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INFLUENCE OF MICRO B_4C AND GRAPHITE PARTICULATES ADDITION ON MECHANICAL BEHAVIOR OF AL2024 ALLOY HYBRID COMPOSITES

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ABSTRACT

The paper is the result of investigations made on microstructure andmechanical behavior of 4weightpercentage of micro sized B_4C and 4 weight percentage of graphite particulate reinforced to Al2024 alloy composites. Al2024 matrix composite havingmicroboron carbide and graphite was fabricated by liquid stir casting method. The microstructure of the composites was examined byscanning electron microscopy and EDS. Further, mechanical behavior of hybridcomposites was studied. Tensile properties like hardness, ultimate tensile strength; yield strength and compression strength wereevaluated as per ASTM standards. Microstructural observation revealed uniform distribution of reinforcementparticles in thematrix and particulates were confirmed by EDS and SEM. The analysisdisclosed hardness, ultimate tensile strength, yield strength and compression strength of composites increased due to addition of reinforcements.

Keywords: Al2024 Alloy, B_4C, graphite, Ultimate Tensile Strength, Yield Strength, Stir casting.

INTRODUCTION

Aluminium based metal matrix composites (AMCs) have found greater applications in the field of automotive, aircraft industries owing to their low density and concomitant high wear resistance, strength, corrosion resistance, stiffness and thermal conductivity [1,2]. AMCs are fabricated by incorporating micro and micro sized ceramic particles, such as SiC, Al_2O_3 and B_4C, into the aluminium matrix. Boron carbide is a superior reinforcement material due to its high hardness, low density, high strength, high wear and impact resistance, high melting point, low coefficient of thermal expansion and good chemical stability [3]. Pankaj et al. synthesized the A356-B_4C (4 wt.%) and graphite particulate metal matrix composite by stirring process and reported that hardness was higher in case of 4wt. % of B_4C and shown improvements in ultimate and yield tensile strength with addition of B_4C and graphite particulates [4]. Krishna Dama et al. investigated the effects of adding micro size B_4C particles to ZA27 alloy on the mechanical properties, observed that the hardness, ultimate tensile strength and yield strength of alloy increased as the level of addition of B_4C particulates increased in steps of 3wt. %, 6wt. % and 9wt. %. Further, researchers concluded that the percentage of elongation decreased for the same % wt. with the addition of B_4C [5].Several methods are currently used to fabricate the metal matrix composites (MMNCs), viz mechanical alloying [6,7] high-energy ball milling [8], spray deposition, powder metallurgy, and various casting techniques [9]. The conventional mechanical stir casting method can be used to disperse B_4C particles in molten aluminium without agglomeration and clustering. mechanical and tribological properties are reviewed of different routes [10].

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EXPERIMENTAL WORK:

Material

The current study used 90 microns sized B_4C and50-micron sizedgraphite as reinforcement and Aluminium 2024 as matrix material with chemical compositions as shown in the below table 1

Table1. Composition of Al2024 alloy

Element	Al+	Cu	Mg	Si	Fe	Mn	Zr	Zn	Cr
% by Wt	Bal	4.5	1.6	0.45	0.25	0.40	0.10	0.20	0.05

Preparation of hybrid Composites

The micro composites containing 4 wt. % of micro B_4C particulates and 4wt. % particulates were prepared from two step stir casting process technique. Initially the required amount of reinforcements and the cast iron die are preheated to a temperature of 350°C-400°C. On the other part, the calculated amount of Al2024 was weighed and placed in a graphite crucible inside an electric furnace and heated to temperature of about 750°C. After the complete melting of Al2024, the degassing powder known as Solid Hexa Chloro Ethane (C_2Cl_6) is introduced into the molten melt so that the unwanted adsorbed gases are forced out from the melt. The molten melt is disturbed by dipping a zirconium coated mechanical stirrer to form a clear vortex by stirring mechanism at a speed of 300rpm. Once the vortex is formed then the preheated micro ceramic particles along with the proper proportion ratio of K_2TiF_6 is introduced into the molten melt in steps of two stages by a constant feed rate, which involves in dividing the entire weight mixture of micro B_4C, graphite and K_2TiF_6 into equal weights. At each stage the continues stirring process is carried out before and after the pouring of mixture of reinforcements and $K_2TiF_6$to avoid clustering of particulates and to have uniform homogenous distribution of micro particulates in the melt. After continues stirring, the entire molten metal was poured into preheated cast iron die. The prepared micro composites were machined as per the standards for characterization purpose.

Testing of Composites

The microstructural study was carried out on the prepared composites using Vegas Tescan made scanning electron microscope. The test sample is 10 -12 mm in diameter cut from the castings and polished thoroughly, for etching the sample Keller's reagent was used.

Indentation response of as cast Al matrix alloy and its micro composites were evaluated by Brinell hardness tester. The required specimens were prepared according to standard metallographic procedures. The experiments were carried out by applying a load of 250kgf and dwell time of 30 seconds. The indentation load depth values were recorded and the hardness was determined. For each sample, the indentation test was repeated 3 times and the averaged data were reported.

Tensile and compression specimens were machined from the cast samples. The tensile specimens of circular cross section with a diameter of 9 mm and gauge length of 45mm were prepared according to the ASTM E8 standard testing procedure using Instron made Universal Testing Machine. All the tests were conducted in a displacement control mode at a rate of 0.1 mm/min. Multiple tests were conducted and the best results were averaged. Various tensile properties like ultimate tensile strength, yield strength and percentage elongation were evaluated for as cast Al2024 alloy, Hybrid composites. Compression test was conducted on the same machine as per ASTM E9 standard. Figure 1 showing the tensile test specimen dimensions used to conduct the experiments.

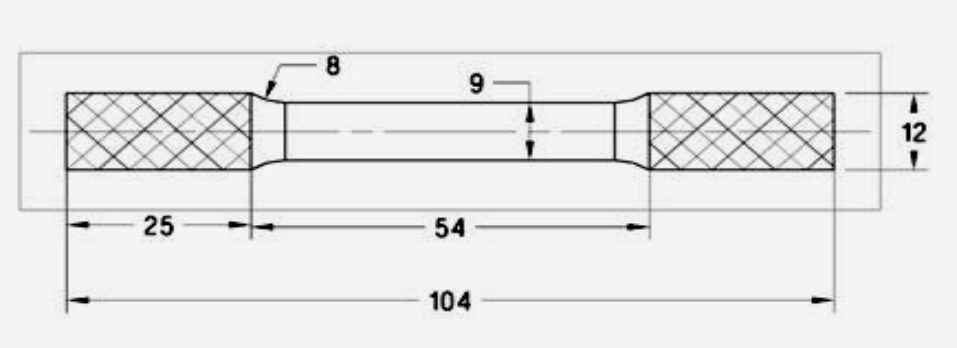

Figure 1: Tensile specimen and its dimensions in mm

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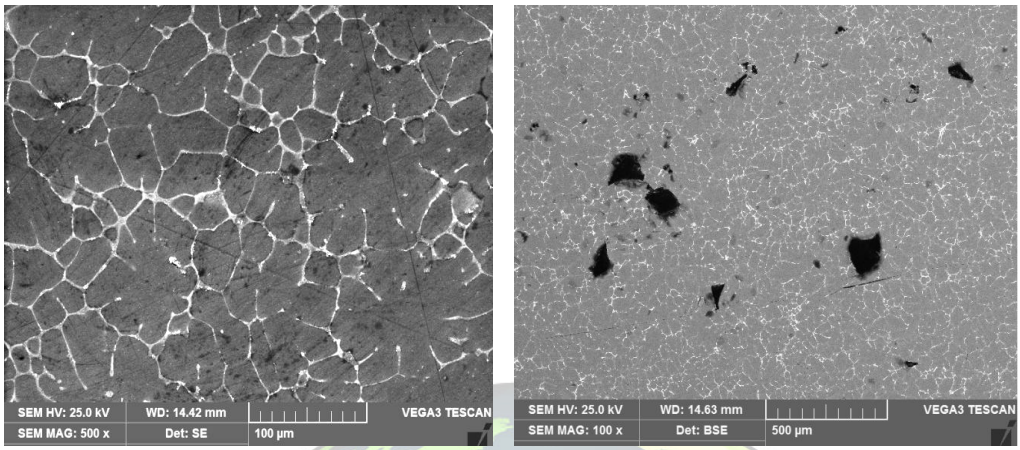
RESULTS AND DISCUSSION

Microstructure Study



(a) (b)

Figure 2. a-b Showing the scanning electron microphotographs of (a) as cast Al2024 alloy (b) 4wt% of B_4C and 4wt% of Gr

Figure 2 (a-b) shows the SEM microphotographs of Al2024 alloy as cast and Al2024 with 4 wt. % of micro B_4C and graphite particulate composites. This reveals the uniform distribution of reinforcement and very low agglomeration and segregation of particles, and porosity.

Fig. 2 b clearly shows and even distribution of micro B_4C and graphite particles in the Al2024 alloy matrix. There is no evidence of casting defects such as porosity, shrinkages, slag inclusion and cracks which is indicative of sound castings. In this, wetting effect between particles and molten Al2024 alloy matrix also retards the movement of the reinforcement, thus, the particles can remain suspended for a long time in the melt leading to uniform distribution.

EDS EVALUATION

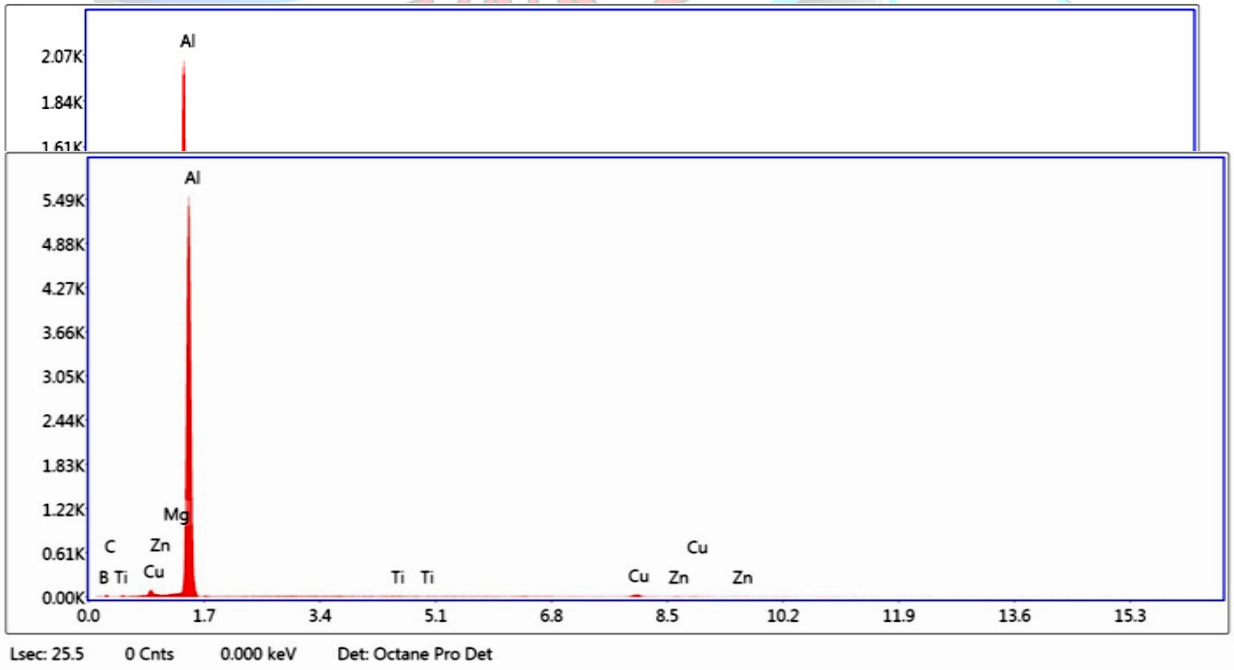


Figure 3a: EDS spectrum of Al-2024 alloy

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Figure 3b: EDS spectrum of Al-2024 alloy and 4% B_4C, 4%Graphite.

In order to confirm the presence of B_4C and Gr energy dispersive spectroscope analysis was carried out at the edge of the reinforcement particle and Al alloy matrix. The EDS spectrum reveals the presence of Al, Zn, Cu, Mg, B, C and Gr in the interface reaction layer (fig. 3b).

Tensile Properties

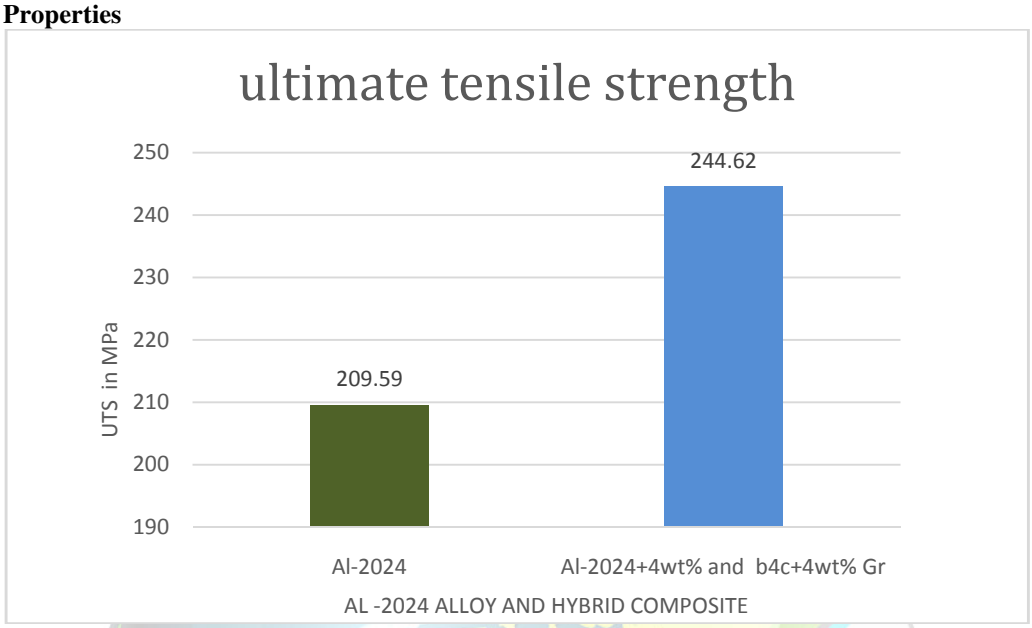

Figure 4a: Ultimate tensile strength of Al2024 and hybrid composites.

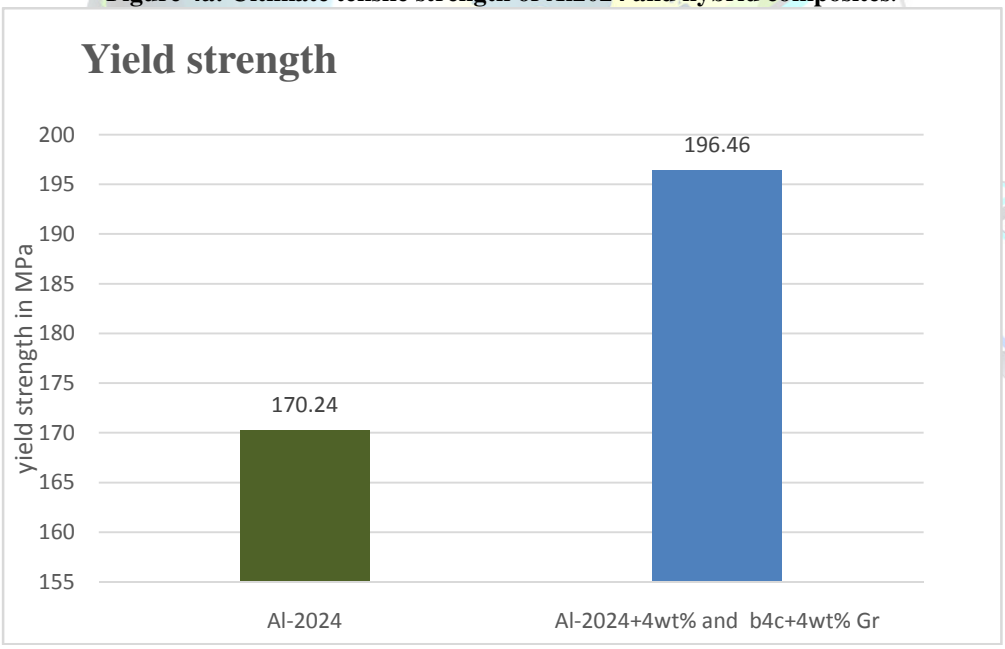

Figure 4b: Yield strength of Al2024 and 4 wt. % of micro B_4C and Gr composites

Figure 4a, shows there is gradual increase in the UTS with 4 % wt. addition of B_4C and Grdue to the fact that the properties of B_4C particulates control the mechanical properties of the composite showing the intense tensile strength. The variation in the UTS is may be because of matrix fortifying with increase in reinforcement size.

Figure 4b indicates yield strength improved from 170.24 MPa to 196.46 MPa with addition of reinforcements. The enhancement in the yield strength is due to the close packing of B_4C and Gr particles providing molecule strength with the aluminum lattice in turn composite.

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CompressionStrength

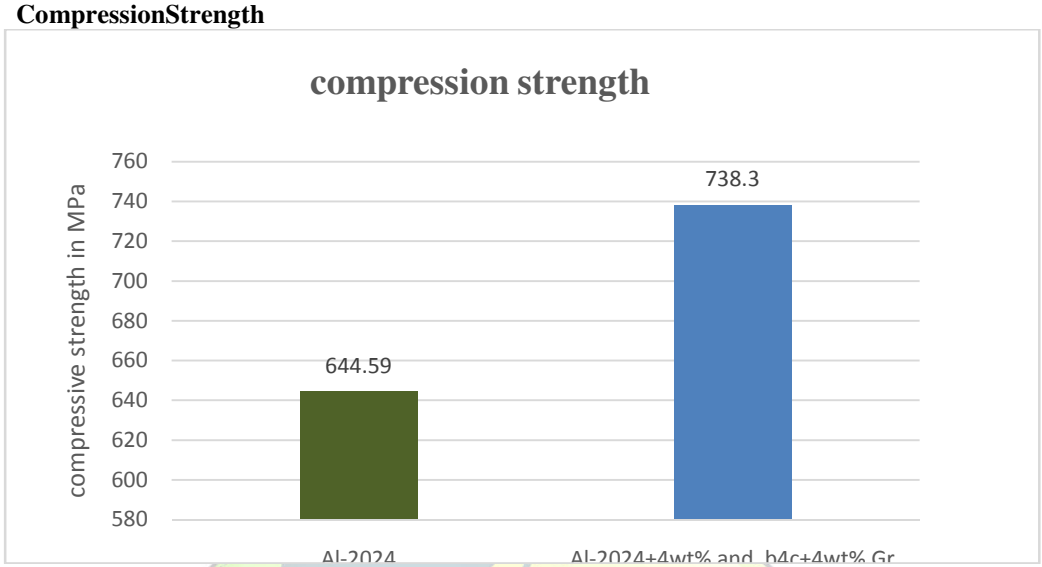

Figure 5: Compression strength of Al2024 and 4 wt. % of micro B_4C composites

The plot 5 indicates the compression strength of the test specimens with 4 wt.% of B_4C in Al2024 alloy. It is clearly evident that the compression strength is varied from 644.59 to 738.3 MPa. Approximately 14.5 % increase is noticed with B_4C and graphite reinforcement.

Hardness Study

Brinell hardness test was conducted on the specimens of Al 2024 alloy and hybrid composites, with ball diameter 5mm, load 250Kgand the values obtained are in the range 69.2 to 78.9 BHN evident from the graph 6. The values indicate that there is gradual increase in the hardness because of the hard boron carbide and graphite inclusion. As the percentage of particulates increased the hardness also increased parallel.

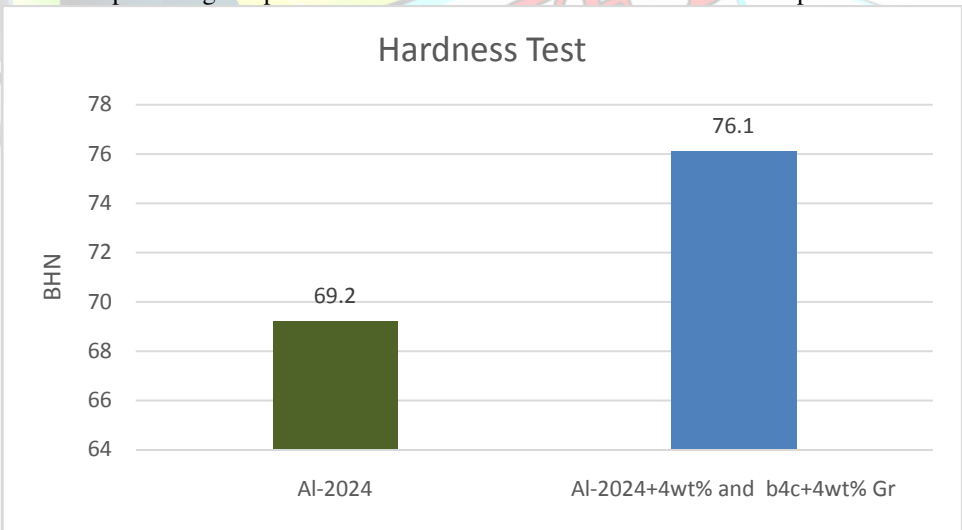

Figure 6:Hardness of Al2024 and 4 wt. % of micro B_4C and Gr composites.

CONCLUSIONS

The mechanical investigations of the Al2024 and B_4C and Gr composites materials produced by stir casting are remarked as below:

- The liquid metallurgy technique was successfully adopted in the preparation of Al2024 and 4 wt. % micro B_4C and micro Gr composites.

- The microstructural studies revealed the uniform distribution of the micro B_4C and Gr particulates in the Al2024 alloy matrix.
- The ultimate tensile strength and yield strength properties of the composites found to be higher than that of base matrix.
- Improvements in compressive strength of the Al2024 alloy matrix were obtained with the addition of micro B_4C particulates. The extent of improvement obtained in Al2024 alloy after addition B_4C and Gr particulates is 14.5%.
- Hardness of the Al2024- micro B_4C-Gr composite was found to be more than base Al matrix.

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