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DEVELOPMENT AND CHARACTERIZATION OF hBN – Gr - CENOSPHERE - Al6061 HYBRID METAL MATRIX COMPOSITE

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Abstract: The use of composites made of Al has increased in the recent years replacing many conventional metals like steel, iron, etc. in the field of automobile, aerospace, marine, high speed trains, etc. Composites of their superior properties of Al6061 have low density, high wear resistance stiffness, reliability, toughness, good strength and low weight. In this project a hybrid composites of Al6061-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% weight for all the composition and varying cenosphere from 2% weight to 6% weight in the increments of 2% weight.
Keywords: Al6061, Hexa Boron nitride, Graphite, Cenosphere, Stir casting, Compression strength, Wear 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. Melting (attaining molten state)

Fig. Stirring the Mixture (Matrix + Reinforcement)

Fig. Removing the impurities – SLAG

Fig. Pouring the molten

B. Compression test

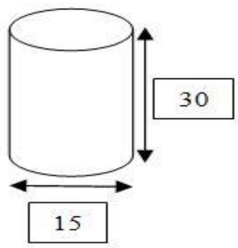

Fig. Compression test specimen dimensions

1. Using Vernier caliper the diameter and gauge length of the specimen are measured.
2. The specimen is placed over the lower cross head and its top surface isbrought in contact with the top plate by moving the middle cross headdownwards.
3. A dial gauge with a least count of 0.01mm is fixed on to the lower cross headits reading is adjusted to zero.
4. The range of loading is set to 0 to 600kN. In this work load is 40kN for all composition.
5. As the load gradually increases, in steps of 5kN, the dial gauge reading is noted.
6. When the load reaches a particular maximum value, the live needle begins to return back leaving behind the follower dummy needle. This load is noted down as the ultimate load.
7. After the fracture, the final diameter and final length of specimen are measured using verniercaliper. Observe the figures indicate before testing and after testing specimens of four different compositions.

Different Compositions


Fig. specimens before testing Fig. specimens after testing.


Fig. specimens before testing Fig. specimens after testing.

C. Wear test

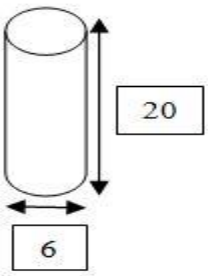

Fig. Wear test specimen dimensions

1. Clamping the Specimen: After thoroughly cleaning the specimen, insert it into the specimen holder and set the height of pin approximately 4mm above the wear disc. Tighten two clamping screws on the holder to clamp the specimen pin firmly. Wear specimens of four different compositons as shown in figures.
2. Setting Wear Track Diameter: Set the wear track diameter between 50-80 mm by moving the sliding plate on base plate. Tighten the sliding plate by clamping the screw sand ensure the assembly is clamped firmly.
3. Applying Normal Load: Normal load is applied by placing dead weight overloading pin. A set of weights from 0.5 to 3 kg (5N to 30N) are provided for this purpose. In this Present work Normal load is 5N.
4. Setting LVDT for Test: Switch on machine; add the required load on the load pin;loosen LVDT lock screw; and rotate thumb screw to bring LVDT position to mid position by observing wear digital display. When wear digital display is within ±50microns, lock the position. Set the display to zero using zero knob.
5. Setting Load Cell for Test: Move the loading arm approximately 2mm away fromthe load cell button and set the frictional force display to zero by operating zero knob.
6. Setting Test Duration: Set the required time of 5minutes using set, reset and enterbuttons.
7. Start the Test: Actuate Start Push button on front controller panel to commence the test.


Fig. wear specimens for different compositions

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. 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.

III. RESULTS AND DISCUSSIONS

A. Compression test

Table: The experimental results of ultimate strength and Peak load.

Compositions name	Ultimate strength(MPa)	Peak load (kN)
A	232	40.940
B	230	40.640
C	228	40.260
D	227	40.120

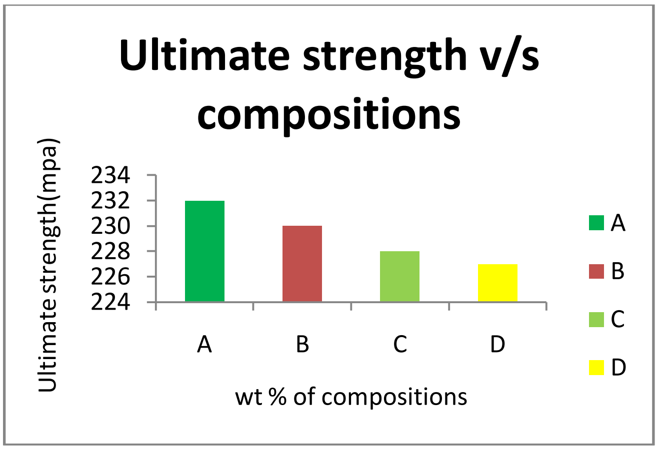

Fig. Bar graph of ultimate strength v/s wt % of compositions

Figure shows, Bar graph of ultimate strength v/s wt % of compositions the Ultimate strength start to decrease as compared to that of base material Al6061. It is because of the increase in the percentage of cenosphere and graphite reinforcement.

B. Wear test

Table: Results for wear and coefficient of friction

Sl. no.	Compositions	Normal load (N)	Wear (µm)	Co.eff. of Friction
1	A	5	1475	0.96
2	B	5	337	0.96
3	C	5	331	0.78
4	D	5	1023	0.6

Above table represents the results for wear test. In case of wear test composition of Al6061+2% hBN+6%Gr+4% Cenosphere (composition C), gives good results compared to composition of Al6061 (composition A), composition of Al6061 + 2%hBN + 6%Gr + 2%Cenosphere (compostion B) and composition of Al6061+2%hBN+6%Gr+6%Cenosphere (composition D).

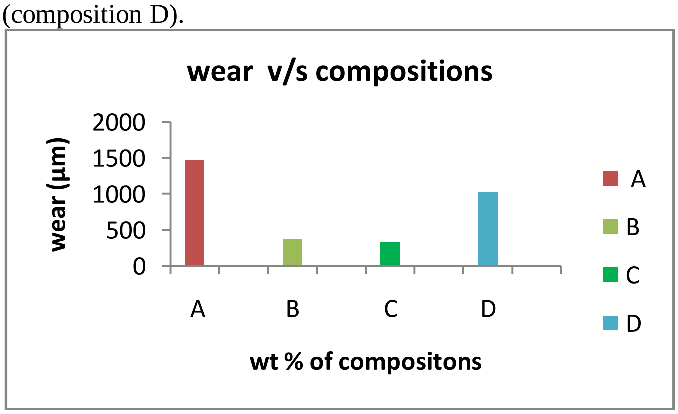

Fig. Bar graph of wear v/s weight % of compositions

Above figure shows bar graph of wear v/s weight % of compositions. it is observed that composition C has the good wear resistance.

C. Microstructure

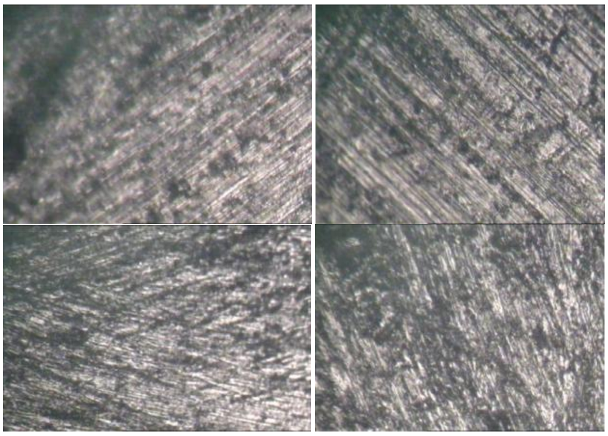

Fig. microstructure of different compositions

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

D. SEM ANALYSIS

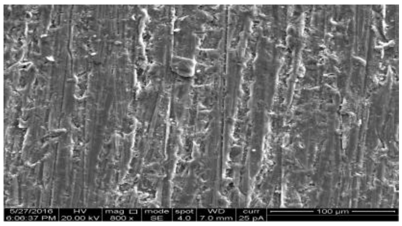

Fig.(a)

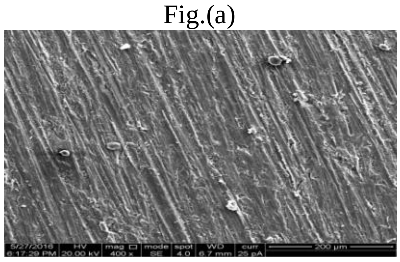

Fig.(b)

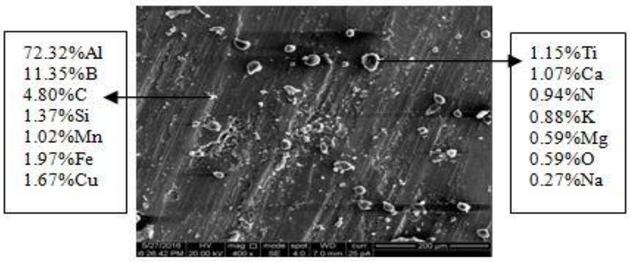

Fig.(c)SEM and EDS Analysis of Al6061+2%hBN+6%Gr+6%Cenosphere

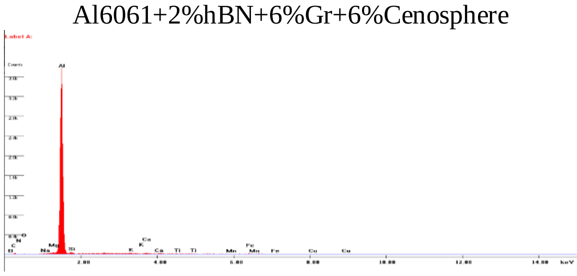

Fig.(d) EDS Analysis of Al6061+2%hBN+6%Gr+6%Cenosphere

Fig.(c) shows compositions Al6061+2%hBN+6%Gr+6% Cenosphere72.32wt%Al, 11.35wt%B, 4.80wt%C,1.37wt%Si, 1.02wt%Mn, 1.97wt%Fe, 1.67wt%Cu, 1.15%Ti, 1.0wt7%Ca 0.94wt%N,0.88wt%K, 0.59wt%Mg, 0.59wt%O, 0.27wt%Na. 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

In Compression test, the Ultimate strength decrease as compared to that of base material Al6061. It is because of the increase in the percentage of cenosphere and graphite reinforcements. The Wear decreased as compared to that of base material Al6061. It is because of increasing percentage of cenosphere until 4%. Wear is increasing while the percentage of cenosphere is increased to 6%. Therefore, in the case of wear test composition of Al6061 + 2% hBN + 6% Gr + 4% Cenosphere (composition C) gives good results compared to composition of Al6061(composition A), composition of Al6061 + 2% hBN + 6% Gr + 2% Cenosphere (composition B) and composition of Al6061 + 2% hBN + 6% Gr + 6% Cenosphere (composition D). The Wear rate of Composition C 331 μm, composition B 337μm. and composition A 1475μm and finally composition D 1023μm. Microstructure analysis results in 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 2wt.% hBN alloy can be considered as a suitable matrix for the development of Cenosphere and Graphite reinforced aluminium based composites by stir casting.

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