RESEARCHERID
THOMSON REUTERS
[Albert* *et al.*, 6(5): May, 2017]
IC™ Value: 3.00
ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

IJESRT
INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

# PREPARATION AND PROPERTIES OF ALUMINIUM COMPOSITE

**T. Albert*, C. Pravin Tamil Selvan**
* Department of Mechanical Engineering, VV College of Engineering, Tisaiyanvilai – 627657

**DOI**: 10.5281/zenodo.573525

## ABSTRACT

A composite material is the combination of two or more materials, which are having different phases and the properties superior to the base material. Aluminium matrix composite (AMCs) are emerging as advance engineering materials due to their strength, ductility and toughness. The aluminium matrix can strengthened by reinforcing with hard ceramic particles like SiC, Al2o3 , B4C etc. In this paper, an effort is made to enhance the mechanical properties like strength and hardness of aluminium matrix composite by reinforcing aluminium matrix with boron carbide particles. By powder metallurgy route, aluminium matrix has been reinforced with boron carbide particulate of 400µ sizes. The aluminium metal powder is blended with boron carbide in weight ratio of 5%wt and 10%wt. The microstructure and mechanical properties of the fabricated aluminium matrix composite has analyzed. The properties of pure aluminium formed by powder metallurgy has been compared with the properties of aluminium boron carbide formed by powder metallurgy. Based on the result obtained by the optical microstructure image reveal the homogeneous dispersion of boron carbide particles in the matrix. The reinforcement dispersion has also been identified with X-ray diffraction (XRD). The strength and hardness was found to increase with increase in wt% of the reinforcement.

**KEYWORDS**: Aluminium powder, Boron carbide particle, Metal matrix composite, powder metallurgy.

## INTRODUCTION

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 $Al_2O_3$, SiC are mostly reinforced with Aluminum metal matrix for their improved mechanical properties like hardness, toughness, and low wear rate (1). 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-SiC composites (2). Similar to boron carbide, Calcium carbide also has good mechanical properties with low density of 2.22 g/cm$^3$. In this work, boron carbide and calcium carbide particles are reinforced with 6063 Al alloy with different volume proportions. Main objective of this research is developing lightweight Aluminium metal matrix composites and analyzes the influence of Boron Carbide and calcium carbide reinforcements. The testing specimen is prepared by powder metallurgy method (3). The mechanical properties like hardness, toughness and stress-strain behavior are calculated by changing the reinforcement material composition (based on different volume percentage of $B_4C$). One of the most imperative aspects of this research is reinforcement of boron carbide particles in Aluminium metal powder results low weight and improved mechanical properties like hardness, and stress strain characteristics when compared with other metal matrix composites.

### ALUMINIUM

Aluminium is a silvery-white metal, the 13$^{th}$ element in the periodic table. One surprising fact about aluminium is that it's the most widespread metal on Earth, making up more than 8% of the Earth's core mass. It's also the third most common chemical element on our planet after oxygen and silicon. It is one of the lightest metals in the world: it's almost three times lighter than iron but it's also very strong, extremely flexible and corrosion resistant because its surface is always covered in an extremely thin and yet very strong layer of oxide film. It doesn't magnetize, it's a great electricity conductor and forms alloys with practically all other metals.

| | |
|---|---|
| Group | 13 |
| Period | 3 |
| Atomic number | 13 |

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

| | |
|---|---|
| State at 20 °C | Solid |
| Melting point | 660°C |
| Boiling point | 2519°C |
| Density (g/c) | 2.70 |

***Table 1 Aluminium fact box***

**BORON CARBIDE**

Boron carbide is characterized by a unique combination of properties that make it a material of choice for a wide range of engineering applications. Boron carbide is used in refractory applications due to its high melting point and thermal stability; it is used as abrasive powders and coatings due to its extreme abrasion resistance; it excels in ballistic performance due to its high hardness and low density; and it is commonly used in nuclear applications as neutron radiation absorbent.

| | |
|---|---|
| Melting point | 2763°C |
| Boiling point | 3500°C |
| Density (g/c) | 2.52 |
| Molar mass | 55.255g/mol |

***Table 2 Boron carbide fact box***

## PREPARATION

The aluminium powder and boron carbide powder are measured using a weight scale to make the required composition. In our project, we are using two composition, first one with 95 of aluminium powder and 5% of boron carbide and second one with 90% of aluminium and 10% of boron carbide.

**POWDER METALLURGY**

Powder metallurgy is the manufacturing science of producing solid parts of desired geometry and material from powders. Powder metallurgy method of forming a metal matrix composite involves three steps, they are as follow

- Blending
- Compaction
- Sintering

**BLENDING**

After taking the required composition of powder materials, we blended the materials using ah “twin shell” shaped blender. The metal powder is fed into the “twin shell” block and it is connected to the lathe. The “twin shell” block is filled with small metal balls for proper mixing. The lathe with “twin shell” shaped blender is made to run for 1 hours. After, that the metal powder are collected from it.

***Fig 1 Blending process***

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

**COMPACTION**

The cylindrical die is applied with graphite as a lubricant. The cylindrical die is filled with the blended powder of metal. Upper punch is placed over the powder. This set up is placed on the universal testing machine to apply load. Load of 300kN is applied on the punch to compress the blended powder to form a green compactor. The work part after compaction is called a green compactor simply a green, the word green meaning not yet fully processed. . Some organic binder is usually required to hold the hard particles together after pressing until the sintering process is ***performed***

***Fig 2 Compacting process***

**SINTERING**

The compressed metal powder is heated in a controlled atmosphere furnace below its melting point, but high enough to allow bounding of the particle. The purpose of heating is to increases the strength and hardness of the green compactor. This heating process is known as sintering.

## COMPOSITE AND COMPOSITION

| Composite | Composition |
|---|---|
| C1 | 100% of pure Aluminium powder |
| C2 | 95% of Aluminium powder + 5% of Boron Carbide powder |
| C3 | 90% of Aluminium powder + 10% of Boron Carbide powder |

***Table 3. Composite proposition***

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

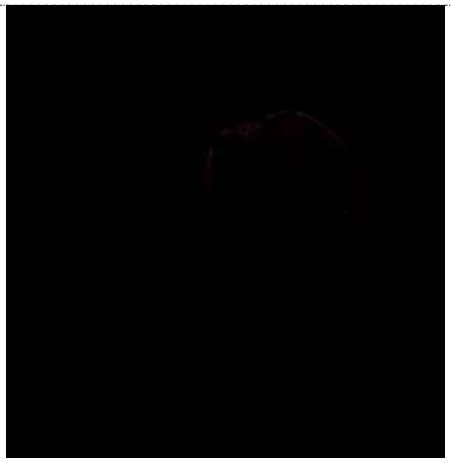

*Fig 3(a) 100% of Al* *Fig 3(b)95% Al + 5% $B_4C$* *Fig 3(c) 90% Al + 10% of $B_4C$*

## RESULT AND DISCUSSION

### SCANNING ELECTRON MICROSCOPE

A scanning electron microscope (SEM) is a type of electron microscope that produces images of a sample by scanning it with a focused beam of electrons. The electrons interact with atoms in the sample, producing various signals that contain information about the sample's surface topography and composition.

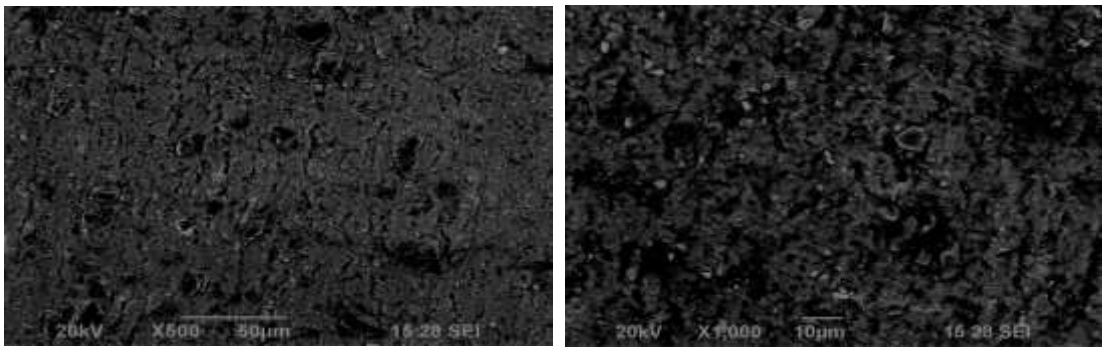


***Fig 4 (a) SEM micrograph showing the interface of Al-C composite 2 (95% of aluminium powder +5% of boron carbide powder) at different magnification. (a) x500 (b) x1000***

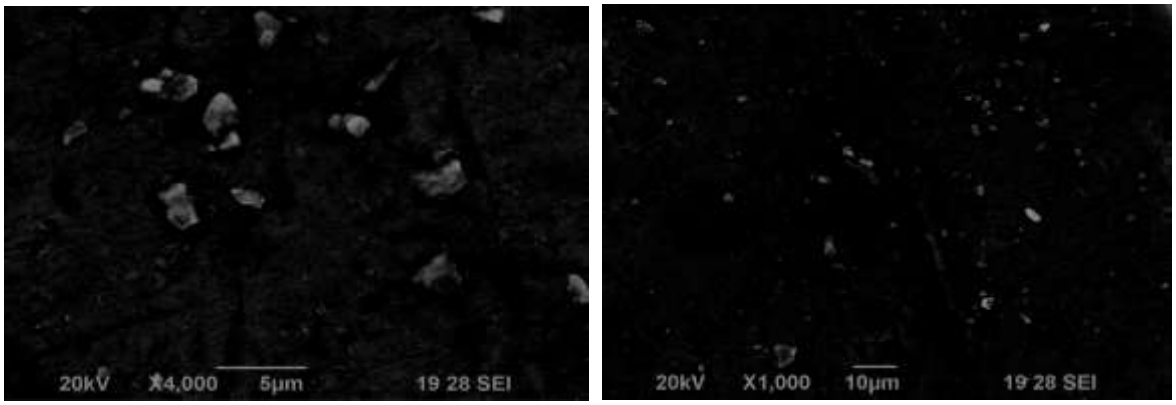


***Fig 4 (b) SEM micrograph showing the interface of Al-C composite 3 (90% of aluminium powder +10% of boron carbide powder) at different magnification. (a) x500 (b) x1000***

### ENERGY DISPERSIVE ANALYSIS OF X-RAY

It is an analytical technique used for the elemental analysis or chemical characterization of a sample. It relies on an interaction of some source of X-ray excitation and a sample.

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

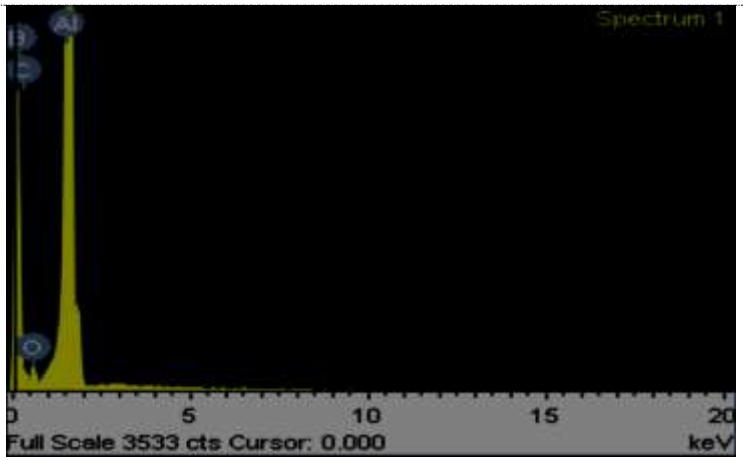


***Fig 5 (a) EDAX spectra showing the element present in the interaction layer at the interface of composite 2 (95% of Al and 5% of boron carbide)***

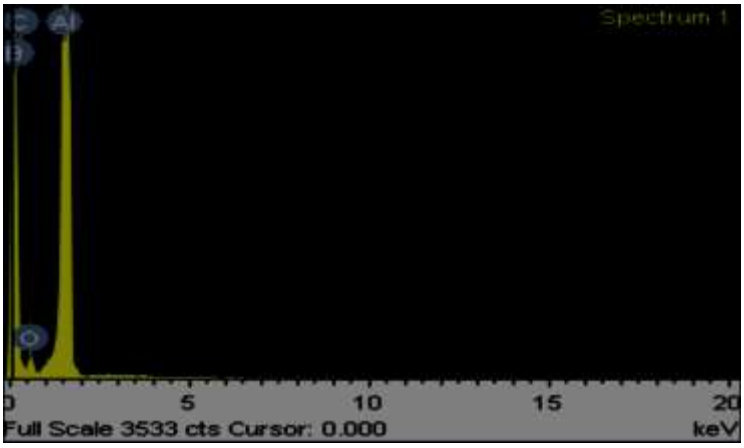


***Fig 5 (b) EDAX spectra showing the element present in the interaction layer at the interface of composite3 (90% of Al and 10% of boron carbide)***

The EDX spectrum reveals the presence of the elements Al, B, C and O in the interface reaction layer. It is believed that the small amount of oxygen detected by EDX is probably coming from a oxide layer formed during sample preparation. It is clear that the Al peak is higher than the boron carbide peak.

**HARDNESS**

The hardness value is determined for various samples by using Rockwell hardness test. The indentation was achieved by using 1/16" ball tip on the samples for the aluminium alloy. The 100 kgf load was applied on samples for indentation. The average hardness value were determined from the number of indentations. The hardness value gradually increasing according to the percentage increases of reinforcement.

| S.NO. | COMPOSITION | HARDNESS |
|---|---|---|
| 1 | 100% pure Aluminium | B60 |
| 2 | 95% of Aluminium and 5% Boron carbide | B71 |
| 3 | 90% of Aluminium and 10% of Boron carbide | B74 |

***Table 4. Hardness of aluminium composite***

## CONCLUSION

The present work on processing of aluminium reinforced with 5 and 10% wt of boron carbide particulate composite via powder metallurgy has lead to the following conclusions.

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

- Powder metallurgy was used successfully to produce aluminium boron carbide metal matrix composite.
- At the sintering temperature of 500°C, the interfacial reaction between aluminium and boron carbide is good.
- SEM, EDAX show the good interfacial reaction of the reinforcement particles and the matrix
- The hardness of the composite increases with increase in percentage of boron carbide

## REFERENCE

[1] R.M. Mohanty, K. Balasubramanian, S.K. Seshadri, Boron carbide-reinforced aluminium 1100 matrix composites: fabrication and properties, Materials science and engineering, 498(2008), p 42-52
[2] T.R. Chapman, D.E. Niesz, R.T. Fox, T. Fawcett, Wear-resistant aluminium-boron-carbide cermets for automotive brake applications, Wear, 236(1999), p81-87.
[3] G.E. Dieter, Mechanical metallurgy, 3rd edit., McGraw-Hill, 1976.
[4] E. Mohammad Sharifi, F. Karimzadeh, M.H. Enayati, Fabrication and evaluation of mechanical and tribological properties of boron carbide reinforced aluminum matrix Nano composites materials and design vol 32 (2011) P 3263–3271
[5] J. Lai, Z. Zhang, X.-G. Chen,Precipitation strengthening of Al–B4Cmetal matrix composites alloyed with Sc and Zr, Journal of alloys and compounds,Volume 552, 5 March 2013, Pages 227– 235
[6] K. Madheswaran, S. Sugumar, "Mechanical Characterization of Aluminium – Boron Carbide Composites with Influence of Calcium Carbide Particles"International Journal of Emerging Technology and Advanced Engineering,Volume 5, Issue 7, July 2015, pages 1-5.

## CITE AN ARTICLE:

**ALUMINIUM COMPOSITE. *INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY*, *6*(5), 179-184. doi:10.5281/zenodo.573525Albert, T., & Selvan, C. T. (2017). PREPARATION AND PROPERTIES OF**