compressive strength are affected and microstructures of these composites are observed.***

Keywords:Aluminum Metal Matrix Composites (AMMC), Silicon Carbide, Mica, Stir Casting Technique.

I. INTRODUCTION

Aluminum is notable for properties like its low density and its corrosion resistance. To achieve the mechanical properties like High Compressive Strength, Tensile strength, Micro-hardness, Flexural strength various aluminium composites are being prepared. Composites can be defined as the materials that are created by the combination of two or more materials to achieve properties that are better than the parent metal or material. In the recent times, Aluminum composites have been used in aerospace and automobile industries [1]. AMMCs can be prepared by liquid state processing methods like stir casting, squeeze casting, infiltration etc., and semisolid processing or powder metallurgical route. In general, the reinforcements used in AMMCs are ceramic and non-metallic particles like silicon carbide (SiC), alumina (Al_2O3), Boron carbide (B_4C), graphite etc. While studying MMCs it was observed that when external loads were applied to the composites, the loads were transmitted by metal matrix to the reinforcements and then the loads were carried by the reinforcements which were bonded with the metal matrix. In order to obtain high strength, strong bonding was necessary between the reinforcements and the matrix at the interface. The interface bonding was formed by mutual dissolution or reaction during casting. Hence, considerable wetting of reinforcements used was necessary during the casting process. [2]. The application of AMCs (reinforced with Alumina or SiC particulates) in engines of automobiles and aircrafts has reduced fuel consumption, overall weight, pollution. The alumina and SiC particulates are dense compared to aluminum alloys, so the weight of the AMMCs directly depends on reinforcements used [3-5]. Research on the materials over the years has given rise to Hybrid Metal Matrix Composites. The properties of the HMC's include toughness, specific strength, low sensitivity to temperature changes and good impact strength [6].In this way, the desired properties of primary and the secondary reinforcements can be imparted to the parent material. Moreover, the stir casting method which is used for the preparation of AMCs is economical and highly productive [7].

This experiment attempts to study the effects of the addition of Mica and SiC to Al 6063. Mica is one kind of phyllosilicate. The phyllosilicates are also called sheet silicates. Mica exhibits two-dimensional sheet structures. Mica possesses properties such as high toughness, high tensile strength, and elastic and in addition to that it has high compression power and flexibility. Silicon Carbide (SiC) is also well-known as Carborundum. It is a semiconductor comprising of silicon and graphite. SiC enhances the properties like hardness, wear resistance, density and tensile strength. The particulate SiC has outstanding wear resistance and it can carry heavy loads and withstand high stresses. Due to these reasons, it is extensively used in tribology and its applications. In this experiment stir casting method is adopted because it is flexible, simple and applicable to mass production. Since stir casting is one of the conventional methods it reduces the final cost. Stir casting ensures proper dispersion of the reinforcements before solidification of the melt. The mechanical attributes like tensile strength, flexural strength, compressive strength, and microhardness were tested. The specimens of Aluminum 6063 keeping 2% Mica as constant and adding SiC by varying its Wt.% by 12%, 13%, 14% were prepared and tested in this work.

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II. EXPERIMENTAL PROCEDURE:

The aluminum 6063 pieces are melted at 700°C in a furnace by placing 600grams in a crucible. When the melting is done, it is stirred with a magnetic stirrer with the help of blades attached to the supporting stand. This also helps as pre-heating equipment. The mixing is done by taking powder of reinforcing materials which are mica and SiC in small packets of aluminum foil in compliance with the percentage of the given mineral, Mica (2%), and another compound silicon carbide (12%, 13% and 14%) and a slight amount of Magnesium is also added to enhance the bonding between the aluminum, silicon carbide and Mica. The molten metal is then poured into a cylindrically shaped dye. This composite is cooled with air as the medium. After a couple of minutes, the solid composite is extracted. The total solid composite is made into specimens required for the tensile, compressive, flexural, micro-hardness and micro-structure tests. For tensile test specimen, the total length of the test specimen is 11.7cm of which 30mm in initial length has to be of 12mm diameter continued by 57mm length with a diameter of 8mm and concluded with again 30mm length with 12mm diameter (Figure 2). For compressive test small pieces with length of 1.4cm with diameter of 1cm are made (figure 3). Figure 4 shows the specimen made for the flexural flat plate test and for the micro hardness and micro structural test a small piece is taken and polished very finely mirror like a face are made. The nomenclature of the specimens used is as follows Aluminum 6063 was named as specimen I and Al6063+12%SiC+2%Mica as specimen II and Al6063+13%SiC+2%Mica as specimen III and Al6063+14%SiC+2%Mica as specimen IV.

Figure 1: Stir Casting

Figure 2:. Tensile test specimens

Figure 3: Compression test specimens

Figure 4. Flexural Test specimens

III. RESULTS AND DISCUSSIONS:

Microstructures obtained are as shown in the figures 5,6 and 7,8.

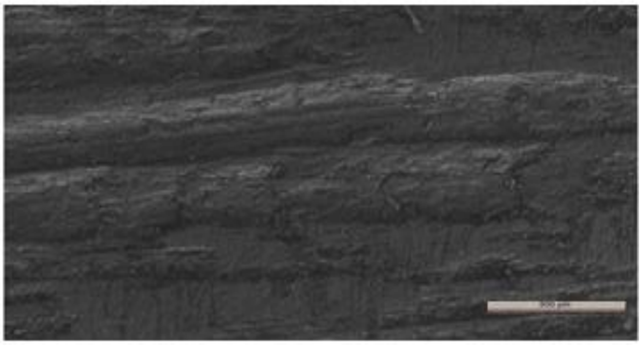

Figure 5: Al6063

Figure 6: Al6063+12%SiC+2%Mica

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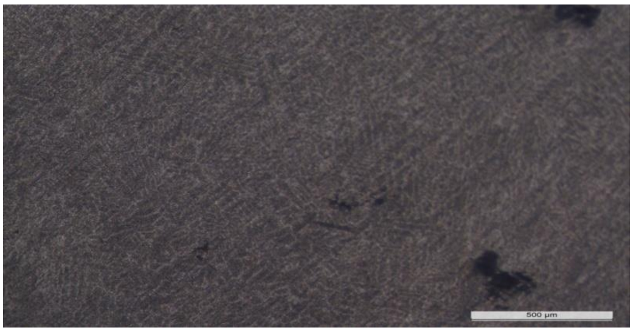


Figure 7: Al6063+13%Sic+2%Mica

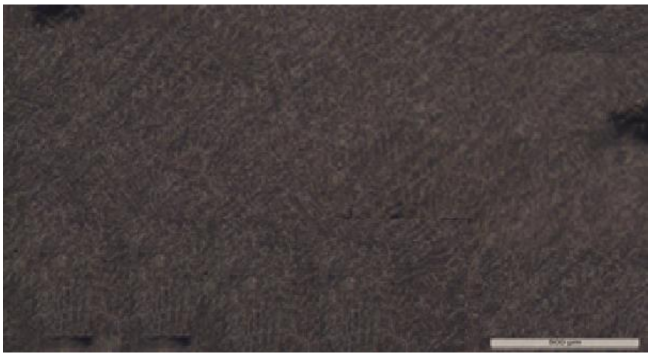


Figure 8: Al6063+14%Sic+2%Mica

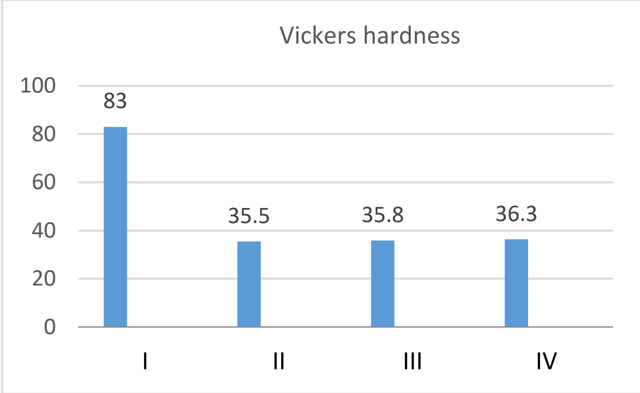
Clustering of Sic has been increased as the percentage of SiC has been increased from 12 % to 13% with Mica remaining constant. The clustering is attributed to SiC's low thermal conductivity and heat diffusivity. This shows that SiC's are always pushed towards dendritic front during solidification

IV. MICRO –HARDNESS

By the Vickers hardness equipment be found that the hardness is decreased. The Hardness had been decreased as compared to ideal Aluminium 6063 alloy as the SiC content increases. The is done for the threecomposites one with 12%, 13%, 14% of SiC and Mica is maintained constant at 2% in both composites

Table 1: Vickers hardness

S.No	Content	Vicker hardness
1	Ideal Al6063 (I)	83
2	Al6063+ 12% SiC+ 2% Mica (II)	35.5
3	Al6063+ 13% SiC+ 2% Mica (III)	35.8
4	Al6063+ 14% SiC+ 2% Mica (IV)	36.3

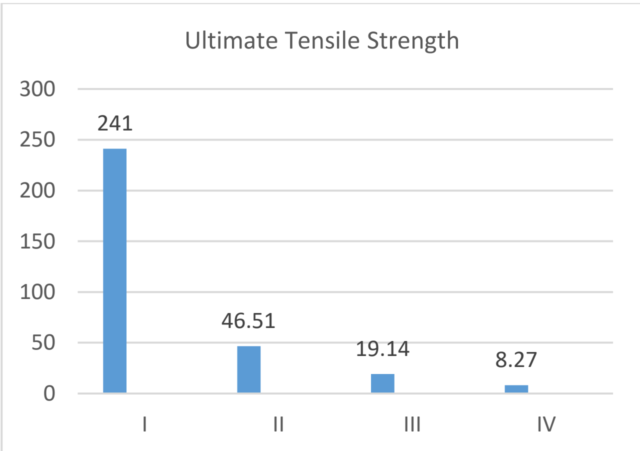


TENSILE STRENGHT TEST:

Tensile strength has decreased as compared to ideal Aluminium alloy as SiC percentage increases from 12%, 13 % and 14% with Mica remaining constant at 2%.

Table 2: Tensile strength test

S.No	Content	Ultimate tensile strength
1	Al6063 (I)	241
2	Al6063+12%SiC+2%Mica (II)	46.51
3	Al6063+13%SiC+2%Mica (III)	19.14
4	Al6063+14%SiC+2%Mica (IV)	8.27



COMPRESSIVE STRENGHT TEST:

The compressive strength test is conducted in Instron machine and the compressive strength is increased drastically for ideal Al6063 and composite material (Al6063+12%SiC+2%Mica).The compressive strength has decreased as SiC content increased.

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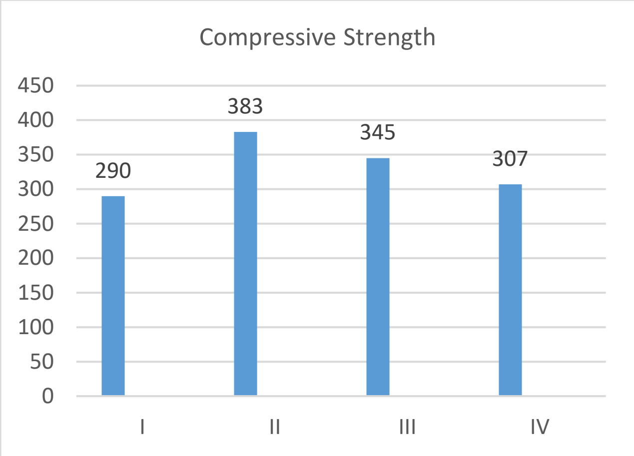
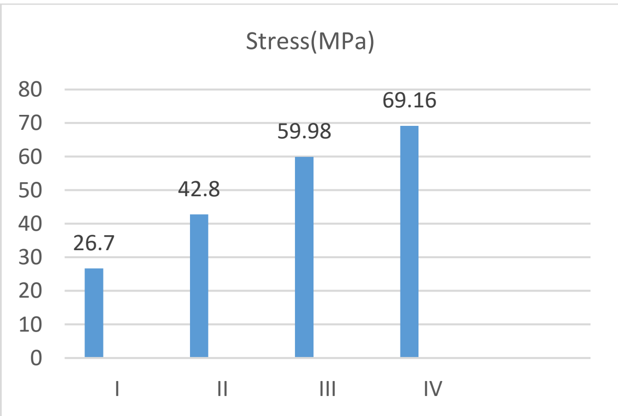


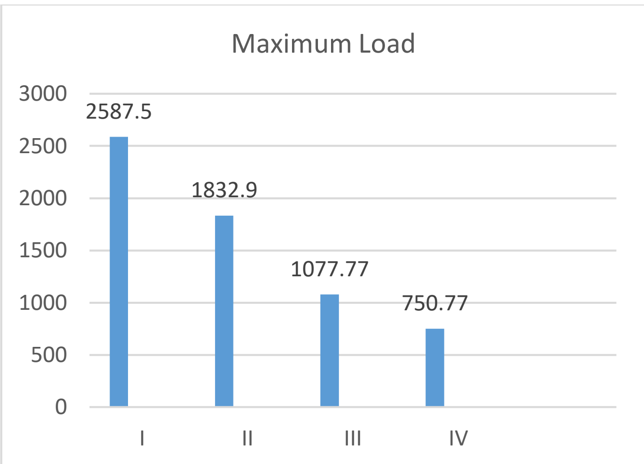
FLEXURAL STRENGTH TEST

Flexural strength has been decreased as the weight percentage of SiC is increased from 12%, 13%, and 14% with Mica remaining constant (2%) but when compared relatively.

Table 3: Flexural strength test

S.No	Content	Stress(MPa)	Maximum Load(N)
1	Al6063	26.7	2587.5
2	Al6063+12%SiC+2% Mica (II)	42.8	1832.9
3	Al6063+13%SiC+2% Mica (III)	59.98	1077.77
4	Al6063+14%SiC+2% Mica (IV)	69.16	750.77





V. CONCLUSIONS

1. Tensile strength decreased by 96.56% in specimen IV with increase in the silicon carbide percentage. So it would not be beneficial to add more SiC content.
2. The flexural strength (in MPa) of the composite (IV) is increased by 159.02% with an increase in the silicon carbide and keeping mica content constant.
3. The Compressive strength of the composite is increased by 32.06% in specimen II.
4. Micro hardness test shows that the hardness increases by increasing SiC content in the composites.
5. Clustering of silicon carbide particle is increased in the composite with increasing SiC content. The clustering is attributed to SiC's low thermal conductivity and heat diffusivity.

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