EasyChair Preprint

№ 7954

Fabrication of Al6061 Metal Matrix Composite Through Stir Casting Method

Vikas Kashyap, Sourav Kumar and Shubham

May 15, 2022

Fabrication of Al6061 Metal Matrix Composite Through Stir Casting Method

ABSTRACT

Aluminium alloys are widely used in aerospace and automobile industries due to their low density and good mechanical properties, better corrosion resistance and wear, low thermal coefficient of expansion as compared to conventional metals and alloys. The excellent mechanical properties of these materials and relatively low production cost make them a very attractive candidate for a variety of applications both from scientific and technological viewpoints. The aim involved in designing metal composite materials is to combine the desirable attributes of metals and ceramics.Present work is focused on the study of behavior of Aluminium alloy (Al 6061) with SiC and Gr composite produced by the stir casting technique. Al 6061 alloy is taken as base material and then it is reinforced with silicon carbide (SiC) and Graphite (Gr). After preparation of suitable samples, tensile test and hardness test were performed and results were analyzed. At last, a comparison is made between the mechanical properties of Al alloy hybrid containing 2 wt% Graphite constant and various SiC compositions namely 3%, 6% and 9% by weight.

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

INTRODUCTION

Metal Matrix composite (MMC) is a mixture of Metal (Matrix) and hard particle/clay (Reinforcement) which gives desirable properties. It is used in the manufacture of Space Craft, Automobiles and other equipment. The expanded requirement of lightweight materials with high particulate quality in the aviation and car enterprises has prompted to the improvement and utilization of Al amalgam based composites (basically Al combination/SiC composites). The MMCs are appealing materials for use in basic applications since they join ideal mechanical properties, great wear resistance, and low warm extension. The half and half SiC foam SiC particles/Al double interpenetrating composites utilized as the brake materials of fast prepare were created by press throwing procedure. The MMCs are metals reinforced with other metal, dismissed or natural mixes. Reinforcement is done to enhance the properties of the parent metal, like, conductivity, quality, etc. The Aluminium MMC is generally utilized as a part of air ship, aviation, autos and different fields. The most ordinarily utilized strengthening does include Silicon Carbide and Aluminium Oxide. Silicon Carbide (SiC) supports sizes the rigidity, hardness, thickness and wear resistance. Aluminium is the most giving metal in the Soil's outside layer, and the third most immeasurable component, after oxygen and silicon. It makes up around 8% by weight of the Soil's strong surface. The cost of producing composite materials utilizing a throwing technique is around 33% larger than that of aggressive strategies besides high volume creation.

The main advantages of composite materials are their high strength and stiffness, combined with low density, when compared with bulk materials, allowing for a weight reduction in the finished part. The industrial need of good materials with light weight, excellent properties and low cost demanded the scientists to research on composite materials.

MATERIALS USED

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. 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.

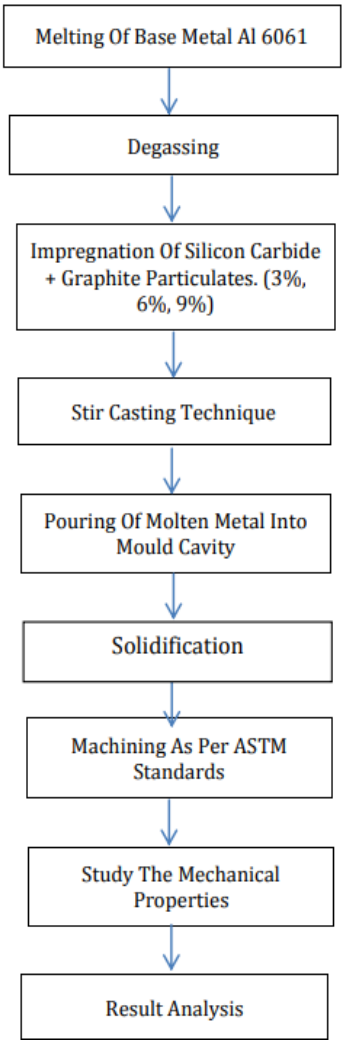
Fig.1 Silicon carbide

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 selflubricating and dry lubricating properties.

Fig.2 Graphite

METHODOLOGY



HYBRID COMPOSITE PREPARATION

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 8000 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.

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

Table-2: Composition of the product

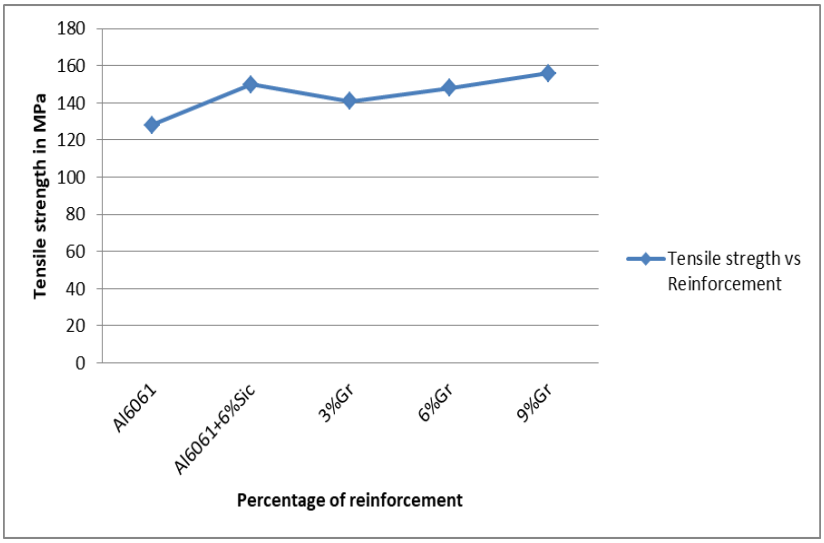
TESTING OF COMPOSITE

a) Tensile Test

A Tensile test also known as tension test is probably the most fundamental type of mechanical test that can perform on material. The ability to predict the loads that will cause a part to fail depends upon both material properties and the machine part geometry. This lab involves two testing procedures that are used to verify these characteristics. The first test is a materials test known as a tensile test which is used to determine/verify material properties. The second test is a failure test which is used to determine/verify the loading level that will cause a machine part to fail.

Table-3: Tensile test results for constant SiC

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



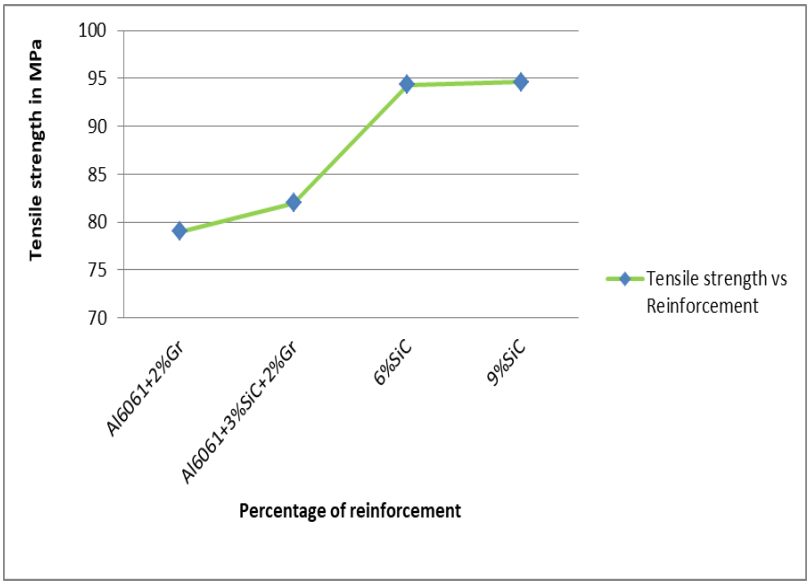
Graph.1 Tensile strength comparison plot for constant SiC

Table 3 shows the tensile test result for constant SiC. 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.

Table-4: Tensile test results for constant Gr

Sl.no.	Composition (wt%)	Tensile Strength (MPa)
1	Al 6061+2%Gr	79
2	Al 6061+3%Sic+2%Gr	82
3	Al 6061+6%SiC+2%Gr	94.36
4	Al 6061+9%SiC+2%Gr	94.59



Graph.2 Tensile strength comparison plot for constant Gr

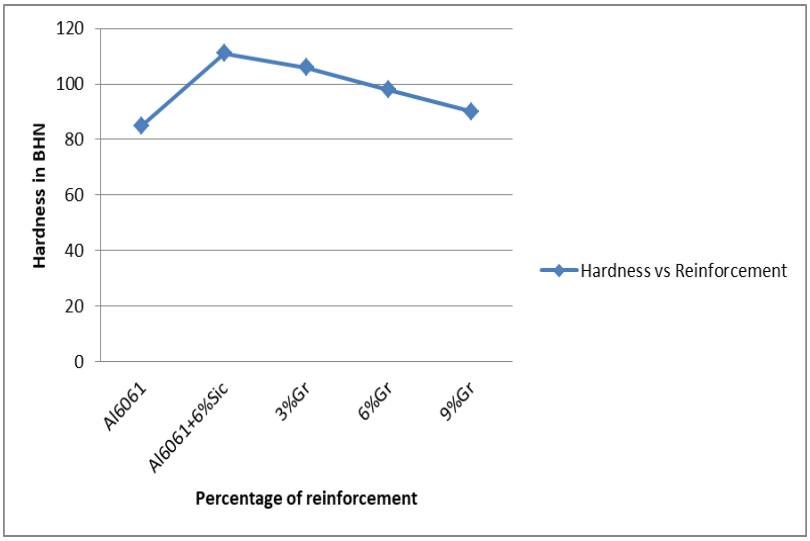
In Table 4 for constant Gr Al alloy it is observed from the graph that there is an increase in Tensile strength by adding SiC & Gr to Al6061.

b) 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.

Table-5:Hardness test results for constant SiC

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

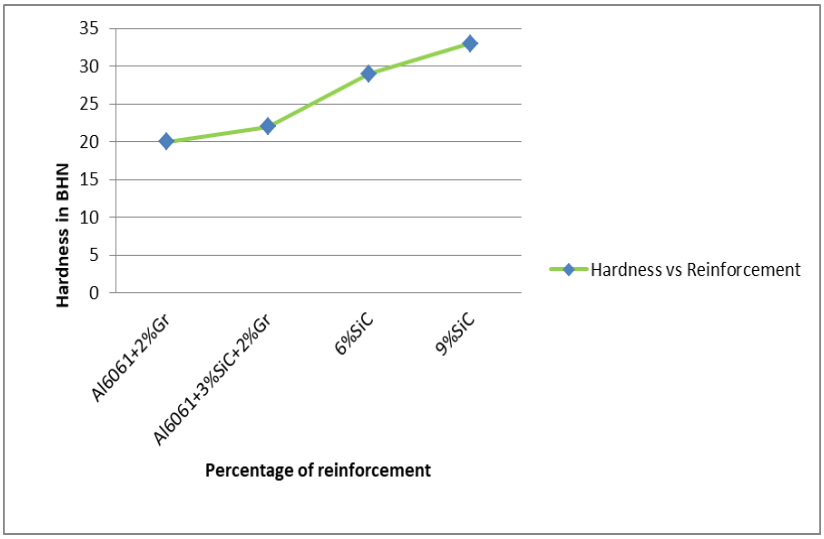


Graph.3 Hardness comparison plot for constant SiC

Table 5 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.

Table-6:Hardness test results for constant Gr

Sl.no.	Composition (wt%)	BHN
1	Al 6061+2%Gr	20
2	Al 6061+3%Sic+2%Gr	22
3	Al 6061+6%SiC+2%Gr	29
4	Al 6061+9%SiC+2%Gr	33



Graph.4 Hardness comparison plot for constant Gr

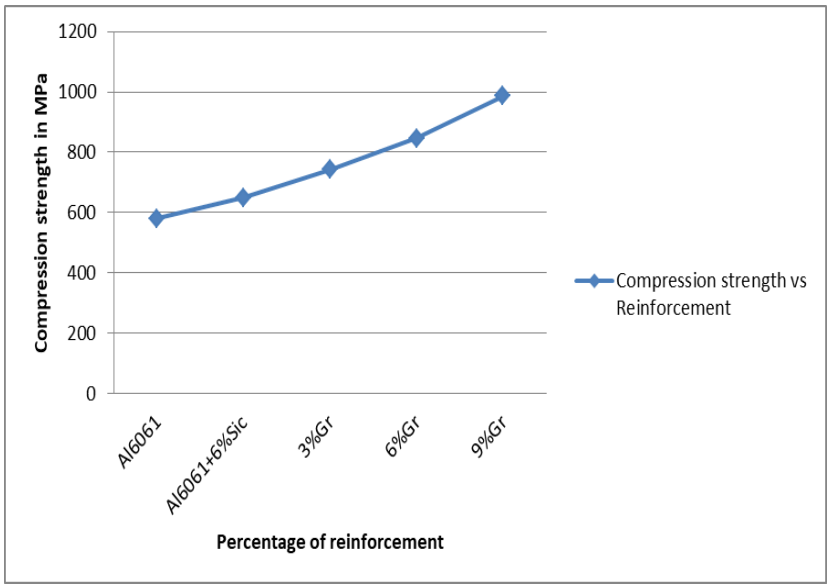
For constant Gr Al alloy It is observed from the graph that adding of SiC to Al6061 increases the hardness because Gr is constant here whereas Gr is varying in table 5.

c) Compression Test

Compression testing is used to determine how a product or material reacts when it is compressed, squashed, crushed or flattened by measuring fundamental parameters that determine the specimen behavior under a compressive load.

Table-7: Compression test results for constant SiC

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

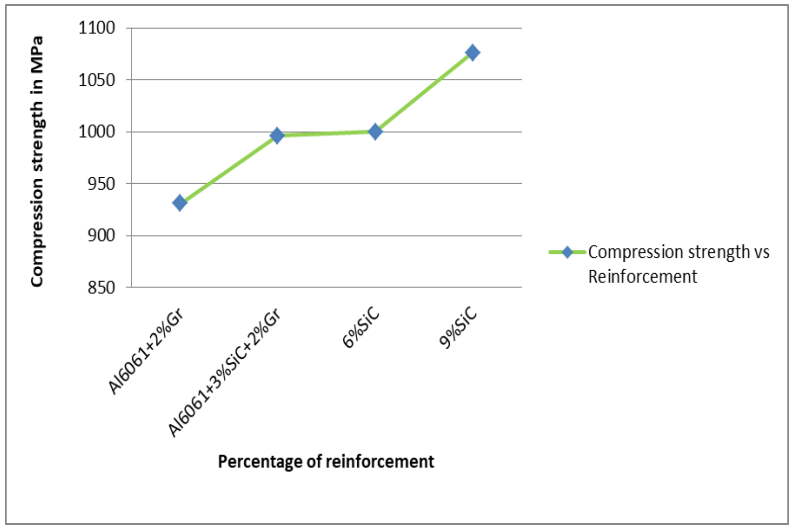


Graph.5 Compressive Strength Graph for constant SiC

Table 7 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.

Table-8: Compression test results for constant Gr

Sl.no.	Composition (wt%)	Compression Strength (MPa)
1	Al 6061+2%Gr	931
2	Al 6061+3%Sic+2%Gr	996
3	Al 6061+6%SiC+2%Gr	1000
4	Al 6061+9%SiC+2%Gr	1076



Graph.6 Compressive Strength Graph for constant Gr

It is observed from the graph that here is an increase in Compressive strength by adding SiC & Gr to Al6061.

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 and successfully compared with constant Gr Al alloy. Tensile strength and Compressive strength increased by adding Sic & Gr to Al6061 in both alloys. Hardness decreased in constant Sic Al alloy while increased in constant Gr Al alloy.

REFERENCES

[1] Prashant S N et al. “Preparation And Evaluation Of Mechanical And Wear Properties Of Al6061 Reinforced With Graphite And Sic Particulate Metal Matrix Composites”, International Journal Of Mechanical Engineering And Robotics Research ISSN 2278 – 0149 Vol. 1, No. 3, October 2012.

[2]. Madeva Nagaral, Bharath V, Auradi,: “Effect of al203 particles on mechanical and wear properties of al6061 alloy metal matrix composites”, Metarial science and engineering, ISSN: 2169-0022 JME, Vol. 2 Issue 1.

[3] Manna A. and Bhattacharyya B.; “Investigation for optimal parametric combination for achieving better surface finish during turning of AlSiC-MMC”, International journal of Advance Manufacturing Technology, Vol. 23, (2004), pp. 658665.

[4] N. Nanda Kumar et al, “Study of Mechanical Properties of Aluminium Based Hybrid Metal Matrix Composites”. International Of Modern Engineering Research (IJMER).

[5] S. Das, “Development of aluminium of alloy composites for engineering application”; Trans india inst. Met. Vol. 57, No. 4, August 2004, Pp 325-334.

[6] Revanasidappa M D , Venkatesh.K.C Naveen C R, “Mechanical and Wear Behaviour of Al6061-SiC-Gr Hybrid Composites”.

[7] Wang.Y.Q,Afsar.A.M.,Song.J.I., ”Tribiogical behaviour of al2o3-sic hybrid MMCs”; ICMAT, kaual lampur,2004, Pp. 836-839

[8] Farshad Akhlaghi, S. Mahdavi ,; “Effect of the SiC Content on the Tribological Properties of Hybrid Al/Gr/SiC Composites Processed by In Situ Powder Metallurgy (IPM) Method” 2011, Advanced Materials Research, 264-265, 1878.