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Fabrication and Characteristic of Boron Carbide Particulate Reinforced Aluminium Metal Matrix Composites

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Abstract: Aluminium matrix composites (AMCs) play a vital role as advanced engineering materials due to their excellent mechanical properties like light weight, strength, wear resistance, toughness. This work focuses on the fabrication of aluminium (AA6061) matrix composites reinforced with 3%, 6% and 9% B_4C particle of 104μm using stir casting method. The wettability of B_4C particles in the matrix has been improved by adding K_2TiF_6 flux in to the molten metal. The microstructure and mechanical properties of the fabricated AMCs are analyzed. Uniform distribution of B_4C particle in the matrix was confirmed using scanning electron microscope (SEM) images. It was found that the tensile strength and hardness of the fabricated AMCs increases with increased B_4C particle content.

Keywords: Metal Matrix Composites, Stir casting, Microstructure, tensile test, Hardness

Introduction

Aluminium matrix composites (AMCs) play vital role in the advance engineering materials due to its excellent mechanical properties such as tensile strength, wear resistance, dimensional stability, stiffness etc, so that it is widely used in aerospace, automobile, structural application, military etc. (1-2) The most commonly used particulates as reinforcement are Al_2O_3, SiC and B_4C. Research on composites reinforced with B_4C is limited when compared to research reinforced with Al_2O_3 and SiC Nieh et al.[3]studied aluminium alloy 6061 reinforced with 23% vol. B_4C found that the B_4C chemically stable at elevated processing temperature. Viala et al. [4] studied the chemical reactivity of boron carbide with aluminium at temperatures ranging from 627 to 1000^oC. It was found that the reaction rate was very slow at a temperature lower than 660^oC. Ravi et al.[5] studied conventional stir casting is an attractive processing method for produced AMCs as it is relatively inexpensive and offer a wide selection of materials and processing condition. Kok et al. [6] state the stir casting produced good bonding between matrix and particle due to stirring action. The recent research studies reported that homogeneous mixing and good wetting can be obtained by selecting suitable processing parameters such as stirring speed, temperature of molten metal, time, uniform feed rate of reinforcement and preheating temperature of mould re important factors to produce ideal composite

Experimental Procedure

Fabrication Process

In this present study AMCs were prepared by Stir casting technique. The chemical composition of AA6061 is given in Table 1.The reinforcing material B_4C particles of

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size 104µm with different weight percentage (3, 6 and 9) are added and stirred to obtain uniform distribution of B_4C particle in the composites. K_2TiF_6 are added to increase the wet ability with Aluminium matrix composite [7].

Table 1. Chemical composition of Aluminium alloy (AA6061)

Elements	Si	Fe	Cu	Mn	Ni	Pb	Zn	Ti	Sn	Mg	Cr	Al
Percentage (%)	0.68	0.1	0.26	0.8	0.06	0.24	0.01	0.02	0.001	0.83	1.07	Balance

A batch of 1400kg of AA6061 was melted to 800°C in a graphite crucible using electric furnace. The molten aluminium was agitated using stirrer [8].This stir casting process set up shown in fig.1. The slag was removed from the molten metal by adding hexa chloro ethane (degassing) tablet .The mixture of preheated (250C) B_4C particles with an equivalent amount of K2TiF6 flux were added at a constant feed rate into the molten metal vortex with mechanical at a stirring speed of 250 rpm for 10 mins. Cover flux (NaCl 45% + KCL 45% + NaF 10%) was added before pouring the molten metal in to the permanent metal to reduce the atmospheric contamination [9]. The various process parameters employed are given in Table 2.

Fig. 1 Stir casting process set-up

Table 2. Process parameters of modified stir casting

<Parameter	Units	Value
Spindle speed	rpm	250
Temperature of melt	°C	800
Stirring time	min	10
Preheated temperature of mould	°C	400
Preheated temperature of B_4C particles	°C	250

Result and discussion

Evaluation of microstructure

Aluminium alloy reinforced with B_4C particulate composites were successfully fabricated by stir casting process. The experimental result shows uniform distribution of B_4C in the composites also good wettability between B_4C and aluminium alloy. The flux reacts with melted surface of B_4C particle and produces Ti compounds around the surface of B_4C particle. This reaction is exothermic in nature and heat is evolved in the vicinity of B_4C particle melt interface. Fig. 2 a-c shows scanning electron microscope images of

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fabricated aluminium matrix composite. It is observed from the SEM figure that B_4C particles are dispersed uniformly in the aluminium matrix for all wt%.

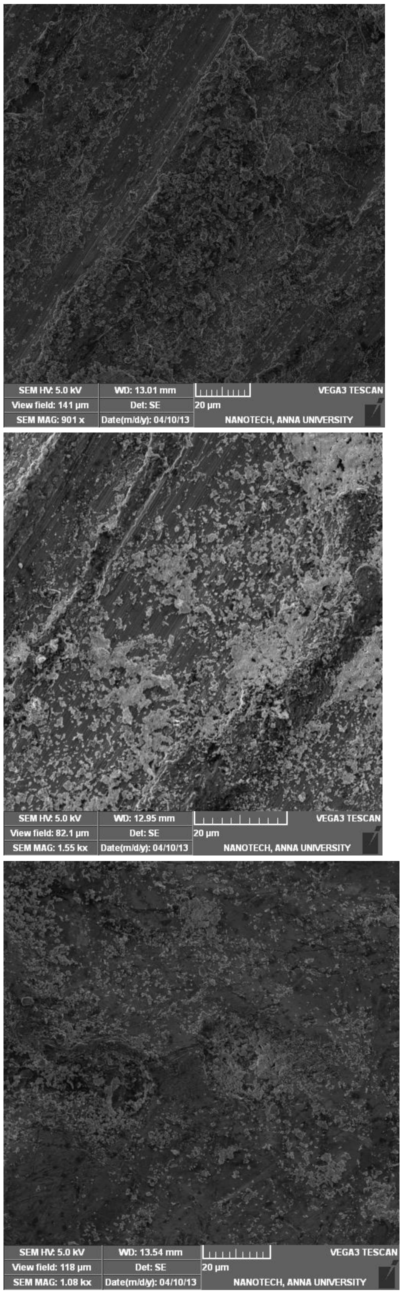

Fig.2 (a)
Fig.2(b)
Fig.2(c)

Fig.2 (a), 2(b) and 2(c) are the SEM images of the fabricated AMCs with 3%, 6% and 9%

Evaluation of mechanical properties

Evaluation of tensile strength

The tensile strength of the AMCs was tested using universal testing machine. The tensile specimens were prepared as per ASTM E8 standard. Fig. 3 shows the relationship between weight percentage of reinforcement B_4C particle and tensile strength of fabricated composites. It is observed that the tensile strength is increased with increasing by increasing weight percentage. This may be attributed to increase in grain boundary area due to grain reinforcement, at the interface and effective transfer of applied tensile load to the uniformly distributed well bonded reinforcement. It is well known that thermal expansion of coefficients of B_4C particle is 5x 10^{-6} /^{o}C and for aluminium alloy is 23 x 10^{-6} /^{o}C respectively. Toptan et al.[11]this thermal mismatch between matrix and reinforcement cause higher dislocation density in the matrix and the load bearing capacity of the hard particles which subsequently increasing the composite strength.

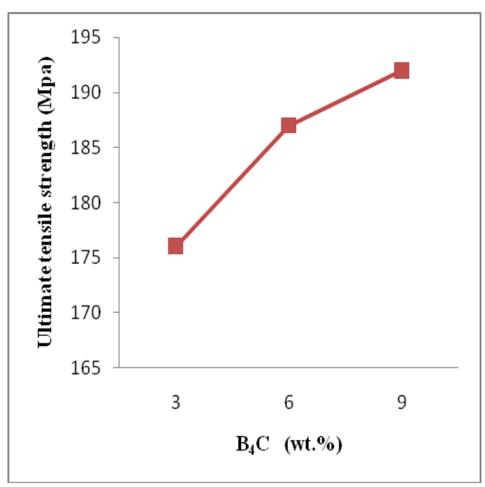

Fig.3 The effect of the amount of B_4C particulates on the tensile strength of fabricated AMCs

A good bonding between reinforcement and aluminium matrix favors an enhancement of the ultimate tensile strength of the composite [12].

Evaluation of hardness

Fig.4 shows the relationship between weight percentage of B_4C reinforcement particle and hardness of fabricated composites. It is observed that the micro and macro hardness is increased with increasing the wt% of the reinforcement. Addition of reinforcement particles in the matrix increases the surface area of the reinforcement and the matrix grain sizes are reduced. So, presence of such hard B_4C particles offers more resistance to plastic deformation which leads to increase in the hardness of composites [10].

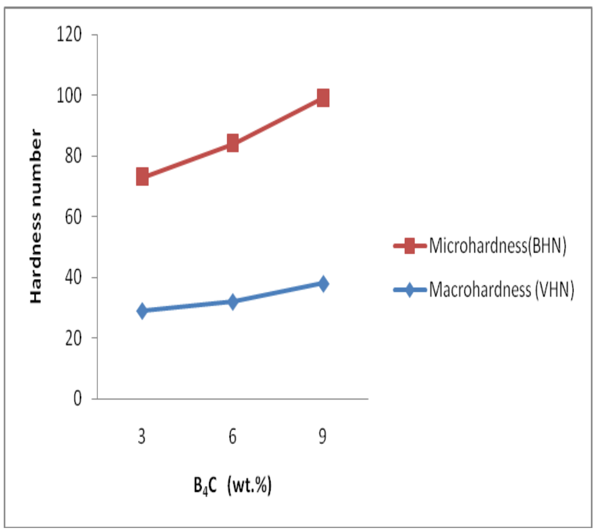

Fig.4 The effect of the amount of B_4C particulates on the hardness of fabricated AMCs

Conclusion

The Al- B_4C composites were produced by stir cast route with different weight percentages (viz 3,6 and 9) of reinforcement and the microstructure ,mechanical properties and were evaluated. From the study the following conclusions are derived.

- Production of Al- B_4C was fabricated successfully by stir casting methods.
- The micro and macro hardness of the AMCs were increased with increasing the wt. % of reinforcement.
- The tensile strength of AMCs was found to be increased with increasing the wt% percentage of reinforcement also observed.

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