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Investigation of Mechanical Behaviour of Al6061T6-SiC-B_4C Metal Matrix Composites by Using Stir Casting Process

Mr. R. Ramesh Babu[1], Mr. A. Chinnappan[2], Mr. P.Gobi[3], Mr.N.Gopinath[4], Mr. K. Naveenkumar[5]
[1]HOD/Assistant Professor, Mechanical Engineering, IndraGanesan College of Engineering, Tiruchirappalli, Tamilnadu, India.
[2,3,4,5]UG Students, Mechanical Engineering, IndraGanesan College of Engineering, Tiruchirappalli, Tamilnadu, India.

Abstract: Stir casting is an economical process for the fabrication of aluminum matrix composites. There are many parameters in this process which affect the mechanical properties of the composites. In this study,SiC, B_4C particles were used as reinforcement to fabricate. The different compositions in volume fraction were chosen namely 90%Al 8%Sic 2%B4c, 90%Al 5%Sic 5%B4c, 90%Al 3%Sic 7%B4c. Finally, the mechanical properties of the composites were Evaluate and their relation with the corresponding process parameters of the composites.

Keywords:Aluminium;Silicon carbide;Boron carbide; Reinforcement;Metal matrix composite; Stir casting process;Mechanical properties

1.INTRODUCTION

Metal matrix composites (MMCs) are those composites in which metals are taken as base or matrix materials and ceramics or organic compounds are used as reinforcements to enhance the properties of the composite as compared to the base metal. Nowadays, aluminum matrix composites(AMCs) and hybrid aluminum matrix composites (HAMCs) are most commonly used MMCs.

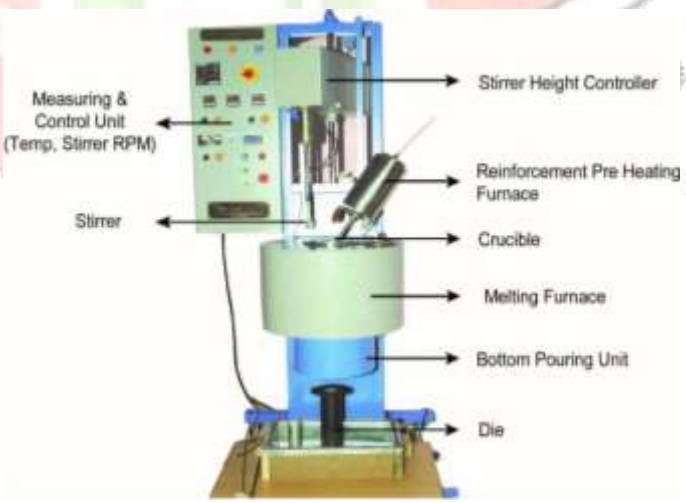

Fig 1: Stir casting machine

Aluminum matrix composites are those type of composites which contains aluminum or aluminum alloy as base material (matrix) and nonmetals as reinforcements. In case of hybrid aluminum matrix (HAMC) more than one reinforcements are added in aluminum matrix. Particles reinforced aluminum matrix composites are used in aerospace, automobile and structural application due very high strength to weight ratio, superior wear resistance, high stiffness, higher fatigue resistance controlled co-efficient of thermal expansion and better stability at elevated temperature, high thermal and electrical conductivity compared to conventional metals and alloys, which makes it suitable for design of an extensive range of components in advanced applications.

2.LITERATURE REVIEW

In the automotive industries aluminum alloys are frequently used because of lower density, light in weight. The other properties of aluminum alloys are that these are high in electrical and thermal conductivity and having good corrosion resistance, malleable in nature and formability is also good. The workability and inability of high performance Al alloys are horizontal to porosity due to gases dissolved during melting processes. The engineering application of pure aluminium and its alloys have occurred some problems like low strength, unstable mechanical properties etc. Hence by the modification of microstructure, mechanical properties of alloying, cold working, heat treatment and making composite by the addition of reinforcement can be improved. It will found that the effect of reinforcements on mechanical properties of base alloys.

Kandpal and Singh have proposed a method using stir casting technique in which fabricated aluminium alloy 6061 reinforced with different percentages of Al_2O_3 particles at wt. 5%, 10%, 15% and 20% was used.SEM techniques were used to study the microstructure of AMMC. It was found that with addition in wt. % of Al_2O_3, microhardness, tensile and compression strength is also increased.

Kumar et al. investigated mechanical properties of combination fly ash and aluminium alloy (Al6061).The stir casting used for processing the samples. The sizes of particle are 4-25, 45-50 and 75-100 μm having three sets of composites were used. The mechanical properties were studied in this research. Also for the same properties, the Unreinforced Al6061 samples were tested. By increasing the size of fly ash particle, decrease in mechanical properties of the aluminium alloy (Al6061) composite were found.

Verma et al. reviewed the effect of addition of various reinforcement in Al 6061 and Al7075 matrix alloys. It was found that stir casting is best technique for fabrication of metal matrix composite.

3.EXPERIMENTAL WORK

This chapter contains the details about materials and the experimental procedure that were considered for the fabrication of composite and the test procedure followed for testing the characterization of composites, respectively.In the present investigation,Al6061 T6-SiC-B_4C composites were manufactured by stir casting technique.

3.1.MATERIALS

Al6061-T6 is a precipitation hardening aluminium alloy, containing magnesium and silicon as its major alloying elements. It has good mechanical properties and exhibits good weld ability. It is one of the most common alloys of aluminium for general purpose use. Silicon carbide and Boron carbide are used as additives. Base material Aluminium 6061-T6 were bought in rods and are weighed as per the composition and are cut into small piece for the convenience of placing them inside the crucible are heated to 750 ^oC in an induction furnace for three to four hours. Reinforcing materials Silicon Carbide and Boron Carbide are also weighed separately as per the weight ratio and are preheated to 800 ^oC at a separate furnace for two to three to improve the wettability of the material.

3.2.PROPERTIES OFALUMINIUM 6061 T6 ALLOY

The T6 refers to the temper or degree of hardness, which is achieved by precipitation hardening. This grade has a good strength-to-weight ratio and is also heat-treatable. With great formability and weldability, it is used for engineering and structural applications, boats, furniture, and more.

Table 1: Properties of Al6061-T6 AlloyProperty Value

Atomic Number	13
Atomic Weight	26.98g/mol
Melting Point	615°C
Boiling Point	2480°C
Density	2.698 g/cm3
Modulus of Elasticity	68.3 GPa
Poisson's Ratio	0.33

Fig2: Aluminium 6061 -T6 Alloy plate

Table2: Chemical Composition Aluminium6061

Element	Minimum%	Maximum%
Magnesium	0.8	1.2
Silicon	0.4	0.8
Iron	No Min	0.7
Copper	0.15	0.4
Manganese	No Min	0.15
Chromium	0.04	0.35
Zinc	No Min	0.25
Titanium	No Min	0.15
Other Elements	No Min	0.05 each0.15 in total

Table3: Mechanical Properties of Aluminium6061.

Ultimate tensile strength (MPa)	124
Yield strength (MPa)	55.2
Property elongation (%)	25.0
Brinell hardness at 500g load BHN-10mm ball	30

3.3.PROPERTIES OF SILICON CARBIDE:

Silicon carbide (Sic) reinforced aluminium matrix composites showed maximumhardness andtensile strength. % of Silicon carbide (Sic) reinforcements in aluminium matrix composites. Pin-on-disc wear test indicated that reinforcing Al matrix with Silicon carbide (Sic) particles increased wear resistance.

Fig3: Silicon Carbide Powder

Typical silicon carbide characteristics include:

- Low density
- High strength
- Good high temperature strength (reaction bonded)
- Oxidation resistance (reaction bonded)
- Excellent thermal shock resistance
- High hardness and wear resistance
- Low thermal expansion and high thermal conductivity.

3.4.PROPERTIES OF BORON CARBIDE:

Boron carbide is a compound that contains boron and carbon, especially B4C; an extremely hard, non-metallic, black crystalline compound or solid solution. Only diamond is harder. In addition to its hardness property, boron carbide has the physical properties of corrosion resistance, heat strength, low specific gravity and high elastic modulus. It is used as an abrasive, neutron absorber for nuclear reactors, and as an alloying agent in composite structural materials.

Fig4: Boron Carbide Powder

Typical boron carbide characteristics include:

- Extreme hardness
- Difficult to sinter to high relative densities without the use of Sinteringaids
- Good chemical resistance
- Good nuclear properties
- Low density.

3.5.ALUMINIUM METAL MATRIX COMPOSITES:

A metal matrix composites (MMC) is a composite in which two or more reinforced materials are added to the metal matrix in order to improve the properties of the composite.Aluminium metal matrix composites (AMMC) are the composites in which aluminium is used as the matrix and several reinforced materials are embedded into the matrix. Present work of the reinforced materials are silicon carbide, boron carbide to making aluminium matrix composites.

Table 4: Composition of proposed metal matrix composite (MMC) for different specimens.

Specimens	Aluminium(Al)	Silicon carbide(Sic)	Boron carbide(B_4C)
1	90%	8%	2%
2	90%	5%	5%
3	90%	3%	7%

Materials for Preparing the Metal Matrix Composite:

In the present work, Al6061 has been chosen as the matrix material for preparing the metal matrix composite as it finds enormous application in the construction, automotive, marine, etc. industries due to characteristics such as moderate strength, good corrosion resistance, and toughness compared to other aluminum alloys.

Stir Casting Process:

In conventional stir casting method, reinforced particulate is mixed into the aluminium melt by mechanical stirring. Mechanical stirring is the most important element of this process. After the mechanical mixing, the molten metal is directly transferred to a shaped mould prior to complete solidification. The essential thing is to create the good wetting between particulate reinforcement and aluminium melt. The distribution of the reinforcement in the final solid depends on the wetting condition of the reinforcement with the melt, relative density, rate of solidification etc.

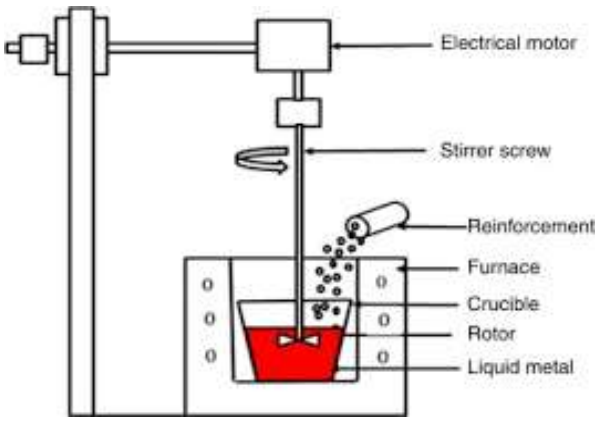

Fig5: Stir casting process

TESTING OF COMPOSITES:

Measurement of Mechanical Properties:

In order to explore the mechanical characterization of the developed Al6061 metal matrix composites, various mechanical tests have been conducted and are discussed below.

TENSILE TEST:

The materials used for engineering applications are usually selected on the basis of their properties, such as ultimate tensile strength, yield strength, and modulus of elasticity. The tensile test is the most common method for determining these mechanical properties. In the present work, a tensile test was conducted on a universal testing machine (UTM) and the developed composite specimens 1, 2, and 3 were prepared as per ASTM standards.

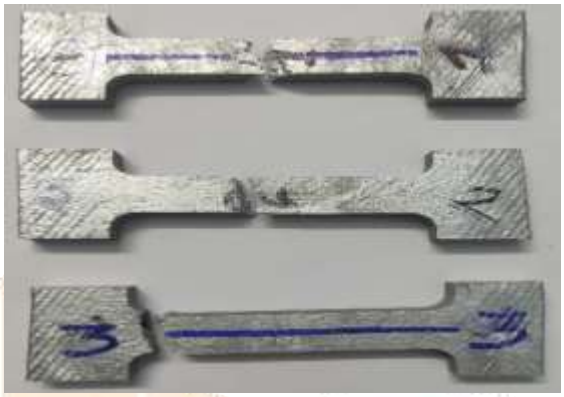

Fig6: Tensile test specimens

Table5: Tensile test specimen reading

Parameters	Specimen-1	Specimen-2	Specimen-3
Ultimate Tensile Strength(N/mm^2)	156.96	149.05	146.95
Yield Strength(N/mm^2)	93.11	73.15	76.25
% Of Elongation	8.87	7.50	3.17

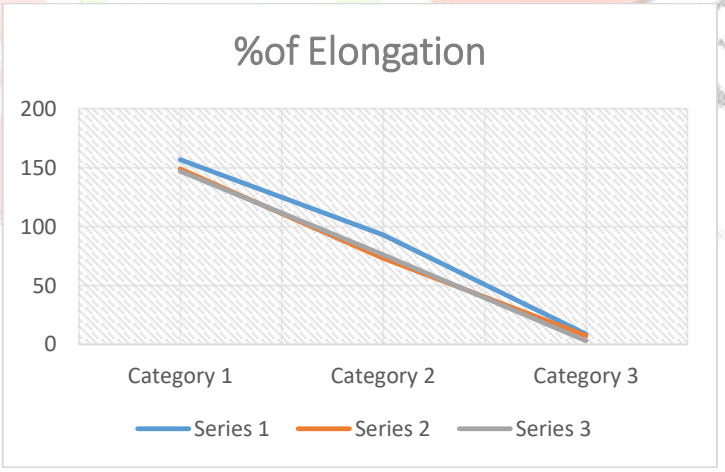

Fig7: Tensile test specimen reading

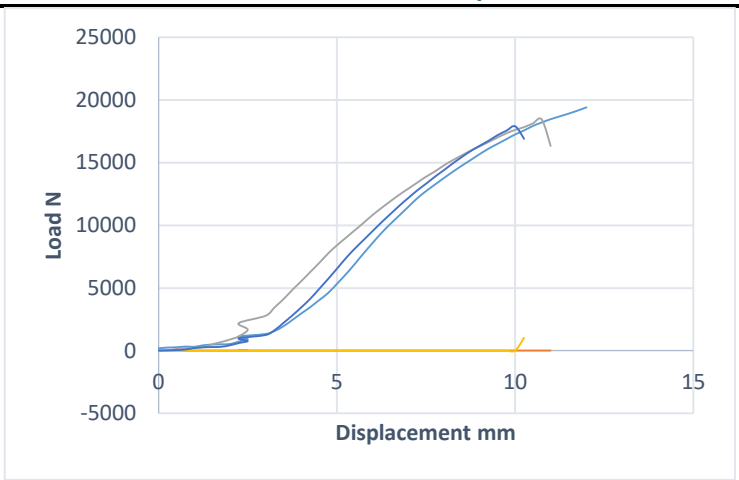

Fig8: Load/displacement chart

HARDNESS TEST:

In the present work, a Brinell hardness tester with an indenter diameter of 5 mm was used to determine the hardness of the specimens A, B, and C of the hybrid composite. A load of 5 kN was applied for 30 seconds on each specimen. The Brinell hardness number (BHN) was calculated by dividing the load applied by the surface area of the indentation. The BHN values obtained for the specimens 1, 2, and 3 were 56.86,49.5, and 51.70 respectively.

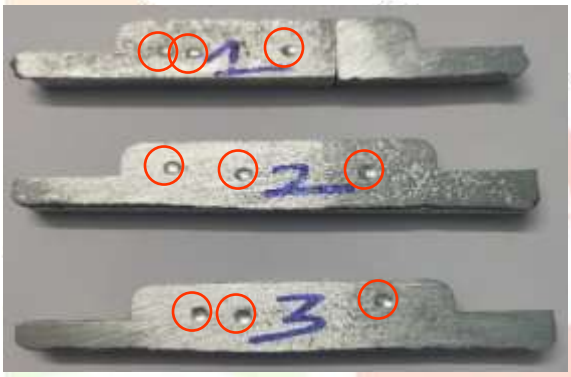

Fig9: Hardness test specimens

Table6: Hardness test reading

Sample Specimens	Trial-1	Trial-2	Trial-3	Average values
1	53.4	58.6	58.6	56.86
2	49.1	49.1	50.3	49.50
3	50.9	52.1	52.1	51.70

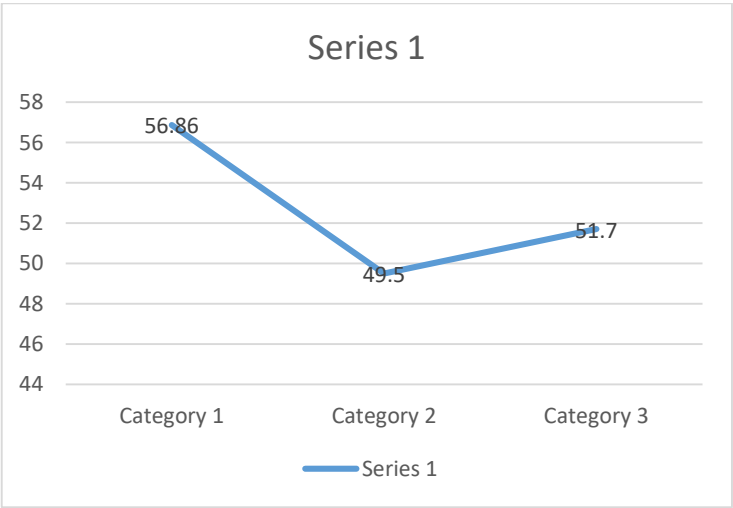

Fig10: Hardness test chart

IMPACT TEST:

The ability of a material to absorb energy before an actual fracture occurs is known as its impact strength. The impact strength of the specimens A, B, and C of the hybrid composite was tested using a standard impact testing machine. The Izod test is carried out by a pendulum-type testing machine which employs a cantilever specimen of 75 mm long and a 10 mm _ 10 mm cross-section having a standard 45_ notch 2 mm deep.

Fig11:Impact test specimens

Table7: Impact test reading

Sample Specimens	Observed values in joules
1	20
2	12
3	10

CONCLUSION:

Al6061 based ceramics reinforced metal matrix composites have been successfully fabricated using stir casting machine with different types of ceramic particulates. Three different composite material with above corresponding ratio will be manufactured and their mechanical properties will be noted with the aid of tensile test, hardness test, toughness test. The technical difficulties associated with attaining a uniform distribution of reinforcement, good wettability between substances, and a low porosity material are presented and discussed. Thus the different compositions in volume fraction namely 90% Al 8%SiC 2%B_4C,90%Al 5%SiC 5%B_4C,90%Al 3%SiC 7%B_4C with above corresponding ratio has been manufactured and their mechanical properties were noted and discussed with the aid of tensile test, hardness test, impact test. In this project work the samples are 90%Al 8%SiC 2%B_4C is reported to be the highest performing sample in tensile test, hardness test and impact test.

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