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Investigation on Casting Anomalies of Liquid Metallurgy - Processed AA 6061-B_4C Composites

V V Monikandan[1], P V Prasanth[2], E R Dhas[3]

[13]*Department of automobile engineering, Noorul Islam Centre for Higher Education, , Calicut, Kerala, India, 629 180*
[2]*Department of mechanical engineering, Ponjesly college of engineering, Nagercoil,Ttamilnadu,India, 629003*

[1]SAAI.MANIKANDAN@GMAIL.COM
[2]FINDPRASANTH@GMAIL.COM
3EDWINRAJADHAS@NIUNIV.COM

***Abstract*— The mechanical properties of aluminium alloys can be enhanced by reinforcing it with hard ceramic particles. In this work 6061 Al alloy was selected to reinforce it with B_4C particles through stir casting. It was found that the hardness of the AA 6061-B_4C composite was higher than the base alloy even though the reinforcement particle distribution is not uniform due to the casting anomalies.**

***Keywords*—composites, stir casting, aluminium metal matrix composites.**

I. INTRODUCTION

MMCs can be considered as a potential candidate for different applications which include aviation, automobile, aerospace etc. The major constituent of the composite is the matrix in to which the reinforcements are added. AA 6061 wrought alloy is one of the widely used aluminium alloys. S. Gopalakrishnan and N. Murugan developed AA 6061-TiC composites using enhanced stir casting technique which differs from the conventional casting methods [1]. If the reinforcement has lower density than the matrix, the composite will have less density and subsequently have less weight than the parent metal. The density of B_4C is 2.52 g/cm^3 which is comparatively less than the 2.7 g/cm^3 density of 6061 aluminium alloy. A. R. Kennedy found increase in hardness by reinforcing B_4C with aluminium alloy, but not at the expense of increased weight compared to the base alloy [2].

Stir casting is one of the most common methods to fabricate MMCs. Stir casting employs a stirrer which keeps the particle in suspension throughout the particle addition process and by actuating the bottom pouring valve, the molten melt was gravity forced to the die through the flow passage. Ali Mazahery et al. and Z. Zhang et al. observed that the particle preheating and coating ensures good wettability and bonding between the matrix material and reinforcement particles [3, 4]. A. B. Gurcan and T. N. Baker reported that significant increase in hardness can be obtained for composites having higher amount of reinforcement particle addition [5]. Guan Li-na et al. obtained better distribution by decreasing the stirring temperature and enhancement in the mechanical properties by increasing the stirring time [6]. Thus it becomes clear that microstructure and mechanical properties of the composites are influenced by the parameters such as the stirring time and temperature

II. EXPERIMENTAL PROCEDURE

A. Fabrication

A stir casting furnace setup which is shown in Fig. 1 was used for fabrication of AA 6061-10 Wt. % B_4C composite. The temperature used for the fabrication is 750˚C. 6061 Al alloy billets were inserted into the crucible when the temperature was about 500˚C. Continuous flow of Argon gas was ensured to create an inert atmosphere and K_2TiF_6 was used as the flux. Al-Mg master alloy of 1 Wt. % was added after the melting of the matrix alloy to ensure good wettability. The temperature of the crucible was maintained at 750˚C. The molten metal was then stirred at about 500 rpm using the stirrer shown in Fig. 2. The B_4C particles were uniformly added in to the melt while the stirring is continued. After the desired amount of powder addition the bottom pouring valve is actuated to let the molten metal pour into the die and the die is allowed to cool at room temperature. The fabricated specimen is shown in the Fig. 3.

B. Metallographic inspection

Metallographic specimens were cut at random locations from the specimen and embedded into rubber moulds using cold mounting compound.

Fig. 1 Stir casting setup furnace

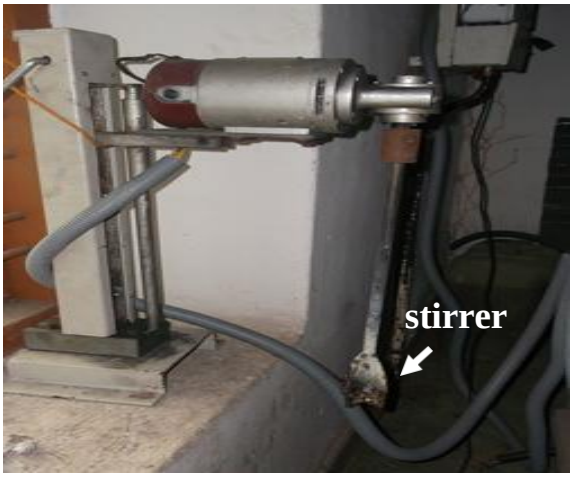

Fig. 2 Stirring equipment

The polishing was started with abrasive paper of grit size 240 to remove hard protrusions and surface irregularities. Then the polishing was carried on to the higher grades of 320, 400, 600, 800, 1000, 1500, and 2000. The diamond abrasive compound of grade 1 and 0.5 micron were applied on the low napped polishing cloth to further enhance the polishing and to maintain the microstructural integrity.

Fig. 3 Fabricated stir cast 6061Al alloy-B4C composites

Etching was done using Keller's reagent. The prepared surfaces were observed under Olympus BX-5 optical microscope under different magnifications.

III. RESULTS AND ANALYSIS

A. *Microstructure*

The microstructure of AA 6061 base alloy is shown in the Fig 4(a). The microstructural images Fig. 4(b) shows that the reinforced B_4C particles were scarcely distributed throughout the metal matrix and the distribution is not homogenous as significant amount of powder rejection was experienced during the casting.

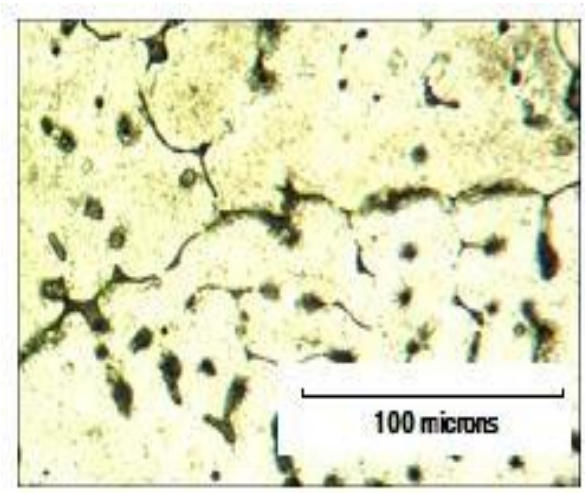

Fig. 4 (a) Photomicrograph of 6061 Al base alloy

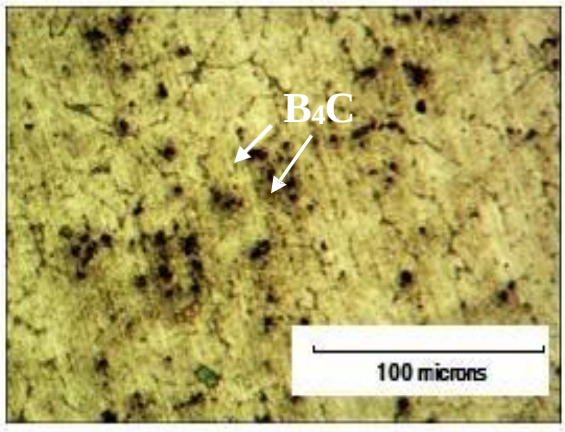

Fig. 4 (b) Photomicrograph of 6061 Al-10% B4C

The SEM image of the rejected powder is shown in the Fig. 5 and its corresponding EDS is shown in the Fig. 6. It can be understood from the EDS that the rejected powder is the combination of reinforcement particle and the traces of aluminium matrix.

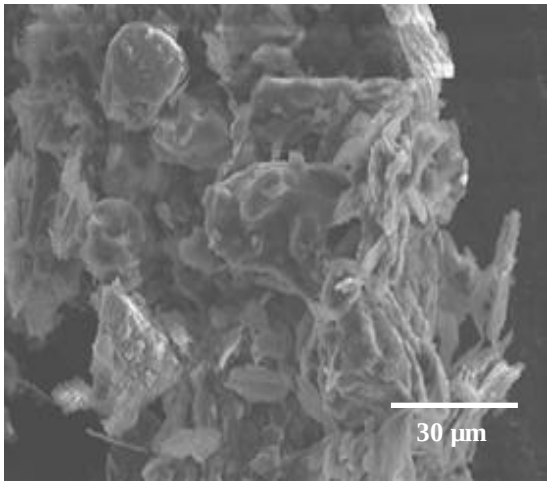

Fig. 5 SEM image of the rejected powder

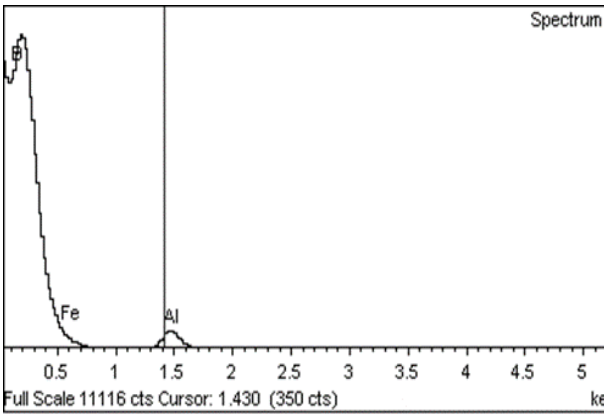

Fig. 6 EDS image of the rejected powder

B. *Hardness*

Brinell hardness tester is used to test the hardness. The intender used is steel having diameter of 10 mm. The test was done by applying 500 kgf load for 30 seconds. The hardness varies for the composite and base alloy as shown in Fig.
7.This may be attributed to the presence of reinforcement

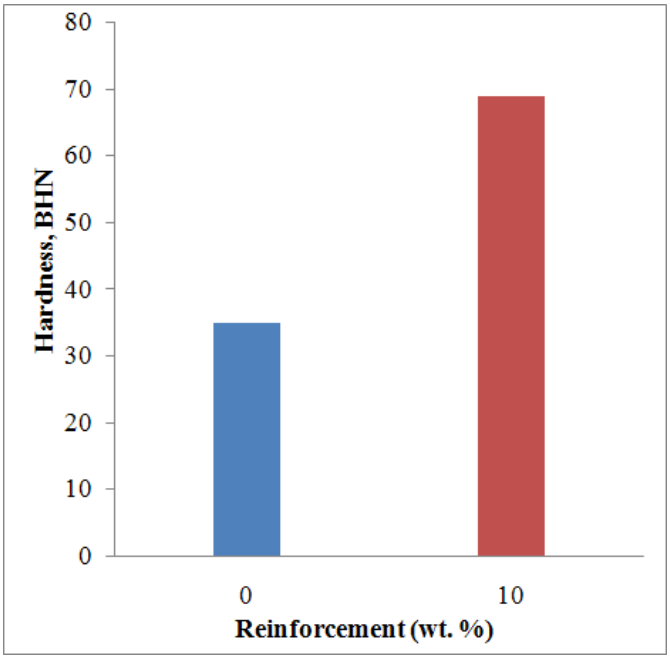

Fig. 7 Hardness variation of base alloy and composite

particles which resisted the mechanical deformation of the composite and thus increasing its hardness.

IV. CONCLUSION

AA 6061-B_4C composite was fabricated through stir casting. The microstructure revealed scarce distribution of reinforcement particles which may be attributed to the powder rejection experienced during casting. Even then the hardness of composite seems to be higher than that of the base alloy. The optimal casting methods can eliminate the casting anomalies like powder rejection and there by enhancing the performance of the composites.

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