

## CERAMIC BORON CARBIDE MICRO-PARTICLES INFLUENCE ON THE MECHANICAL AND FRACTOGRAPHIC BEHAVIOUR OF Al2005 ALLOY COMPOSITES

### UTICAJ KERAMIČKIH MIKRO ČESTICA BOR-KARBIDA NA MEHANIČKO FRAKTOGRAFSKO PONAŠANJE KOMPOZITNIH LEGURA Al2005

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#### Keywords

- Al2005 alloy
- B<sub>4</sub>C particles
- microstructure
- hardness
- tensile strength

#### Abstract

The current study involves the production of composites consisting of Al2005 alloy and B<sub>4</sub>C using a liquid metallurgical technique. The Al2005 alloy is employed to fabricate composites with 4 and 8 weight percent of B<sub>4</sub>C particles. The microstructure of the produced composites is examined utilising Scanning Electron Microscopy (SEM) and Energy Dispersive X-ray Spectroscopy (EDS). The density, hardness, ultimate strength, yield strength, and elongation are assessed according to the ASTM E8 standard for tensile testing and the E10 standard for hardness testing. The consistent distribution of B<sub>4</sub>C particles throughout the Al2005 alloy is validated by SEM. EDS analyses indicate the existence of B<sub>4</sub>C particles within the Al2005 alloy. The incorporation of lighter B<sub>4</sub>C particles into the matrix diminishes the density of aluminium alloy composites. The incorporation of particles results in an improvement in the hardness, ultimate tensile strength, and yield strength of the Al2005 alloy by 33.73 %, 36 %, and 41.84 %, respectively. The tensile fractured micrographs offer additional proof of the distinct fracture characteristics shown by the Al2005 alloy and its composites.

#### INTRODUCTION

Composite materials are synthesised through the combination of two or more materials that possess separate properties and are incapable of dissolving into one another. Composite materials are created by mixing elements with distinct characteristics, resulting in a distinctive property that sur-

#### Ključne reči

- legura Al2005
- čestice B<sub>4</sub>C
- mikrostruktura
- tvrdoća
- zatezna čvrstoća

#### Izvod

U ovom radu bavimo se istraživanjem proizvodnje kompozita od legure Al2005 i B<sub>4</sub>C primenom metode metalurgije u tečnom stanju. Legura Al2005 se uvodi za izradu kompozita sa 4 i 8 težinskih procenata čestica B<sub>4</sub>C. Mikrostruktura proizvedenih kompozita se ispituje skeniranjem elektronskom mikroskopijom (SEM) i energetsom disperzivnom rendgenskom spektroskopijom (EDS). Gustina, tvrdoća, zatezna čvrstoća, napon tečenja, i izduženje se određuju prema standardu ASTM E8 za ispitivanja zatezanjem i prema standardu E10 za ispitivanje tvrdoće. Nepromenljiva raspodela B<sub>4</sub>C čestica unutar legure Al2005 se proverava SEM. Analize EDS ukazuju na postojanje B<sub>4</sub>C čestica unutar legure Al2005. Uvođenjem lakih čestica B<sub>4</sub>C u matricu se smanjuje gustina kompozita od legure aluminijuma. Prisustvo čestica dovodi do poboljšanja tvrdoće, zatezne čvrstoće, i napona tečenja legure Al2005 za 33,73 %, 36 % i 41,84 %, respektivno. Mikrosnimci prelomnih površina dobijenih zatezanjem pružaju dodatni dokaz za uočljive osobine loma kod legura Al2005 i njihovih kompozita.

passes the individual properties of the constituent materials /1, 2/.

Constituents maintain their identity while also combining in a way that produces new traits that are superior to the sum of their individual parts. As technology continues to improve, there is an increased need for materials that are energy-efficient, lightweight, and affordable in the aerospace,

defence, aviation, automation, and many other sectors /3-5/. Therefore, the principal applications revolve on reducing weight while simultaneously preserving improved mechanical and other tribological qualities, for which aluminium composites are best suited /6, 7/. Aluminium is suitable for usage because its resistance to corrosion is high as compared to magnesium and other alloys, especially for aerospace applications /8, 9/. When its surface reacts with air, it forms oxides that provide protection against erosion caused by rubbing between two surfaces in an application. Therefore, it is often utilised in aircraft applications where it lacks significant inherent wear resistance. Hence, there is a pressing want for substantial improvements on its properties /10-13/.

The use of contemporary materials with greater qualities in the automotive and aerospace industries has led to a steady advancement of metal composites /14, 15/. A metal composite is made up of reinforcements like ceramics and a matrix material like metal or an alloy. At the microscopic level, composites are heterogeneous, yet at the macroscopic level, they are homogeneous.

The crucial aspect is in the assessment of a material's macroscopic characteristic, wherein the components produced by these composites may be seen identified without the aid of magnification. At a macroscopic level, different types of materials are joined, such as alloys of metals. These materials appear to be homogeneous to the naked sight, meaning that their pieces cannot be distinguished and they clearly work together /16, 17/.

The fundamental benefit of composites is that a good design shows off the premium attributes of its constituent parts. Both naturally occurring and man-made composites exist. Among the former are wood, where lignin serves as the matrix and is reinforced by cellulose fibres. The human body is also made up of composites, with soft collagen being strengthened by bone-salt of calcium and phosphate ions.

Utilising a composite material by integrating two or more substances requires more effort compared to using conventional monolithic steel and aluminium components. Essentially, these metals and their alloys consistently fail to fulfil the demands of modern advanced technology. Required performance is achieved solely through the utilisation of diverse material combinations. Currently, the aircraft industries have experienced an increase in acceptability due to the use of new materials.

Due to their outstanding properties such as low ductility, good wear resistance, low thermal expansion, good thermal conductivity, good damping characteristics, and excellent thermal expansion, aluminium matrix composites (AMCs) /18-20/ have garnered a lot of attention in recent decades and are seen as the most promising materials to encounter the ever-increasing demands of current technology /21, 22/. For as long as composites have been around, aluminium and its alloys have been the go-to matrix material. Reasons for this include the inexpensive production cost of AMCs and the wide variety of excellent mechanical and thermal qualities already stated, /23, 24/.

The major reason to choose the boron carbide particles as a reinforcement particle in the present study is due to its compatibility with Al alloy matrix /25, 26/. The density of

Al2005 alloy is 2.80 g/cm<sup>3</sup> and the density of B<sub>4</sub>C is 2.52 g/cm<sup>3</sup>, which is not too high or low as compared to the matrix. Further, with the addition of these particles density of composites will reduce. On the other hand, if one uses SiC or TiC, the density of these particles is high as compared to the Al2005 alloy, which causes wettability issues with the matrix /27, 28/. Further, the hardness and Young's modulus of B<sub>4</sub>C are very high as compared to the base matrix alloy. This high hardness and modulus of the reinforcement particle helps in enhancing the hardness and tensile strength of the base material, /29, 30/.

The extant literature indicates that there has been little research on the use of B<sub>4</sub>C particles in an Al2005 alloy matrix, specifically with particle sizes ranging from 80 to 90 microns. The B<sub>4</sub>C metal matrix composite, based on aluminium, is fabricated using the stir casting technique. In the present research to improve the wettability between the Al2005 matrix and B<sub>4</sub>C particles, a halide salt K<sub>2</sub>TiF<sub>6</sub> is used. In order to avoid clumping together, B<sub>4</sub>C particles are introduced into the aluminium melt in two separate phases. After being prepared, the AMMC is subjected to various mechanical testing.

## EXPERIMENTAL DETAILS

### Materials used

Al2005 can be processed in a subsequent operation. With a density of 2.80 g/cm<sup>3</sup> and a melting point of 660 °C, Al2005 is primarily alloyed with copper. Many industries, including transportation and aerospace, rely on the Al2005 alloy. When it comes to welding, Al2005 shines thanks to its excellent self-healing capacity, strong raised temperature strength, and excellent corrosion resistance. Table 1 shows the chemical composition of Al2005.

Table 1. Chemical composition of Al2005 alloy.

Elements	Si	Fe	Cu	Mg	Cr	Mn	Ti	Al
% wt.	0.8	0.70	4.80	0.20	0.10	0.90	0.10	bal.

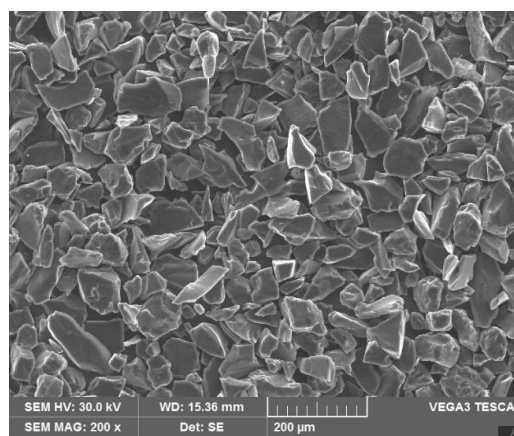


Figure 1. SEM micrograph of 80 to 90 micro sized B<sub>4</sub>C particles.

Boron carbide, ranging in size from 80 to 90 μm, is acquired from Speedfam Chennai Ltd., India, and is used as a reinforcing material. Black is the colour of the reinforcement, having a melting point of 3300 °C and a range of hardness 3100-3600 kg/mm<sup>2</sup>, the density of reinforcement particles is 2.52 g/cm<sup>3</sup> /31, 32/. Figure 1 shows the scanning

electron micrograph of B<sub>4</sub>C particles used to make the metal composites.

#### Composites preparation and testing

By using liquid metallurgy, Al2005 alloy with various weight rates of B<sub>4</sub>C composites are created. Al2005 composite metal pieces weighing a certain amount are placed into the electric furnace and heated till liquid metal stage. The temperature of Al2005 compound liquid metal is raised to 750 °C. The correct thermocouples are used to measure and record the superheating and dissolving temperatures. For around three minutes, potassium titanium fluoride (K<sub>2</sub>TiF<sub>6</sub>) /33, 34/ is used to degas the superheated liquid metal in the crucible. To blend the metal in the liquid, a shaft stirrer is utilised in conjunction with a zirconium-coated steel rotor. For the purpose of creating vortices, the stirrer is spun at a speed of around 300 rpm while submerged in the crucible's liquid metal to a depth of approximately 65 %. The molten metal of Al2005 alloy with B<sub>4</sub>C is stirred for 5 minutes. The process of blending is prolonged until the overall wettability of Al2005 composites with particles reaches a certain level at which interfacial strength is recognised. At that time, the cast iron moulds with the requisite dimensions are filled with the liquid metal mixture of Al2005 composite and B<sub>4</sub>C particulates. Figure 2 indicates the Al2005-B<sub>4</sub>C composites.



Figure 2. Al2005-B<sub>4</sub>C composites prepared.

In order to determine whether the Al2005 alloy contains a uniform distribution of reinforcing B<sub>4</sub>C particles, a SEM analysis is performed on the specimen after casting. Al2005 alloy and Al2005-B<sub>4</sub>C composites have their microstructures photographed. The microstructure specimen has a 15 mm diameter and a 5 mm height. Paper with grits ranging from 300 to 1000 is used to grind the surface of the sample. After that, the surface is polished using polishing paper with a thickness of 3 μm to get an even smoother finish on the polishing machine.

To conduct the hardness test, the specimen is prepared by grinding it in line with the ASTM standard E10 /35, 36/. A Brinell hardness tester is employed for the purpose of quantifying hardness. The sample exhibits a smooth and impeccable surface. Upon exerting a force of 250 kg on the specimen, a 5 mm depression is created by a ball. The specimen's surface exhibits five depression marks which are subsequently analysed.

The optical microscope is used to inspect the specimens' indent marks in order to calculate their hardness values using the given relation.

$$\text{BHN} = \frac{2P}{\pi D(D - \sqrt{D^2 - d^2})},$$

where:  $P$  (kg) is load;  $D$  (mm) is diameter of steel ball; and  $d$  is size of indent.

To analyse tensile properties of Al2005 alloy and B<sub>4</sub>C reinforced composites, it is necessary to use specimens prepared following the guidelines specified in ASTM standard E8 /37, 38/. To obtain the most accurate findings, the tensile strength is tested by using three specimens. In order to examine the response of Al2005-B<sub>4</sub>C composites to unidirectional tension, assess the influence of uniform distribution, and determine the tensile strength, a computer-controlled tensile machine is utilised. The tensile sample is 104 mm in total length, with gauge length of 45 mm and gauge diameter of 9 mm. The tensile test is used for evaluating the maximum, yield, and elongation strengths of cast alloys and composites. Figure 3 exhibits the tensile test specimen.

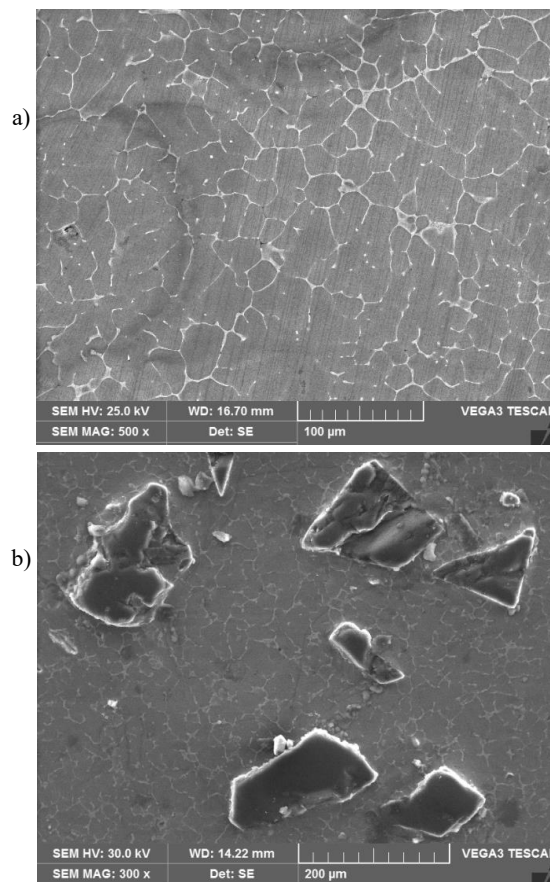


Figure 3. Tensile test specimen.

## RESULTS AND DISCUSSION

### Microstructural analysis

SEM microphotographs in Fig. 4a-c display composites that have been strengthened with 4 to 8 wt.% B<sub>4</sub>C particles. Figure 4a displays a SEM of the Al2005 alloy. The lack of particles is indicated by pristine grain boundaries. The micrograph does not exhibit any discernible voids or casting defects. Figures 4, b and c, display microphotographs of composites containing Al2005-4 % B<sub>4</sub>C and Al2005-8 % B<sub>4</sub>C, in respect.



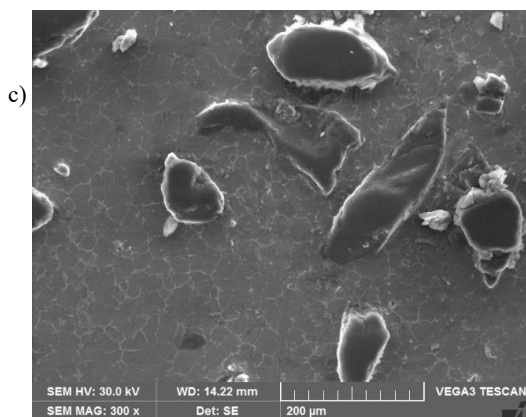


Figure 4. SEM microphotographs of: a) Al2005 alloy; b) Al2005, 4 wt.% of B<sub>4</sub>C; c) Al2005, 8 wt.% of B<sub>4</sub>C composites.

The micrographs clearly show that B<sub>4</sub>C particles are present in reinforced composites at 4 and 8 wt.%. The innovative two-step casting method used to create the composites ensures that the particles do not clump together or agglomerate. In addition, the microstructure surface of Al2005 composites with 8 wt.% B<sub>4</sub>C comprises a greater number of B<sub>4</sub>C particles dispersed throughout the matrix Al2005 alloy.

Figure 5 displays the EDS analysis of composites that are reinforced with Al2005 alloy and include 8 wt.% of B<sub>4</sub>C particles. Figure 5 (top) clearly illustrates that Cu is a prominent alloying element in the Al2005 alloy, along with Fe, Mn, and Zn. Additionally, Figure 5 (bottom) displays EDS spectra of composites strengthened with Al2005 and 8 wt.% B<sub>4</sub>C particles. The existence of boron and carbon particles in the Al2005 alloy is identified using the spectrum of EDS. The presence of B and C elements, along with Zn, Fe, Cu, Mn, and Si, confirms the integrity of the casting procedure employed in the production of the composites.

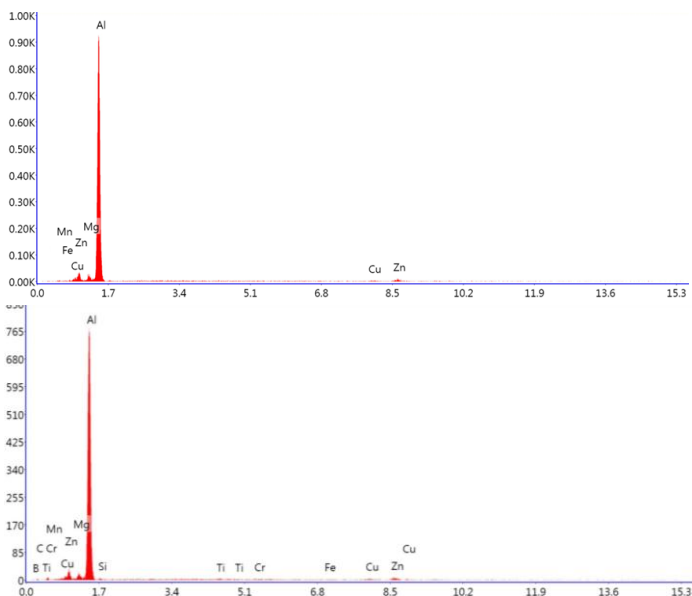


Figure 5. EDS analysis of Al2005 alloy (top); Al2005, 8 wt.% of B<sub>4</sub>C composite (bottom).

*Hardness measurements*

Table 2 and Fig. 6 show hardness values of Al2005 alloy, Al2005- 4, and 8 wt.% of B<sub>4</sub>C reinforced composites. As the plot shows, the hardness of Al2005 alloy improves from

4 to 8 wt.% B<sub>4</sub>C particles. The hardness of the Al2005 is 67.77 BHN, but it increases to 80.36 and 90.18 BHN after adding 4 and 8 wt.% of B<sub>4</sub>C particles, in respect. A hardness enhancement of 24.85 % is seen in B<sub>4</sub>C composites with an Al2005 alloy content of 8 wt.%. Because of the hard B<sub>4</sub>C particles present in the flexible matrix, the hardness of Al2005 alloy is enhanced. Incorporating B<sub>4</sub>C particles of 3500 BHN into a soft matrix helps to increase the hardness. As a result of dislocation density caused by the thermal coefficient mismatch between Al2005 alloy and B<sub>4</sub>C particles, this procedure also increases straining in the composites /39, 40/. The composites get harder due to the strain hardening.

Table 2. Hardness of Al2005-B<sub>4</sub>C composites.

Sl No.	Materials	BHN with standard deviation	Improvement (%)
1	Al2005 alloy	67.77 ± 1.38	---
2	Al2005 - 4 wt.% B <sub>4</sub> C	80.36 ± 0.98	15.66
3	Al2005 - 8 wt.% B <sub>4</sub> C	90.18 ± 0.89	24.85

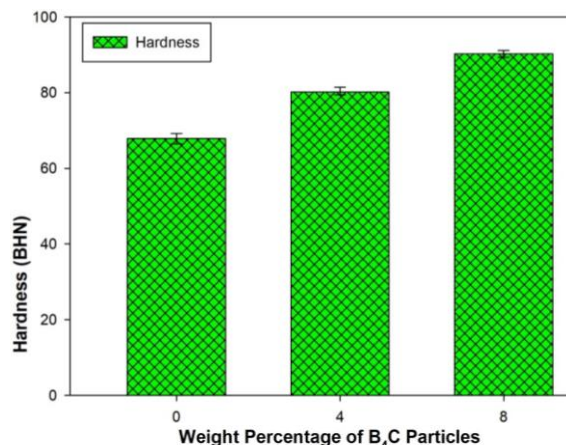


Figure 6. Hardness of B<sub>4</sub>C reinforced Al2005 alloy composites.

*Tensile properties*

Figure 7 and Table 3 show the consequence of B<sub>4</sub>C on strength of Al2005 alloy. The strength is upgraded as the wt.% of B<sub>4</sub>C particles in the soft Al2005 matrix increases, as shown in Fig. 7. Al2005 alloy has an ultimate tensile strength (UTS) of 207.2 MPa. In addition, the UTS of composites of Al2005 with 4% B<sub>4</sub>C is 247.7 MPa, and with 8% B<sub>4</sub>C is 272.8 MPa, in respect. The addition of 8 wt.% B<sub>4</sub>C

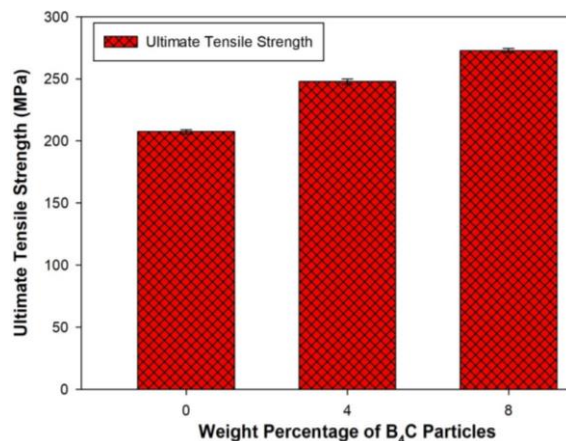


Figure 7. UTS of boron carbide reinforced Al2005 alloy composites.

particles ranging in size from 80 to 90 microns improves the UTS of Al2005 alloy by 24 %.

Table 3. Ultimate strength of Al2005-B<sub>4</sub>C composites.

Sl No.	Materials	UTS (MPa) with standard deviation	Improvement (%)
1	Al2005 alloy	207.20 ± 1.73	---
2	Al2005 - 4 wt.% of B <sub>4</sub> C	247.71 ± 2.01	16.35
3	Al2005 - 8 wt.% of B <sub>4</sub> C	272.84 ± 1.60	24.05

In Fig. 8 and in Table 4 are the effects that B<sub>4</sub>C particles have on the yield strength of Al2005. Figure 8 shows that the strength of Al2005 is enhanced with an increase in the wt.% of B<sub>4</sub>C particles in the Al matrix. At 173.3 MPa, the Al2005 alloy yields its full strength. In addition, the YS of composites made with Al2005 and 4 wt.% B<sub>4</sub>C is 212.8 MPa, while that of composites made with 8 wt.% B<sub>4</sub>C is 237.9 MPa. The addition of 8 wt.% of B<sub>4</sub>C particles ranging in size from 80 to 90 μm improves the YS of Al2005 alloy by 27.14 %.

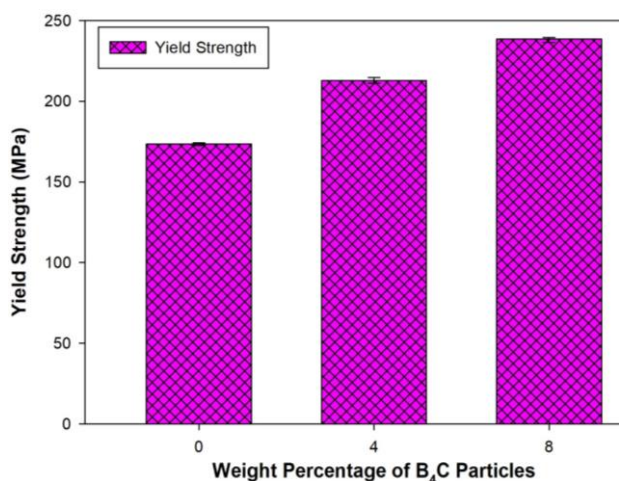


Figure 8. YS of B<sub>4</sub>C reinforced Al2005 alloy composites.

Table 4. Yield strength of Al2005-B<sub>4</sub>C composites.

Sl No.	Materials	Yield strength (MPa) with standard deviation	Improvement (%)
1	Al2005 alloy	173.33 ± 0.80	---
2	Al2005- 4 wt.% B <sub>4</sub> C	212.80 ± 1.76	18.57
3	Al2005- 8 wt.% B <sub>4</sub> C	237.91 ± 1.64	27.14

Plots 7 and 8 demonstrate that the inclusion of 4 and 8 wt.% of minuscule B<sub>4</sub>C particles into the Al2005 alloy result in an increase in its ultimate and yield strengths, respectively. Incorporating B<sub>4</sub>C into the matrix enhances the tensile strength of the Al alloy. Due to the particle's hardness, the matrix material becomes more fragile and is able to endure higher directed loads. Within the realm of composites, these resilient particles function as load-bearing elements, hence enhancing the strength of the composites. Furthermore, as per the Hall-Petch strengthening mechanism, the incorporation of minuscule particles into the aluminium matrix leads to a decrease in grain size. Consequently, the strength of the composites is enhanced. The presence of density dislocations in the Al2005 alloy is attributed to the significant difference in expansion coefficients between the alloy and B<sub>4</sub>C particles, as explained by the Orowan principle [41, 42]. Strain hardening takes place in the Al-B<sub>4</sub>C melt due to the presence of density dislocations, resulting in enhanced strength.

Figure 9 shows the ductility of Al2005 and Al2005 alloy composites reinforced with 4 and 8 wt.% of B<sub>4</sub>C particles, respectively. The graph shows that the ductility of the matrix drops as the percentage of B<sub>4</sub>C particles rises. The presence of hard B<sub>4</sub>C particles in the matrix is responsible for the decrease in ductility. The material is able to resist further elongation due to the significant multidirectional stresses at the interface of the Al2005 alloy and B<sub>4</sub>C. Thanks to the strong bonding between Al and B<sub>4</sub>C particles, the applied load is effectively transferred to the evenly distributed micro B<sub>4</sub>C particles, and the overall performance is improved. All things considered, the Al2005 alloy-8 wt.% B<sub>4</sub>C composites exhibit lower elongation than the base amalgam and 4 wt.% B<sub>4</sub>C particle reinforced composites.

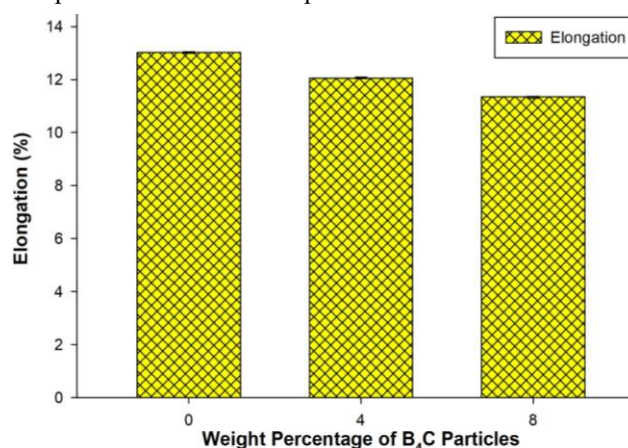
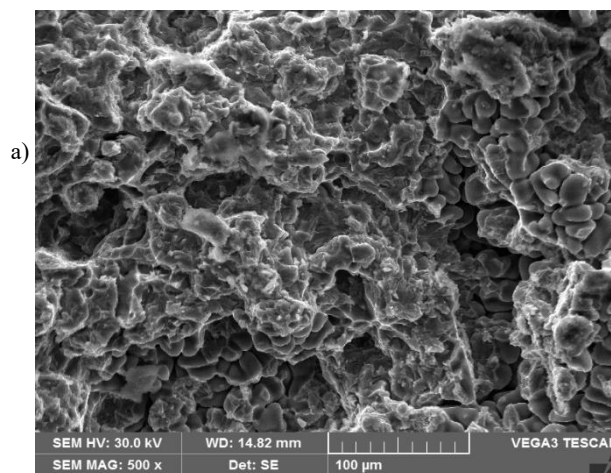


Figure 9. Elongation (%) of B<sub>4</sub>C reinforced Al2005 alloy composites.

#### Tensile fractography

The SEMs of fractured surfaces of Al2005 and Al2005 with 4 and 8 wt.% B<sub>4</sub>C composites are shown in Fig. 10a-c. The tensile fracture micrographs show that the matrix alloy and B<sub>4</sub>C reinforcement are well-bonded. Figure 10a shows the fractured surface of Al2005 alloy taken at 500× magnification. The visible grains on the cracked surface of the cast alloy indicate a ductile fracture.

Also, the fractured surfaces of Al2005- 4 wt.% B<sub>4</sub>C and Al2005- 8 wt.% B<sub>4</sub>C composites can be seen in Fig. 10b-c. The micrographs show that the composites become more brittle with increasing amounts of B<sub>4</sub>C reinforcement. The surface of tensile fractured Al2005- 4 wt.% B<sub>4</sub>C composites



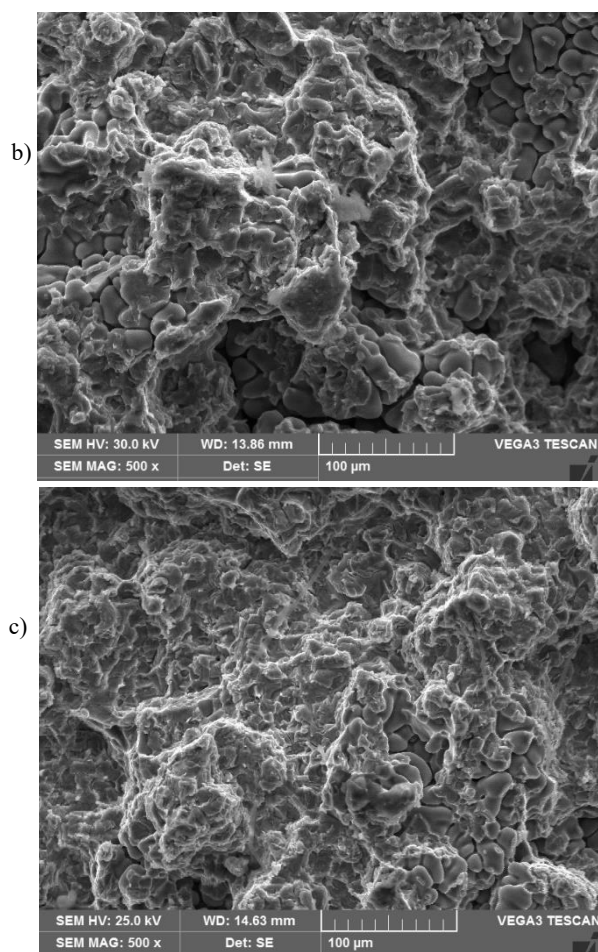


Figure 10. SEM images of tensile fractured surfaces: a) Al2005 alloy; b) Al2005, 4 wt. % B<sub>4</sub>C; c) Al2005, 8 wt. % B<sub>4</sub>C composites.

shows this increased brittleness clearly. This brittle fracture also occurs in tandem with the composites' elongation. There is a decline in composite ductility with increasing wt.% of B<sub>4</sub>C particles, as mentioned in the elongation section.

#### Compression strength

Figure 11 and Table 5 show the compression strength of Al2005 and Al2005 composites with 4 and 8 wt.% B<sub>4</sub>C, in respect. The plots show that the compression strength of Al2005 is strengthened by the hard particle phase, and that

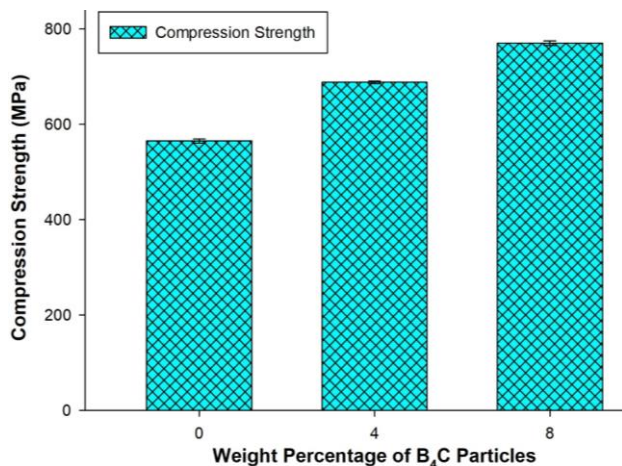


Figure 11. Compression strength of boron carbide reinforced Al2005 alloy composites.

this enhancement continues as the weight percentage of B<sub>4</sub>C particles grows. Compressive strength is a reliable indicator of the strength of carbide or oxide particles in ceramics because of their naturally hard character, [43, 44]. Because of the addition of B<sub>4</sub>C particles, which greatly refine the grains, the presence of uniformly distributed tougher components, and the dislocations caused by modulus mismatch and thermal expansion coefficient, Al-B<sub>4</sub>C composites are very strong. Findings from Fig. 11 show that compressive strength is significantly affected by the B<sub>4</sub>C content. This proves what is already known: that B<sub>4</sub>C particles enhance Al-B<sub>4</sub>C composites.

Table 5. Compression strength of Al2005-B<sub>4</sub>C composites.

Sl No.	Material	Comp. strength (MPa) with standard deviation	Improvement (%)
1	Al2005 alloy	565.06 ± 4.69	---
2	Al2005- 4 wt.% B <sub>4</sub> C	688.32 ± 3.00	17.91
3	Al2005- 8 wt.% B <sub>4</sub> C	770.35 ± 4.41	26.65

#### CONCLUSIONS

Al2005 alloy with 4 and 8 wt.% of B<sub>4</sub>C composites are produced by stir casting and the following conclusions are made.

Microstructures of the produced Al2005 and Al2005 composites with 4 and 8 wt.% B<sub>4</sub>C are examined by SEM and EDS.

SEM micrographs and EDS confirm the presence and distribution of B<sub>4</sub>C micro particles in the Al2005 alloy.

The Al2005 alloy with 8 wt.% B<sub>4</sub>C composites has a 24.85 % increase in hardness.

In addition, the ultimate, yield, and compression strengths of Al2005 alloy are increased by 24 %, 27 %, and 26.6 %, respectively, with the addition of 8 wt.% of carbide particles.

By adding 4 and 8 wt.% of carbide particles, the ductility of the aluminium alloy is reduced.

Ductile mode fracture is seen in Al2005 material on fractured surfaces of tensile specimens. Additionally, brittle mode of fracture is noted in the composites as the reinforcing amount increases to 8 wt.%.

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## CALENDAR OF CONFERENCES, TC MEETINGS, and WORKSHOPS

August 10-14, 2026	ICSID2026 - International Conference on Structural Integrity and Durability	Dubrovnik, Croatia	<a href="https://icsid2026.fsb.unizg.hr/">https://icsid2026.fsb.unizg.hr/</a>
September 6-11, 2026	European Conference on Fracture ECF25	Athens, Greece	<a href="https://ecf25.eu/en">https://ecf25.eu/en</a>
September 6-11, 2026	TC2, Thematic Symposium 'Micromechanisms of Fracture and Fatigue' within the framework of European Conference on Fracture - ECF25	Athens, Greece	<a href="#">link</a>
September 6-11, 2026	TC4, Thematic Symposium within the framework of European Conference on Fracture - ECF25	Athens, Greece	<a href="https://ecf25.eu/en">https://ecf25.eu/en</a>
September 6-11, 2026	TC14, Thematic Symposium 'Integrity of Biomedical and Biological Materials' within the framework of European Conference on Fracture - ECF25	Athens, Greece	<a href="https://ecf25.eu/en">https://ecf25.eu/en</a>
September 6-11, 2026	TC20, Thematic Symposium 'Cultural Heritage Preservation' within the framework of European Conference on Fracture - ECF25	Athens, Greece	<a href="#">link</a>
October 7-8, 2026	TC4, Fall meeting	Kaiserslautern, Germany	
February 15-17, 2027	IGF29 - 29 <sup>th</sup> International Conference on Fracture and Structural Integrity	Vicenza, Italy and online	<a href="#">link</a>
April 14-16, 2027	Very High Cycle Fatigue (VHCF10)	Paris, France	<a href="#">link</a>
September 19-23, 2027	TC4, The 10 <sup>th</sup> International Conference on Fracture of Polymers, Composites and Adhesives	Les Diablerets, Switzerland	