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Experimental Evaluation of The Mechanical Properties Of Aluminium 6061-B_4c-Sic Composite

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Abstract— ***Metal matrix composite (MMC) focuses primarily on improved specific strength, high temperature and wear resistance application. From the collected literature it is found that, metal matrix composites are under serious consideration as potential candidate materials and it is mainly used to replace conventional materials in aerospace and automotive applications. So, the MMC are highly used in automotive and space applications. And the Aluminium Matrix Composite is a material with two constituent parts, one being a metal, and other being reinforcement. The aluminium matrix can be strengthened by reinforcing with hard ceramic particles like SiC, Al_2O_3, B_4C etc. In this project, aluminium 6061 alloy is chosen as one of constituent parts, which has good mechanical properties and exhibits good weldability. The mechanical properties like tensile strength and Hardness can be increased by reinforcing 6061Al matrix with Boron Carbide (B_4C) and Silicon carbide (SiC) particles. In this project, the fabrication of aluminium 6061 with boron carbide and aluminium 6061 with silicon carbide is done by stir casting process, which is a liquid state material fabrication and cost effective method. Then, the samples are tested for mechanical properties like tensile, hardness, impact, flexural. Finally the Scanning Electron Microscope (SEM) analysis is done, which helps to study topography of composites and it produces images of a sample by scanning it with a focused beam of electrons.***

Keywords— Metal Matrix composite, Aluminium 6061, Boron Carbide, Silicon Carbide, StirCasting.

I. Introduction

The metal matrix composites (MMCs), like all other composites consist of at least two chemically and physically distinct phases, suitably distributed to provide properties not obtainable with either of the individual phases. For many researches the term MMCs is often equated with the term light metal matrix composites. Substantial progress in the development of light metal matrix composites has been achieved in recent decades, so that they could be introduced into the most important applications. Aluminum matrix composites (AMCs) are the competent material in the industrial world. Due to its excellent mechanical properties, it is widely used in aerospace, automobiles, marine etc. [1].

The aluminum matrix is getting strengthened when it is reinforced with the hard ceramic particles like SiC, Al_2O_3, and B_4C etc. Aluminium alloys are still the subjects of intense studies, as their low density gives additional advantages in several applications. These alloys have started to replace cast iron and bronze to manufacture wear resistance parts. MMCs reinforced with particles tend to offer enhancement of properties processed by conventional routes. 6061Al is widely used in numerous engineering applications including transport and construction where superior mechanical properties such as tensile strength, hardness etc., are essentially required [2].

6061Al is quite a popular choice as a matrix material to prepare MMCs owing to its better formability characteristics. Among different kinds of the recently developed composites, particle reinforced metal matrix composites and in particular aluminium base materials have already emerged as candidates for industrial applications. Boron Carbide particulate reinforced aluminium composites possess a unique combination of high specific strength, high elastic modulus, good wear resistance and good thermal stability than the corresponding non-reinforced matrix alloy system.

A limited research work has been reported on AMCs reinforced with B_4C due to higher raw material cost and poor wetting. B_4C is a robust material having excellent chemical and thermal stability, high hardness (HV = 30 GPa), and low density (2.52 g/cm3) and it is used for manufacturing bullet proof vests, armor tank etc. Hence, B4C reinforced aluminum matrix composite has gained more attraction with low cost casting route [3, 6].

II. EXPERIMENTAL DETAILS

The following section highlights the material, its properties and methods of composite preparation and testing.

Materials Used

The matrix material for present study is Al6061. Table.1 gives the chemical composition of Al6061. The reinforcing material selected is B_4C of particle sizes 37, 44, 63,105 and 250 μ m.

Elements	Si	Fe	Cu	Mn	Ni	Pb
Percentage	0.43	0.7	0.24	0.139	0.05	0.24

Table 1: Chemical Composition of Al6061 by Wt%

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Fabrication Process

The liquid metallurgy route (stir casting technique) was adopted to prepare the cast composites as described below. A batch of 200g of 6061Al was melted to 750°C in a graphite crucible using resistance furnace. The melt was agitated with the help of stirrer to form a fine vortex. 3g of degassing tablet (C2Cl6 – solid hexachloro ethane) was added to the vortex and slag was removed from the molten metal.

At the temperature of 800°C the preheated B4C particles of 8vol.wt% was added into the vortex with mechanical stirring at 300rpm for 5mins. Before pouring the molten metal to mould, 2g of cover flux (NaCl 45% + KCl 45% + NaF 10%) was added to the molten metal to reduce the atmospheric contamination.

The molten metal at a temperature of 850˚C was then poured into mould preheated to 300˚C and allowed to solidify. The AMCs having different particle sizes (37, 44, 63, 105 and 250µ) and particle size of 105µ with different weight percentage (6, 8, 10 and 12wt %) of B_4C were fabricated by the same procedure.

Microstructure and Testing

To study the microstructure of the specimens were cut and prepared as per the standard metallographic procedure. The specimen surfaces were prepared by grinding through 600 to 1000 mesh size grit papers. Velvet cloth polishing is done for the specimen to get fine surface finish.

After that the specimens were etched using Keller's reagent (HCl+HF+HNO3). The microstructures of etched specimens were observed using optical microscope.

The hardness was measured at different locations. The micro-hardness of polished samples was measured using Zwick/Roell Vickers hardness tester at a load of 50g for 10s.The tensile specimens were prepared as per ASTM E8M standard.

Tensile specimens before and after test of different particle sizes and different wt% of reinforcement are shown in Figure.1 and Figure.2 respectively. The ultimate tensile strength was estimated using computerized uni-axial tensile testing machine.

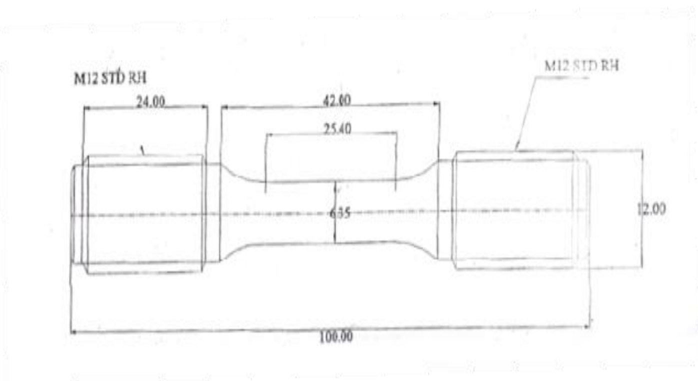

Figure 1: Dimension of Tensile Specimen

III. RESULTS AND DISCUSSIONS

Evaluation of Microstructure

Aluminium reinforced with B_4C particulate composites are successfully fabricated by stir casting process. The optical micrographs of the fabricated AMCs with different particle sizes of B4C and different wt% of reinforcement of 105µ size are shown in Figure.2 & Figure.3 respectively.

It is observed from the figure that B_4C particles are dispersed uniformly in the aluminium matrix for all particle sizes and for all wt%. This can be attributed to the effective stirring action and the use of appropriate process parameters. XRD analysis confirms the presence of B_4C reinforcement within the matrix.

Evaluation of Mechanical Properties

Hardness Test Results

It was observed from Figure.4 and Figure.5 that, the micro-hardness of AMCs has increased with increase in both particle size and wt% of reinforcement. Addition of reinforcement particles in the melt provides additional substrate for the solidification to trigger there by increasing the nucleation rate and decreasing the grain size.

The micro vicker's hardness of AMCs was found to be maximum (129 VHN) for the particle size of 250µ . There is 72% increased in hardness compared to the base alloy, and for the wt% hardness was found to be maximum (121.33VHN) for 12wt%, there is 76% increased in hardness compared to the base alloy. The presence of such hard surface area of particles offers more resistance to plastic deformation which leads to increase in the hardness of composites.

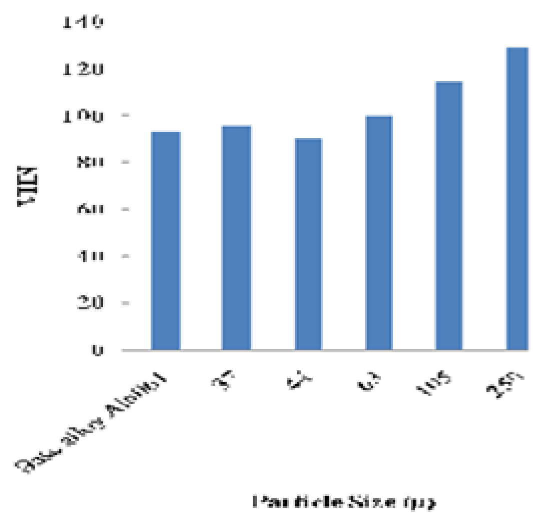

Figure 4: The Effect of the Particle Size of B_4C Particulates on the Hardness of Stir Cast Amcs

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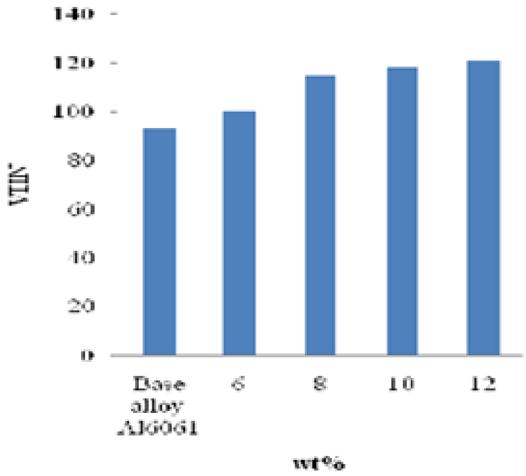

Figure 5: The Effect of Wt% of B_4C Particulates on the Hardness of Stir Cast Amcs

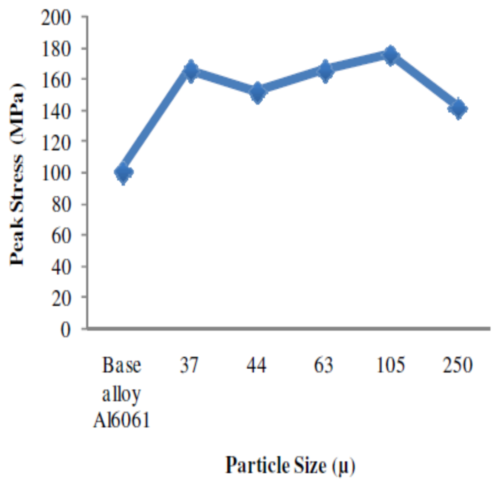

Figure 6: The Effect of the Particle Size of B4C Particulates on the Peak Stress of Stir Cast AMCs

Tensile Test Results

The mechanical properties of matrix alloy Al6061 has improved on B4C incorporation. Figure.6 and Figure.7 shows the relation between tensile strength of the fabricated composites and B4C of different particle size and varying wt% respectively. It can be inferred that B_4C particles are very effective in improving the tensile strength of the composite. The tensile strength of AMCs increases with increase in particle size. The tensile strength of AMCs was found to be maximum (176.37 MPa) for the particle size of 105µ .

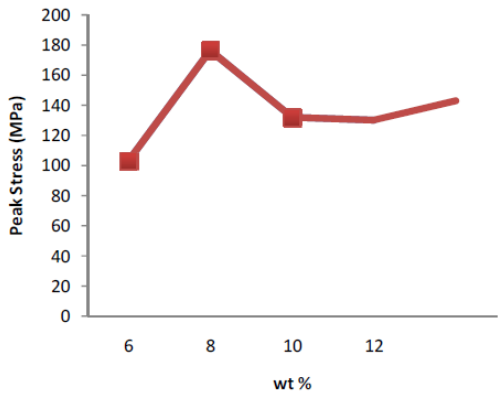

Figure 7: The Effect of Amount of B4C Particulates on the Peak Stress of Stir Cast AMCs

But in varying wt% case the tensile strength increased up to 8wt% and then decreased gradually with the increase in wt% of reinforcement. The addition of B_4C particles in the matrix induces more strength to matrix alloy by offering more resistance to tensile stresses. Increase in the strength is due to the increase in hardness of the composite.

IV. CONCLUSIONS

The Al-B_4C composites were produced by stir cast route with different particle size (Viz 37µ , 44µ , 63µ , 105µ , 250µ) of reinforcement and the microstructure, mechanical properties are evaluated. From the study, the following conclusions are derived.

- Production of Al-B_4C composites was completed successfully.
- The Optical micrographic study and XRD analysis revealed the presence of B4C particles in the composite with homogeneous dispersion.
- The micro vicker's hardness of AMCs was found to be maximum for the particle size of 250µ and found maximum for 12 wt% in case of varying wt% of the reinforcement of 105µ size.
- The tensile strength of AMCs was found to be maximum for the particle size of 105µ and found maximum for 8 wt% in case of varying wt% of the reinforcement of 105µ size.

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