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# FABRICATION OF hBN- Gr- CENOSPHERE - Al6061 HYBRID METAL MATRIX COMPOSITE AND ITS CHARACTERIZATION BY STIR CASTING METHOD

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***Abstract: In this project a hybrid composites of Al6061-hexa boron nitride-graphite and cenosphere will be created and the different mechanical and physical properties of the composites are discovered and compared with the properties of the reinforced Al6061 alloy. Al6061 is selected as the base metal matrix. Boron nitride, graphite and cenosphere are selected as the reinforcement. Boron nitride and graphites is maintained at constant of 2% and 6% weight for all the composition and varying cenosphere from 2% weight to 6% weight in the increments of 2% weight. The composites will be developed by stir casting method hardness test, and density test will be conducted. Specimens are prepared according to ASTM E8 standard. To know the uniform distribution of reinforcements into matrix by conducting microstructure analysis. The bonding between matrix and reinforcements of different compositions will be found out by using SEM Analysis.***

***Keywords: Al6061, Hexa Boron nitride, Graphite, Cenosphere, Stir casting, Hardness test, Density test, Microstructure analysis and SEM Analysis.***

## I. INTRODUCTION

The use of aluminium metal matrix composites has increased in the recent years replacing many conventional metals like steel, iron etc. in the fields of automobile, aerospace, marine, high speed trains etc. Composites have low density, high wear resistance, stiffness, reliability, toughness, good combination of strength to weight ratio[1]. Mechanical properties of aluminium will be improved by adding excellent reinforcement. The improvement of properties is through creating hybrid composite with two or more reinforcements[2]. Boron nitride is added to improve the mechanical properties of matrix but machinability problem occurs. Graphite and cenosphere is added to improve machinability [3].

## II. EXPERIMENTAL

### *A. CASTING METHOD*

Varieties of processes have been and are being developed for the manufacture of MMCs. Some of them are Sand casting, Stir casting, Die casting, Powder metallurgy, Centrifugal casting, Squeeze casting, Investment casting, Spray casting, and Liquid metal Infiltration. The stir casting process is preferred because of its low cost, easy adaptability and also near-net shape formation of the composites. Stir Casting is a liquid state method of composite materials fabrication, in which a dispersed phase (ceramic particles, short fibers) is mixed with a molten matrix metal by means of mechanical stirring.

Fig.1 Melting (attaining molten state)

Fig.2 Stirring the Mixture (Matrix + Reinforcement)

Fig.3 Removing the impurities – SLAG

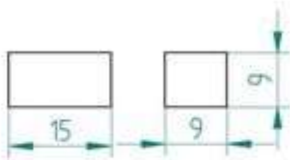
Fig.4 Pouring the molten

Fig.5 Removing of cast from moulds

Fig. 6 Casted specimen removed

*B. Hardness Test*




All dimensions are in mm.
Fig. 7 Hardness test specimen dimensions

- Select the indenter type (5mm ball indenter) and major load to be applied (250Kgf).
- Place the specimen on the anvil and rise by the elevating screw until the specimen comes in contact the tip of the indenter.
- Rise elevating screw until the minor load is applied i.e. 10kg here a small pointer in the dial moves and stop over set red mark.
- For about 10seconds apply the major load by operating the side handle.
- After the major load application bring back to the side handle to its initial position.
- Lower the anvil by using the elevating screw and take out the specimen.
- Now measure the diameter of impression made on specimen using the Brinell microscope.
- Calculate the BHN for each specimen using the formula given.
- Repeat the procedure for other specimens.the indented specimens are shown figure 8.

(A) Composition A

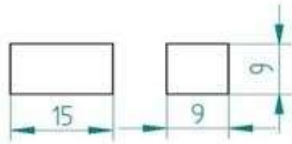
(B) Composition B

(C) Composition C

(D) Composition D

Fig.8 Indentations on the specimens

*C. Density Test*




All dimensions are in mm.
Fig.9 Density test specimen dimensions

Fig. 10 Density test set up

For less defined shapes, volume can be determined by water displacement. Volumes of liquids such as water can be readily measured in a measuring jar. To use the water displacement method, an object (in this case, a small cubical metal) is inserted into a measuring jar partially filled with water. The object's volume occupies space, displacing liquid and raising the water level shown in figure 10. The initial and final reading of measuring cylinder is recorded. The difference in the volume is calculated as final-initial level of water in measuring jar. The mass of the specimens is calculated by using commercially weighing machine. The density of the specimens is calculated using relevant formula and unit conversions.

*D. Microstructure Analysis*

The samples for microstructure examination were prepared as shown in Figure.

The following standard metallurgical procedures,

1. Grinding process:

Papers name; P400, P600, P800, P1000, P2000, P2500, P3000.we should rub the specimen to each paper for 5minutes.

2. Polishing process: 3. Etching process: Etched in etchant prepared using 99.5% of Distilled water, 0.5% of HCL, and were examined using Optical Microscope.

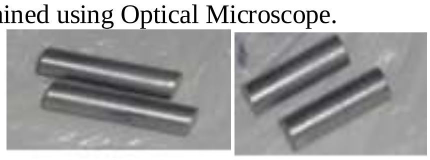


Fig.11 microstructure specimens

*E. SEM Analysis*

Scanning Electron Microscopy (SEM): high vacuum, high resolution SEM to evaluate surface structure. Environmental scanning electron microscopy can also be performed on hydrated samples. Energy Dispersive Spectroscopy (EDS): provides elemental information about the composition of the structure of the surface of a sample. Performed in conjunction with SEM. Elements with atomic numbers down to carbon can be viewed with EDS. Energy Dispersive X-Ray Analysis (EDX), referred to as EDS or

EDAX, is an x-ray technique used to identify the elemental composition of materials. Applications include materials and product research, troubleshooting, deformulation.

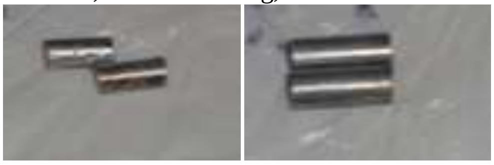


Fig.12 SEM specimens

## III. RESULTS AND DISCUSSIONS

### *A. HARDNESS TEST*

Brinell hardness test is conducted to know the hardness of composites. Here load of 250Kgf is applied for about 10 seconds. Then the diameter of impression was measured using the Brilnell microscope. BHN is calculated using brinell hardness formula. Table1 shows the good results for hardness test.

Table1: Hardness Test Results

| Compositions | Hardness(Kgf/mm²) |
|---|---|
| A | 35.68 |
| B | 40.20 |
| C | 43.65 |
| D | 47.55 |

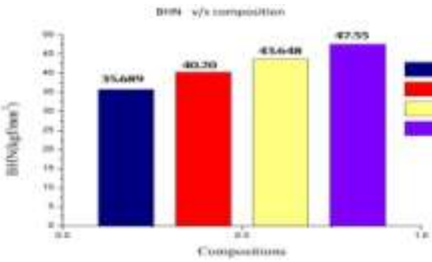



Fig. 13 Bar graph of Hardness v/s % weight of Compositions

Figure 13 shows, Bar graph of Hardness v/sweight % of Compositions. Brinell hardness is found to be increasing with increasing percentage of the reinforcement. This is because of the uniform distribution of matrix phase. The hard nature of the hBN (third hardest known after diamond and boron nitride) is used as reinforcement.

### *B. DENSITY TEST*

Table 2: Density Test Results

| Compositins | Density(kg/mm³) |
|---|---|
| A | 2824.05 |
| B | 2816.02 |
| C | 2812.32 |
| D | 2748.74 |

Table 2 shows the Density test results. Density is found to be decreasing with increasing in percentage of reinforcement. This is because of the fact, that graphite and cenosphere are light materials.

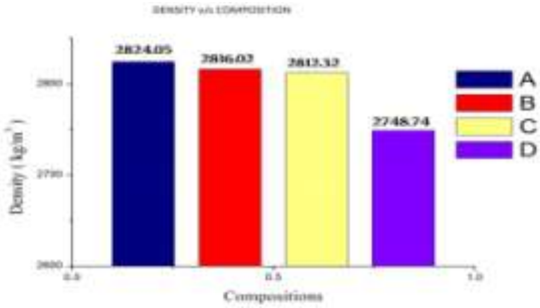



Fig.14 Bar graph of Density v/s weight % Compositions

Figure 14 shows bar graph of density v/s compositions, density is decreasing compared to the base material Al6061with increasing in percentage of reinforcement.

### *C. Microstructure*

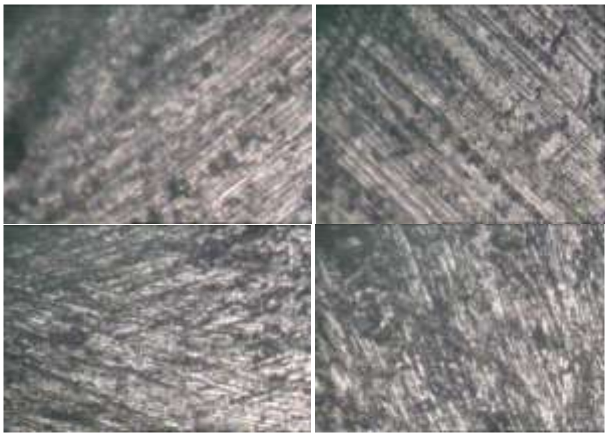


Fig.15 microstructure of different compositions

Microstructure figures shows the uniform distribution of ceramic reinforcements namely, hBN, Graphite and Cenosphere in Al6061 matrix.

### *D. SEM ANALYSIS*

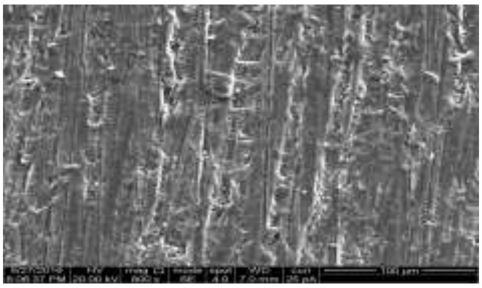


Fig.16(a)

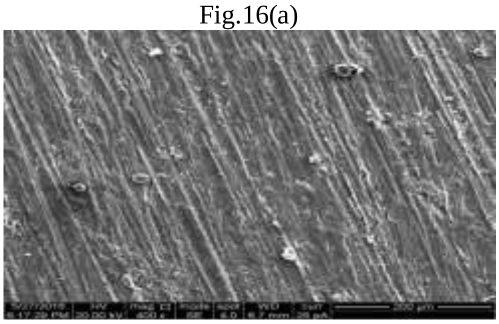


Fig.16(b)

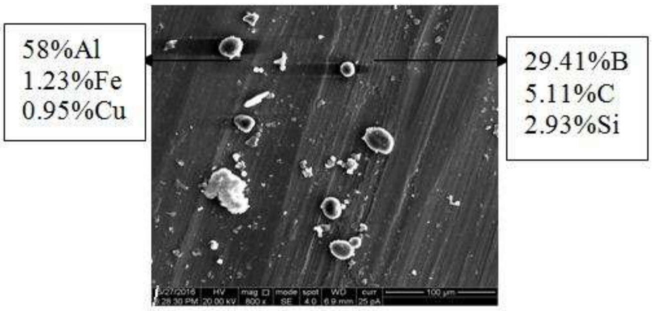



Fig.16(c) SEM and EDS Analysis of Al6061+2%hBN+6%Gr+6%Cenosphere

Fig.16(d) EDS Analysis of Al6061+2%hBN+6%Gr+6%Cenosphere

Fig.(c) shows compositions Al6061+2%hBN+6%Gr+6% Cenosphere 58 wt%Al, 29.41wt%B, 5.11wt%C,2.93wt%Si, 1.23wt%Fe, 0.95wt%Cu.

Fig.(d) shows graphical representation of compositions Al6061+2%hBN+6%Gr+6% Cenosphere by EDS analysis.

In this present work the surface structure and weight percentage of four different compositions is obtained by conducting SEM/EDS Analysis. The morphologies of compositions A, B, C, and D along with EDS analysis are shown in above figures.

## IV. CONCLUSION

- The hardness of the composites was found to be increased with the increase in the % weight of the cenosphere. The hardness is more for the composition D (2% hBN, 6% Gr and 6% cenosphere).
- The density of composites was found to decrease with the increase in the % weight of the cenosphere. The density is less for the composition D(6%Gr and 6% cenosphere) than the other composites due to light weight property Gr and cenosphere.
- Microstructure analysis results the uniform distribution of ceramic reinforcements namely, hBN, Graphite and Cenosphere in Al6061 matrix.
- Microphotographs shows better bonding between matrix, hBN, Gr and Cenosphere with no fracture observed at matrix particle interface. Overall, Al6061 can be considered as a suitable matrix for the development of 2wt.%hBN Cenosphere and Graphite reinforced aluminium based composites by stir casting.

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