DEVELOPMENT AND CHARACTERISATION OF ALUMINIUM ALLOY REINFORCED BORON NITRIDE METAL MATRIX COMPOSITES

Shreenivasaiah P.H.[a], Thammaiah Gowda[a], Kuldeep B.[b]., Ravikumar K.P.[c]

[a]Department of Mechanical Engineering, Adichunchanagiri Institute of Technology, Chikmagalur, VTU, India.
[b]Department of Mechanical Engineering, Malnad College of Engineering, Hassan, VTU, India.
[c]Department of Automobile Engineering, Malnad College of Engineering, Hassan, VTU, India.

Abstract:

Al2014 alloy reinforced with BN composites were processed by stir casting technique. The developed composite was subjected to micro-structural, Tensile, hardness and density studies. Tensile strength and hardness were increased by 13.3% and 18.7% respectively due to increased dislocation density with the addition of reinforcement. Grain refinement with reinforcement addition was observed. It is found that with increasing reinforcement the strength improves considerably up to certain extent. Thus in the present work an attempt is made to use BN to enhance the property of Al2014

Key Words: BN, Composites, Stir casting.

1.1 Introduction

Aluminum composites are most ideal material owing to their benefits over conventional alloys [1]. In aluminum based composites, strength to weight ratio and toughness character of aluminum are combined with the strength and hardness of ceramics [2]. For development of metal matrix composite stir route are more favored because of its simplicity and cost effectiveness [3]. Owing to poor wettability and porosity stir-casting is popular and low cost method, the problem with wettabality can be overcome by heat treatment of reinforcements prior to addition in melt and also by the accumulation of alloying elements [4].

Many researchers had attempted to improve the behavior of Aluminium by addition of ceramic reinforcements [4]. Baradeshwaran and perumal [5] considered the effect of alumina and graphite on Al7075 composites and concluded that the strength amplified with in corporation of reinforcement. Muthanna et al. [7] stated that, addition of particulate reinforcements acts as obstacles for grain growth which helps to increase the strength of the composites. Kuldeep et al. [6] studied the effect of h-BN on mechanical properties of Al7075 composites and found that with increasing reinforcement the strength improves considerably up to certain extent. Thus in the present work an attempt is made to use BN to enhance the property of Al2014

1. MATERIAL AND METHODS

Al2014 alloy with the chemical composition as shown in Table 1 is chosen as base metal.

Table 1. Chemical Composition of Al2014 in Wt%.

Elements	Zn	Mg	Cu	Cr	Fe	Mn	Ti	Si	Al
wt%	0.2	0.8	4.1	0.1	0.4	1.2	0.2	0.5	Balance

Table 2. Composition of Composites in Wt%.

Sample Code	Composition (wt%)
A	Al2014
B	99% Al2014+2% c-BN
C	98% Al2014+4% c-BN
D	97% Al2014+6% c-BN

Boron nitride (BN) of size >150µm is used as reinforcement having a density of 2.28 g/cm^3,

Figure 1. Casting Setup

Stir casting (figure 1) is employed for the development of composite. Hexa-chloro ethane is used for degassing purpose. To deal with wettabality magnesium is used as alloying element and also the reinforcements are heated prior to introduction into the melt to a temperature of 400°C. The reinforcements are added by stirring at a speed of 400rpm. And then the melt is poured into permanent mould (pre-heated to 400°C) and left to solidify for duration of 10hours.

Developed materials are machined to ASTM standards and subjected to test. Average of 3 specimens were considered from each composition. For micro-structural study (OLYMPUS -BX51M with Clemex Image Analyzer) the specimens are polished and treated with Keller's reagent. Density was found using volume and mass relationship, with electronic balance of accuracy 10^{-3} mg to measure the mass of specimen and Vernier caliper with least count of 0.001 mm to measure the dimensions of specimen for volume calculation. Tensile test was conducted according to ASTM E8M standard, and ASTM E10 for hardness.

2. Results and Discussion

The microstructure of prepared material are shown in Figure. 2

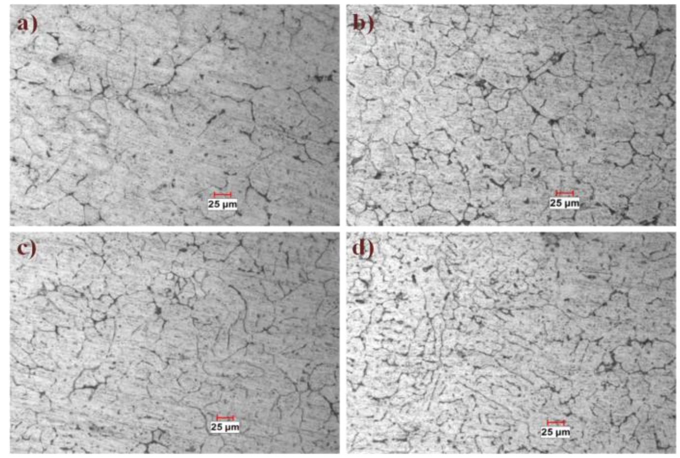

Figure 2. Microstructure of different composition a) A, b) B, c) C and d) D (at 25 µm)

Reinforcements acts as nucleation sites there by reducing the grain size, which can be observed from figure 2. Microstructure consists of fine particles distributed along the grain boundaries with pores. At higher percentage of reinforcement more pores are comparatively due to entrapment of gases through stirring and pouring.

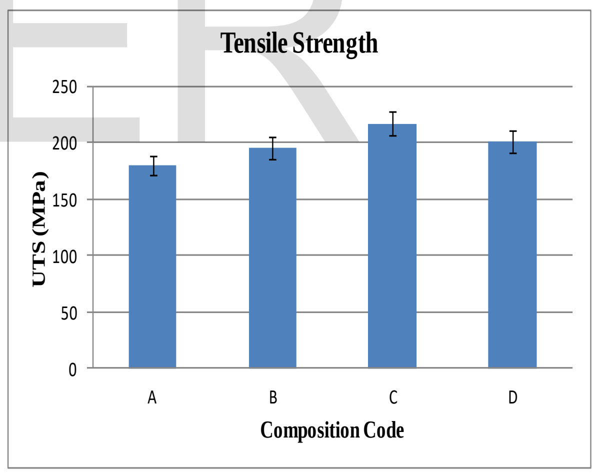

Figure 3. Ultimate Tensile Strength V/S Composition

The ultimate tensile strength and hardness of prepared samples are represented in graphs (figure3 & 4), because of grain refinement and increased dislocation density the strength of the composites increases dramatically [4]. And also strength and hardness of BN imparts strength to prepared composite.

The improvement in tensile strength is observed only up to 4% of reinforcement addition with further addition the tensile strength suffers because of increased porosity and poor wettabality at higher percentage of reinforcements. The

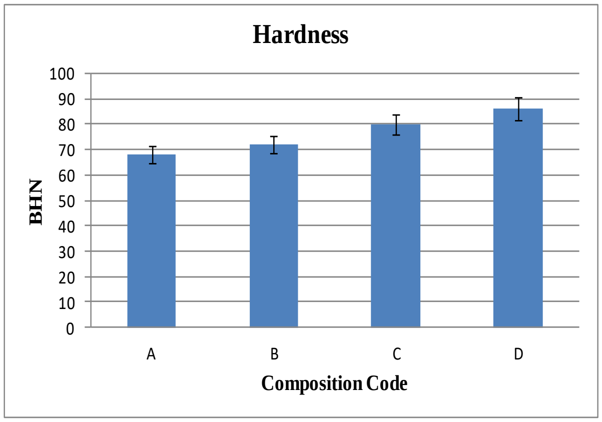

Figure 4. BHN V/S Composition

Due to incorporation of lower density material and also due to pores formed, the density of developed composite shows a down trend. During stirring and pouring there will be gas entrapment in the prepared composite which leads to porosity. Higher the reinforcements more will be the stirring time which results in more pores and gas entrapment comparatively.

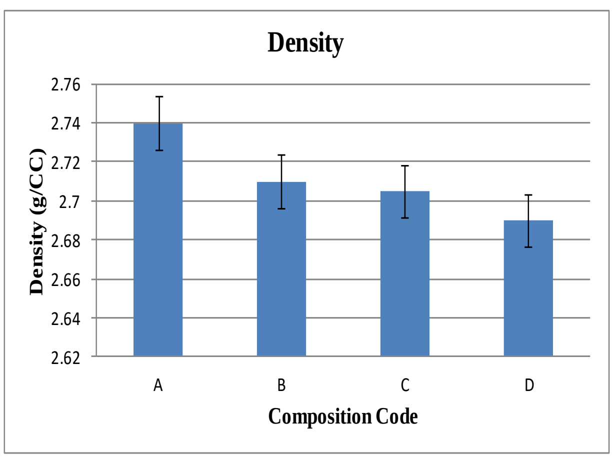

Figure 5. Density V/S Composition

4 Conclusion

The outcome of BN on microstructure and mechanical properties were analysed,

- Hardness increased to 26.5% by addition of 6% reinforcement
- Ultimate tensile strength increased by 11.6% at 4% BN reinforcement.
- Increase in percentage of reinforcement contents lead to decreased density of resulting material.

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