

# **Fabrication and Testing of AL6063/B<sub>4</sub>C/Gr Hybrid Metal Matrix Composites**

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**ABSTRACT:** In the field of material science and engineering, there is a great impact ever since the invention of composites materials. Metal matrix composite is composite material with at least two constituent parts, one being a metal necessarily, the other material may be a different metal or another material, such as a ceramic or organic compound. When at least three materials are present, it is called a hybrid composite. Hybrid materials are composites consisting of two constituent at the nanometer or molecular level. In this project, composite materials based on Aluminum alloy(AL 6063) 85% reinforced with 10% wt fraction of Boron carbide (B<sub>4</sub>C) particulates and 5% wt fraction of Graphite particles is produced by stir casting method. The other specimen Aluminum alloy(AL 6063) 90% reinforced with 5% wt fraction of Boron carbide(B<sub>4</sub>C) particulates and 5% wt fraction of Graphite particles is produced by same casting method.

## **I. INTRODUCTION**

Hybrid Metal Matrix Composite (HMMC) is engineered combination of metal (Matrix) and hard particles (Reinforcement) to tailored properties. Hybrid Metal Matrix Composite (HMMC's) have very light weight, high strength, and stiffness and exhibit greater resistance to corrosion, oxidation and wear. Fatigue resistance is an especially important property of AL-MMC, which is essential for automobile application. A hybrid metal matrix composite (HMMC) is composite material with at least two constituent parts, one being a metal necessarily, the other material may be a different metal or another material, such as a ceramic or organic compound. When at least three materials are present, it is called a hybrid composite. An HMMC is complementary to a cermets. HMMCs are made by dispersing a reinforcing material into a metal matrix. The reinforcement surface can be coated to prevent a chemical reaction with the matrix. For example, carbon fibers are commonly used in aluminum matrix to synthesize composites showing low density and high strength. The matrix is the monolithic material into which the reinforcement is embedded, and is completely continuous. This means that there is a path through the matrix to any point in the material, unlike two materials sandwiched together. In structural applications, the matrix is usually a lighter metal such as aluminum, magnesium, or titanium, and provides a compliant support for the reinforcement. In high-temperature applications, cobalt and cobalt-nickel alloy matrices are common. The reinforcement material is embedded into a matrix.

However, aluminum alloy with discontinuous ceramic reinforced HMMC is rapidly replacing conventional materials in various automotive, aerospace, and automobile industries. Amongst various processing routes stir casting is one of the promising liquid metallurgy technique utilized to fabricate the composites. The process is simple, flexible, and applicable for large quantity production. In this study, different weight fraction of boron carbide and graphite particulates are added with aluminum matrix to fabricate the Al/B<sub>4</sub>C/Gr metal matrix composites. Different samples have been fabricated by melt-stirring casting and their microstructure, hardness are studied. In this study the influences of the reinforced particulate size and weight fraction (5%,10% and 5%,5%) on mechanical property of hardness. The reasons for aluminum's extensive application in the aircraft industry will then be identified and the use of metal matrix composite (MMC) to counter the pure element's (aluminum) shortcoming will be advocated.

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## II. RAW MATERIALS

### A. AL6063

Aluminum 6063 (Al6063) is chosen as the matrix material since, it is low cost and has better properties like good thermal conductivity, high shear strength, abrasion resistance, high temperature operation, non flammability, minimal attack by fuels and solvents, and the ability to be formed and treated on conventional equipment. It possesses excellent casting properties and reasonable strength. This alloy is best suited for mass production of lightweight metal castings. Fig. 1 shows Al6063.



Fig 1 Al6063

### B. Boron Carbide

Boron (Boron Carbide –  $B_4C$ ) (usually of size 2-4 micron) is used for reinforcement in the form of particulates. Boron is a very hard material, its hardness is 7.5 on Mohr's scale and specific gravity is 4.6-4.7. The principal structural unit of boron is a chain of alternating edge-sharing  $SiO_4$  tetrahedron and  $ZrO_8$  triangular decahedra. Fig. 2 shows.



Fig 2 Boron Carbide

### C. Graphite

Graphite particles (usually of size 0.5-100 micron) which are extracted from residues generated in the combustion of coal. Graphite has low density having good wet ability between Graphite & matrix Al alloy. It has low cost with advantages like isotropic properties and the possibility of secondary processing. It has high electrical resistivity and low thermal conductivity. It posses low density of Graphite may be helpful for making a light weight composites. Fig. 3 shows Graphite.

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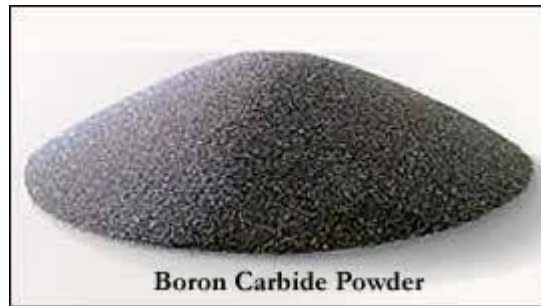


Fig 3 Graphite powder

### III. SPECIMEN PREPARATION

Two specimens were prepared by using stir casting. Table I shows composition of different reinforcements which were added in matrix material Al6063.

TABLE I COMPOSITION OF DIFFERENT RAW MATERIALS USED

Sample no.	Boron Carbide( $B_4C$ ) in Wt%	Graphite(Gr) in Wt%
1	10	5
2	5	5

#### A. Stir Casting Procedure

Al6063 was melted by raising its temperature to 9500C and degassed using a solid dry hexachloroethane compound. The Boron and Graphite particles were preheated for 30 min at 4000C for improving the wetability and added to the molten metal, and stirred continuously with an impeller at a speed of 600 rpm for 5 min. The melt with reinforcement particles was poured into a cubic permanent metallic mold with a diameter of 5 mm, 6 mm and 13 mm .The cast cubs were rapidly cooled to room temperature by knocking them out, 5mins after casting. Fig.4. shows the Stir Casting Machine.

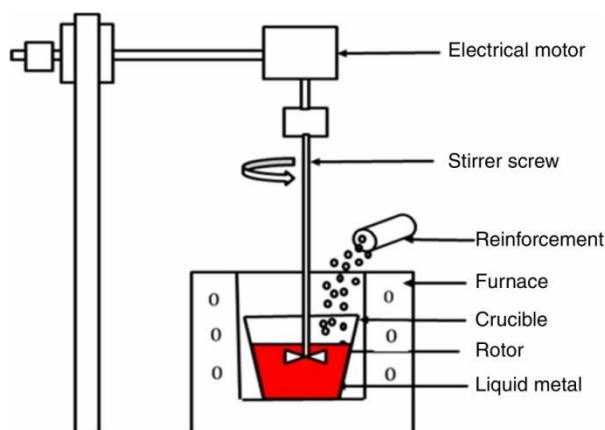


Fig 4 Stir casting Machine

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## IV. RESULTS AND DISCUSSION

### A. Hardness Test

Hardness is the resistance of a material to localized deformation. A hard material surface resists indentation or scratching and has the ability to indent or cut other materials. Hardness of the four stir casted samples was tested on Brinell Hardness Tester. In the Brinell hardness test, a hardened steel ball is pressed into the flat surface of a test piece using a specified force. The ball is then removed and the diameter of the resulting indentation is measured using a microscope. The Specimen used is of IS 1500 standard. Readings on 3 locations were taken and average reading of each sample was considered. Fig. 5 shows the specimens of hardness test.

Table I shows the hardness of the composites. Among the different specimen, Al6063 reinforced with 10% Boron and 5% Graphite has the highest hardness of 38 BHN. But for Al6063 5% Boron carbide, 5% Graphite Hardness value decreases to 34 BHN.



Fig 5 specimens of hardness test

TABLE I HARDNESS OF THE COMPOSITES

	Al6063+10% B <sub>4</sub> C+5%Gr	Al6063+5% B <sub>4</sub> C+5%Gr
HARDNESS (BHN)	38	34

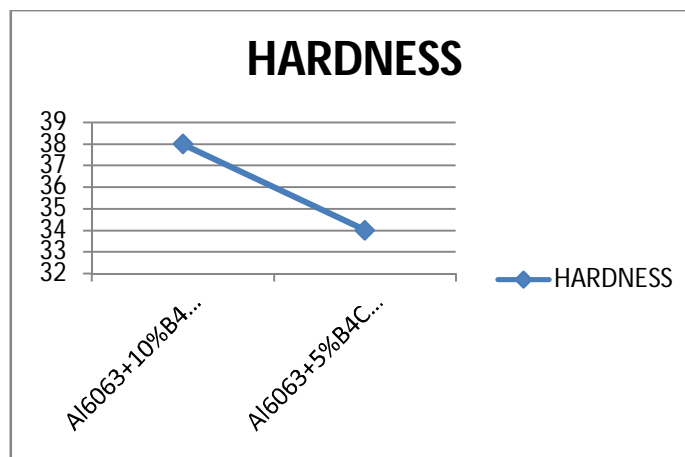


Fig.6. Comparison of hardness

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### B. Impact test

In an impact test a notched bar of material, arranged either as a cantilever or as a simply supported beam, is broken by a single blow in such a way that the total energy required to fracture it may be determined. The energy required to fracture a material is of importance in cases of -shock loading when a component or structure may be required to absorb the K.E of a moving object. Energy absorbed is the energy which is absorbed by the material. The energy is calculated in joules. The energy absorbed is calculated the energy available at the end. The energy absorbed can be found with the help of Charpy impact tests. The standard specimen size for Charpy impact testing is 10mm×10mm×55mm. Fig.7 shows the specimens of Impact testing.



Fig 7 specimens of Impact testing

Table II shows the energy absorbed by the composites. For Al7075, Al7075 + 3% Zircon, Al7075 + 6% Fly Ash and Al7075 + 3% Zircon + 6% Fly Ash energy absorbed are 2J. It is clear that energy absorbed is same for all compositions. Fig. 10 shows energy absorbed by the Composites.

TABLE II ENERGY ABSORBED BY THE COMPOSITES

	Al6063+10% B <sub>4</sub> C+5%Gr	Al6063+5% B <sub>4</sub> C+5%Gr
IMPACT (JOULS)	2.1	2.1

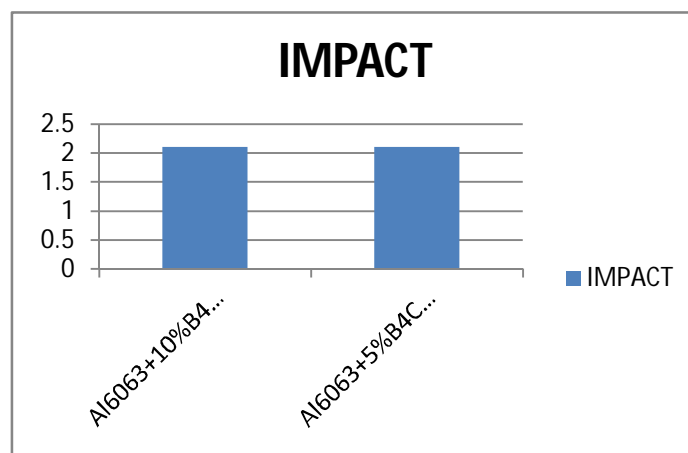


Fig.8. Comparison of Impact of composites

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### C. Wear Test

The dry sliding wear tests were performed on pin-on-disc apparatus. Wear test samples were made of size  $\phi 7 \times 50$  mm. The rotating disc material is made of EN-31 steel with the hardness of 63 HRC. Sliding wear tests were conducted on track diameter 15 mm with load 10 N, sliding speed 0.314 m/s and sliding distance 113.097 m. The dry sliding wear was observed by measuring weight loss. Weight loss of pins was converted into volume loss using density of specimens. Fig.9 shows the specimens used for wear tests. Table III shows Wear rate, Specific Wear rate and Coefficient of Friction.

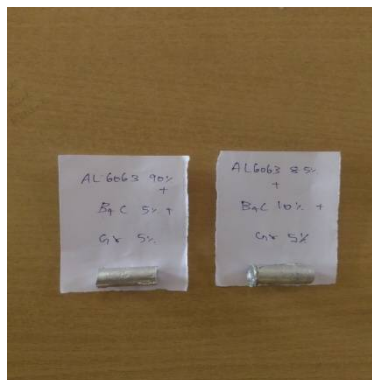


Fig 9 Specimens of wear test

TABLE III WEAR RATE, SPECIFIC WEAR RATE AND COEFFICIENT OF FRICTION

S N O	L O A D	SP EE D	DISTA NCE	WEAR RATE	SPC. WEAR RATE	CO.F RC
1	10	.31	113	0.0093	0.00093	0.426
2	10	.31	113	0.0071	0.00071	0.374

### V.CONCLUSION

From the experiments on Al6063/B<sub>4</sub>C/Gr hybrid metal matrix composites, the following conclusions are obtained.

- Hardness is more for Al6063+10%B<sub>4</sub>C+ 5%Gr than composition of Al6063+ 5% B<sub>4</sub>C + 5% Gr.
- Impact energy absorbed is same for all four compositions.
- Wear rate, Specific Wear rate and Coefficient of Friction is less for than Al6063+ 5% B<sub>4</sub>C + 5% Gr that of Al6063+10%B<sub>4</sub>C+ 5%Gr.

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