Determination of Effect of B_4C Content on Density and Tensile Strength of AA7075/ B_4C Composite Produced via Powder Technology

Cihad Nazık, Necmettin Tarakçıoğlu, Serdar Özkaya, Fatih Erdemır, and Aykut Çanakçı

***Abstract*—In this work, gas atomization technique was used to produce aluminum matrix powders (AA7075). Thereafter; boron carbide (B_4C) particle reinforcements participated into matrix and then composite powders mixtures were prepared via powder technology. SEM analyze method was used to describe composite material's microstructural properties and it was observed that B_4C particles were homogeneously distributed in the AA7075 matrix after 4h of milling time. As a result; parameters which were milling time, closeness of each other the particle size of the matrix with reinforced material and increasing density enhanced pure material of tensile strength approximately % 40.**

***Index Terms*—Aluminum, B_4C, mechanical properties, metal-matrix composite, powders metallurgy.**

I. Introduction

Composite materials represent a kind of advanced engineering materials. Usage area of these materials has been increasing day by day since the time that they entered into the entire area of our lives in this century. The interest in composite materials and research in this field have been rising gradually due to performance characteristics, lightness, and excellent mechanical and thermal features of these materials [1]. One of the matrix materials which is commonly used on composite materials is the aluminum. It has a high strength when it is chosen as low density matrix [2]. Some of the main reinforcements are used for improving mechanical properties of aluminum matrix composites are the ceramics like SiC, Al_2O_3, TiC, and B_4C. Working difficulties and limitation of the mechanical properties of B_4C particles reinforced composites can be significantly reduced by using aluminum as the matrix material [3]. B_4C particle reinforced composites are currently roled industrial applications such as nuclear, automotive, army.

Homogeneity is the main problem of these composites and one of the common methods used for producing metal matrix composites is the powders metallurgy technique. The purpose of this study is to get in-depth knowledge of the Al–B_4C system and to manufacture the composite material by powders metallurgy techniques [4].

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II. Materials and Methods

- A7075 alloy powders (matrix)

Produced by gas atomization in Kütahya Dumlupınar University, Mechanical Engineering Research Laboratory, Turkey) and average particle size of the matrix is 43.9 µm.

- B_4C powders (reinforcement)(+99% purity)

Bought from Alfa Aesar, A Johnson Matthey Company, average particle size and density of reinforcement is 49.5 µm and 2.52 g/cm^3.

Furthermore, alloy elements of matrix was shown Table I, experimental procedure was indicated in Fig. 1 and Fig. 2 (a-b) show the morphologies of the matrix and reinforcement powders.

TABLE I: Alloy Elements of AA7075 Alloy Powders (ASTM, B316-10)

Cu	Mg	Mn	Fe	Si	Zn	Cr	Ti	Al
1,2 – 2	2,1 – 2,9	0,3 (max)	0,5 (max)	0,4 (max)	5,1 – 6,1	0,18 – 0,28	0,2 (max)	87,1 – 91,4

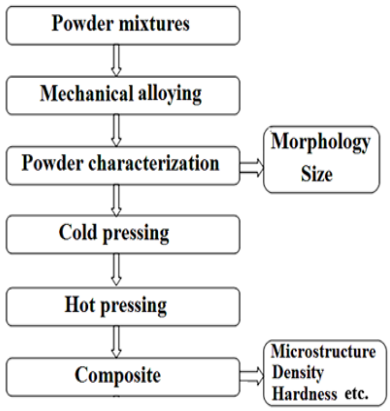

Fig. 1. Processes of producing of the composites.

III. Discussion And Results

A. Measurement of Composites Density

Fig. 3 shows the change of density with increasing milling time. The powders' compaction mechanism can be explained as follows:

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1) Sliding and rearrangement of the particles
2) Elastic deformation of ductile powders and fragmentation of brittle solids
3) Plastic deformation of compacted powders.

At the first stage of the compaction process, particle sliding and rearrangement of the powders are the dominant mechanisms of strengthening. When the applied hot press pressure increases, the movement of the particles is restricted and the pressing energy that applied to the compact powders is spent generally through the process of fragmentation and plastic deformation of powders [5]. In addition; density of the composites increased until 1h of milling time. This can be attributed to the ability of filling the pores by small and ductile powders. Powder particles exposed to work hardening. On account of this; compaction becomes difficult. As illustrated in Fig. 3, because of the work hardening, density values decreased after 1h milling time.

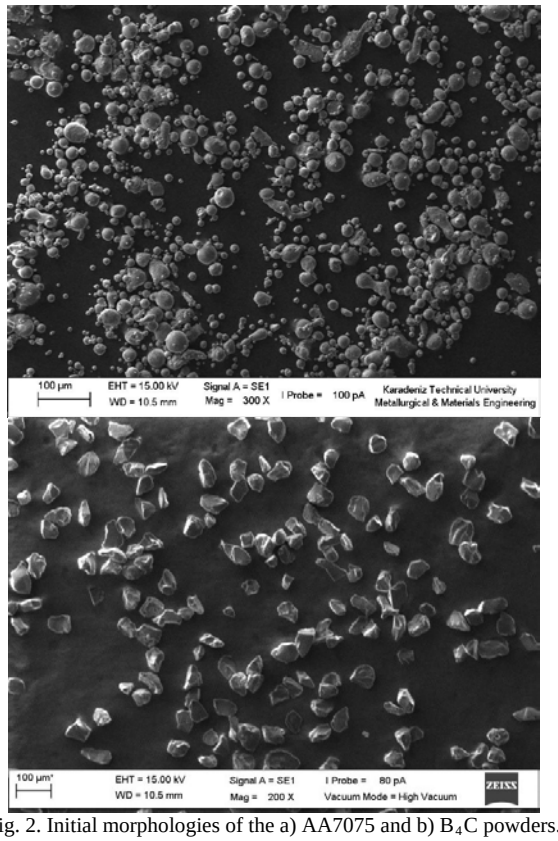

Fig. 2. Initial morphologies of the a) AA7075 and b) B_4C powders.

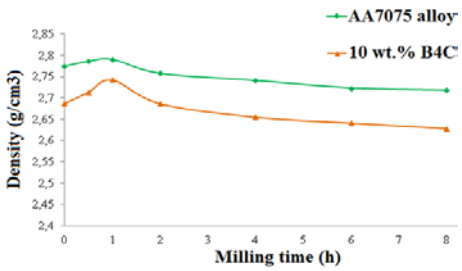

Fig. 3. The change of density with increasing milling time.

Composites and alloy group's tensile strength increased up to 1h and then decreasing. The highest tensile strength is obtained in 10% B_4C reinforced composite material (Fig. 5). The main problem of this situation is that the density of the composite, increasing at a certain amount and then decreasing.

B. Tensile Test

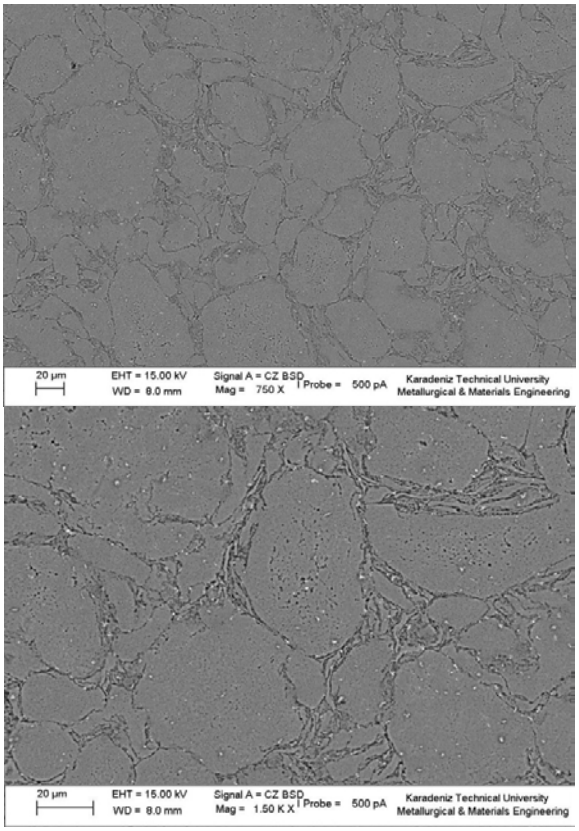

Fig. 4(a). Small particles which get in flaky structure after 1h milling time AA7075-%0 B_4C.

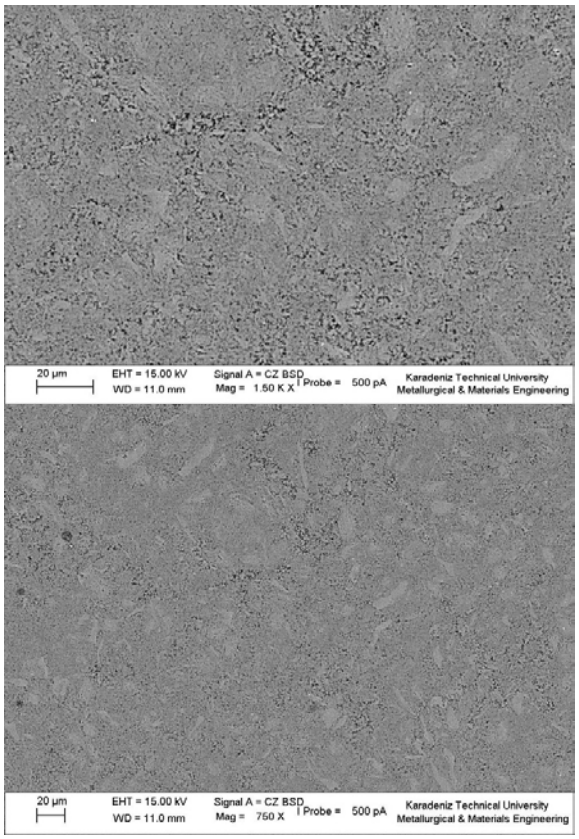

Fig. 4(b). Porosities that occurred after 8h milling time (AA7075-%0 B_4C).

Conditions that cause density decrease:

Dust hardness with increasing milling time; reduction of packaging ability among powders of the composites.

During 1h milling, the form of particles takes a flaky structure and a large amount of very small particles in the

starting powders creates a higher density structure by entering between this growing the flaky structure. This can be seen clearly in Fig. 4(a). After 1h, these great flaky structures break. Due to the increase of both porosity and the amount of deformation, the density of the composite and tensile strength decrease. It can be seen clearly in Fig. 4(b) [6].

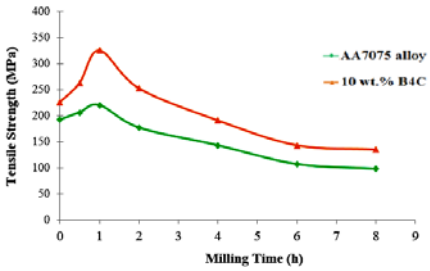

Fig. 5. Change of tensile strength of composite (%10 B_4C) and pure AA7075 by milling time.

C. Microstructure

Fig. 6 points out the distribution of B_4C particles in the AA7075 matrix in AA7075 – 10 wt% B_4C composites. B_4C particles agglomerated among the matrix powders in the first stage of 0h and 0.5h of milling time and this situation was seen nakedly in Fig. 6(a) and Fig. 6(b).

Fig. 6(a) and Fig. 6(b) show that the low milling time is not appropriate to produce uniform composites. Therefore, samples milled from 0h to 8h were studied and the effect of the milling time was investigated to investigate the particle distribution. The results showed that an increase in milling time resulted in the fragmentation of hard particles and homogeneous distribution due to the impacts of balls Fig. 6(e).

IV. Conclusion

The mechanical alloying method can be used to produce AA7075 10 wt% B_4C particulate composites in which the B_4C particles are distributed uniformly within the AA7075 matrix alloy. It was also seen that both milling time and B_4C content have a great effect on the particle size of the milled powders. The particle size decreased until creation of a balance between the rate of welding and fracturing. The composite density decreased with an increasing the milling time. Tensile strength of 1h milled composite samples increased to maximum value but other samples' values were decreased to 8h milling time (Fig. 5).

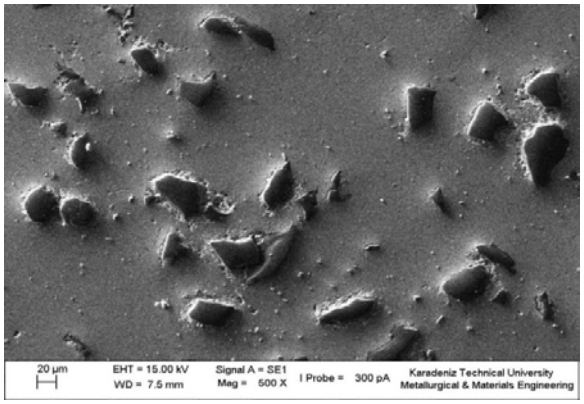

Fig. 6 (a). Microstructure of AA7075 10 wt% B_4C, 0h.

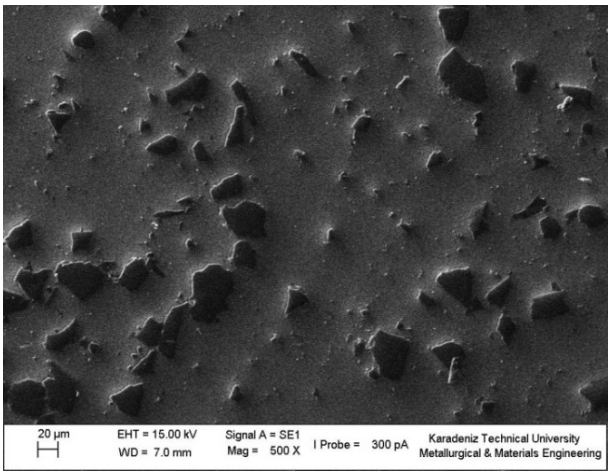

Fig. 6 (b). Microstructure of AA7075 10 wt% B_4C, 0.5h.

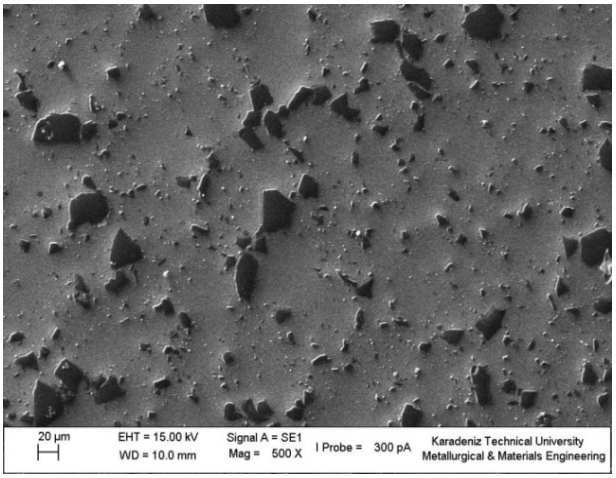

Fig. 6 (c). Microstructure of AA7075 10 wt% B_4C, 2h.

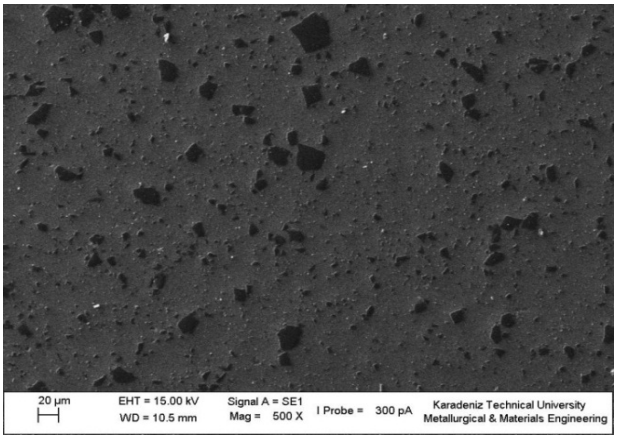

Fig. 6 (d). Microstructure of AA7075 10 wt% B_4C, 4h.

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