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INVESTIGATIONAL EXPLORATION OF MECHANICAL BEHAVIOUR OF ALUMINIUM BASED COMPOSITES

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ABSTRACT

Owing to their superior strength and resistance aluminum based metal matrix composites are widely used in automobile industries. Due to easier control of matrix structure, low cost of processing,the composite is prepared by using Liquid Metallurgy Route.In the present study, an Al 7075 alloy is used as the matrix with varying weight percentage of Boron Carbide particulate as the reinforcing material. Uniform distribution of reinforcement within the matrix is achallengeable task, which affects directly on the properties and quality of composite material. In this report a critical survey of various mechanical properties of the fabricated specimen with different weight percentage were analyzed. The mechanical tests report reveals that there is an increase in hardness and tensile strength of the developed composites than the base metal alloy.

Keywords: Reinforcement, hardness, metal matrix composites, weight percentage, casting.

Introduction

A composite composed of a combination of two or more micro or macroconstituents that diverge in form, chemical composition and which are basicallyunsolvable [1]. Reinforcing phase is rooted in the matrixto give the preferred characteristic [2]. Metal matrix composites are increasingly becoming smart materials foradvanced aerospace applications and their properties can be personalizedthrough the addition of reinforcement [3-4]. Among the various matrix materials available, aluminium and its alloys are widely used in fabrication of MMCs[5].The various hard and soft reinforcements like SiC, Al_2O_3, Zircon, Graphite ,Boron carbide, Mica were used [6]. Boron carbide particulates, , low density material particulate MMCs produced represents a variety of engineeringapplications such as automotive components [7].Aluminium matrix composites containing Boron carbide particles have the potential forlight weight tribocomponents. Investigation of mechanical behaviour of aluminium alloys reinforced with Boron carbide is an interesting area of research. The adding up of high potency, high modulus

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refractory particles such as SiC, TiC, B_4C, Al_2O_3, MgO, TiO_2, etc. to a ductile metal matrix produce a material whose mechanical properties are intermediate between the matrix alloy and the ceramic reinforcements [8]. In current years, particulate reinforced metal matrix composites have attracted considerable attention due to their cost-effectiveness, isotropic properties, and their ability to be processed [9,10]. Particulate rein forced Aluminiu composites can be processed more easily by the liquid state. Stir casting is an attractive processing method since it is rather inexpensive and offers a wide selection of materials and dealing out conditions [11,12].Therefore, the aim of this study is to investigate the effect of Boron Carbide content on the hardness, tensile strength and tribologicalbehavior of Al7075- varying wt. % of B_4C (5%,10%,15%) composites, made by stir casting method.

2. EXPERIMENTAL INVESTIGATION AND PROCESS METHODOLOGY

Material and Sample Details

Due to high strength, low density, thermal properties and ability to be highly polished, 7075 is widely used in mold tool manufacture. The 7xxx series aluminium alloy have good wear resistance with added reinforced particulates. B_4C is an effective reinforcement material because of its good chemical and thermal stability. B_4C has lower density and higher hardness compared to Al_2O_3[13–16].Mechanical tests were performed on B4C particulates reinforced with Al 7075 matrix composite**.** Table 1 shows the nominal composition weight percentage of matrix materials Al7075. The range of reinforcement materials B_4C are 10-20 μm. The value of density for matrix and reinforcement materials are diminutive and hence resullts in uniform mixing. The samples were in the form of circular rod 10mm diameter and 30mm height fabricated by stir cast techniques.

Processing Methodology

Stir casting technique is one of popular LMR method and also known as a very promising route for manufacturing near net shape hybrid metal matrix composite components at a normal cost.This stirrer was connected to 1HP DC Motor through flexible link and was used to stir the molten metal in semisolid state. The screw operator lift is used to bring the stirrer in contact with the composite material. The melt was maintained at a temperature between 700°C to 715°C for one hour. Vortex was created by using a mechanical stirrer. Weighed quantity of B_4C (5, 10 and 15 wt%) were added to the melt with constant stirring for about 10 min at 500 to 650 rpm. After complete addition of the particles to the melt, the composite alloy was tilt poured into the preheated (300°C) permanent steel mould and allowed to cool in atmospheric air. The billet was then removed from the mould and machined for required dimensions. The execution of stir casting technique yields relatively homogenous and fine microstructure which improves the addition of reinforcement material in the molten metal. In addition, the porosity level of composite should be minimized and the chemical reaction between reinforcement and matrix should be avoided.The experimental set up was as shown in figure 1.The tensile strength for the fabricated composite Al7075

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alloy is measured through the universal testing machine. This tensile test is carried out as per the ASTM EO8-8 standard. 10 KN is considered as the applied load to carry out the tensile test and evaluate at cross head speed of 2 m/min. The universal testing machine is used to carry out the compression test according to the ASTM E9-09 standards. The composite material Al7075 samples are compressed and the compressive value for the samples are noted and graphs are plotted. The fundamental behavior ofsamples were studied when the samples are subjected to crushed or compressed by compressive test. The hardness value for the matrix alloy are calculated using the Micro Vickers hardness testing machine. This test is performed on the polished samples of composites according to the ASTM E10-07 standards. Vicker hardness test at load of 0.5Kg load for the interval of 10s was carried out on the composite samples. Various indentations at a gap of 1mm has been made and the average of hardness readings has been taken as hardness value. The hardness value for the matrix alloy are calculated using the Micro Vickers hardness testing machine. This test is performed on the polished samples of composites according to the ASTM E10- 07 standards. Vicker hardness test at load of 0.5Kg load for the interval of 10s was carried out on the composite samples. Various indentations at a gap of 1mm has been made and the average of hardness readings has been taken as hardness value.

Fig 1 Stir casting Setup

3 .Results and Discussion

3.1Tensile Test

It is apparent that tensile strength of composites containing 15 wt% B_4C particulates is superior when compared to other two composites.

improve the tensile strength of composite. The presence of B_4C particles in aluminum matrix during deformation causes the boundary to crack and debondingsince the matrix undergoes plastic gush

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while the particles do not deform. Fig 1 shows the variation of Tensile strength.The ductility of the Al alloy-based composites, quantified in requisites of tensile elongation, decreased with an increase inB_4C particle size. The accumulation of B_4Cparticles into composites increased the tensile strength.

Compression Test

A compression test is a method for decisive the activities of materials under a compressive load. Compression tests are conducted by loading the test specimen among two plates, andapplying a force by moving the crossheads simultaneously. Fig 2 shows the variation of compressive strength. During the test, the specimen is compressed, and deformation versus the applied load is recorded. The compression test is used to determine elastic limit, proportional limit, yield point, yieldstrength, compressive strength. As deformation occurs, internal intermolecular forces arise that oppose the applied force. If the applied force is not too great these forces may be sufficient to completely resist the applied force and allow the object to assume a new equilibrium state and to return to its original state when the load is removed. A larger applied force may lead to a permanent deformation of the object or even to its structural failure.

Hardness Evaluation

A significant increase in hardness of the alloy matrix was seen with the addition of SiC particles. This indicated that the existence of particulates in the matrix improved the overall hardness of the composites. This is due to the fact that aluminum is a soft material and the reinforced particles being hard, contribute positively to the hardness of the composites. The presence of stiffer and harder B_4C reinforcement leads to the increase in resistance to plastic deformation of the matrix. Fig 3 shows the hardness evaluation.

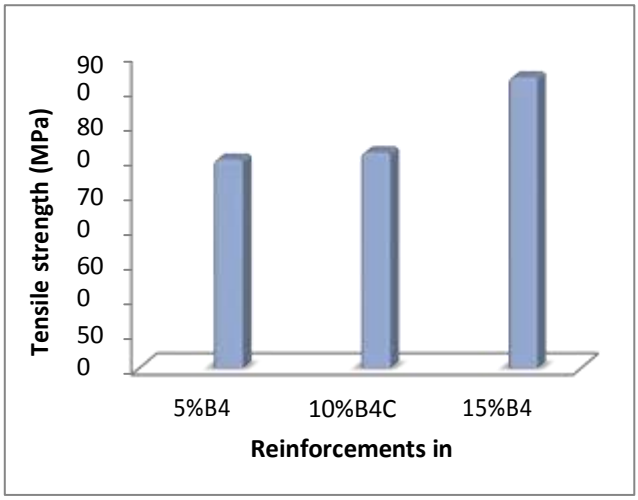

Fig.2. Ultimate Tensile strength of Al7075 composite alloy

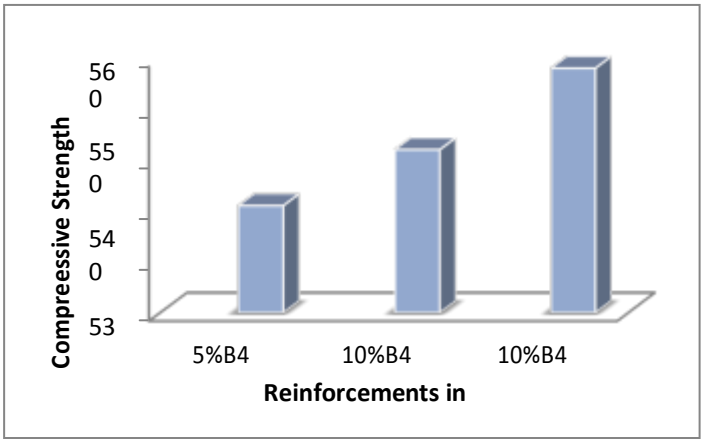

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Fig 3. Ultimate Compressive strength of Al7075 composite alloy

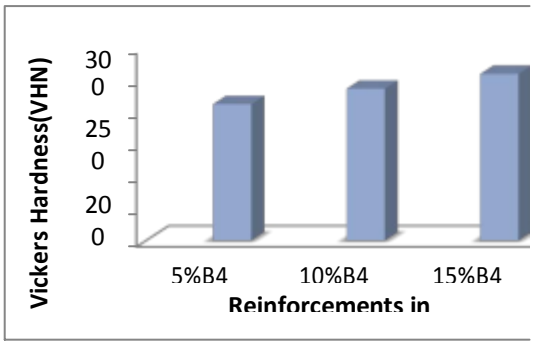

Fig 4. Hardness Evaluation of Al7075 Composite alloy

4. Conclusion

a. The presence of the higher reinforcing particles causes a crucial increase in tensile strength.
b. The incidence of stiffer and harder B_4C reinforcement leads to the increase in resistance to plastic deformation of the matrix.

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