DESIGN AND FABRICATION OF ALUMINIUM METAL MATRIX COMPOSITES BY USING STIR CASTING METHOD

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Abstract: Now a days with the modern development, need of advanced engineering materials for various engineering applications goes on increasing. To meet such demands metal matrix composite is one of the reliable sources. Aluminum matrix composites (AMCs) are potential materials for various applications due to their good physical and mechanical properties. So, this project deals with the design and fabrication of Aluminium matrix composite by reinforcing with Aluminium oxide (Al_2O_3) using Stir casting method**.** The scope of this project is to produce Aluminium matrix composites with low cost which may be the replacement of copper and steel alloys.

***Index Terms*–Aluminium matrix composites (AMCs) , Stir casting.**

I. INTRODUCTION

The engineering fraternity has always been on the lookout for wonder-materials which would fit the bills for all types of service conditions. It stem from the need to make progressive discoveries made by scientists, affordable. This affordability quotient has persuaded many researchers to develop such materials which would satisfy various hitherto unexplored conditions. In today’s world almost all generic materials have been tried for various uses and their limitations have been met. But the never ending quest of civilization requires that materials qualify for harsher environments. This unavoidable situation demands that new materials be created from various combinations of other compatible materials. It is to be noted here that this method is not new; it has been with mankind since ages. In every part of the world, various materials have been combined to achieve some intended properties, albeit each case differs from the others, i.e. one can create new materials with unique properties, which can be tailor-made and are different from their base ingredients. This concept holds true for a genre of materials called Composite materials where in, various types of matrices may be combined with reinforcements which contribute to the enhancement of the properties.

II. EXPERIMENTAL DETAILS

The casting unit consists of a graphite crucible of about 5kg capacity, which is heated by electrical resistance type heating coils. The temperature level of the heating unit is controlled by thermocouple activated controlling unit. Duration of heating is determined based on the quantity of material to be melted.

The furnace used in the present work is of bottom pouring type, which is regulated using a valve operated from the bottom. A motor operated stirrer is provided at the top, for mixing the particulate reinforcement with the molten metal. Arrangement is made at the bottom of the crucible for exact positioning of the mould below the valve as shown in Fig 2.1

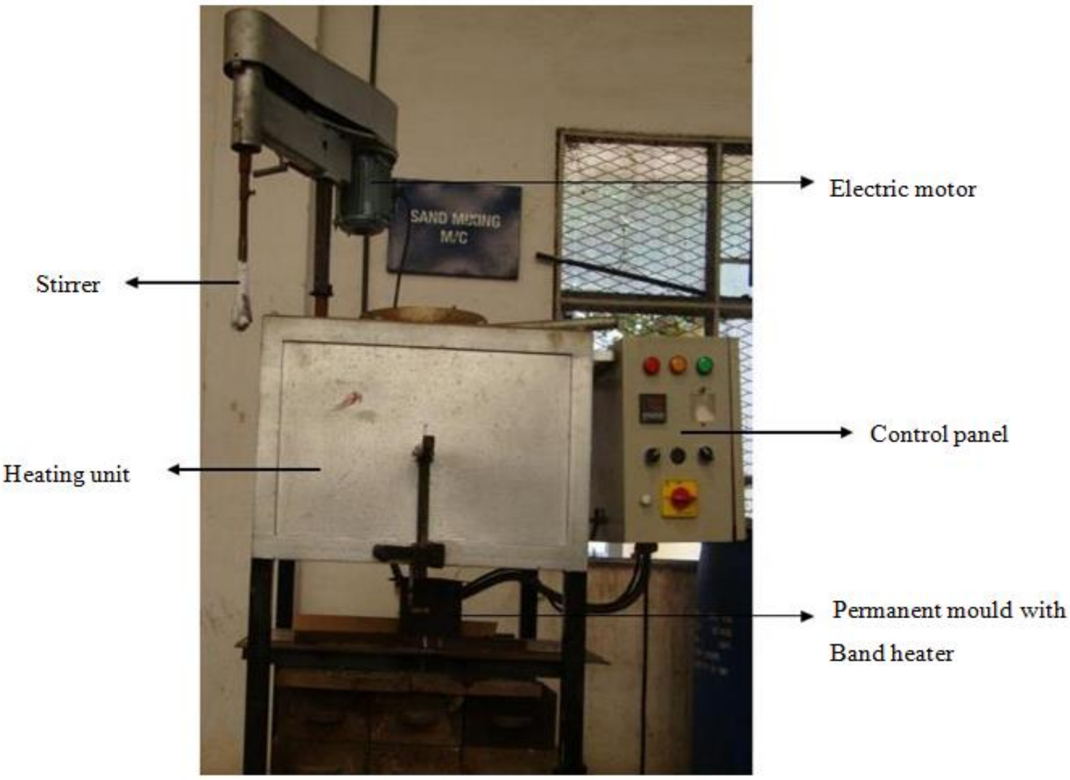


Fig 2.1: Electric Heating Furnace

a) Permanent mould box details:

Split mould **Mould assembly**

Fig 2.2: Permanent spilt mould

b) Mechanical stirrer:

The mechanical stirrer used for stirring the molten alloy during fabrication of composites is made of steel blades coated with Alumina powder and sodium silicate mixture to withstand high temperature and to avoid iron pickup by the melting.

Fig 2.3: Alumina- sodium silicate powder coated stirrer

Ceramic-coated impeller can be immersed up to ¾ of molten metal from top and rotated at a speed of about 800 rpm to create the vortex. Fig 2.3 shows the Al_2O_3 coated stirrer

2.1Procedure to Fabricate Composites:

Cleaned A356 ingot (Fig 2.4) of required quantity is to be placed in the melting crucible. The furnace top is to be closed by refractory material and heater is to be switched on and set to the required temperature (900^0C). Heating is to be continued for about 2 hrs and stabilize it for 20 minutes after reaching 900^0C

- The Al_2O_3 reinforcement particulates of about 23 microns size are to be heated to 450^0C for about 1 hr in another closed furnace.
- Add the Slag remover (fig2.5) to the molten metal to remove the slag.
- Chlorine based solid degassing tablet hexachloroethane – C_2Cl_6 Tablet (fig2.6) is to be added to remove gasses entrapped during melting point.
- Magnesium of about 0.5% is to be added to the melt to improve the wet ability. Stirrer is to be immersed up to ¾ of the molten metal and stirring action to be carried for about 2 minutes while heated Al_2O_3 material is to be added slowly.
- Heat the mixture for 15 min after stirring.
- After stirring the molten composite metal is poured into pre heated mould by opening the bottom valve of the furnace.
- After allowing the mould to cool at room temperature, the cast material (fig2.7) is taken out, by opening the mould halves.
- Aluminium alloy specimens as well as Aluminium metal matrix composites with Al_2O_3 reinforcement of 15% by weight were cast, by the above mentioned procedure.

Fig 2.6 ingot material **Fig 2.5 Slag remover**

Fig 2.4 Al raw ingot

Fig 2.6: Degasser hexachloroethane C_2Cl_6 tablet

Fig 2.7: Cast Aluminium composites

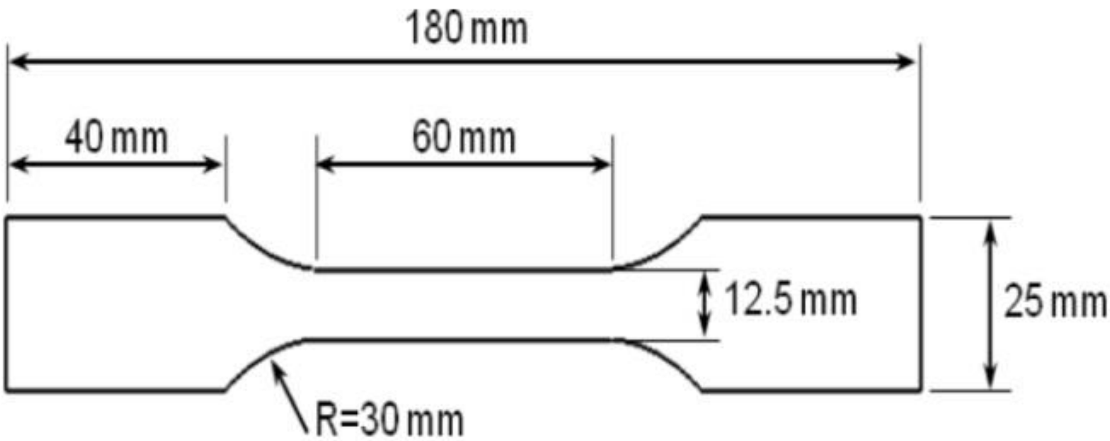
2.2MEASUREMENT OF TENSILE STRENGTH

Tensile testing machine

The tensile tests were conducted using standard computerized Universal Testing Machine. The machine is of 20 KN capacities with a loading rate of 0.02 mm/sec. The equipment is best suited for tensile, compression, and Shear, Flexural properties of different materials.

The tensile test was performed in accordance with ASTM–B557 for standard Aluminium alloy. From the tensile strength tests, the effect of reinforcement on the tensile strength and ductility of composite materials can be studied. Shows the tensile testing machine and fig.2.8 how the specimen geometry as per ASTM B557 Standard is.

Fig 2.8 Tensile testing machine



specimen B557 standard, all dimensions are in mm ASTM

Fig2.9. Tensile Specimen

III.RESULTS AND DISCUSSION

3.1 MECHANICAL CHARACTERIZATION

3.1.1 HARDNESS

Brinell hardness number

Fig 3.1 Brinell hardness testing machine

Aluminium alloy load (P) = 100 kgf

Indenter size (D) = 1/16 inch ball = 1.5875 mm

Indentation size (d) = 1.1 mm

Brinell hardness number (BHN) = $2P/\pi D\,(D-(D^2-d^2)^{1/2}$

= 90.381 kgf/mm^2

Specimen	Brinell Hardness Number(BHN)
Al-Sic composite at 15% weight	58.7
Al-Al_2O_3 composite at15% weight	90.381

Table 3.1 BHN values

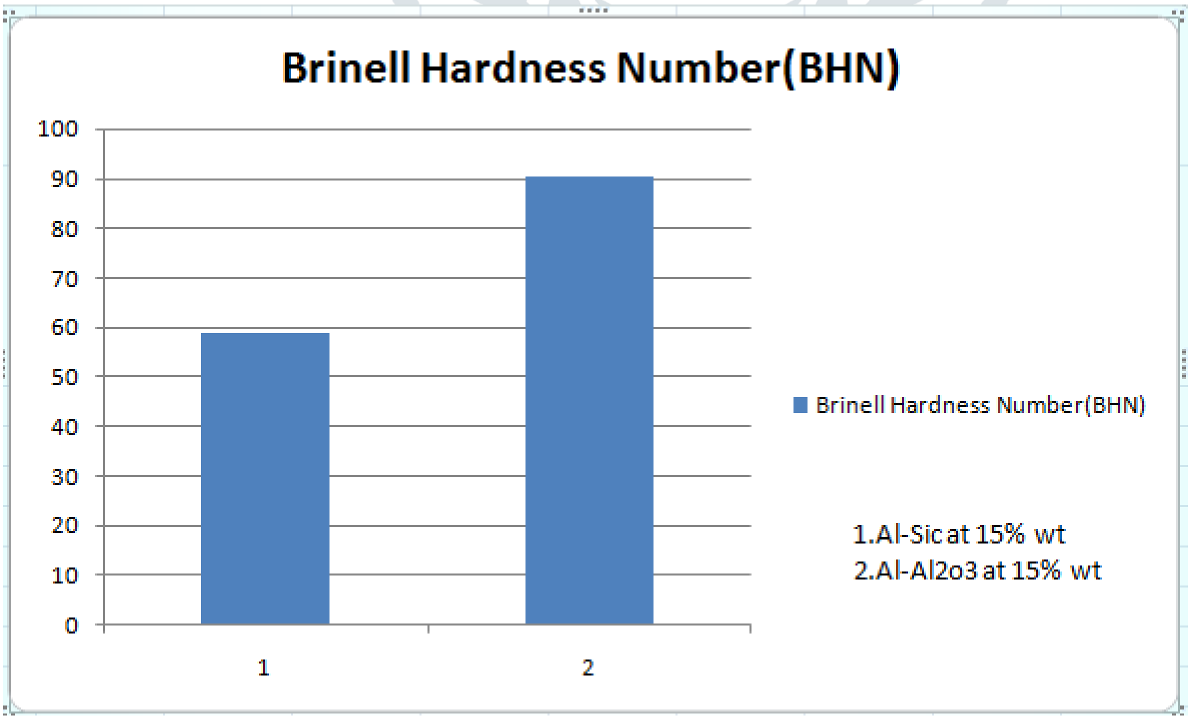


Fig 3.1 BHN comparison graph

It can be observed from the results that there is an increasing trend in the hardness values of the composites when compared with other aluminium reinforcements. The increase in hardness can be attributed to the uniform distribution of SiC particulate reinforcement in A356 matrix, forming strong interfacial bond between the matrix and the reinforcement.

3.2.1 TENSILE STRENGTH

Tensile load (P) = 12KN

Diameter (D) = 12.5mm

Area (A) = $\pi/4(D)^2$ = 122.7184 mm^2

Ultimate Tensile strength (σ_u) = P/A = 97.784 MPa

Specimen	UTS(MPa)
Al-Sic at 15% weight	55.8
Al-Al_2O_3	97.78

Table 3.2 UTS values

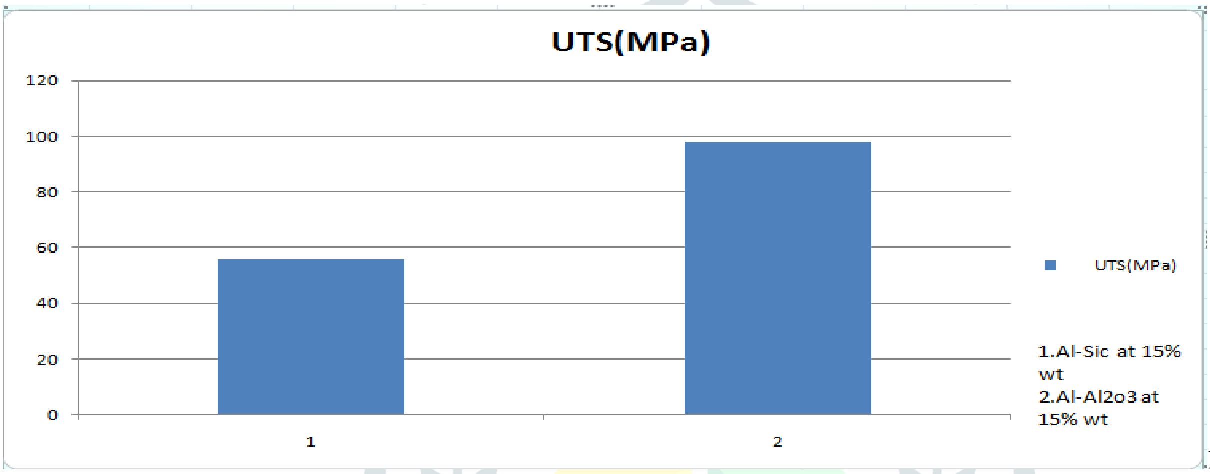


Fig 3. 2 show the Ultimate tensile strength of Al-Sic and Al-Al_2O_3 as cast specimens with 15% reinforcement respectively.

Impact Energy

Fig 3.2 Impact strength testing machine

Specifications of specimen:

Length of the specimen = 75 mm

Thickness of the specimen = 10 mm

Impact energy = 38 Joules

Fig 3.3 Impact specimen

Specimen	Impact energy in joules
Al-sic at 15% weight	61
Al-Al_2O_3	58

Table 3.3 impact energy values

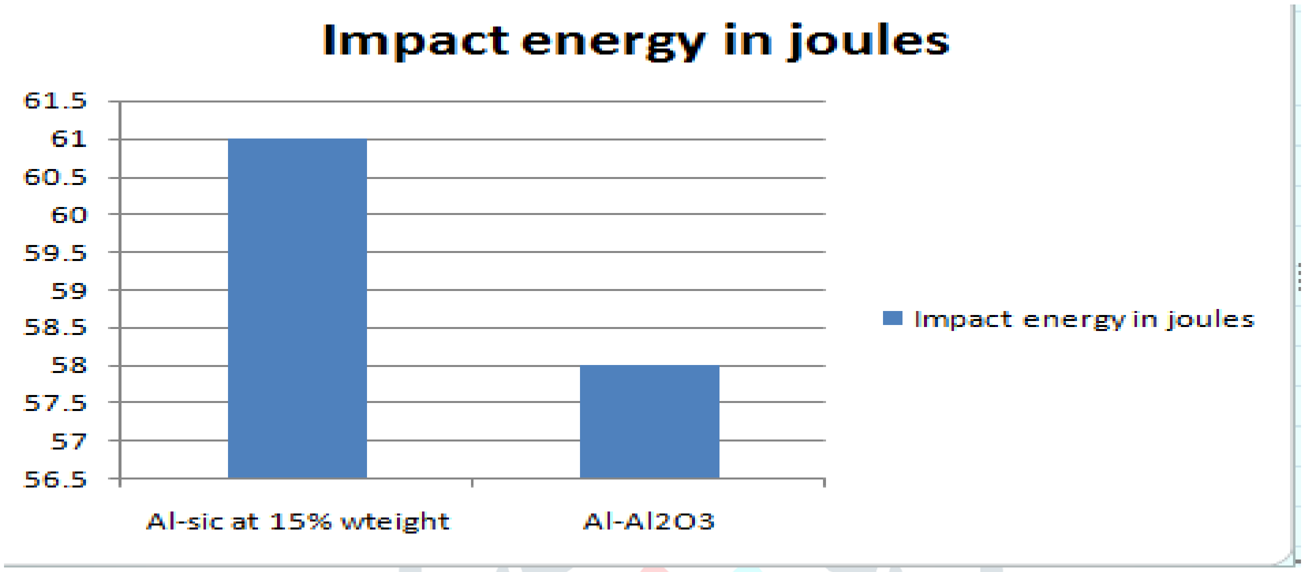


Fig 3.3 Impact energy comparison graphs

IV.Conclusion

Experimental investigations conducted in the present work to study the influence of percentage composition of Al_2O_3 particulates in A356 Aluminium matrix alloy on the microstructural, mechanical and fatigue characteristics have provided the following conclusions.

- SEM analysis shows that the Al_2O_3 particles are evenly distributed.
- An improvement of about 53.97% in hardness of composite specimen is observed as compared to Al-Sic specimen.
- An improvement of about 75.23% in tensile strength of composite specimen is observed as compared to AL-Sic specimen.
- A decrement of 4.915% in impact energy of composite specimen is observed as compared to Al-Sic specimen.

V.References

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