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Microstructure and Mechanical Properties of Al2024-B_4C-hBN Reinforced Metal Matrix Composites

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Abstract: In the present work, Al2024 MMC is processed using boron carbide [B_4C] and h-BN particulates as reinforcement by stir casting method. B_4C is used because of its high stiffness and hardness and h-BN is used because smooth machining properties and act as solid lubricants. Stir casting technique is gaining importance due to its easy setup, low cost, uniform dispersion of reinforcement compare to other technique. MMC is obtained by incorporation of reinforcements by keeping B_4C 6% constant and h-BN varied as 3%, 6%, 9% to investigate mechanical properties. Microstructural study shows that the B_4C particulates in the molten matrix forms strong matrix reinforcement interface. The mechanical properties like tensile test and hardness test are investigated for Al2024-B_4C and h-BN reinforcedMMC. From optical metallurgical microscopic analysis uniform distribution of B_4C and h-BN particles along the aluminium matrix is observed. The hardness of Aluminium matrix increased with addition of 3%, 6%,9% of h-BN with keeping 6% of B_4C constant.

Keywords: Stir casting, h-BN, Microstructure, Tensile test, Hardness test.

I. INTRODUCTION

Many of engineering application in the world today require materials with usual combination of properties that cannot be met by conventional metal like alloys, ceramic or polymers. In the advancement of new materials and its alloys, the application of composites also gains in future quickly. This happen because the demand for composites in the field of engineering enhanced rapidly [1].

MMC's material is a structural can be defined as a combination of two or more constituents combined on a macroscopic scale and are not soluble in each other's to form a third material that result in better properties than the individual constituents. MMC's have been used for many years for aerospace and automobile industrial application [1]. MMC's made by dispersing a reinforcing material into a metal matrix. The reinforcement surface can be coated to prevent a chemical reaction with matrix. The MMC's mainly uses the light metals such as magnesium, titanium, and aluminium at high temperature applications cobalt, cobalt-nickel alloy are used. MMC's can be fabricated by using solid, liquid and vapours processes for example in case of solid type of fabrication that is powder metallurgy, in liquid phase process like squeeze, spray and stir casting.

In this experiment stir casting is choosen because it very much suitable for Al MMC's. Conventional stir casting process has been employed for producing discontinuous particle reinforced MMC's. Aluminium MMC's are fabricated by different processing temperature with different holding time to understand the influence of process parameter on the distribution of particle in matrix results in good mechanical properties [2]. Some of the characteristics of stir casting is distribution of dispersed phase throughout the matrix is not homogenous and contents dispersed phase are limited. Al is special because of its wide availability, low cost, light weight, low melting point. However, such light weight material demand strong reinforcement which proliferate mechanical corrosion resistance and several properties [3]. Boron carbide is characterised by its unique combination of properties. It is extremely hard. Different type of (particulate, whiskers, flake etc) has been used in matrix but they have different properties depends on techniques, weight% and reinforcement size.

Al based MMC's has potential for wear resistance. Particulate reinforcement are mostly used in aluminium based MMC's in many industries. h-BN a white graphite has similar crystal structure of graphite. It is a good lubricant at both low and high temperatures [4]. Another advantage of h-BN over graphite is that its lubricity does not require water or gas molecules trapped between the layers In the present study mechanical properties such as tensile microstructure and hardness are conducted as per ASTM Standards for MMC is obtained by incorporation of reinforcements by keeping B_4C 6wt% constant and h-BN varied as 3wt%, 6wt%, 9wt% to investigate mechanical properties.

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II. EXPERIMENTAL DETAILS

A. Materials Used

1) *Al2024:* Al2024 is a aluminium alloy, with copper as the primary alloying element. It is used in application requiring high strength to weight ratio, as well as good fatigue resistance. It is weldable only through friction welding and has average machinability [5].

TABLE 1: Composition of Al2024.

Components	Copper	Magnesium	Silicon	Iron	Manganese	Zinc	Titanium	Chromium	Aluminium
Amount(wt%)	3.8-4.9	1.2-1.8	0.5	0.5	0.3-0.9	0.25	0.15	0.1	remaining

2) *Boron Carbide [B_4C]:* Boron carbide (B_4C) have excellent physical and mechanical properties, such as a high melting point, hardness good abrasion resistance, high impact resistance and excellent resistance to chemical agents. As a good ceramic material, B_4C has wide variety of applications.

TABLE 2: Physical and thermal properties of Boron Carbide.

Property	Density	Melting point	Hardness	Toughness	Young's Modulus
Units	Kg/m^3	^{0}C	Vickers hardness in GPa	MPa/m$^{1/2}$	GPa
Value	2520	2445	38	2.9-3.7	450-470

3) *Hexagonal Boron Nitride [h-BN]:* Hexagonal Boron Nitride (h-BN) is also known as 'White Graphite', has similar (hexagonal) crystal structure as of Graphite. It is a good lubricant at both low and high temperatures This crystal structure provides excellent lubricating properties. h-BN is much superior to Graphite [6].

TABLE 3:Physical and thermal properties of hexagonal boron nitride.

Properties	Density	Melting point	Coefficient of friction	Young's modulus	Temperature stability
Units	Kg/m^3	^{0}C	-	MPa	^{0}C
Value	2300	3000	0.15-0.7	20-102	1800

B. Fabrication of Test Specimens

Stir casting technique is used to prepare Al2024 Hybrid Composites.Al2024 is cut into pieces.B_4C was weighed to 6% to the weight of Al 2024 matrix material K_2TiF_6 and salt was added to it. h-BN was weighed to 3%, 6% and 9% to the weight of Al 2024 respectively.Capsules of these powders were prepared using Al foil paper.Al 2024 is heated in an open furnace up to 750^{0}C using graphite crucible.Degassing agent C_2Cl_6 was added to the molten Al2024 to remove the entrapped gases.Vigorous stirring is done and the generated slag is removed using skimmers.Reinforcement is preheated to 400^{0}C are added in two stages.In first stage, the B_4C particulates are added and heated. The mixture is stirred and then the h-BN particulates are added in second stage. The molten metal is poured into the permanent mould and allowed for solidifying. The specimens are removed from the mould and allowed for cooling. Machining is done to remove extra material, if any. Specimens are machined according to the required dimensions and testing is carried out.

C. Testing

Microstructure of prepared specimens is studied by taking the composite block at the center part. The specimen to be examined is prepared by polishing through 400,600,800,1000 and 1200 grit papers and diamond polish. The Keller's reagent is applied to specimen before it is tested under optical microscope. The Microvickers Hardness and Tensile test are made. The micro-vickers hardness of casted specimen containing Al, 3,6 and 9wt% of h-BN and 6wt% of B_4C reinforced specimens were measured on polished samples using diamond cone indenter. To investigate the mechanical properties or behaviour of the composites the tensile test is carried out.

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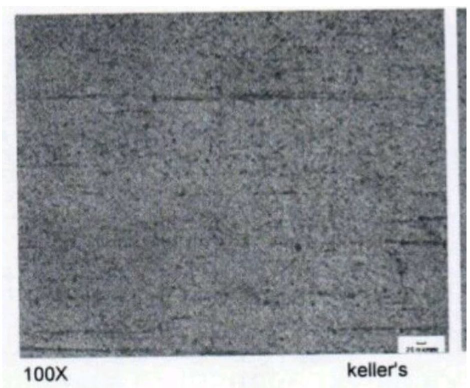
III. RESULT AND DISCUSSION

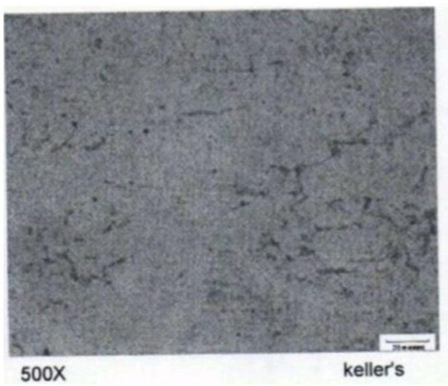
A. Microstructure Studies

The specimens were examined to carry out the micro-structural study. One specimen for each compositions and a base alloy was selected to investigate the microstructure by optical microscopy at high magnifications. The microstructure of specimen is studied by taking central part of the composition block. The investigation of microstructure B_4C, h-BN and Aluminium MMC reveals that the particle are not segregated in the inter-dendritic eutectic region.The optical micrograph of aluminium metal matrix composites at different magnification are 100X and 500X. The figure 1 shows the optical micrographs of aluminium metal matrix and MMC for different weight% of h-BN(3%, 6%, 9%) by keeping 6% B_4C constant. Presence of entrapped air and moisture in the reinforced particles results in the porosity in casting. Homogeneous distribution of particles in a molten alloy is achieved due to higher shear rate caused by stirring which also minimize the particles agglomeration.

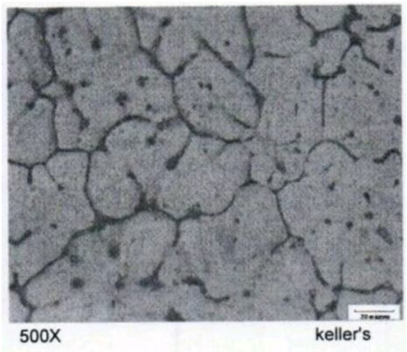
Fig 1:



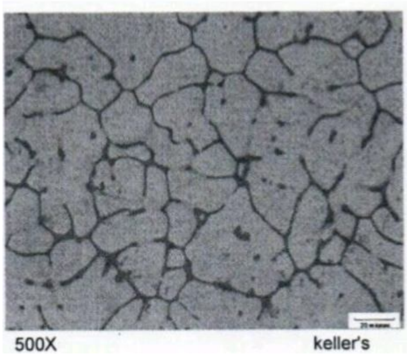
[a]



[b]



[c]



[d]

Optical microscopy micrograph of (a) Base material (b) B_4C-6% & HBN-3%, (c) B_4C-6% & HBN-6%,(d) B_4C-6% & HBN-9%.

B. Tensile Test

The tensile behaviour of the composites were tested as per ASTM E8 standards. To test the variations in the tensile properties three specimens were tested in the same compositions. The graph is plotted with respect to Ultimate tensile strength v/s wt% of reinforcements. The nature of the graph clearly shows the variation in the tensile properties. The Fig 3 indicates the nature of the graph of different specimens of different weight% of h-BN (3%, 6%, 9%) by keepingB_4C (6%) constant. The strength of hybrid composites are increased significantly even for the addition of very low volume percentage of the reinforcements. The improvements in strength properties of composites can also be attributed to effect of effective load transfer from matrix to second phase due to presence of fine hybrid reinforcements. The improvements in tensile strength were attributed to presence and uniform distribution reinforcement.

Fig 4 indicates the decrease in the elongation with increase in the % of reinforcement. This is because the barriers for the dislocations motions increases and so the % elongation of the composites decreases.

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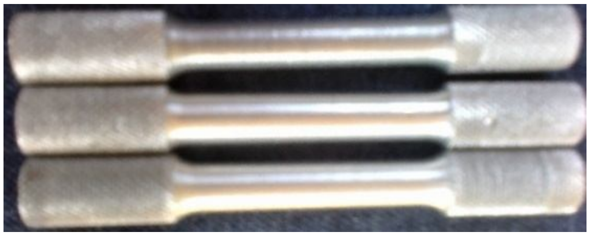
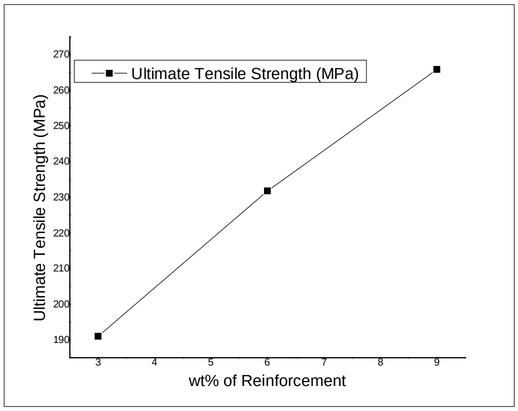


Fig 2 Tensile test specimen.



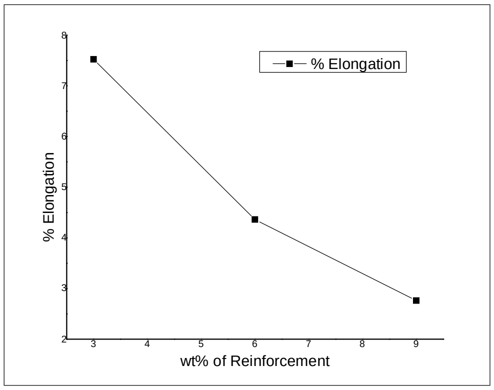


Fig 3.Ultimate tensile strength of as cast Al2024 composites

Fig 4.Showing the Elongation of Al2024 composite.

C. Micro Hardness Test

To study the uniform distribution of hybrid reinforcement, the hardness value is measured on the various portion of the specimens. Three specimens of each compositions 6% of B_4C and 3%, 6%, 9% of h-BN. In Fig 5 we can observe that hardness increases by increase in wt % reinforcement.The better distribution of the reinforcing phase in the matrix and acts as barriers for the deformation of the soft matrix thus improving the hardness of MMC with increasing wt% of the reinforcement.

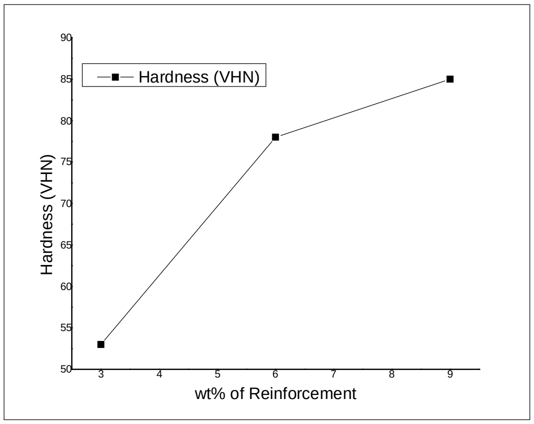


Fig 5 : Showing hardness of Al2024 and its Composites

IV. CONCLUSIONS

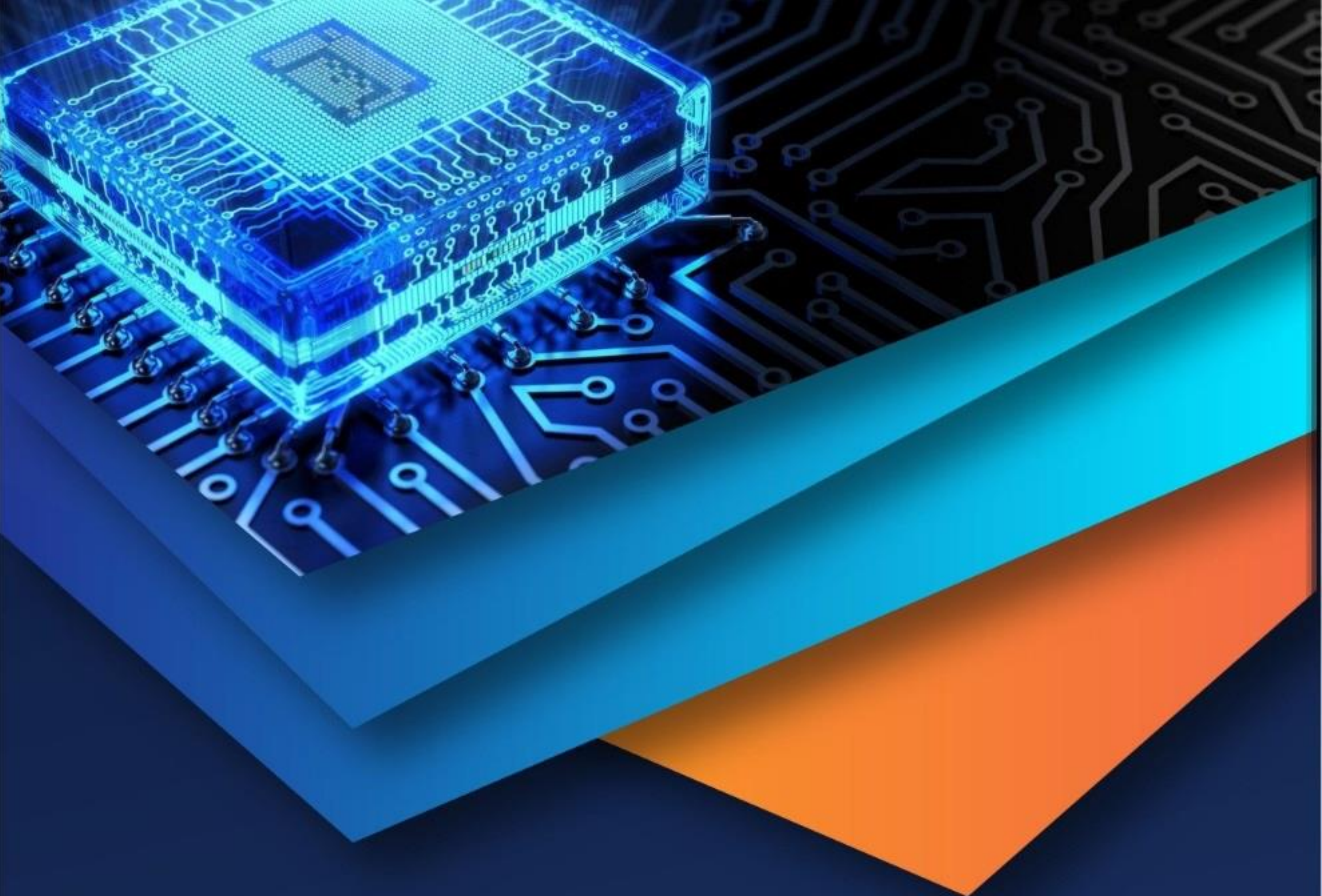
The present work on Microstructure and Mechanical properties of Al 2024-B_4C-HBN reinforced metal matrix composites by stir casting method has led to following conclusions. A fair uniform distribution of B_4C and HBN particle along the aluminium matrix can be observed by Optical Metallurgical Microscopic analysis. The tensile strength of the Al metal matrix composites increases by the uniform distribution of the reinforcement addition. The hardness value of composition of 6% of B_4C and 3% of HBN is 53

HV0.5 and for the composition of 6% B_4C and 6% HBN is 85 HV0.5 and for the composition of 6% of B_4C and 9% HBN is found that 85 HV0.5.

The percentage elongation decreases with respect to increases in wt% of reinforcements. For B_4C 6% as constant and h-BN 3%, 6%, 9% was found to decreased by 7.52%, 4.36% and 2.76% respectively.

REFERENCES

[1] F.H Froes "Advance metals for aerospace and automotive use",F.H vol.184,page no..119-133,1994
[2] D.K Das , P.C Mishra, S.Singh and S. Pattanaik "Fabrication and heat treatment of ceramic reinforced aluminium matrix composites- a review", IntJ.Mech.mater. Eng Vol.9,no.1,page 6,Dec 2014.
[3] R Dasgupta "Aluminium alloy –based metal matrix composites: a potential material for wear resistance applications", ISRN Metall.,vol.2012,pp,1-14,2012.
[4] L. Song et al., "Large scale growth and characterization of atomoc hexagonal boron nitride layers" pp.,3209-3215,2010.
[5] Preetam kulkarni "Evaluation of mechanical properties of Al2024 based hybrid metals composites", ,vol12,ver.IV,pp 108-122,sep-oct2015.
[6] Ji,X., Chen, Y., Wang.,X and Liu "Tribological behaviour of novel tri(hydroxymethyl) propane esters containing boron and nitrogen as lubricant additives, vol 11,no..12,pp 315-320,2016.
[7] Gopal Krishna U.B. Sreenivas Rao K V. Vasudev "Effect of Boron carbide reinforcement on Aluminium matrix composites". B.IJMMSE.ISSN 2272-2516 .Vol 3 Issue on March 2013.
[8] Jinkwan Jung and Shinoo kang.J.AM Ceram . "Advances in manufacturing Boron carbide – aluminium composite" Soc.87 [vol..1].pp 47-54.2004.
[9] Siddheshkumar N G "Mechanical and wear behaviour of aluminium metal matrix hybrid composites" ,Procedia material science 5.pp 908-917.2014.
[10] Pardeep Sharma .Dinesh khanduja. Satpal Sharma "Parametric study of dry sliding wear of aluminium metal matrix composites by response surface methodology, Materials today: Proceedings 2.2015.



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