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Characterization of Un Heat Treated and Heat Treated Al 6063/B_4C Particulate Composites

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***Abstract:-* The mechanical characteristics of Aluminium-Boron Carbide Al6063-B_4C Metal Matrix Composites(MMC) using a stir casting method is discussed. MMC's with varying percentage of B_4C 3-9% with Aluminium as matrix is fabricated and subsequently mechanical characteristics of Al-B_4C was studied. The heat treated & non heat treated Al-B_4C was also studied. The hardness and tensile strength of the material is increased as reinforcement added with Aluminium.**

Keywords: Al-B_4C, Stir casting method, heat treatment

1 INTRODUCTION

Composite materials are a result of the continuous attempts to develop new engineering materials with low weight to strength ratios and improved properties. Among modern composites materials, particulate reinforced metal matrix composites (MMCs) are finding increased applications due to their favorable mechanical properties such as improved strength, stiffness and increased wear resistance over unreinforced alloys. In particular, composites show enhanced properties compared to unreinforced alloys. Aluminium metal matrix reinforced with Boron Carbide (B_4C) is a novel composite, which is used in automotive industries (ex. brake pads and brake rotor) due to high wear resistance, high strength to weight ratio, elevated temperature toughness and high stiffness.

Metal matrix composite (MMC) is a material which consists of metal alloys reinforced with continuous, discontinuous fibers, whiskers or particulates, the end properties of which are intermediate between the alloy and reinforcement. Aluminium metal matrix composites have become the necessary materials in various engineering applications like aerospace, marine and automobile products applications such as engine piston, cylinder liner, brake disc/drum etc. and also material is used for architectural applications, shop fittings, irigation tubing, window frames, extrusions and doors. [1]

The work is made to develop the composite involving aluminium matrix reinforced with particulates of Boron carbide (produced by stir casting technique), the cast composites were tested for hardness tensile and impact properties.

II. EXPERIMENTAL PROCEDURE

The details of the experiments carried out on Al6063 alloy subjected to refinement B_4C and with T6 heat treatment has been highlighted under the following.

- Preparation of Composites
- Melting and casting
- Heat Treatment Process

A. Preparation of Composites

Matrix Material

The base matrix chosen in the work is the aluminium 6063. Alloy 6063 is an aluminum alloy containing copper, magnesium, manganese and some minor alloying elements. They have high strength to weight ratio, good formability, age hardenability and other appropriate properties.

Reinforcement Material

Boron carbide is an attractive reinforcement for aluminium and its alloys. It Posses many of the mechanical and physical properties required of an effective reinforcement, in particular high stiffness properties and high hardness properties.

B. Melting and casting

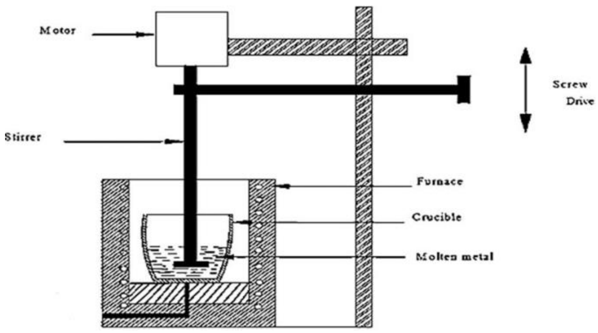

Fig1.Stir Casting Technique

1) Production of the metal matrix composite (MMC) through stir casting technique.

2) The Al6063 alloy melts at a temperature of 656˚C in a graphite crucible in melting furnace and degassing was carried out using hexa chloro ethane degassing tablets.
3) The stirring device was a stainless steel rod, which was equipped with four stirring blades, each 1 mm thick. The blades were mounted radial on the rotating rod, being angled 5° to the radial horizontal rotational plane
4) The addition of B_4C will be added on the percentage weight of the aluminium alloy.
5) The mixture starts from 3% by weight and will go on up to 9% by weight, with the increment of 3% per trial.
6) The molten alloy was stirred at 400 rpm for up to 1 min until a vortex is formed. Preheated B_4C particles at 2000˚C was added into the formed vortex slowly and steadily while continuing stirring for 3-5 min in a maneuvering way to ensure the complete insertion of particles.
7) The molten metal will be poured into preheated finger mould die.

C. Heat treatment process
The Aluminum composites were heat treated and tempered to T6 condition, i.e. the samples were heated at 521˚C for 3 hours and then immediately quenched in water at room temperature and finally were artificially aged in the furnace at 177˚C for 8 hours and then air cooled to room temperature.

III. EXPERIMENTAL DETAILS

1.Hardness Test

Hardness is the property of a material that enables it to resist plastic deformation, usually by penetration. However, the term hardness may also refer to resistance to bending, scratching, abrasion or cutting.
Hardness is not an intrinsic material property dictated by precise definitions in terms of fundamental units of mass, length and time. A hardness property value is the result of a defined measurement procedure. This deformation may be in the form of scratching and mechanical indention or cutting. Indenters in the form of spheres and cones are frequently used. Hardness of the material was found out on Brinell hardness testing machine. Brinell hardness was carried out as follows:
1) The specimen or the area or location must be selected and polished so as to give a reliable indication of the properties of the material.
2) The specimen was placed on the anvil so that the surface is normal to the direction of applied load.
3) The anvil is raised by means of elevating screw.
4) Now, raise the anvil, the pointer comes to the red dot on the dial. [i.e., it indicates the application of minor load (10 kg) acting on the indenter. This is done to ensure the perfect seating and loading of the specimen].
5) Apply the major load (60 kg) with a 5 mm diameter steel ball indenter and wait for 30 seconds duration, to ensure the complete acting of the load on the specimen by the indenter.
6) Remove the load after 30 seconds, measure the indentation by using travelling microscope and find out the BHN using formula.

According to ASTM E18 standard
- Symbol of scale B
- Indenter 1⁄16-in. (1.588-mm) ball
- Total Test Force 60 kgf
- Dial Figures Red

The BHN is calculated according to the formula given below

$$BHN=2P/(\Pi D(D-\sqrt{(D2-d2)})$$

Where,
P (Load Applied)
D (Dia Of Ball Indenter)
d (Dia Of Indentation)

From hardness data in Figure 1 it can clearly be seen that, with the exception of the ductility, the addition of B_4C particles improves the mechanical properties of the resulting composite. It is shown the hardness of Al reinforced with 3-9% percentage level of B_4C. The results show that increasing the percentage level of B_4C with Al, hardness of the composite also increased

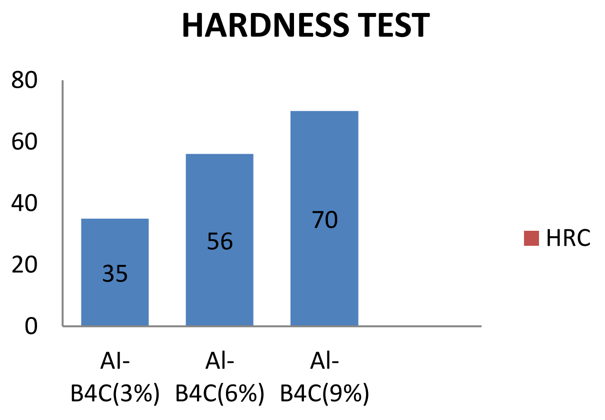

Fig.1: Hardness of Al in 3-9% of B4C
Hardness values 35, 56, 70.

2. Impact Test:

According To ASTM E23

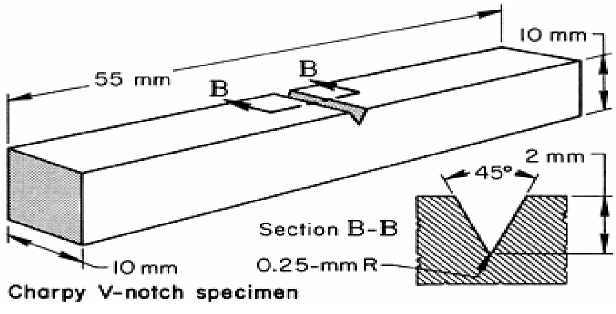

Fig 2 Charpy v-notch specimen

Fig 2. Shows that varying 3-9% of B_4C, Impact strength of Al- B_4C. The results shows while added B_4C in various percentage level with aluminium, the brittleness of the material also increased. Because of high brittleness, the impact strength of the material is decreased.

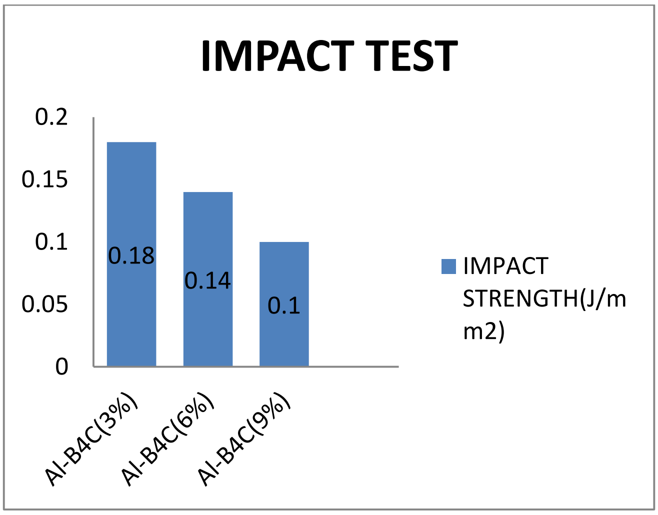

Fig. 2: Impact strength of Al-B4C (3-9%)

3. Tensile test

The tensile specimens were prepared as per ASTM E8M standard. The dimensions of the specimen are shown in Figure 3. The ultimate tensile strength was estimated using computerized uni-axial tensile testing machine The tensile strength of AMCs was found to be maximum (170.3MPa).

According To ASTM E8M

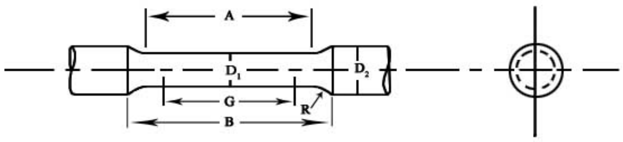

Fig 3: Tensile specimen

Gauge length (G)=25.40mm Distance between shoulders (B) = 42mm, Length of reduced section (A) =32 mm, Diameter of reduced section (D1) = 6.35 mm, Grip diameter (D2) = 12mm, Radius of curvature (R) = 10mm

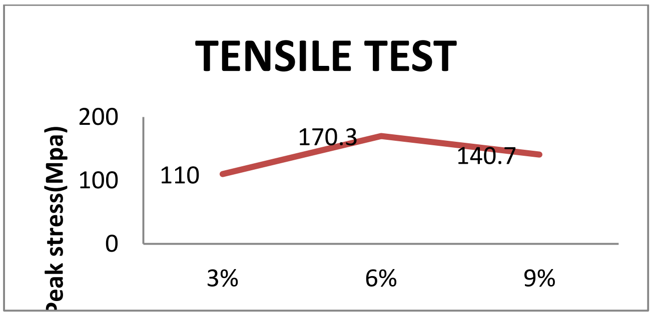

Fig 4.The Effect of Amount of B4C Particulates on the Peak Stress of Stir Cast AMCs

4 Compressive Strength

The graph showing the effect of B_4C content on the compressive strength of cast Al6063- B_4C composites. The graphite content increases 3-9%, the compressive strength of the composite material increases significant amounts. In fact, as the B_4C content is increased from 3% to 9%, the compressive strength increases by about 60% and this increase in compressive strength may be due to the B_4C particles acting as barriers to dislocations in the microstructure.

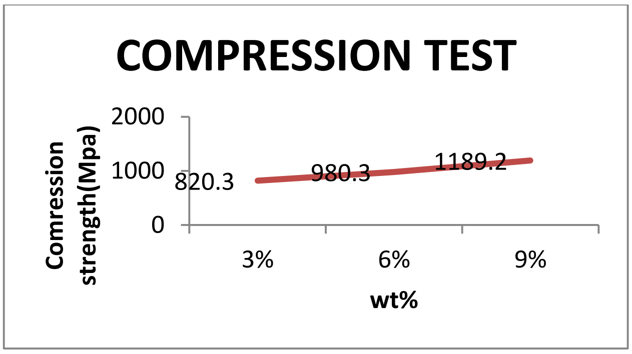

Fig 5 Effect of the B_4C content on compression strength

IV. CONCLUSIONS

The heat treated & non heat treated on Al- B4C (3-9%) which shows results

- The heat treated material of Al- B4C which is less harder than non heat treated.
- The hardness of the material is increased as reinforcement added with Aluminium.
- The Impact strength of the material is decreased as reinforcement added with Aluminium
- The tensile strength of the material is increased as reinforcement added with Aluminium
- The compression strength of the material is increased as reinforcement added with Aluminium.

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