STUDY OF MECHANICAL PROPERTIES ON AL 6061 HYBRID COMPOSITE BY STIR CASTING METHOD

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Abstract - *Composite materials are known as advanced materials for their high strength, high wear resistance, good damping characteristic and their enhanced high temperature performance. The hybrid metal matrix composite ($HMMC_S$) materials are prepared by using stir casting technique. Development of Al6061alloy based metal matrix Hybrid composite reinforced with 6wt% of SiC and varying steps of graphite by 3wt%, 6wt%, and 9wt%. Experimental study was carried out to investigate the mechanical properties such as hardness, tensile strength, compression strength. As a result hardness decreases with the increase in the percentage of Gr, tensile strength and compression strength increases with the increase in Gr particulates with the influence of SiC particulates.*

Key Words*: *Hybrid metal matrix composite (HMMC), stir casting, Al6061, SIC, Graphite, Reinforcement, Hardness, Tensile strength, Compression strength.

1. INTRODUCTION

There is a growing interest worldwide in manufacturing hybrid metal matrix composites [HMMCs] which possesses combined properties of its reinforcements and exhibit improved physical, mechanical and tribological properties. Aluminium-based Metal Matrix Composites (MMCs) have received increasing attention in recent decades as engineering materials. Use of single reinforcement in Al matrix may sometimes lead to deterioration in its physical properties. However, to overcome the drawback of single reinforced composites, the concept of use of two different types of reinforcements is being explored in Al matrix. Of the two reinforcements normally one of the reinforcement will be a hard phase and the other being a soft lubricating phase. Hard reinforcements such as SiC, TiO_2, Al_2O_3, TiB_2 etc. will enhance the hardness and abrasive wear resistance of Al while it has a negative effect on the machinability and conductivity of Al. To offset these effects, reinforcements like graphite which is a solid lubricant and possessing good conductivity can be dispersed in Al along with hard reinforcements. The introduction of a ceramic material into a metal matrix produces a composite material that results in an attractive combination of physical and mechanical properties which cannot be obtained with monolithic alloys. Interest in reinforcing Al alloy matrices with ceramic particles is mainly due to the low density, low coefficient of thermal expansion and high strength of the reinforcements and also due to their wide availability. Among the various useful aluminum alloys, Aluminum alloy 6061 is typically characterized by properties such as fluidity, castability, corrosion resistance and high strength-weight ratio. Aluminium alloy-based particulate-reinforced composites have a large potential for a number of engineering applications such as transport and construction sectors where superior mechanical properties like tensile strength, hardness etc., are essentially required.

2. MATERIALS

2.1 Aluminium 6061

The material used in the present study is Al 6061 whose chemical composition is listed in Table 1. It therefore has a low melting point 660°C. The molten metal has high fluidity and solidifies at constant temperature. It possess excellent mechanical properties, such as good corrosion resistance, good deformation behavior, high specific modulus, tensile strength, hardness, good wear resistance and low coefficient of thermal expansion.

Table-1: Chemical composition of Al 6061 by wt%.

Cu	Mg	Si	Fe	Mn	Cr	Zn	Ti	Al
0.22	0.82	0.60	0.25	0.03	0.24	0.10	0.1	Bal

2.2 Silicon Carbide

The reinforcement material used in the investigation was Silicon carbide in which it is kept constant (6wt %) and it is composed of tetrahedral of carbon and silicon atoms with strong bonds in the crystal lattice. It has high thermal conductivity coupled with low thermal expansion and high strength giving exceptional thermal shock resistant properties. It is used in abrasives, refractories, ceramics, and numerous high-performance applications.

2.3 Graphite

Another reinforcement material used in the present investigation was Graphite which is diversified into 3wt%, 6wt%, 9wt% at a suitable interval of 3wt% in steps of 3. It is a solid lubricant which enhances the wear and anti-frictional properties. The acoustic and thermal properties of graphite are highly anisotropic. Graphite's high thermal stability and electrical and thermal conductivity facilitate its widespread use as electrodes and refractories in high temperature material processing applications. Graphite and graphite powder are valued in industrial application for their self-lubricating and dry lubricating properties.

3. METHODOLOGY

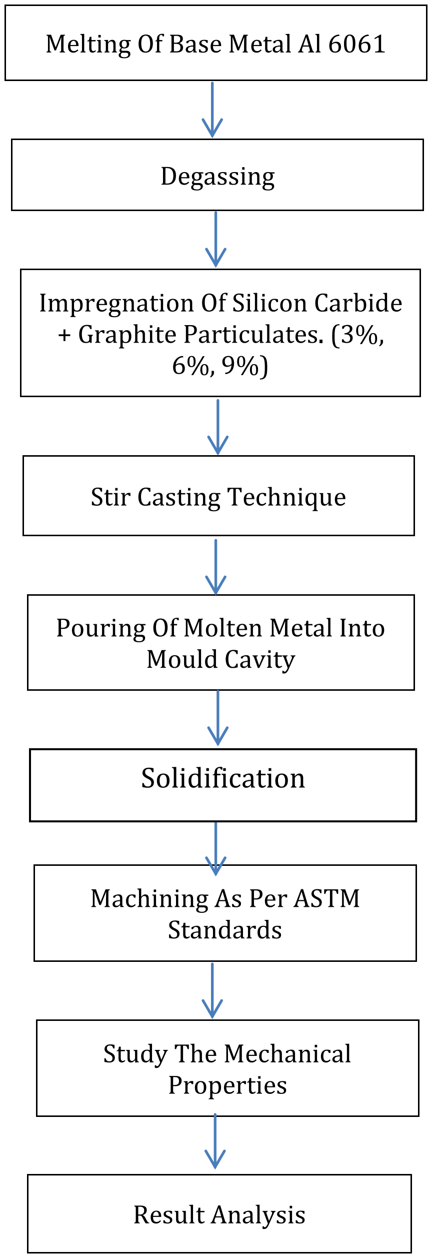


Fig-1: Methodology for production of hybrid composite

4. HYBRID COMPOSITE PRODUCTION

In the present study, stir casting method is used for the preparation of hybrid composite. In this process Al 6061 bars are cut into small ingots. These ingots are placed in crucible in which it is kept in electrical resistance furnace. The ingots are melted at a temperature of 800^0 C, after effective degassing predetermined mass of preheated 6wt% of SiC is added into the melt and stirred continuously in order to achieve uniform distribution of particles in the matrix. Gr of 3wt%, 6wt%, 9wt% at suitable intervals of 3wt% in steps of 3 is then added to the mixture of Al 6061 and SiC. After the mixing of the reinforcements (SiC and Gr) with the base matrix, the crucible is taken out from the furnace and the molten metal is poured into the metal mould and allowed to solidify. After the solidification, the casted specimen is removed from the mould and machined as per ASTM standards for testing.

Table-2: Composition of the product

Sl.no.	Hybrid Composition
1	Al 6061
2	Al 6061+6%SiC
3	Al 6061+6%SiC+3%Gr
4	Al 6061+6%SiC+6%Gr
5	Al 6061+6%SiC+9%Gr

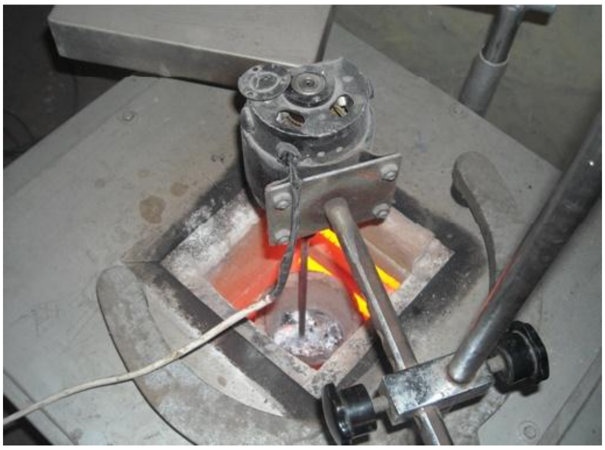


Fig-2: Stir casting technique

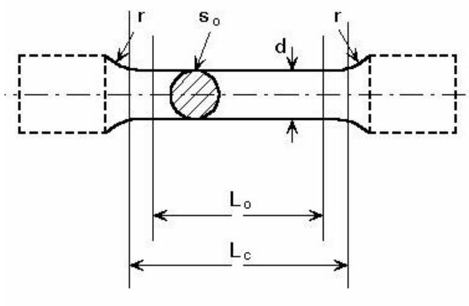
Fig-3: Pouring of molten metal into mould cavity

Fig-4: Casted hybrid composite

5. PREPARATION OF SPECIMEN FOR TESTING

5.1 Tensile Test

The tensile tests were conducted on UTM at room temperature. The samples were prepared according to ASTM E8M. The tensile properties of the alloys were determined by performing the tension test on standard cylindrical tensile specimens. The machining involves facing and turning. Before to testing, the surface of the specimens was finished by using 400 grid emery sheets. A typical tensile specimen as per ASTM standard is shown in Fig 5.



L_o = Gauge length
Lc = Parallel length
r = Transition radius
So = Original cross section area
d =gauge length diameter

Fig-5: Tensile test specimen

5.2 Compression Test

Compression tests were conducted on a UTM E8M in accordance with ASTM Standard at room temperature. Load values were recorded from load indicator, while displacement measurements were taken using a dial gauge fixed against the moving platen of the machine. In this test the compression loads were gradually increased and the corresponding strain was measured until the specimen failed. The specimen height before and after the test are measured using 0.05 accuracy by using vernier. A typical compression test specimen as per ASTM standard is shown in Fig 6.

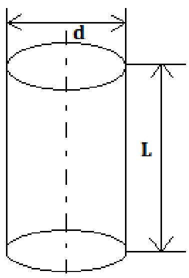


Fig-6: Compression test specimen

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5.3 Hardness Test

Hardness, is the measure of a material's resistance to surface indentation, also it is a function of the stress required to produce some specific types of surface deformation. The Brinell's test is frequently used to determine the hardness of forgings and castings that have a grain structure too course for Rockwell or Vickers testing. The hardness test was carried out for the hybrid composite by using 10mm ball indentation by applying 500kg load for 30 seconds in a Brinell's hardness tester. A typical hardness test specimen as per ASTM standard is shown in Fig 7.

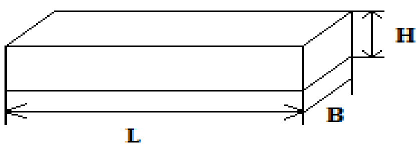

Fig-7: Hardness test specimen

6. RESULT AND DISCUSSION

6.1 Hardness Test

Table-3: Hardness test results

Sl.no.	Composition (wt%)	BHN
1	Al 6061	85
2	Al 6061+6%SiC	111
3	Al 6061+6%SiC+3%Gr	106
4	Al 6061+6%SiC+6%Gr	98
5	Al 6061+6%SiC+9%Gr	90

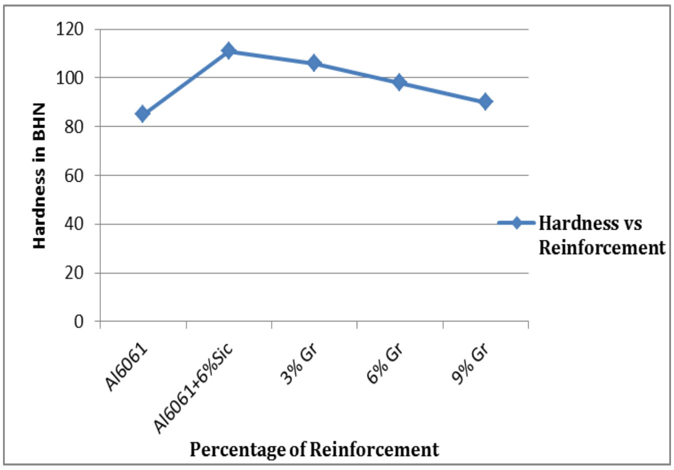

Chart-1: Effect of graphite on hardness

Table 3 shows the Brinell's hardness test result. It is observed from the graph, the hardness of Al 6061-hybrid composite decreases significantly with increasing content of the graphite particulate. However, decrease in hardness of Al6061-hybrid composite possibly due to poor wetting characteristics of Graphite by Al 6061. A significant increase in hardness of the alloy matrix can be seen with addition of SiC particles. The measurements show that an increase in graphite content for the same amount of SiC reduces hardness of the composite.

6.2 Tensile Test

Table-4: Tensile test results

Sl.no.	Composition (wt%)	Tensile Strength (MPa)
1	Al 6061	128
2	Al 6061+6%SiC	150
3	Al 6061+6%SiC+3%Gr	141
4	Al 6061+6%SiC+6%Gr	148
5	Al 6061+6%SiC+9%Gr	156

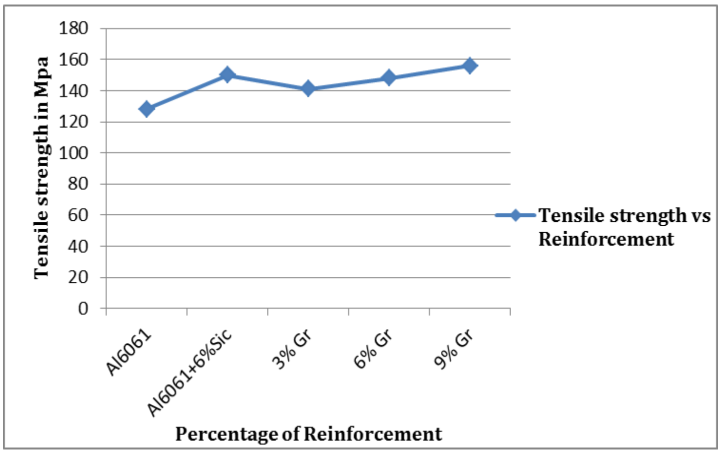

Chart-2: Tensile strength comparison plot

Table 4 shows the tensile test result. From the test it is inference that the improvement in ultimate tensile strength in base matrix with 6% SiC, this is due to the fact that SiC is a hardest ceramic which on reinforcement forms a stronger composite. From the graph, tensile strength of composites containing 6 wt% of Sic particulates is higher when compared to as base Al 6061. It is clear from the graph is that the tensile strength increases with the increase in the percentage of Gr particulates.

6.3 Compression Test

Table-5: Compression test results

Sl.no.	Composition (wt%)	Compression Strength (MPa)
1	Al 6061	580
2	Al 6061+6%Sic	650
3	Al 6061+6%Sic+3%Gr	743
4	Al 6061+6%Sic+6%Gr	847
5	Al 6061+6%Sic+9%Gr	987

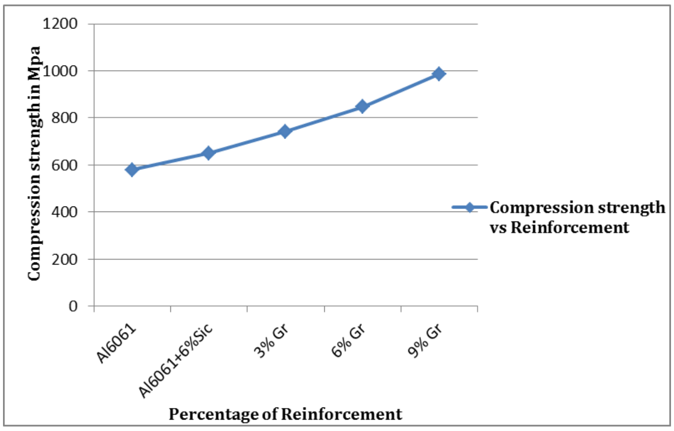

Chart-3: Compression strength comparison plot

Table 5 shows the compression test result. It can be seen from the graph is that as the graphite content increases, the compressive strength of the hybrid composite material increases monotonically by significant amounts. In fact, as the graphite content is increased from 3% to 9% the compressive strength increases due to the graphite particles acting as barriers to dislocations in the microstructure.

7. CONCLUSIONS

Al 6061 hybrid composite material containing SiC and Gr particulates were fabricated successfully by varying wt% of Gr from 3% to 9% using stir casting method. Keeping Sic 6% as constant, by increasing the Gr particulates of 3%,6%,9%, we can conclude that Hardness of the prepared hybrid composites is higher than the base AL 6061 alloy. Addition of 6wt% SiC increases hardness considerably. Whereas the addition of Gr particulates decreases the hardness, but is higher than the Al6061 alloy. However, decrease in hardness of Al6061-hybrid composite possibly due to poor wetting characteristics of Gr by Al 6061. Tensile strength of prepared Al6061 hybrid composites is higher when compared to base Al 6061 composite. Addition of 6% SiC and Gr varies from 3% to 9% increases the tensile strength considerably with respect to base matrix Al6061. It can be seen that as the Sic and graphite content increases, the compressive strength of the hybrid composite material is also increases.

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