International Journal of Latest Engineering Research and Applications (IJLERA) ISSN: 2455-7137

Volume – 02, Issue – 04, April – 2017, PP – 32-36

Compressive and Shear Behaviour of AA6063-TiC Composites

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Abstract: The development of aluminium metal matrix composite materials by combining the desirable attributes of metals and Ceramics. Here AA 6063 used as the matrix material in which TiC added as the reinforced material. The present investigation focuses to improve the properties of AA6063 by the addition of TiC. AA 6063-TiC composite was fabricated by stir casting route by varying percentage of TiC reinforcement. An addition of 9 wt. % of TiC has achieved maximum compressive strength 294.3 MPa and shear strength 95.9MPa compared to as- cast AA6063.

Keywords: AA6063, TiC, Compressive strength, Shear strength.

1. INTRODUCTION

Aluminium metal matrix composites are well-known for their high-specific strength, hardness, and attractive tribological properties. Due to high strength to weight ratio, AMCs are the best suitable material for structural applications in aircraft, automotive and military industries compared to other MMCs. Yilmaz [1] produced hybrid composites of Al-10 wt. % Al_2O_3-x wt. % Gr (x = 0, 1, 2, 3, 4 and 5 wt. %) and observed that the surface texture parameters are decreasing as graphite content increases in the matrix. However, the hardness of hybrid composites started to decrease when the graphite content in the matrix was more than 1wt%. Hebbar et al. [2] studied the mechanical properties of silicon carbide particle reinforced AA2024 composites and found that tensile strength, tensile modulus, hardness, impact strength increased. Hayrettin Ahlatci et al. [3] investigated the mechanical properties of aluminium Silicon with 60 volume % SiC composites and concluded that as amount of Si increased up to 1%, the strength of composites increased without significant loss in toughness after which the strength showed a decline with further in crease in Si content. Abdizadeh et al. [4] investigated the influence of ZrO_2 content and casting temperature on the mechanical properties and fracture behavior of A356 Al/ZrO_2 composites. A356 aluminium alloy composite reinforced with 5, 10 and 15 vol. % ZrO_2 were fabricated at 750, 850 and 950°C temperature through the stir casting method. Reinforcing the ZrO_2 in aluminium matrix alloy increases the hardness and ultimate tensile strength. The best mechanical properties were achieved for the specimen prepared at 750°C with 15 vol. % of ZrO_2. Ajay Singh et.al [5] focused on the behavior of aluminium cast alloy (6063) with alumina. They conducted various tests like impact, hardness and tensile test and it was observed that with the increase of alumina weight percentage increases brittleness and the ultimate tensile strength, yield strength increased with the addition of alumina weight percentage in the matrix. Kima et al. [6] reasoned the increase in hardness of the composites to the increased strain energy at the periphery of particles dispersed in the matrix. Ranjit Bauri has explained Al-TiC composites are processed at different temperatures from 700°C to 1200°C and with different Ti:C ratios to asses the effect of these two parameters on the formation of TiC particles[7]. Bao et al. [8] has investigated the shear strength of Ti_3AlC_2 was measured respectively by means of double-notched sample and punch shear tests. When the loading was parallel to hot-pressing direction of the material, compressive strength of 749+77 MPa and slip angle of 38° were obtained; when the loading was perpendicular to the hot-pressing direction, compressive strength of 841+40 MPa and 26° angle were measured. In this investigation the effect of TiC additions on the compressive and shear strength of Aluminum matrix composite by using stir casting route is detailed.

2. EXPERIMENTAL WORK

In this study, the matrix AA 6063(0.44% Si, 0.5% Mg, 0.4% Fe, 0.02% Ti) was selected which is procured in the form of ingots. Titanium carbide is a smart reinforcement for aluminium composites because of its high elastic modulus, high hardness, and wear resistance. TiC particles are used as reinforcement with 3, 6, 9 and 12 percentage of weight was used to prepare the composites by stir casting route is shown in Fig.1 [9].

AA6063 was melted in a crucible by heating the furnace at 750°C. The TiC particles were preheated at 1000ºC to make their surfaces oxidized. The temperature was first raised above the liquidus temperature of AA6063 near about 750ºC to melt the AA6063 completely and was then cooled down just below the liquidus to keep the slurry in semisolid state. The preheated TiC was added at this temperature and stirring of the slurry was performed for 3-5 minutes with a motor controlled stirrer. The composite slurry was then heated to 720^{o}C and a second stirring performed by a mechanical stirrer to improve the distribution of the TiC particles in the molten of AA6063. The molten composite was then cast into prepared cast iron molds.

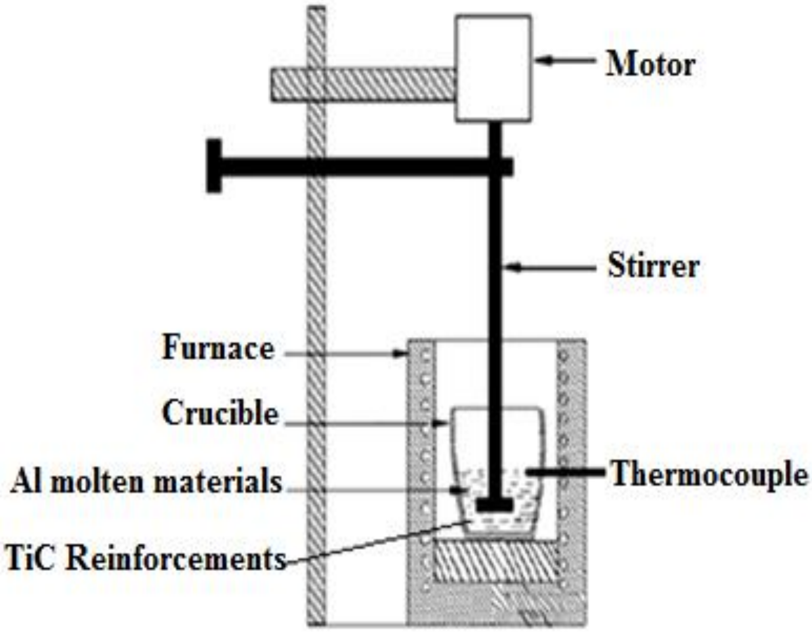

Fig.1 Experimental setup of stir casting process [9].

3. RESULTS AND DISCUSSION

3.1 Compressive Strength Examination

The compressive strength is the ability of a material to withstand forces tending to reduce size. It is a key value for design of structures. The AA6063-TiC composite was machined to produce round shaped compressive specimens was prepared as per ASTM E9M [10]. In Fig.2 for conducting a compressive test, the load was applied hydraulically by using computer-interfaced Universal Testing Machine [Model: MTS/C64.106] operated at a constant cross-head speed of 1mm/s. The composite material is subjected to the compressive load on both side of the specimen. It tends to buckling and reducing the length of the specimen with increase in diameter of the rod. The load is applied to the specimen continuously after reaching the yield point the fracture will occur. Three repeat tests were performed for each test condition to guarantee the reliability of the data generated. The variation of compressive strength with weight percentage of TiC reinforcement is also shown in Fig.3. The compressive strength started to increase up to 9 wt. % of TiC particles and then it’s decreased. The compressive strength of composites was 164.2 MPa, 232.5 MPa, 268.2 MPa, 293.3 MPa and 273.6 MPa for 0, 3, 6, 9 and 12 wt. % of TiC in the AA6063 matrix. When the compressive stress is applied to the composite, the AA6063 matrix around the TiC particles run away in the direction perpendicular to the applied load, which reduces the load transfer ability of AA6063 matrix. The addition of TiC reinforcement to AA6063 matrix increases its density and there by its compressive strength. In 12 wt. % of TiC composite compressive strength was decreased due to the formation of agglomeration of TiC reinforcement over the AA6063 matrix.

Fig. 2 Compression test setup in Universal Testing Machine.

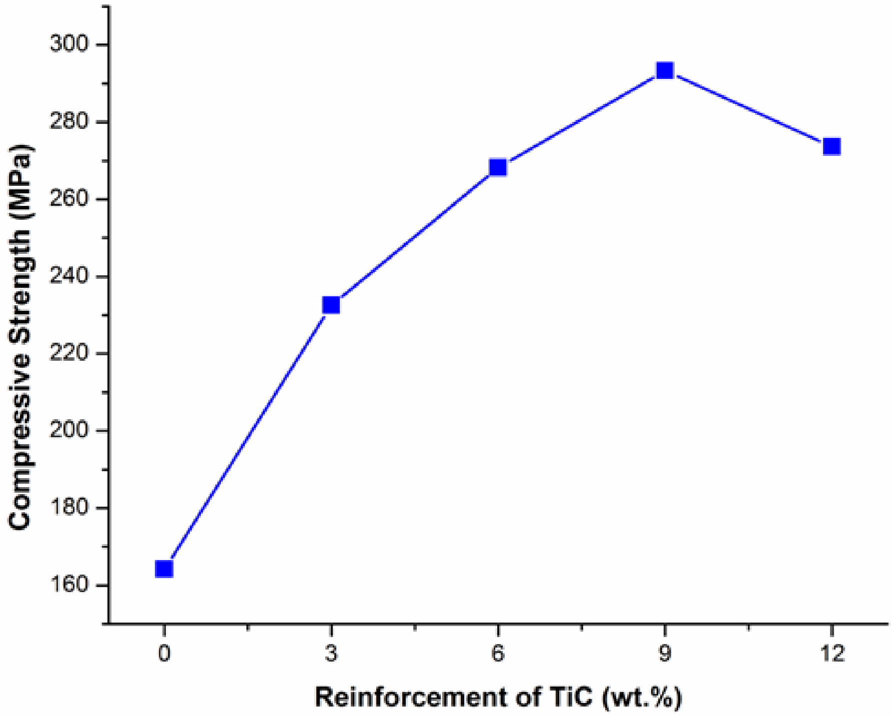

Fig. 3 Variation of compressive strength in the AA6063-TiC composites.

3.2 Shear Strength Examination

Shear strength is a materials ability to resist forces that can cause the internal structure of the material to slide against it self. In double shear test a load applied in one plane that would result in three fastener pieces. The specimens were prepared according to the ASTM size of 10 mm diameter and 50 mm length. Total of five specimens were prepared for each weight percentage of TiC such as 0, 3, 6, 9 and 12. The shear tests were performed on a universal testing machine in double shear attachment at room temperature. The cross head moving with a speed of 2mm/min was used to apply load on the samples gradually and shear values were calculated. After the shear test, the shear specimen is shown in Fig.4. The variation of shear strength with weight percentage of TiC reinforcement is also shown in Fig.5. The shear strength of composites was 53.1 MPa, 73.9 MPa, 82.8 MPa, 95.9 MPa and 86.2 MPa for 0, 3, 6, 9 and 12 wt. % of TiC in the AA6063 matrix. The shear strength started to increase up to 9 wt. % of TiC and then it's decreased, due to the hardening of AA6063 by TiC.

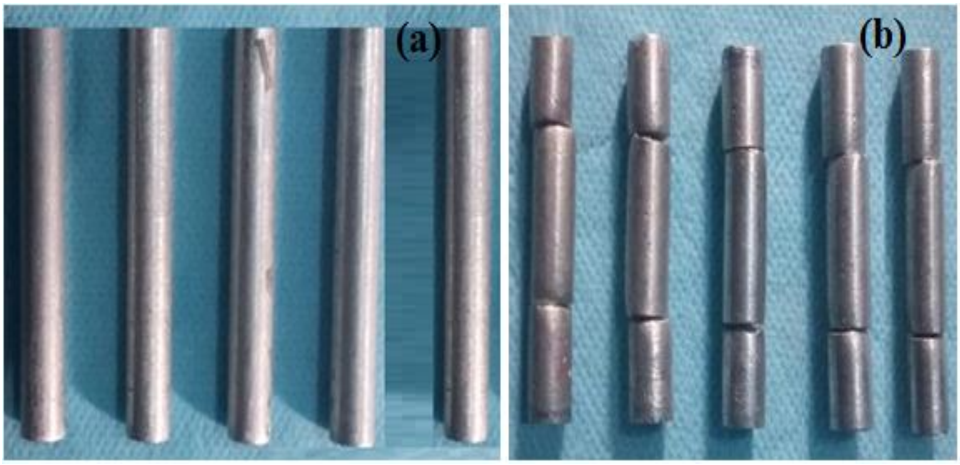

Fig. 4 Shear samples of AA6063-TiC composites (a) before testing (b) after testing.

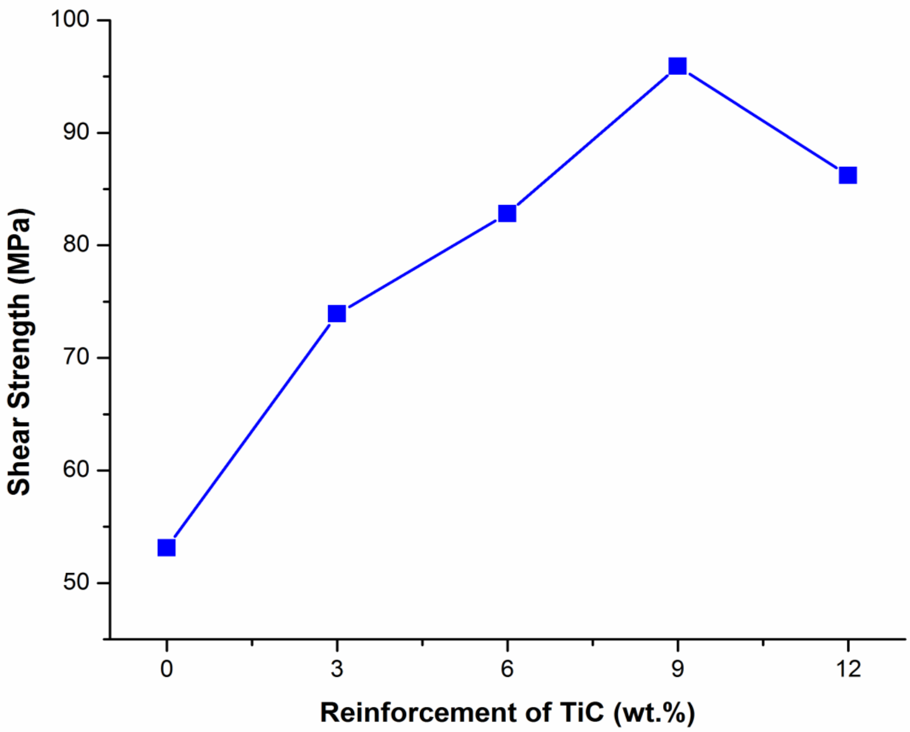

Fig. 5 Variation of shear strength in the AA6063-TiC composites.

4. CONCLUSION

The stir casting route was used to produce the AA6063-TiC composites. The addition of TiC can improve the strength of AA6063. The addition of TiC was increased to increase the compressive and shear strength due the grain refinement. An addition of 9 wt. % of TiC has achieved maximum compressive strength 294.3 MPa and shear strength 95.9MPa compared to as-cast AA6063.

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