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Investigation of Thermal Characterizationon Aluminium Based Hybrid MMCs

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Abstract: *In the current research work, Al6061 reinforced with SiC/Gr particles of various configurations has been processed by adopting the stirred casting technique. Energy dispersive spectrometer tests have authenticated that the processed compounds are made up of Al6061 and SiC/Gr hybrid composites. The composition of SiC/Gr has been used in varied concentration of 0, 2, 4, 6 and 8% by weight and added to Al6061. An optical microscopy study has been carried out to identify the configuration of the composite material. In this study, we have attempted to examine the microstructures and thermal behavior of SiC/Gr-reinforced composites with different weight fractions. The microstructure, thermal conductivity, and coefficient of thermal expansion were also examined after adding SiC/Gr to Al6061. Al6061 reinforced with SiC/Gr particles exhibited better thermal properties than without SiC/Gr reinforcement*

Keywords: Al6061; SiC; Gr; Hybrid composites; Stir casting; Thermal analysis

I. INTRODUCTION

Composite materials do play a great significance and an effective role in many engineering industries applications because of the physical properties that are characterized by thermal properties. Thermal properties are one of prime physical properties of composites, which also include electrical, magnetics and optical properties. Thermal property of a material is its physical property related to application of heat energy and explain its response. As a solid body absorbs energy in the form of heat, its temperature increases and its dimensions increase. Thermal properties that are often critical in the practical utilization of solids. In this project we are developing and doing analysis on thermal properties of Al6061 and SiC/Gr hybrid composites. In our daily life, AMMCs have found many applications [1-6]. AMMCs are composites that only use aluminium as the matrix and incorporate a few reinforced components into the matrix. There are a few benefits such as low Coefficient of Thermal Expansion (CTE), improved stiffness, greater hardness and strength, light weight, high specific modulus, enhanced damping capabilities, enhanced wear-resistance and greater Thermal Conductivity (TC) when the reinforced is used in matrix. The matrix may include reinforcing elements in a manner of continuous fibers, particulates or monofilaments. They have been used in the fields of industrial goods, automotive and aeronautics applications. The reinforcement particulates must be robust, flexible and anti-reactive in the specified operating temperature. SiC, Al6061, graphite, are commonly used as reinforcements. In order to gain the optimum properties, selection of good reinforcement and the matrix materials are not only sufficient, processing method also plays a significant role [7-10]. There are different techniques available to produce AMMCs like powder metallurgy, squeeze casting, stir casting, chemical vapour deposition, pressure infiltration etc. Among these manufacturing techniques stir casting is the prevalent technique which has been used by many investigators since the process is cost-effective, and this process have greater hardness and refined micro structure grains than other techniques.Properties of composites are strongly dependent on the properties of their constituent materials, their distribution and the interaction among them. The composite properties may be the volume fraction sum of the properties of the constituents or the constituents may interact in a synergies SiC/Gr way resulting in improved or better properties. Apart from the nature of the constituent materials, the geometry of the reinforcement (shape, size and size distribution) influences the properties of the composite to a great extent. The concentration distribution and orientation of the reinforcement also affect the properties. The shape of the discontinuous phase (which may by spherical, cylindrical, or rectangular cross-sanctioned prisms or platelets), the size and size distribution (which controls the texture of the material) and volume fraction determine the interfacial area, which plays an important role in determining the extent of the interaction between the reinforcement and the matrix. Composites as engineering materials normally refer to the material with the following characteristics [11-16].

1.1 Matrix Material

Aluminium alloy (Al6061) is an aluminium alloy with zinc as the primary alloying element. It has excellent mechanical properties and exhibits good ductility, high strength, toughness, and good resistance to fatigue. The Al6061 is widely used for construction of aircraft structures, such as wings and fuselages. Its strength and light weight are also desirable in other fields. Rock climbing equipment and bicycle components are commonly made from 6061 aluminium alloy. Aluminium alloy matrix as shown in figure 4.1 and table 4.1 shows the chemical compositions of Al6061 alloy.

Table 1: Chemical composition of Al6061 alloy

Chemical composition [%]					
Element	wt. %	Element	wt. %	Element	wt. %
Si	0.67	Ti	0.2	Fe	0.6
Mg	1.58	Zn	0.17	Cu	0.27
Cr	0.2	Mn	0.22	Al	Bal.

Silicon carbide and graphite are polycrystalline composite materials, consisting of silicon carbide and graphite grains (single crystals) embedded in a matrix of amorphous or partially crystallized glassy phase. Their properties are not only determined by the intrinsic properties of silicon carbide and graphite single crystals, but strongly depend on the size and morphology of silicon carbide and graphite grains, as well as the volume fraction and chemistry of glassy phase at the grain boundaries of silicon carbide and graphite. In the first part, the article describes the structure, properties and manufacturing routes of silicon carbide and graphite single crystals. The last part describes the room temperature mechanical properties (hardness, strength, fracture toughness), high temperature mechanical properties (oxidation and creep resistance), and functional properties (thermal conductivity and biological properties) of silicon carbide and graphite.

II. RESULTS AND DISCUSSIONS

2.1 Microstructure

Significant improvements in mechanical characteristics was observed mainly due to the restructured grain structure, whereas increased splitting was mainly due to the presence of refurbishing particles that reduced the elongation properties and improved cargo capacity. Studies of particle additions found that with heterogeneous nucleation of the reinforcement grains, mechanical characteristics improved with the development of the precise structure. Composite characterization refers to the wide-ranging and general method by which composite structure and properties are analyzed and evaluated to ensure that materials meet performance criteria for various applications. In scanning electron microscopy, Figure 1 shows the slicked pattern observed systematically, with different magnifications and measurements. Analyses of 100X magnification of the microscopic structure show that the deformation observed can be attributed to the formation of a solid SiC/Gr solution. The visible dark grey area is determined to be the solid solution of the reinforcement particles with the rest of the area being the Al alloy matrix. The dark and white part in the image of the microstructure, as shown in Figure 1 a, explains the aggregation of SiC/Gr particles.Comparison of microscopic illustrations on Al alloy and divergence breaks was observed in both samples. However, the dendrite arm distance was not as large as the reinforcing-parts inhibition width during solidification, as seen in figure 1 b. Dendrite arm distance in the composite was observed in both samples. Particulate involvement in matrix molecules greatly improves its microstructure, weakening roughness when freezing of the primary dendrites. Ni3S4 particles mainly pass through primary dendrite boundaries of the Al alloy though some are found in aluminum slab. Porosity in the cluster region of SiC/Gr particles was seen frequently after small scale engraving. Processing of microstructures on the silicon surface throughout the SiC/Gr particles occurred. The microstructure had a viscous solution from the Al alloy, with some unspecified non-metallic additions. The combined surface appeared to include small boulders, with the whole dendritic form being clearly visible at 200X. Microstructural qualities of the metal matrix Al combination composites rely basically on the idea of lattice amalgam fortification, their holding, and dissemination. The present discussion relies upon 6 wt. % fortresses since mechanical properties are optimum in the 6 wt. % of SiC/Gr. Further augmentation in the

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stronghold substance (to 8 wt. %) lead to at the care group improvement which self-destructs the mechanical properties due to the distinction between the thickness and higher percentage of reinforcement

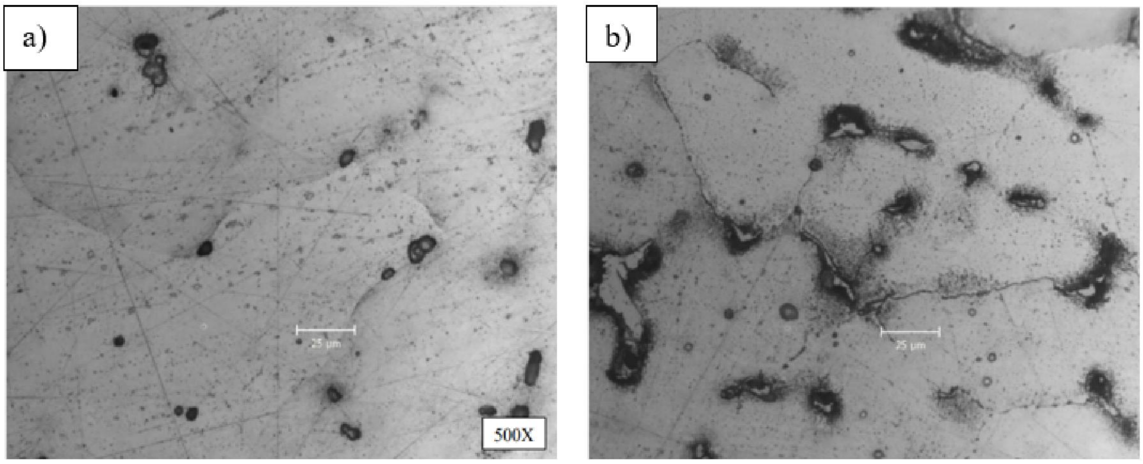

Figure 1: Microstructure of base alloy and composite

2.2 Thermal Conductivity

It is known that when an object is heated it lengthens and changes physical dimensions. This is due to the expanded development of the high temperature component atoms. An increase in temperature forces these molecules to maintain normal separation above low temperatures. The linear thermal expansion, as a function of temperature, focuses at the rate at which an object will elongate. This experiment may be used for design purposes and to determine the presence of thermal stress disorder. Knowledge of the relative production characteristics of the two materials is essential for implementation. In composite material, investigation of thermal conductivity was estimated at various temperatures for various Al6061 combinations, with varied rates of steady weight of SiC. The fundamental after effect of the test was that Al6061 combinations thermal conductivity with the expansion of Al6061 composite (base metal) and SiC/Gr increases continually with increasing temperature up to 8 weight %. With the expansion in weight level of SiC/Gr the thermal conductivity increases as the temperature rises. Figure1 shows that thermal conductivity for the Al6061 composite changes at varied temperatures of 167 W/m °C without reinforcements.

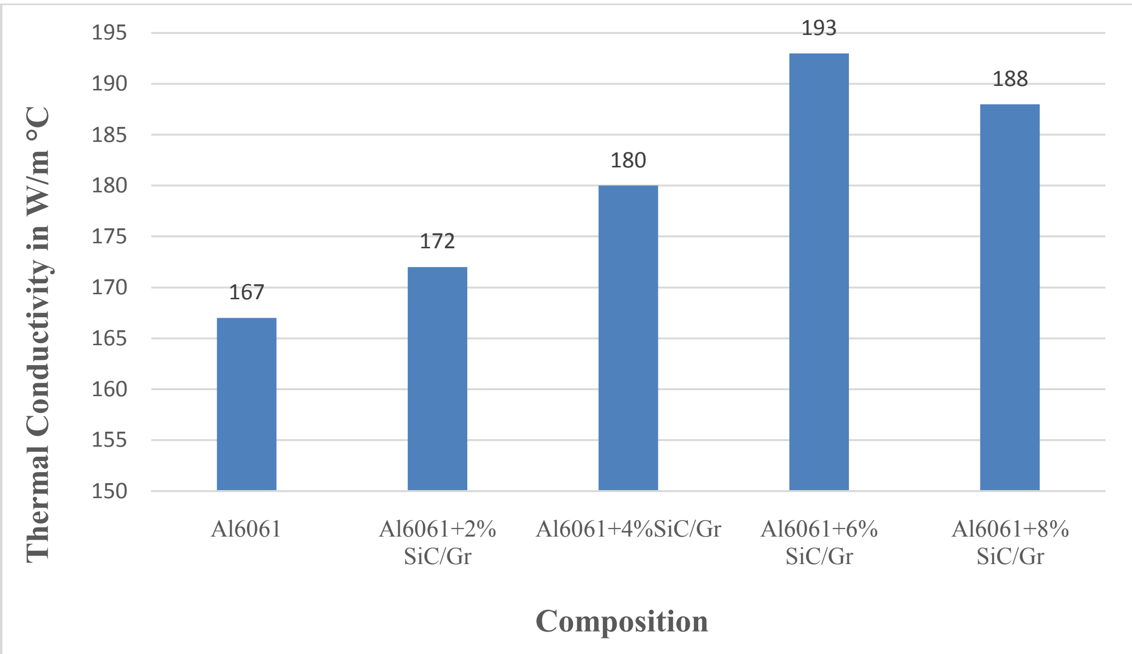

Figure 1: Thermal conductivity of the Al6061&SiC/Gr MMC

Highest thermal conductivity for the Al6061 junction structure was 193.30423W/m °C in 6 wt. % of SiC/Gr hybrid composite materials, while basic thermal conductivity was 167.02145 W/m °C. Despite the temperature, thermal conductivity constantly increased up to 6 weight percentage of SiC/Gr with increasing reinforcement content from the plot. For the content of reinforcements greater than 6 wt.% thermal conductivity decreased despite aggregation of reinforcements (as evident from microstructural observation). Decreased thermal conductivity was witness in the ceramic phases, i.e. reinforcement at 8 percent wt. in the ductile phase of SiC/Gr with Al6061 alloy.

However, it was concluded that thermal conductivity was affected by temperature content and the reinforcement. The thermal conductivity ofAl6061composite at different temperatures. For Al6061 alloy specimens with different percentages of SiC, thermal conductivity for different temperatures was measured in this composite material study, as illustrated in Figure 1. The result of the test is that in both Al6061 alloy (base metal) and SiC, thermal conductivity increased with SiC/Gr temperature increase to 6%. As the weight of SiC/Gr increased, thermal conductivity rate decreased as a result of temperature increasing up to 4,300 °C, after which the composite thermal conductivity gradually decreased, with a further 8% rise in temperature of SiC.

3.3 Coefficient of Thermal Expansion (CTE)

Compatibility of its material properties is the principal point of composite materials. Composite material (CTE) thermal expansion coefficient plays a part in the scope of its application. It is known that between the matrix phase and the reinforcements there is often a state of microtubules. Adjustment in the individual stage of thermal extension causes pressure which approximately influences the quality and disappointment of the properties of the mode. It is hard to completely surmise the coefficient of thermal extension of a metal lattice grid, with specific variables influencing it. The pliancy of the material includes the size and position of the fortification, type of guide, dissemination of fortifications, and voids in the composite metal network. The coefficient of thermal development (CTE) addresses the estimation of changes in a material with temperature. The proportion of CTE material in its constituent particles is associated with its bond.

In the current investigation, at various temperatures the coefficient of thermal expansion was ascribed to the Al6061 combination of composites withvarying weight percentage of SiC/Gr reinforcement particulates. The consequence of the experiment was that the coefficient of thermal expansion for both Al6061 composite material (base metal) and Al6061 alloy composite with reinforcements materials (SiC/Gr) decreased with increasing temperature as shown in Figure 2.

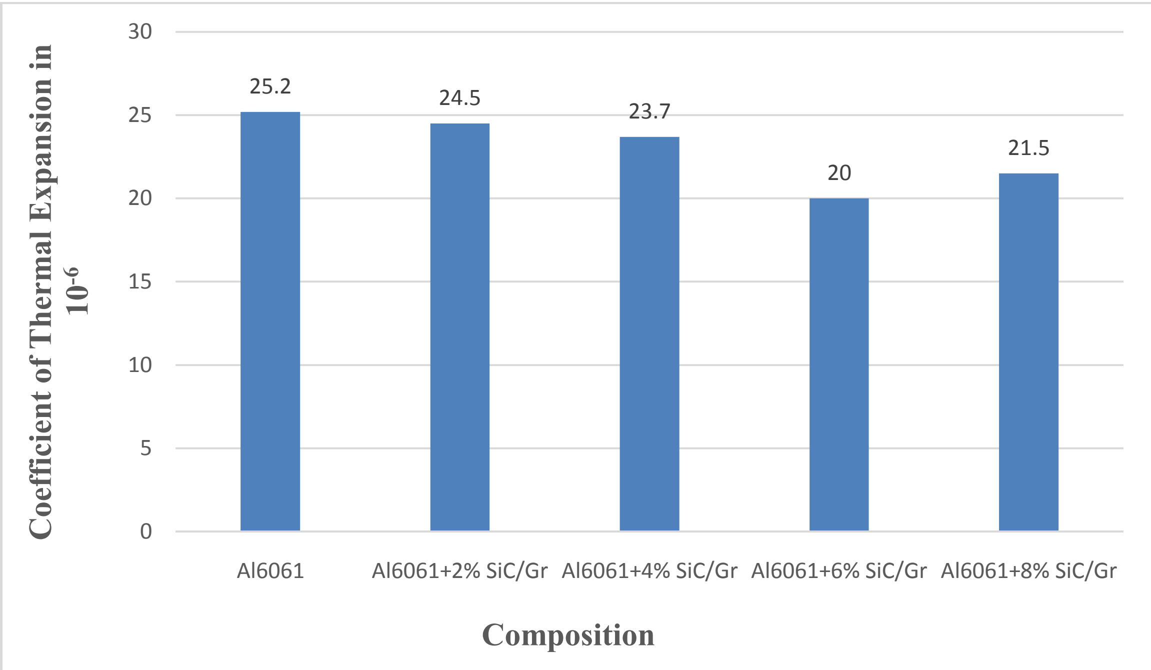

Figure 2: Coefficient of Thermal Expansion of Al6061& SiC/Gr MMC

As the reinforcing material increases, CTE gradually drops by a certain temperature up to 6 % weight of SiC. The update ratio hits its minimum value and then increases by 8% as material improvements begin at the rate of reinforcement. The percentage is caused by ceramic phase SiC/Gr ductile (FCC) matrix (Al6061 alloy) reinforcement of 6% SiC/Gr weight. CTE value decreases the importance of aggregation and reinforcement clustering (as microstructural observations show). Thus, 8 percent weight is used to get the least CTE from a composite perspective. Maximum is the ratio of the substitutions applied. Figure 2 further indicates that the maximum CTE (25.2) is obtained by the Al6061 alloy and lower CTE (20) for composites, despite information on reinforcement. Therefore, it is concluded that the MMCs and temperature reinforcement affect the CTE of the developed Al6061-alloy MMCs.

Adjustment of its material properties is one of the remarkable components of composite material. In its range of application, an important part is the thermal expansion coefficient (CTE) of the composite material. It was found that there was often a micro stress between the matrix and strengthening phases. It is difficult to fully anticipate the thermal expansion of a composite grid given the fact that few elements affect it which include. For example, plasticity of the matrix, size and state of reinforcement, support type, reinforcement circulation and vacuum in the metal network composite, etc. For Al6061 alloy samples with different weight percentages of reinforcement cast using stir casting techniques; the thermal expansion coefficient is measured in this study.

III. CONCLUSION

The main contributions of this project work have been summarized and the scope for future work listed at the end of this chapter.

Microstructure SEM analysis showed uniform distribution of SiC/Gr particulates with the smallest number of porosities and agglomeration was observed. The fine grains dendrite structure was formed by adding SiC/Gr particulates.

Formation of fine dendrite structure was observed in all metal matrix composite specimens due to faster solidification and density change of the composites by metal casting. The same was also observed in thermal conductivity tests.

Agglomeration of hard ceramic particles was observed in higher composites i.e. 8 wt. % SiC/Gr due to higher volume rations and insufficient stirring time and speed.

Thermal conductivity of the metal matrix composites increased due to increases in (SiC/Gr) particulates in the matrix alloy. This was because the hard ceramic particulates in the matrix alloy resisted the higher stiffness of matrix lattice which lead to increases thermal conductivity in the composites.

Coefficient of thermal expansion of composites from 2-8 wt. % of SiC/Gr HMMCs decreased by 2.77%, 5.9%, 20.6% and 14.6% respectively, compared to the Al alloy base metal.

The influence of hard ceramic particles (SiC) in the composite, the coefficient of thermal expansion for both Al alloy and the composites decreased as temperature increase.

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