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Research Article

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# Investigate the Impact and Wear Analysis of Aluminum Metal Matrix Composite via Stir Casting

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## Abstract

The aim of this study is to investigate the mechanical and metallurgical properties of the aluminum metal matrix composite (AMMC). Aluminum 7075 is the matrix material, and the boron carbide ($B_4C$) selected as the reinforcement particle. The AMMC is made through the stir casting process with various reinforcement ratios. The metallurgical properties wear rate is investigated through pin on disc tester. Absorption energy rate during fracture. Based on the results, we can conclude the effective reinforcement percentage of AMMC, which is used for the constraint application.

## Keywords

Al7065, Boron carbide, Impact strength, Wear rate, Stir casting

## Introduction

Aluminum matrix composites (AMCs) are excellent substitutes for conventional materials, especially in the automotive and aeronautical sectors. AMCs are constructed from aluminum [1]. Ceramic-reinforced alloys have been developed to produce cost-effective composites with enhanced strength, excellent thermal stability, and wear resistance as compared to single-component alloys [2-3]. Metal matrix composites (MMCs) are produced by adding solid ceramic-based particles as reinforcement into an aluminum matrix material. A metal matrix with ductile qualities and ceramics with high toughness combine to generate a material that reaches a desired amount of composite strength [4-6]. AMCs are used for their great resistance to refractoriness and in the continuing development of electronic components, structural corrosion, and tribological importance [7]. AMMCs' mechanical characteristics are greatly affected by altering the volume or weight proportion of reinforcing particles [8]. AMCs provide advantages, including advanced automated machinery, seals, bearings, high-performance bicycle parts, valve components, turbine parts, brake components, optical and laser equipment, and semiconductor industrial machinery. Magnesium-based matrix alloys in the six series, known as AMCs, have been widely used in many applications due to their exceptional mechanical properties, such as malleability, weldability, ductility, and accessibility [9-10]. Many academics have explored the reasons behind the widespread investigation of 7xxx series alloys. This study concentrates on producing AMCs by the stir casting technique by incorporating a maximum of 15% by weight of $B_4C$.

## Experimental Procedure

MMCs are popular engineering materials due to their low density and exceptional mechanical properties such as hardness, wear resistance, tensile and flexural strengths, and aluminum content. They are used in various industries, including nuclear power, aerospace, automotive, marine, and armour production. $B_4C$ is utilized in various technical applications because of its exceptional hardness, corrosion resistance, and mechanical properties, which make it an excellent material for reinforcement. $B_4C$ is commonly used in refractory applications requiring materials with strong resistance to ballistics due to its high hardness, low density, high melting point, and thermal stability. It is utilized in applications such as tank armor, neutron radiation absorbers, and ballistic protection (Table 1). Aluminum alloy-based composites with a metal matrix were analyzed, containing 15% volume of additional reinforcement (Figure 1).

The $B_4C$ was made with uniform grain size using a ball-milling process. The $B_4C$ particles were mixed with Al7075, and the mixers were compacted with the power hydraulic press. The solid particle is removed from the die, and then the specimen is under the sintering process. This process is used to strengthen the prepared workpiece through the heating process. The work utilizes Al7075, and its chemical composition is detailed in table 2.

Al7075 samples were produced by incorporating 3, 5 and 10 wt percentage commercial-grade $B_4C$ powder by the stir casting.

## Results and Discussion

### Impact toughness test

One typical way to find out how strong a material is under impact is to do a Charpy impact test. The standard size for Charpy V-notch testing specimens is 10 mm × 10 mm × 55 mm, as shown in figure 2, according to ASTM A370. A notch 2 mm deep and 45° angled is necessary for the test. The impact strength was determined by averaging the results of three separate tests.

**Table 1:** Properties of $B_4C$ reinforcement material.

| Properties | $B_4C$ Particle |
|---|---|
| Density (kg/m³) | 2.52 × 103 |
| Hardness (Mohr's scale) melting | 9.3 |
| Young's modulus (N/mm²) | 450 × 103 |
| Temperature (°C) | 2445 |

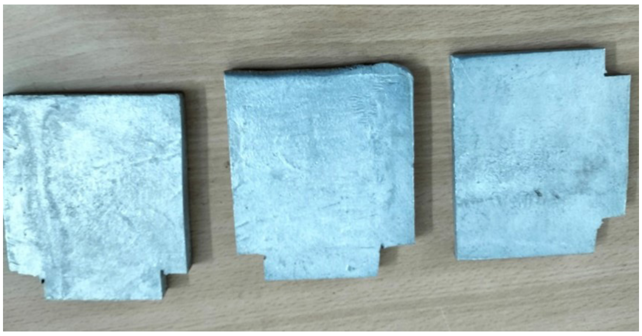

**Figure 1:** Prepared aluminum composite.

### Wear analysis

The findings of the wear tests conducted on the AA7075 composites and the unreinforced specimens while they were subjected to a dry sliding condition have been displayed in this part. The weight loss of the test specimens during sliding was used to compute the wear rate of the specimens, and the result was expressed in millimetres per metre (mm³/m). The wear test was carried out with three different loading circumstances, including a sliding velocity of 10 Newton metres per second, a speed of 1.57 m/s, and a sliding distance of 1600 m (Figure 3). The examination was carried out on three different combinations of the composite's components: AA7075 plus 3, 5, and 7% by weight of $B_4C$, respectively.

## Conclusions

The stir casting technique allows for the correct distribution of reinforcing particles during the manufacturing of AL 7075-B4C-Gr hybrid composites. These findings about the mechanical characteristics of the $B_4C$ reinforced Al7075 hybrid composite were derived from the experimental investigation.

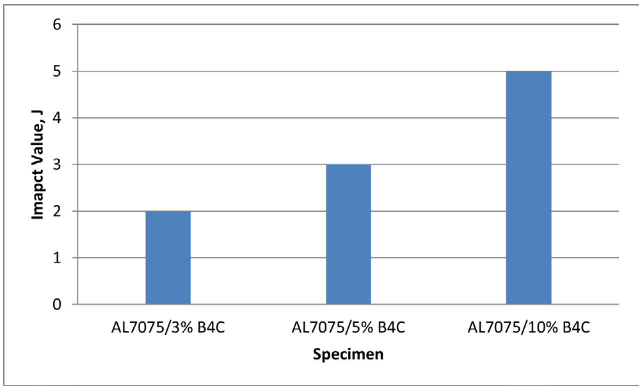


**Figure 2:** Standard size for Charpy V-notch.

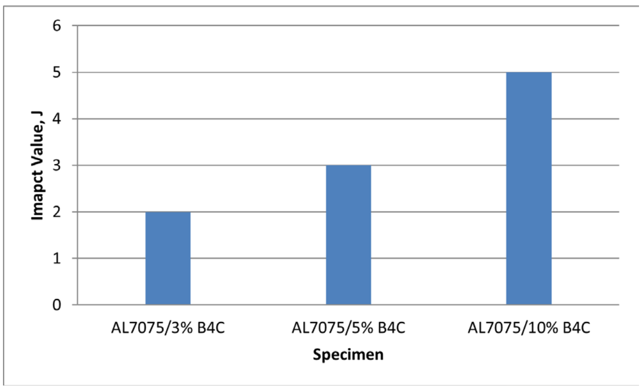


**Figure 3:** Wear rate.

**Table 2:** Chemical composition of Al7075.

| Iron (%) | Silicon (%) | Chromium (%) | Manganese (%) | Magnesium (%) | Zinc (%) | Copper (%) | Titanium (%) | Aluminum (%) |
|---|---|---|---|---|---|---|---|---|
| 0.5 | 0.5 | 0.2 | 0.4 | 3.25 | 1.8 | 1.9 | 0.15 | Bal |

- The impact strength increases significantly as the fraction of $B_4C$ particles on the metal matrix improves when using 10% $B_4C$.
- When the sliding distance remains the same, it has been demonstrated that all composites exhibit a decrease in wear rates as the sliding velocity increases. 10 Newtons is both its maximum and minimum load capacity.

## Acknowledgements

None.

## Conflict of Interest

None.

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