

COMPARISON OF MECHANICAL AND MICROSTRUCTURAL EXAMINATION OF AL7075 COMPOSITES REINFORCED WITH MICRO AND NANO B₄C

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ABSTRACT

Due to the demand for lightweight materials in the field of automobiles, aeronautics and some other application, there is a need to develop lightweight materials. For the last few decades, aluminum matrix composites are being developed in order to meet out the demand of the above-mentioned industries. aluminum the above, lightweight material in the form of composites of B₄C reinforced in Al7075 alloy is considered for the present investigation. The composite was produced using the stir casting method. In this investigation, the micro and nano B₄C particles were used as reinforcements. The fabricated composites were characterized for microstructure and mechanical properties. From the microstructural examination, it was observed that 12% of B₄C nanocomposites was having fine microstructure as compared to others. The hardness and strength were found to be maximum for 12 % B₄C nanocomposites which impact strength was lowest for 12% micro composites.

Keywords: Al7075 alloy, B₄Cp, Stir casting, and UTS.

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1. INTRODUCTION

Aluminum matrix composites are being used in various fields such as automobiles, aerospace marine, etc. due to their favorable properties [1]. An alloy of the Al7075 series is having the highest strength to weight ratio. This properly makes Al7000 series alloys a good option for reinforcement. The reinforcement can be a ceramic oxide, nitride carbide particulates. These reinforcements are improving the properties of Al7000 series alloys[2],[3],[4]. In an investigation, Al7075 alloy was reinforced with LM 13 aluminum/ B₄C by means of liquid metallurgy techniques to find the wear behavior[5]. V. Ramakoteswara Rao et al[6] have synthesized Aluminium matrix composites reinforced with titanium carbide particles to find the sliding wear behavior. E. Zalenhad and A.D. Sachan investigated fretting fatigue resistance of Al7075-T6 with surface treatment of Ti-TiN multilayer coating[7].

From most of the investigation done by various researchers, it was observed that the composite of the Al7000 series is made by casting technique[8]. Harichandran and Selvakumar instigated that mechanical properties such that impact energy was higher in composites having nano reinforcement as compared to composites having micro reinforcement[9]. Daniel et al [10] having investigated the influence of wt. percentage of SiC particles reinforced in aluminum metal matrix composites. Nagral et al[11] have reported that Al2024 alloy composites were manufactured with B₄C particles using a stir casting technique. Singh and Chuahan[12] have reported about the second generation of composites. They reported that hybrid aluminum matrix composites are belonging to second-generation composites. According to the second generation, composites have substantial potential as an alternative to Singh reinforced composites. AA7075 matrix was reinforced with TiC particles through the stir casting technique[13]. The investigators found the effect of load on the friction and wear of matrix as well as composites. In a research paper, the authors developed a statistical model to envisage vibration amplitude[14]. Dhokey and Rane have applied aluminum-based TiB₂ reinforced composites as brake drum material. They observed that the wear behavior of the composites was considerably good in correlation with its mechanical properties[15].

In the present investigation Al7075 alloy has been used as a matrix. This was reinforced with micro and nano B₄C particles. The composites were characterized in terms of microstructure and mechanical properties,

2. MATERIALS

Al7075 alloy was selected as a composites matrix. micro and nano B₄C chosen for the fabrication of the composites reinforcement particle. The composites were manufactured by stir casting techniques. The Al7075 alloy framework made of Al7075 was melted in a vacuum furnace for the preparation of the composites. After passing through a sieve for each composite, weighted and preheated dispersoids of size between 50 μ m and 90 nm with 6, 8, 10 & 12 weight % were poured into the melt. The melt was continuously stirrer during the insertion of the dispersoid, using a stirrer put in the melt driven by a motor.

3. STIR CASTING TECHNIQUES

The vacuum furnace (Fig.1) was used to produce the composites. A scattered phase (micro and nano B₄C particles) was inserted in molten metal. The stir was used to uniformly distribute the reinforcement particles.



Figure 1 Experimental setup for fabricating Al7075 and B₄C particles.

4. MICROSTRUCTURAL AND MECHANICAL PROPERTIES

The microstructure was examined using an optical microscope. XRD spectra were performed on the composites to find the crystal structure. The hardness was measured using a Brinell Hardness Tester. The load and dwelling times applied were 187.5 kgf and 5s, respectively. Tensile experiments were conducted on a Universal Testing Machine (UTM). The tests were performed as per the ASTM E8 standard. The impact tests were carried out on an impact testing machine. The impact tests were performed as per the ASTM E23 standard.

5. RESULT AND DISCUSSION

5.1. Compositional analysis

The compositions of the Al7075 and B₄C are shown in Tables 1 and 2 respectively.

Table 1 Chemical analysis of Al 7075 alloy.

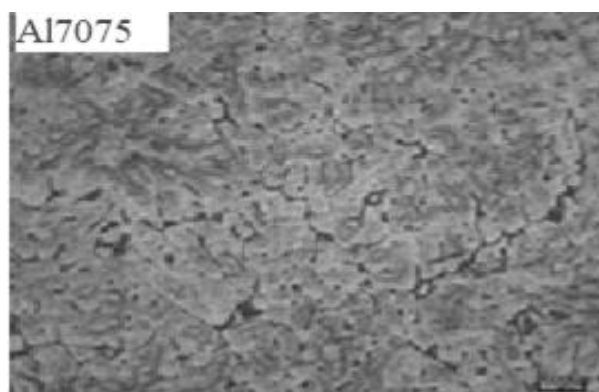
Elements	Zn	Mg	Cu	Fe	Cr	Al
% by wt.	5.8	2.4	1.5	0.2	0.2	Balance

Table 2 Chemical analysis of B₄C micro powder (50µm) and nanopowder (90nm).

Elements	Assay	Boron	Carbide	O	N	Si	Ni
% by wt.	99.9	77.2	22.3	<0.1	<0.08	<0.1	<0.01

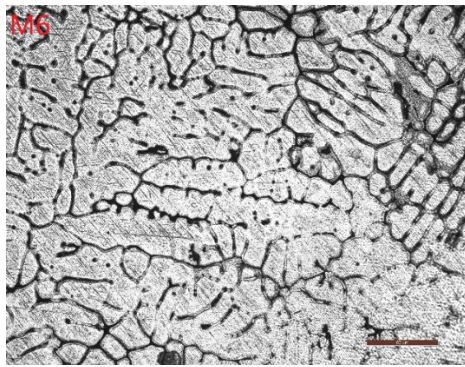
5.2. Microstructural Examination

Fig. 2, show the microstructure of Al7075 and Fig. 3 and Fig. 4, show the microstructure of the Al7075 with micro and nano B₄C respectively. The analysis of microstructure clearly shows that the surfaces are transparent with few porosities. The investigation into Optical microscope micrographs shows that microstructure consists of a uniform distribution of micro B₄C particles and intermetallic compounds scattered along the grain boundary in the Al7075 alloy matrix. Uniform micro- and nano B₄C particle dispersal and better bonding within Al7075 improve the properties.

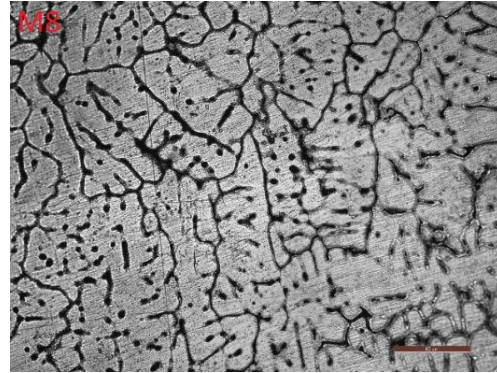


Al7075 alloy

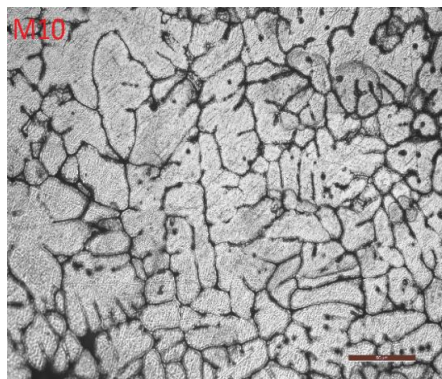
Figure 2 The microstructure of Al7075 alloy



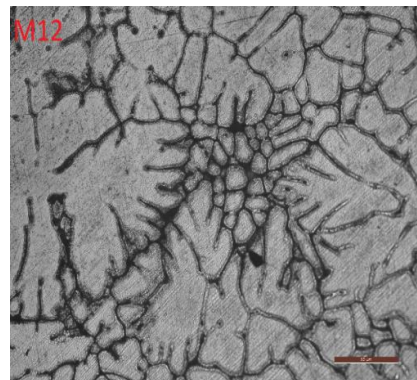
Al7075-6 wt. % of micro B₄C



Al7075-8 wt. % of micro B₄C

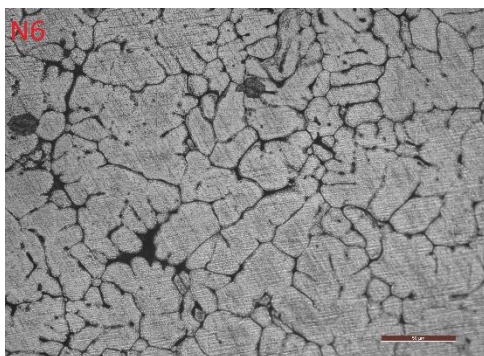


Al7075-10 wt. % of micro B₄C

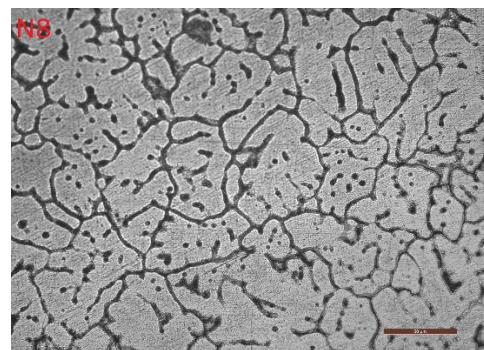


Al7075-12 wt. % of **micro B₄C**

Figure 3 The microstructure of Al7075 with micro B₄C.

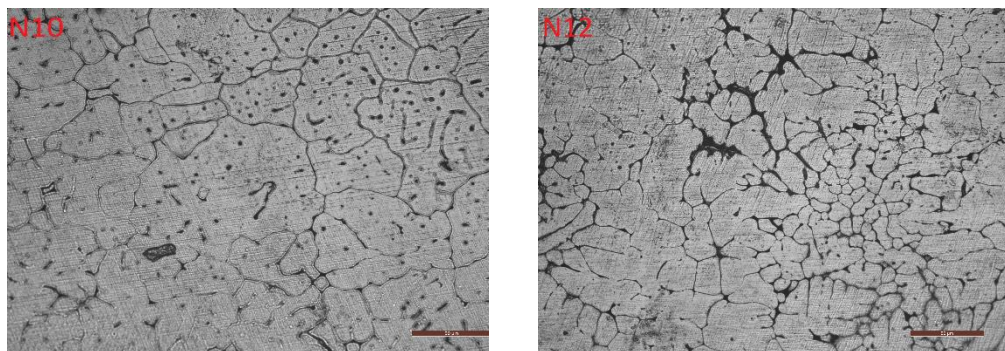


Al7075-6 wt. % of nano B₄C



Al7075-8 wt. % of nano B₄C

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Al7075-10 wt. % of nano B_4C

Al7075-12 wt. % of nano B_4C

Figure 4 The microstructure of Al7075 with nano B_4C .

5.3. X-ray diffraction analysis

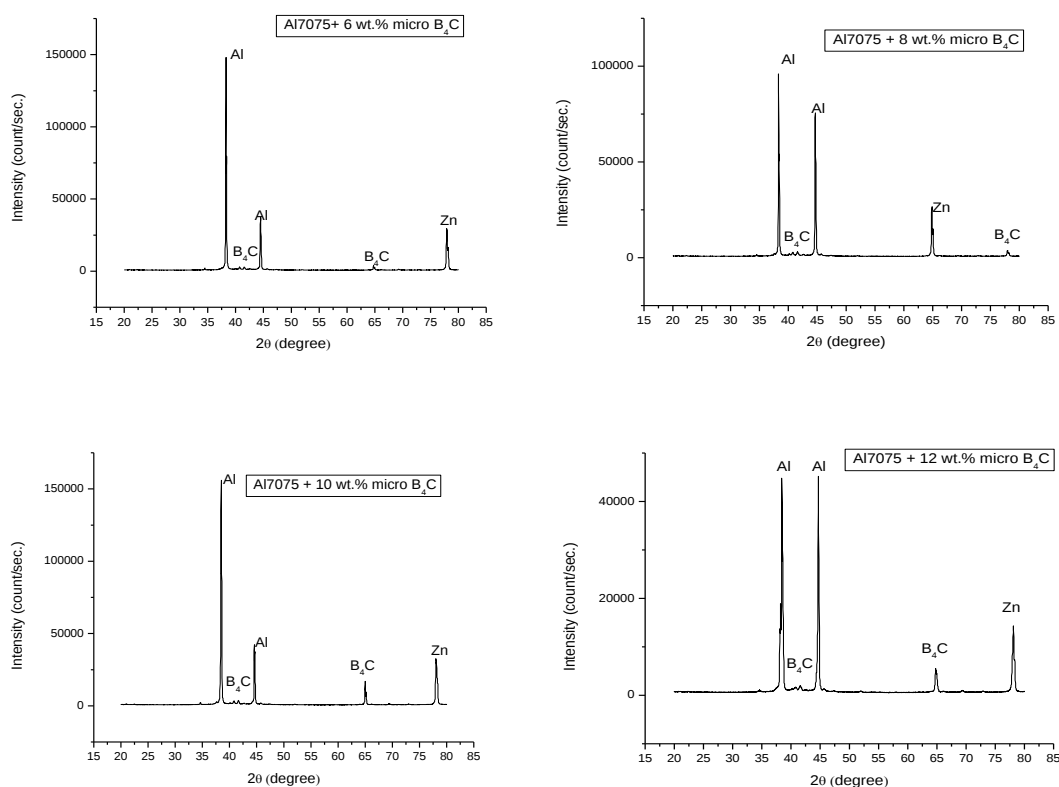


Figure 5 XRD of Al7075 alloy with wt. % micro B_4C .

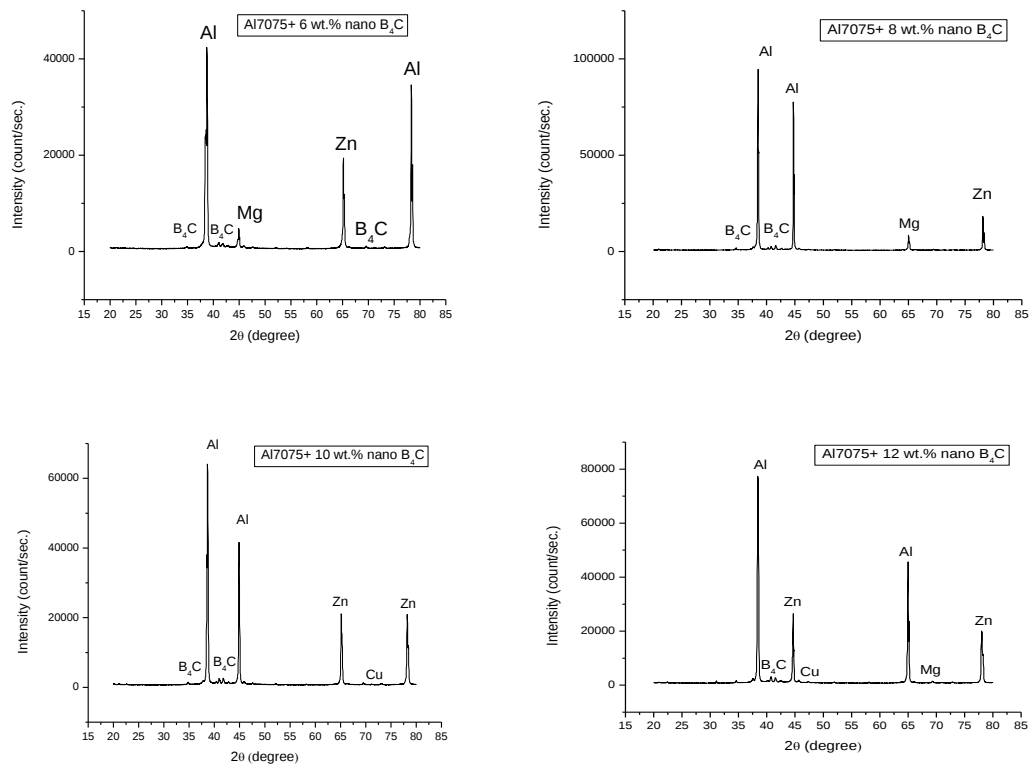


Figure 6 XRD of Al7075 alloy with wt. % nano B_4C

Fig. 5 and Fig. 6 respectively, indicate X-ray diffraction spectra of as-cast Al7075 alloy and reinforced with micro and nano B_4C . The XRD analysis study reveals that the height of the peak shows the presence of elements as mentioned.

5.4. Tensile Tests

Fig. 7 Demonstrates a comparative bar graph of AMCs reinforced with B_4Cp of 6, 8, 10 and 12 % micro and nano B_4C . The increase in the tensile strength of AMCs containing nano B_4Cp is due to the strengthening of the matrix.

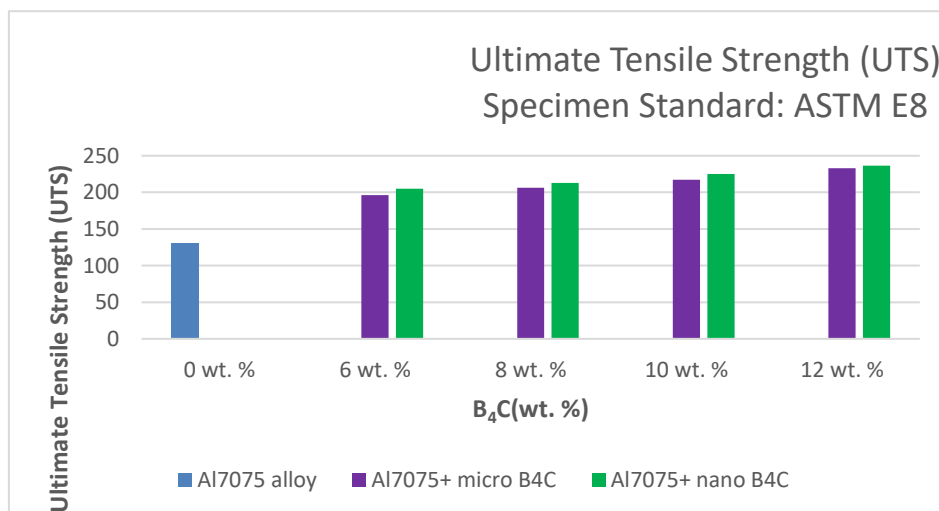


Figure 7 Comparative bar chart for UTS of Al7075 and its composites.

5.5. Hardness Test

Fig. 8 indicates the effect of the particle content of micro and nano B₄C on the hardness of the micro and nano B₄C reinforced composites. The values of hardness seem to depend on the weight of micro and nano B₄Cp. The composites made with nano B₄C are having the same what higher hardness. With the addition of 12 wt.%, the hybrid composites reach optimum hardness.

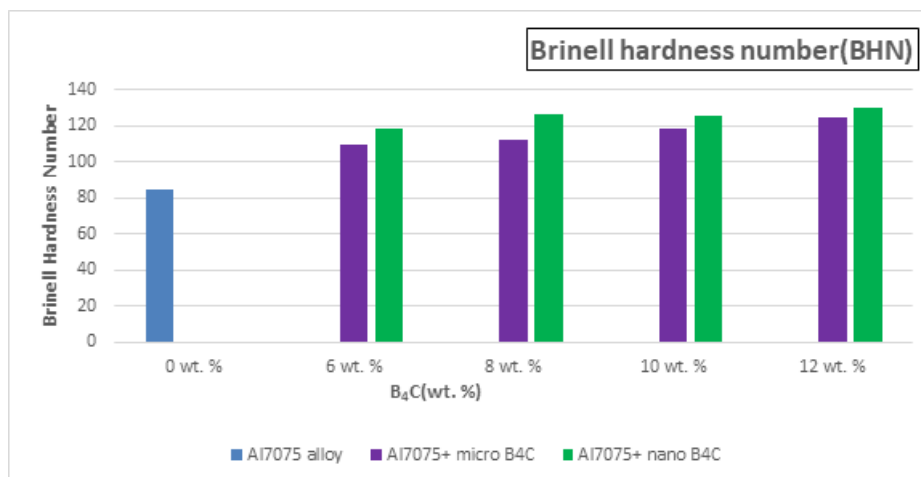


Figure 8 Comparative bar chart for BHN of Al7075 and its composites.

5.6. Impact test

The toughness value of the alloy and the composites is shown in Fig. 9. It is observed that there is a decrease in toughness due to an increase in the volume fraction of reinforcements.

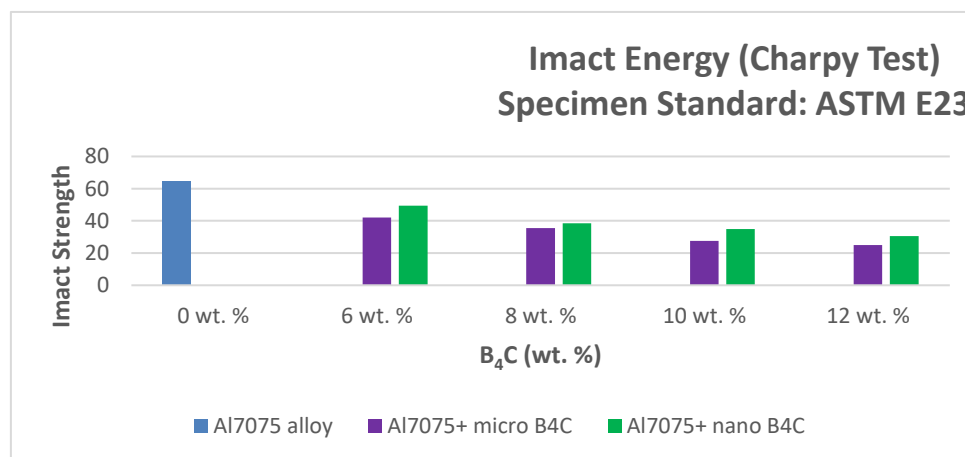


Figure 9 Comparative bar chart for Impact strength of Al7075 and its composites.

6. CONCLUSIONS

The micro and nano B₄Cp reinforced with Al7075 were produced using stir- casting. The composites were examined to investigate the effect of various weight percentages of micro and nano B₄Cp on the microstructure and mechanical properties of the composites.

The nanocomposites having higher strength than that of micro composite and Al7075 alloy

The impact energy of nano B₄Cp reinforced aluminum composites was higher than that of micro B₄Cp reinforced Al7075 composites.

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