Assessment of UTS and Yield Strength of Aluminium 6061alloy-based Metal Matrix Composites

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Abstract - Metal Matrix Composites (MMCs) constitute an important class of design and weight-efficient structural materials thatare encouraging every sphere of engineering application and mainly in aerospace applications. The present study deals with Aluminium Alloy 6061 reinforced with graphite and silicon carbide. Aluminium alloy 6061 is strong, with strength comparable to many steels, and has good fatigue strength, but has less resistance to corrosion than many other Al alloys. The composites are prepared for the different compositions of Graphite and Silicon carbide particulates using stir casting technique. The test specimens are prepared as per the ASTM standards to conduct tensile test and hardness test. Results shows and conclude that the Metal matrix Composite obtained has got better tensile strength and hardness compared to unreinforced Aluminium alloy (6061).

Key words -Silicon carbide,Graphite, Al6061 alloy composite, tensile strength and hardness.

I. INTRODUCTION

Composite materials have successfully substituted the traditional materials in several light weight and high strength applications. The reasons why composites are selected for such applications are mainly their high strength-to-weight ratio, high tensile strength at elevated temperatures, high creep resistance and high toughness.It has been demonstrated that Aluminum matrix composites reinforced with various discontinuous reinforcement materials have potential for application in both automobile and aerospace industries.
Alloy 7075-T6 an Al-Zn-Mg-Cu alloy, was introduced in 1943. Since then, most aircraft structures have been specified in alloys of this type. The first aircraft designed in 7075-T6 was the Navy's P2V patrol bomber. A higher-strength alloy in the same series, 7178-T6 was developed in 1951 and it has not generally displaced 7075-T6, which has superior fracture toughness. Alloy 7178-T6 is used primarily in structural members where performance is critical under compressive loading.

II. LITERATURE REVIEW

In this chapter literature review have been carried out on aluminium matrix composite to know the type of reinforcement used on Al alloy and its composition. Investigator used different fabrication technique for preparation of composite material and evaluation of mechanical properties of formed composites.
Analysed that A356-fly ash chemosphere composites can be synthesized using gas pressure infiltration technique over a wide range of reinforcement volume fraction from 20 to 65% [1]. Investigated the tribological behaviour of aluminium alloy reinforced with alumina and graphite which is fabricated by stir casting process. The wear and frictional properties of the hybrid metal matrix composites was studied by performing dry sliding wear test using a pin – on- test wear test. The results show that sliding distance has the highest influence followed by load and sliding speed. Finally, confirmation test was carried out to verify the experimental results and scanning electron microscopic studies were done on the wear surfaces [2]. Investigated the better stir process and stir time of high silicon content aluminium alloy –silicon carbide MMC material, with 10% SiC by using a variance stirring speeds and stirring times. The results with respect to that stirring speed and stirring time influenced the microstructure and the hardness of composite. They also concluded that at lower stirring speed with lower stirring time, the particle group was more. Increase in stirring time and speed resulted in better distribution of particles. The mechanical test

results also revealed that stirring speed and stirring time have their effect on the hardness of the composite [3]. Studied mechanical properties of Al and particle reinforced 3%($Al_2O_3$and SiC), and 6% ($Al_2O_3$and SiC) composite structures wereinvestigated by casting or powder metallurgy method. Hardness of formed composites increased when wt.% of SiC increased on SAE 1020 steel formed during casting technique when compared to powder metallurgy technique. [12].

III. EXPERIMENTAL DETAILS

The main objective of this study is to develop hybrid composite material Al6061/SiC/Gr through stir casting technique. Silicon carbide in Al6061 alloy was varied as 0, 2, 4 and 6 wt.% with constant graphite particles in wt.% of 1, 3, 5 and 7. Machining have been carried out by using conventional machine tool as per ASTM standard size. Evaluation of hardness and tensile properties such as yield strength, UTS and ductility was done and compared with Al6061 alloy alone.

Further, microstructure study of the Al6061/SiC/Gr hybrid composites were done through optical microscope to know the distribution of reinforcement particles in the Al6061 matrix material.

3.1 Material selection and preparationof hybrid composites.

For the present investigation Al 6061 alloy have been chosen as matrix material and Silicon carbide and graphite have been chosen as reinforcements for fabrication of hybrid composites through stir casting technique. The chemical composition of Al6061 is given in the Table 1.

Table -1 Chemical Composition of 6061

Chemicals	Si	Ti	Fe	Mn	Zn	Cu	Mg	Cr	Other	Al
Wt. (%)	0.4-0.8	0.15	0.7	0.15	0.25	0.15-0.40	0.8-1.2	0.04-0.35	0.05	Balanced

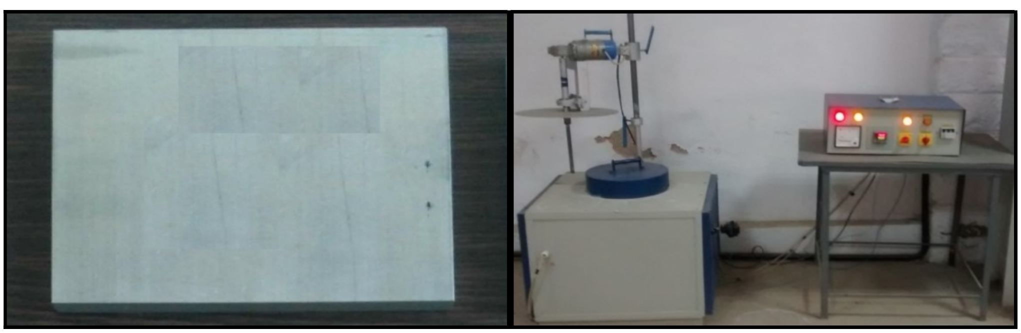


Figure 1.(a) Photograph of Al6061 alloy (b) Photograph of Melting furnace

Figure 1 (a) and (b) represent the photograph of Al6061 alloy and melting furnacein the present investigation. Al-Mg-Si based alloy used for fabrication of the Al6061/SiC/Gr hybrid composites. The calculated amount of Al6061 alloy were cut into the required shape and kept inside the pre-heated crucible for melting. The pre-heated reinforcement (SiC and graphite) was introduced into the molten metal in a controlled manner and proper mechanical stirring were done to ensure proper mixing of reinforcement into the Al6061 matrix. Then the mixture is poured into the pre-heated die cavity and allowed to solidify to room temperature. The cast component is taken out from the die for machining.

3.2 Machining

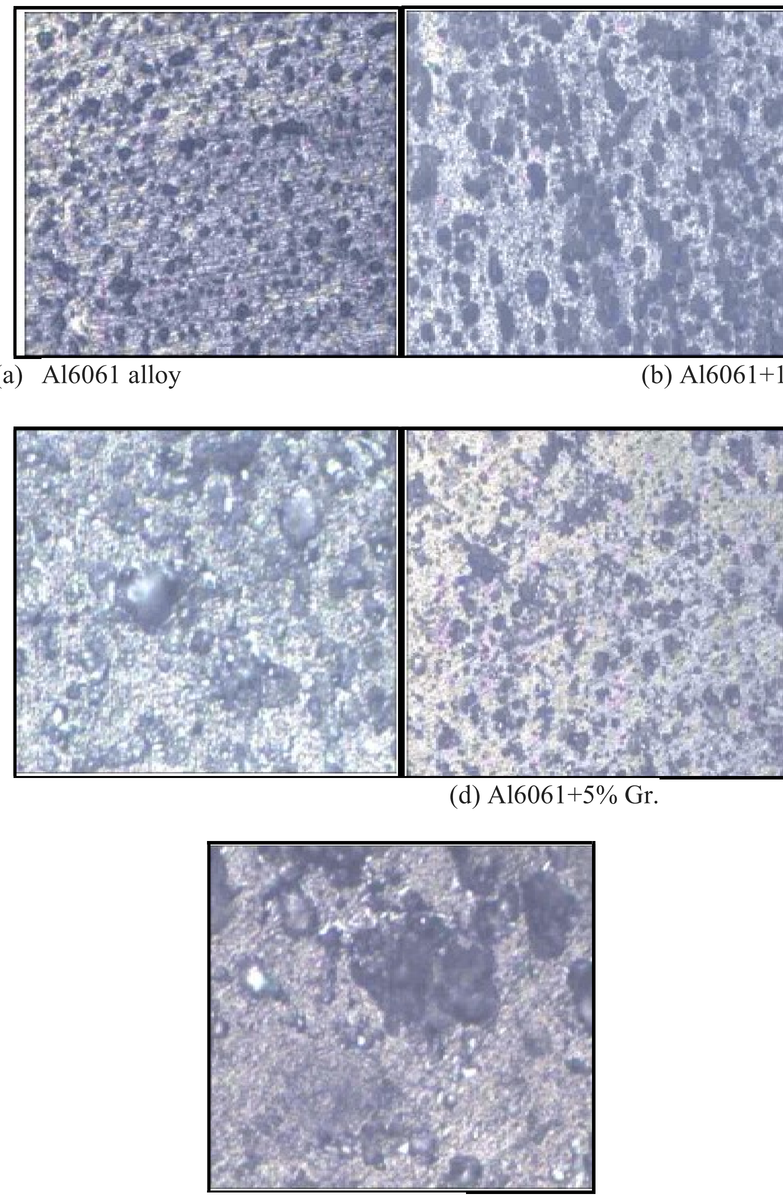
After formation of hybrid composites, the test specimens were prepared by using conventional lathe machine tool as per ASTM standard size to evaluate the hardness and tensile properties such as yield strength, UTS and ductility of the Al6061/SiC/Gr hybrid composites. Further, microstructure specimens have been prepared for the formed hybrid composites.

IV. RESULTS AND DISCUSSION

4.1 Microstructure Studies

Microstructure studies were conducted on Al6061 alloy, Al6061/Gr composites and its hybrid composites (Al6061/SiC/Gr.). The studies revealed the dispersion and bonding of reinforcements with the Al 6061 matrix. Further, it is revealed the type of fracture occurred.

4.1.1 Effect of wt.% of graphite on Al601 alloy.



(a) Al6061 alloy (b) Al6061+1% Gr.

(c) Al6061+3% Gr. (d) Al6061+5% Gr.

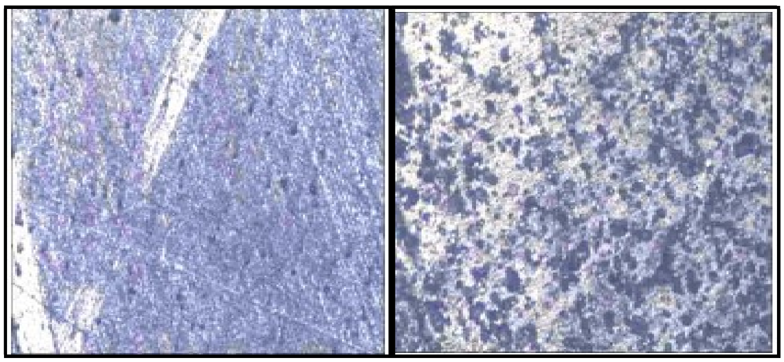
(e) Al6061+7% Gr.

Figure 2. (a-e) Optical micrograph of Al6061 alloy and Al6061/Gr. Composites.

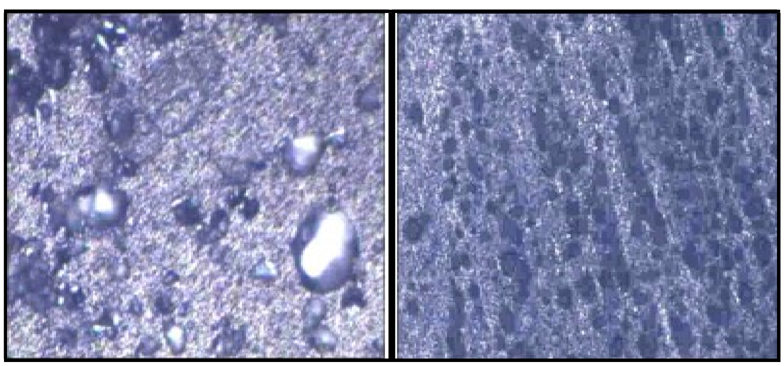
Figure 4.1 (a) represent it's a pure Al6061 alloy consists of small porosity in the matrix of Al6061 alloy which may be due to casting defect during preparation of alloy. Figure (b-d) representthe presence of Graphite particles in the matrix material. It is observed that graphite exhibitsbetter bondage in the matrix material and uniform mixing is revealed. Due to this strength of matrix has increased when compared to Al6061 alloy. These composites exhibit enhanced hardness and strength to matrix material resulting ductile tearing.

Figure (e) represent the Al6061+7% graphite composites, it is examined that the content of graphite particles is embedded more in the matrix material which results in agglomeration of reinforcement in the matrix material which may be attributed due to improper stirring of reinforcement. Hence the strength of matrix material not have a significant improvement.

4.1.2 Effect of wt.% of graphite on Al601+6 wt.% of SiC composites.



(a) Al6061+ 6% SiC + 1% Gr. (b) Al6061+ 6% SiC + 3% Gr.



(c) Al6061+ 6% SiC + 5% Gr. (d) Al6061+ 6% SiC + 7% Gr.

Figure 3. (a-d) Optical micrograph of Al6061/SiC/Gr. hybrid composites.

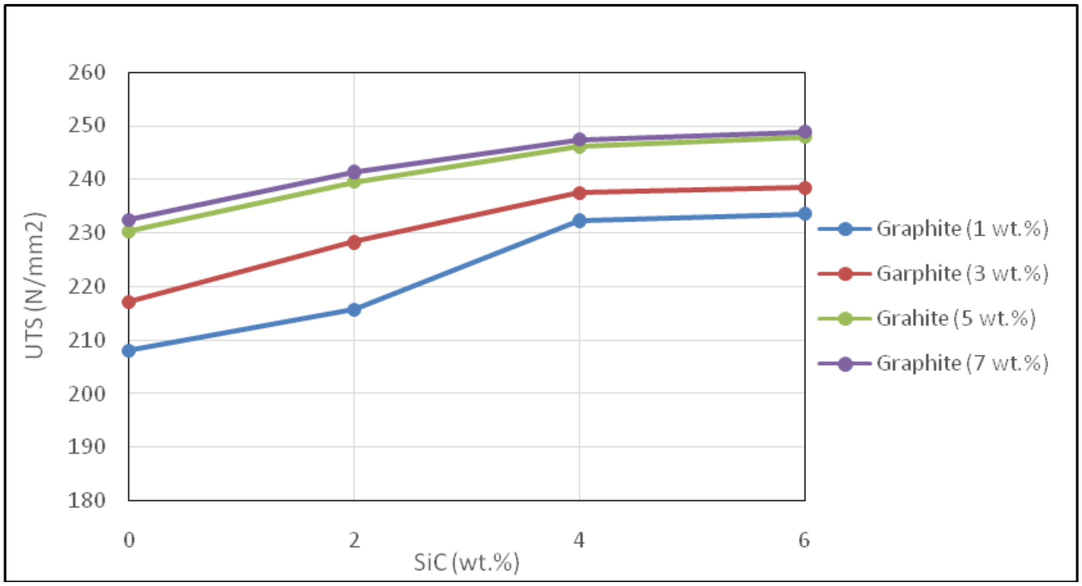
Figure 3. represent the optical micrograph of Al6061 hybrid composite reinforced with 6 wt.% of SiC with varying wt.% (1, 3,5 and 7) of graphite.

Figure3 (a-d) reveals that thegrey and dark grey inside the microstructure revealing the presence of silicon carbide particles. For any processing technique it is utmost important that the dispersion of reinforcements should be uniform and free from clustering. In present case, from micrographs it is quite clear that the dispersion of both the reinforcements was found to be fairly uniform throughout the matrix, which carries load uniformly by the reinforcements and enhances the properties of reinforced metal matrix composites.

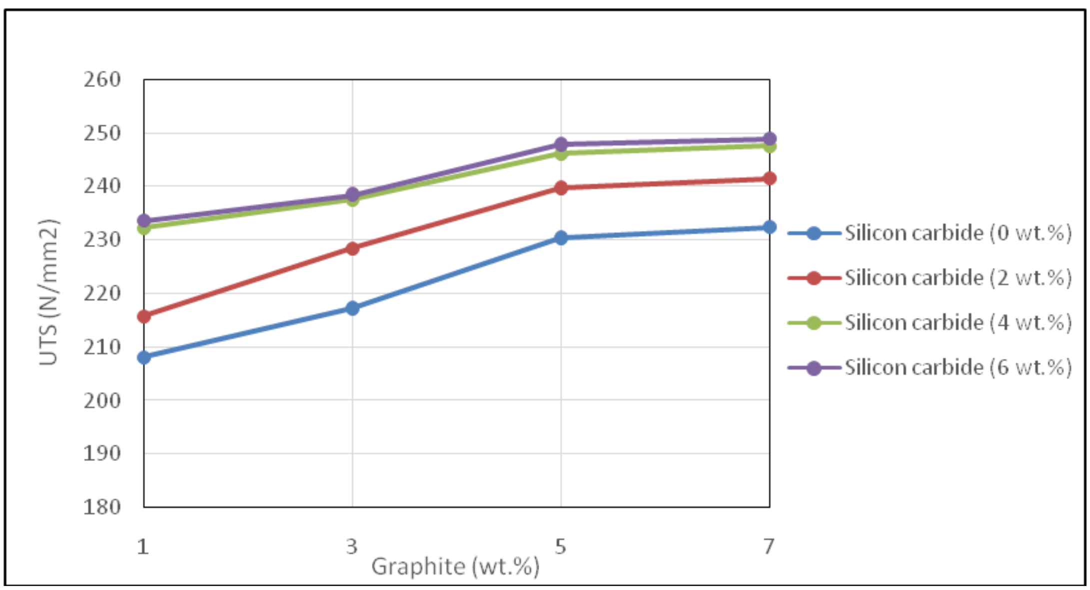
4.2 Evaluation of UTS and yield strength

The variation of UTS and yield strength evaluated by using UTM for increasing percentage of Gr. and SiC in Al6061 is as follows.

4.2.1 Effect of SiC and Graphite on UTS of Al 6061 alloy



(a) Variation of UTS of Al6061 alloy reinforced with constant graphite and varying silicon carbide particle.

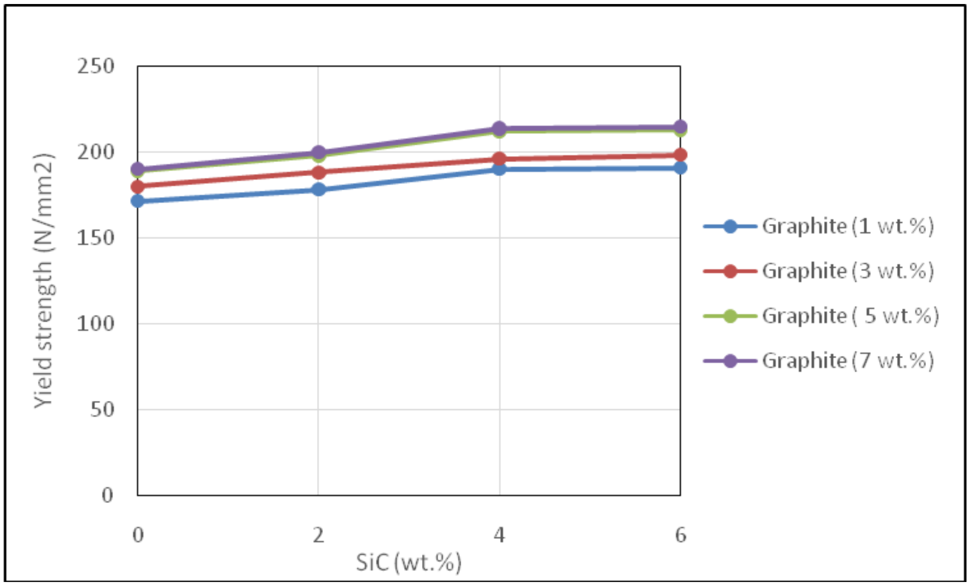


(b) Variation of UTS of Al6061 alloy reinforced with constant silicon carbide and varying graphite particle.

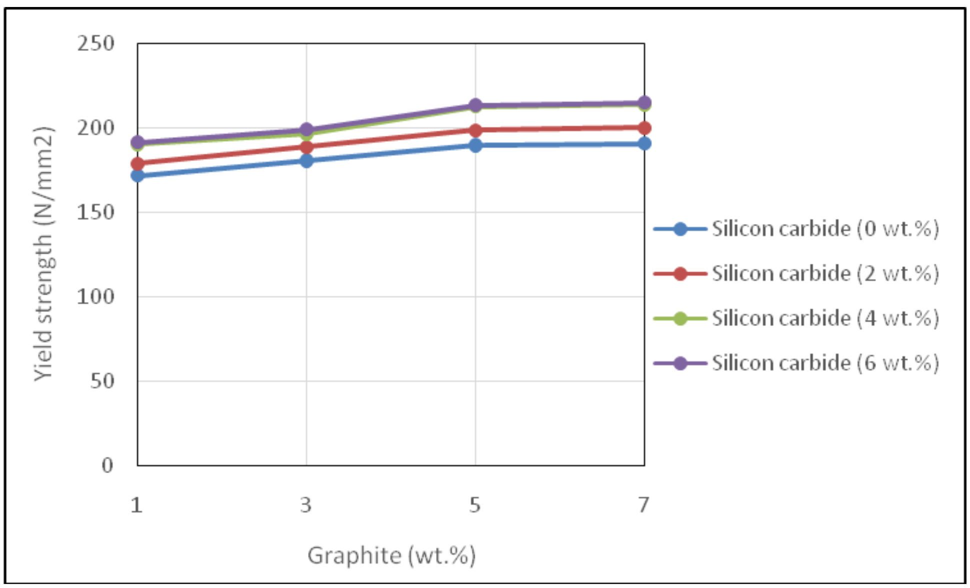
Figure 4. (a-b) Variation of UTS of Al6061/SiC/Gr. hybrid composites.

Fig. 4 (a-b) represent theHMMCs of Al6061 exhibits increasing UTS with increasing wt.% of silicon carbide and graphite particles in the Al6061 alloy. The increase in UTS is attributed due to amount of reinforcement content in the matrix material and good bonding between matrix and reinforcement materials.Higher ultimate tensile strength (UTS) was observed for 7 wt.% of graphite and 6 wt.% of silicon carbide in the Al6061 matrix materials which may be due to uniform distribution of reinforcement particles in the matrix material.

4.2.2 Effect of SiC and Graphite on yield strength of Al 6061 alloy



(a) Variation of UTS of Al6061 alloy reinforced with constant graphite and varying silicon carbide particle.



(b) Variation of UTS of Al6061 alloy reinforced with constant silicon carbide and varying graphite particle.

Figure 5. (a-b) Variation of yield strength of Al6061/SiC/Gr. hybrid composites.

Fig. 5 (a-b) represent the variation of yield strength of Al6061/Sic/Gr. hybrid composites. It exhibits increasing yield strength with increasing wt.% of silicon carbide and graphite particles in the Al6061 alloy. The increase in yield strength is attributed due to amount of reinforcement content in the matrix material and good bonding between matrix and reinforcement materials.Higher yield strengthwas observed for 7 wt.% of graphite and 6 wt.% of silicon carbide in the Al6061 matrix materials which may be due to uniform distribution of reinforcement particles in the matrix material. Further, it was observed that for 5 wt.% and 7 wt.% of graphite in the Al6061 with varying silicon carbide exhibited almost same results as shown in figure 5 (a). Similarly, results were observed for 4 wt.% and 6 wt.% of silicon carbide in the Al6061 with varying graphite particles as shown in figure 5 (b).

IV.CONCLUSION

Stir casting technique can be adopted for preparation of Al6061/SiC/Gr. hybrid composite material by varying reinforcement material. Microstructure study reveals homogeneity in matrix and reinforcement material which may be due to proper stirring process during casting process. This homogeneity in the hybrid composites resulted in enhancement of UTS and yield strength of the matrix material. Ductile fracture was observed in the Al6061/SiC/Gr. hybrid composite material. Increase in wt.% of silicon carbide and graphite particles in the Al6061 alloy contributed to increase in UTS and yield strength when compared with as cast Al6061 alloy.

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