PRODUCTION AND CHARACTERISTIC OF BORON CARBIDE REINFORCED ALUMINIUM A356 COMPOSITES

Sridhar Raja K.S..[1], Bupesh Raja. V.K.[2]

[1]Research Scholar, Sathyabama University, Chennai-600119, Tamil Nadu, India
[2]Sathyabama University, Chennai-600, Tamil Nadu, India.

Abstract

Aluminum-based composites reinforced with hard ceramic particles are a unique advancement in engineering materials that have been developed to use in high strength, high wear resistant. In this paper aluminum metal matrix composite was fabricated by reinforcing various weight percentages of boron carbide particles using stir casting technique. By the addition of K_2TiF_6 into the metal, the wettability of boron carbide particle has been improved. The microstructure and mechanical properties of the composite were investigated. The microstructures were analyzed by optical microscope (OM) and the SEM structure shows the homogenous distribution of boron carbide in aluminum matrix. By increasing the weight percentage of boron carbide in the aluminum matrix the hardness and tensile have been considerably improved.

Keywords: Boron carbide, Metal matrix composites, stir casting, SEM.

I. INTRODUCTION

Aluminum metal matrix composites (Al MMCs) are considered as new advanced materials for its high strength, light weight, low co-efficient of thermal expansion, high specific modulus, and good wear resistance. Mechanical properties such as ultimate tensile strength and hardness have been improved significantly. Metal matrix composite (MMC) materials are one of the widely known composites because of their superior properties such as high strength to weight ratio, hardness, stiffness, wear and corrosion resistances etc. over monolithic metals & its alloys. Boron carbide particles have been homogeneously distributed through out the matrix. [1] The aluminum matrix gets strengthened when reinforced with the hard ceramic particles like SiC, Al2O3, B4C etc. resulting in good wear resistance and strength to weight ratio [2]. The use of aluminum metal matrix has been limited in very specific applications such as aerospace and military weapon due to high processing cost. Al matrix composites have been used for the automobile products such as engine piston, cylinder liner, brake disc/drum etc [3]. MMC can be processed in different technique: (a) liquid state processing, (b) semisolid processing and (b) powder metallurgy [3]. Some of the important controlling parameters like grain size, morphology etc. which influence the property of reinforcement of composites material.MMC's have low ductility and fracture toughness when compared to Al alloy[4] However, stir casting is attractive and most inexpensive method, but it has inherent problems such as good wetting between the particulate reinforcement and the liquid aluminum alloy melt[5].There are some technical difficulties in stir casting technique: achieving a uniform distribution of the reinforcement material, wettability between the two main components; porosity in the cast metal matrix composites; and chemical reactions between the reinforcement material and the matrix alloy[6]. By decreasing the particle size and by increasing the weight percentage of reinforcement particles the porosity of the composites has been increased [7].By increasing the reinforcement percentage of B4C the hardness and the impact strength have been increased [8].The literature shows that the homogeneous mixing of composites and good wetting property can be obtained by parameters like stirring speed, time and temperature of molten metal and uniform feed rate of the particle [1].

II. EXPERIMENTAL PROCEDURE

A. Material

In this study LM25 (A356) aluminum alloy was used, having the chemical composition as shown in Table – 1. The ultimate tensile strength of the cast material is found to be 126MPa and the hardness of the material is 59 BHN. Boron Carbide (B_4C) was used as the reinforcing material having a mesh size of 104 micron.

Table 1. Chemical composition of A356 alloy

Si	Fe	Cu	Mn	Mg	Ni	Zn	Ti	Al
6.58	0.16	0.06	0.06	0.57	0.01	0.01	0.14	balance

B. Fabrication of Composite

Initially the Aluminum alloy (A 356) was melted at 650° using an electric furnace. The metal was agitated with the help of mechanical stirrer to form a fine vortex [1]. The experimental setup of the stir casting is shown fig (1) . The alloy was charged in to the crucible, and it was heated at 650°C above the melting point. The boron carbide powder (104 micron) along with K_2TiF_6 flux is preheated at about 340°C and it is added with the molten metal. The molten mixture is then stirred continuously at 320 rev/min. The molten metal is poured into the permanent mould which has preheated at 300°C. By varying the weight percentage of the boron carbide (3%, 6%, 9%) the material has been fabricated by the same stir casting method.

Fig. 1. Furnace used for stir casting

C. Examination of Microstructures and Mechanical Properties

The composite is not only depending upon the size of the particle but also the distribution and volume of the reinforced particle. The microstructure of B_4C reinforced aluminum composite was analysed by using optical microstructure and scanning electron microscope (SEM). To examine the microstructure study (OP) the specimens were prepare by grinding followed by polishing with diamond paste and etched with Keller's reagent (2 ml of HF, 3 ml of HCl (conc), 5 ml of HNO_3 (conc), 100 ml of distilled water). The macro hardness was studied using Brinell hardness at a load of 0.5Kg for 10 Sec. Also the micro hardness was studied by Vickers method at a load of 0.5Kg for 10sec. As per ASTM-E8 standard the specimen is prepared for tensile test as shown in fig ------. The ultimate tensile strength was estimated using a computerized Universal Testing Machine.

III. RESULTS AND DISCUSSIONS

A. Mechanical Properties Evaluation

The mechanical properties of the alloy A356 has been considerable increased by reinforcing the B_4C particles. The fig.2 shows increase in the hardness of the composite by increasing the weight percentage of B_4C particle. By addition of reinforcement particles in the Al matrix, it increases the surface area of the reinforcement particle and the matrix grain sizes. The hard surface in the matrix gives more resistance to plastic deformation which leads to increase in the hardness of the composites.

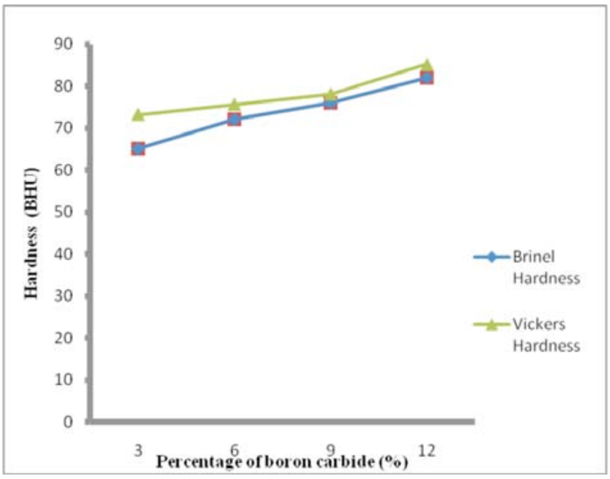


Fig. 2. Hardness and weight percentages of boron carbide

The fig 3. shows the relation between tensile strength of the A356 composite and the weight percentage of the B4C particle. It shows that the tensile strength of the composite had considerable improvement from 126 MPa to 146MPa.

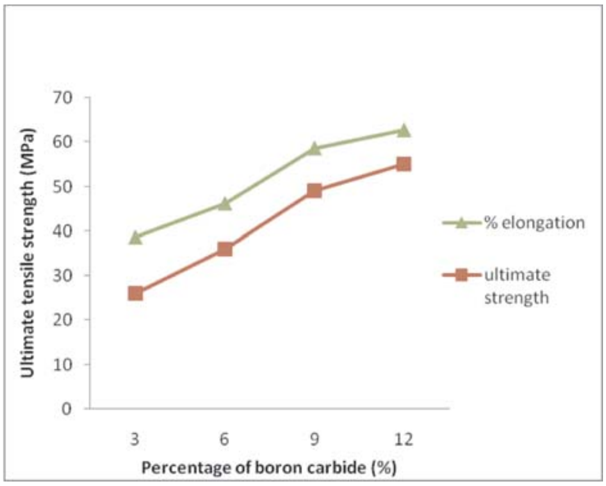
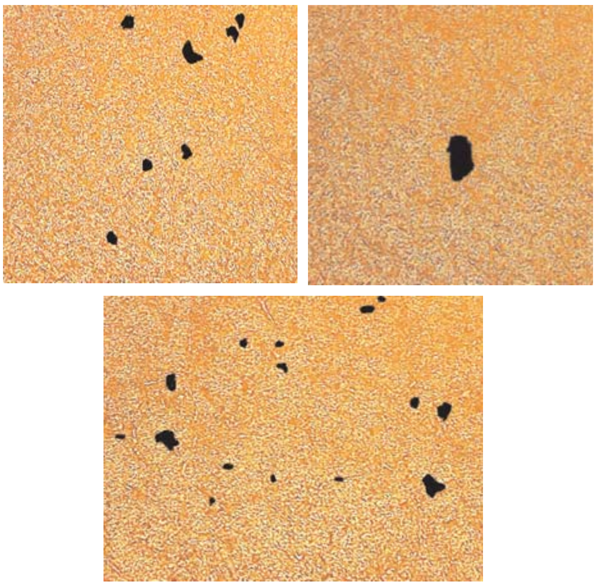


Fig. 3. Ultimate strength and % elongation with weight percentages of boron carbide

B. Evaluation of Microstructure

Aluminum A356 reinforced with boron carbide particle composite is fabricated by modified by stir casting method. By the addition of ceramic particle there exist a poor wettability, it can be improved by adding K_2TiF_6 to the molten metal.

The optical microstructure of the fabricated composite is shown in fig 4. The structure clearly shows the distribution of boron carbide. But the distribution area is limited due to large size of reinforced particle. If the size of boron carbide is reduced further the distribution area will be more and the strength of the matrix will also increased considerably.



(c)
(a) (b) (c)

Fig. 4. Optical microstructure of composite material: (a) 3% (b) 6% (c) 9%

The fig 5. shows SEM images of fabricated A356-B_4C AMCs. The SEM images reveal that the homogeneous dispersion of B4C particles in the matrix.

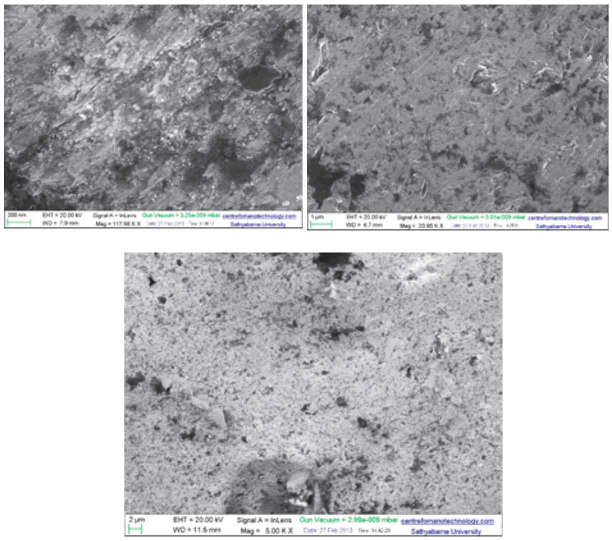


Fig. 5. SEM images of composites

IV. CONCLUSIONS

The A356-B_4C composites were prepared by stir casting technique with varying weight percentage of boron carbide and their microstructural, mechanical properties were analyzed. The following conclusions were arrived from this study

(a) Homogeneous distribution of boron carbide particle in the matrix was obtained.

(b) The optical and SEM images revels the presence of boron carbide particle in the composites.

(c) The hardness of the composite was considerably improved by the addition of boron carbide particle.

(d) By increasing the reinforcing particle the tensile strength of the composite.

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