



## EVALUATION OF MECHANICAL PROPERTIES OF ALUMINIUM – BORON CARBIDE COMPOSITES

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### ABSTRACT:

*Materials technology and Engineering design field requires advanced engineering materials with high end mechanical, electrical and magnetic properties. To suit the requirements of engineering industries, the ceramic particles like  $Al_2O_3$ , BORON are mostly reinforced with Aluminum metal matrix for their improved mechanical properties like hardness, toughness, and low wear rate. Recent researches show that, boron carbide reinforced Al metal matrix composites has attractive properties like good tensile strength, high hardness and low density than Al-BORON composites in this thesis, to develop lightweight Aluminum - Boron carbide composites and evaluate the mechanical properties with effect of addition of calcium carbide particles Objective of this research is to fabricate and testing the mechanical properties of Aluminum metal matrix composites with Boron Carbide at different volume proportions. Mechanical properties like tensile strength, impact strength and hardness of newly developed metal matrix composites is improved significantly by incorporating boron carbide particles.*

**Keywords:** Aluminum - Boron carbide composites, metal matrix composites, Stir Casting

### 1.0 INTRODUCTION:

A composite is a structural material that consists of two or more constituents that are combined at a microscopic level and are not soluble in each other in which one

constituent is called the reinforcing phase and the other in which the reinforcement is embedded is called the matrix phase. Reinforcement provides strength and rigidity, helping to support structural load.

#### Characteristics of Composites:

**High strength to weight ratio:** Fiber composites are extremely strong for their weight. By refining the laminate many characteristics can be enhanced. Stiffness should not be confused with strength.

**Light weight:** A standard fiber glass laminate has a specific gravity in the region of 1.5, compared to alloy of 2.7 or steel of 7.8. When you then start looking at carbon laminates, strength can be many times that of steel, but only a fraction of weight.

**Translucency:** Polyester resins are widely used to manufacture translucent moulding and sheets. Light transmission of up to 85% can be achieved

**Low Thermal conductivity:** Fiberglass Developments has been involved in the development and production of specialized meat containers which maintain prime cuts

of chilled meat at the correct temperature for Export markets. They are manufactures using the RTM process, with special reinforcing and foam inserts.

### **Advantages of Composite**

#### **Materials**

- Tensile strength of the composite is four to six times greater than that of steel or aluminum.
- Improved torsional stiffness and impact properties.
- Higher fatigue endurance limit.
- Lower embedded energy compared to other structural metallic materials like steel, aluminum etc.

Composites are less noisy while in operation and provide lower vibration transmission than metals.

#### **2.0 LITERATURE REVIEW:**

[1] **B.Stalin, S.Arivukkarasan (2015)** Mechanical investigation of Aluminum alloy (AA) LM 6, B4C (boron carbide) and TiO<sub>2</sub> metal matrix composites. Aluminum is the matrix metal having properties like light weight, high strength and ease of machinability. Boron carbide which has excellent hardness and fracture toughness is added as reinforcements with TiO<sub>2</sub>. It has been inferred that the tensile strength of sample 1 is marginally higher than other two samples because of its Aluminum content. But, the sample 3 has higher tensile strength (157.1 MPa) than sample 2 (148.48 MPa).

[2] **Dr.B.Stalin C.Murugan (2016)** the fabrication of 5,10,15 wt % of Boron carbide reinforced with Aluminum alloy LM4 metal matrix composite by using liquid

stir casting technique was performed and fabricated under ASTM standard B557M for finding its tensile strength, Hardness and Impact tests were carried out and compared with the base metal and its metallographic structure of its each proportion. In this evaluation Aluminum Metal Matrix Composites of LM4-B4C were fabricated in three different proportions like LM4 reinforced with different Wt% of boron carbide with its value of density, hardness, tensile, impact tests showed that improved its mechanical behavior and characters. Percentage of Elongation, density values were decreased by increasing the percentage of reinforcement.

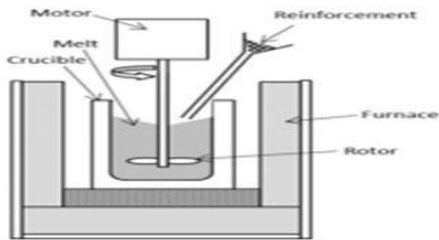
[3] **Saikerthi.S.P, Vijayaramnath.B (2014)** Metal matrix composite (MMC) focuses primarily on improved specific strength, high temperature and wear resistance application. From the collected literature it is found that, metal matrix composites are under serious consideration as potential candidate materials and it is mainly used to replace conventional materials in aerospace and automotive applications. So, the MMC are highly used in automotive and space applications. And the Aluminum Matrix Composite is a material with two constituent parts, one being a metal, and other being reinforcement.

[4] **AifWakeel, 2mustafa Saleem(2017)** the aluminum metal matrix composite fabricated through different powder metallurgy process. This MMC's has wide application in aerospace, automobile, sports and industrial appliances due to their high strength to weight ratio, high temperature, better corrosion and wear resistance. This

study will reveal the effect of different reinforcement in an aluminum matrix composite and review the technique that different researcher used to fabricating and estimating different mechanical and tribological properties.

**3.0 PREPARATION OF SPECIMENS:**

Casting process is a simplest and cost effective liquid state fabricating method of metal matrix composites, in which a distributed phase (ceramic particulates) is mixed with a molten matrix by means of mechanical stirring which ensures a more uniform distribution of the reinforcing particles. In this process, 6061 Aluminum alloy was superheated to 800°C and then the temperature is lowered gradually below the liquids temperature to keep the matrix material in the semi-solid state. At this temperature, the preheated boron carbide with different volume proportions of (10 % B<sub>4</sub>C, 15 % B<sub>4</sub>C, 20 % B<sub>4</sub>C, 25 % B<sub>4</sub>C) average size of 45 μm & 100 μm respectively were introduced into the slurry and mixed using a graphite stirrer.



*Fig: Line diagram of Stir Casting*

**Table: Properties of Boron carbide:**

Physical properties	Metric
Density	2.52 g/cc
Mechanical properties	Metric
Young's modulus	450-470 Gpa
Poisson's ratio	0.18-0.21

**Table: Properties of Al-6061:**

Physical properties	Metric
Density	2.7 g/cc
Mechanical properties	Metric
Modulus of elasticity	68.9 Gpa
Poisson's ratio	0.33

**Matrix material:**

Aluminum Alloy is greatly influence the engineering industrial applications Where most necessary areas of stress. And which can be accommodating thin sections and can able to cast varying cross sections. Cast alloy can also heat treated to improve the mechanical properties and also LM4 has the high static loads are anticipated and creep extinction at the elevated higher temperature.

**Machining process for double shape:**

The shape of the machined surface is determined by the contour of the cutting edges on the broach, particularly the shape of final cutting teeth. Broaching is a highly productive method of machining. Advantages include good surface finish, close tolerances, and the variety of possible machined surface shapes, some of them can be produced only by broaching. Owing to the complicated geometry of the broach, tooling is expensive. Broaching is a typical mass production operation. Broaching can be used for machining of various integrate shapes which cannot be otherwise machined with other operations. Some of the typical examples of shapes produced by internal broaching are: Productivity improvement to ten times or even more is not uncommon, as

the metal removal rate by broaching is vastly greater. Roughing, semi finishing and finishing of the component is done just in one pass by broaching, and this pass is generally accomplished in seconds.



**Figure: double shape machining process**

#### **Tensile Test:**

Tensile testing, also known as tension testing is a fundamental materials science test in which a sample is subjected to a controlled tension until failure. The results from the test are commonly used to select a material for an application, for quality control, and to predict how a material will react under normal forces. Properties that are directly measured via a tensile test are ultimate tensile strength, maximum elongation and reduction in area. From these measurements the following properties can also be determined: Young's modulus, Poisson's ratio, yield strength, and strain-hardening characteristics. Uniaxial tensile testing is the most commonly used for obtaining the mechanical characteristics of isotropic materials



**Figure: Tensile test machine**

#### **Hardness Test:**

Hardness is a characteristic of a material, not a fundamental physical property. It is defined as the resistance to indentation, and it is determined by measuring the permanent depth of the indentation. The Brinell hardness test method as used to determine Brinell hardness is defined in ASTM E10. Most commonly it is used to test materials that have a structure that is too coarse or that have a surface that is too rough to be tested using another test method, e.g., castings and forgings. The Rockwell hardness test method, as defined in ASTM E-18, is the most commonly used hardness test method. You should obtain a copy of this standard, read and understand the standard completely before attempting a Rockwell test.



**Figure: Hardness Test machine**

**Impact Test:**

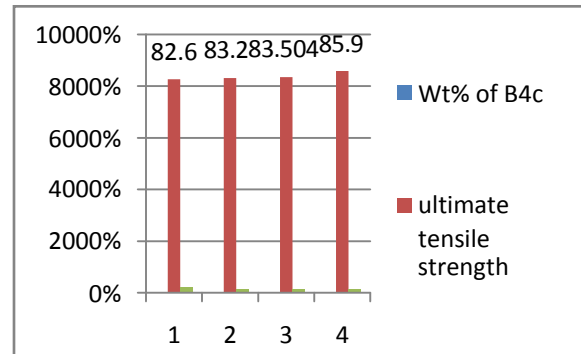
The impact test, also known as the Charpy V-notch test, is a standardized high strain-rate test which determines the amount of energy absorbed by a material during fracture. This absorbed energy is a measure of a given material's notch toughness and acts as a tool to study temperature-dependent ductile-brittle transition. It is widely applied in industry, since it is easy to prepare and conduct and results can be obtained quickly and cheaply. A disadvantage is that some results are only comparative. The technical contributions and standardization efforts by Charpy. The test was pivotal in understanding the fracture problems of ships utilized in many industries for testing materials, for example the construction of pressure vessels and bridges to determine how storms will affect the materials used.



**Figure: Impact Test**

**RESULTS AND DISCUSSIONS: Table 4.1**

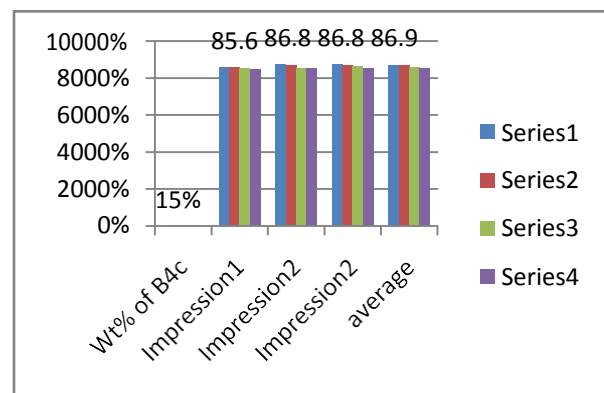
Wt% of B4c	Tensile and impact test results	Impact value /absorbed energy
10%	82.6	2
15%	83.2	1.5
20%	83.504	1.42
25%	85.9	1.42



**Graph: Effect of Wt% of boron carbide on tensile strength**

**Table 4.2 Hardness test results**

Wt % of B4c	Impression1	Impression2	Impression2	average
10%	86.0	87.2	87.3	86.83
15%	85.6	86.8	86.8	86.9
20%	85	85.3	86.1	85.76
25%	84.8	85.3	85.2	85.1



**Graph: Effect of Wt% of boron carbide on BHN value.**

## CONCLUSIONS:

This experimental evolution of Aluminum and Boron Carbide composites leads to the following conclusions:

- Production of Al-Boron Carbide composite was completed successfully.
- From mechanical investigation, there is increase in the tensile strength and BHN value with the increase in wt% of B<sub>4</sub>C.
- There is decrease in the absorbed impact energy with increase in wt% of B<sub>4</sub>C. This phenomenon may be due to the increased.

## FUTURE SCOPE OF RESEARCH:

There is a wide scope for future scholars to explore this area of research. The research results may be used in designing of mechanical components against vibrations which are,

- Propeller blades.
- Cutting tools.
- Cylinder liners.
- Aerospace applications

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