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Fabrication and Characterization of B_4C_p Particle Reinforced LM24 Al Alloy Composites

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Abstract--In the present investigation, LM 24 Al alloy/B_4C_p composites containing three different weight percentages (1, 2, and 3%) with particle size of 10µmm of boron carbide have been fabricated using a compo casting method. Tensile tests and hardness were conducted to examine the mechanical behavior of the aluminium alloy and its composites. The uniform distribution of B_4C_p particles was observed in the micro structural investigation of developed composites. Results showed that composites reinforced with B_4C_p particles exhibit superior mechanical behavior. Composite Surface is analyzed using Scanning Electron Microscope to study the uniform distributions.

Keywords: Boron carbide, compo casting method, micro structure, Scanning Electron Microscope

I. INTRODUCTION

In the modern technology the composite materials are plays a vital role . In the industrial world an Aluminium matrix composite (AMC) are an important material. AMC are widely used in aerospace, automobile, marine because its has good mechanical properties. In conventional diesel engine piston by replacement of aluminum matrix composite instead of the nickel cast iron results lighter and cheaper product [K.K. Chawla (1998)]. In applications such as automotive drive shafts, cylinder liners, connecting rods and because of conductivity and low thermal expansion. In computers and electronics equipments Aluminium composites are used such as heat sinks, high speed integrated circuit packages and base plates [K. K. Chawla (1998)]. Aluminium metal matrix reinforcement are lighter in weight and strengthened by reinforcing less dense hard ceramic particles such as B4C, Al2O3,SiC,TiB2, and AIN etc which improves the mechanical properties [Ramesh et al. (2009) and state methods, liquid state method, deposition and insitu process [William et al. (1998) and Kalaiselvan et al. (2011)] out of these stir casting has an attractive economic method to combined the particular with wide selection of materials and processing condition which is a liquid state method [Shorowordi et al. (2003) and Kerti et al. (2008)]. In traditional stir casting process, reinforcement material is being added to molten matrix and poured in to permanent molds after stirring mechanism [Gopalkrishnan et al. (2010)]. By the Stir casting process results better bonding between matrix and reinforcement. The Metal Matrix Composites are difficulty to fabricate in achieving homogeneous distribution of particles, wettability, chemical reactions at the interface and porosity [Hashim et al. (1997), Hashim et al. (2002) and Hashim et al. (2002)]. Maximum Al based MMC's fabrication has been being on SiC, Al2O3, TiB2 as reinforcement material in present research works; but due to high cost and poor wetting with the Al matrix below 1100°C of boron carbide particulates are very limited [Canacki et al. (2007)]. B4C is having ,specific density (2.52g/cc),high stiffness(445GPa) , wear resistance, hardness of 3800Hv is the third hardest material next to diamond and C-boron nitride and thermal conductivity (35W/mK) which makes it to find applications like ballistic armor, as abrasive, nozzles etc [Katkar et al. (2011)]. Wettability of ceramic particles can be improved by several ways which include pre-treatment, use of surface active agents [Kennedy et al. (2001)] which decreases surface tension and interfacial forces [Sajjadi et al. (2011)]. Bonding between Al and B4C particles facilitating better mechanical properties are improved in the composite material by Using K2TiF6 halide salt during casting [Kalaiselvan etal. (2011)]. Further, the proper distribution of reinforcing particles in the matrix getting due to melt stirring. Due to density differences of base material and ceramic particles are may e sink or float, the dispersion becomes non homogeneous which may lead to clustering and segregation of particles at a particular place in the melt. Such effect could lead to several microstructural defects like porosities, oxide inclusions and interfacial reactions [Sajjadi et al.(2011)].

In the present works an attempt is being made to process LM24- B4C particulate composites at a temperature of 750°C by melt stirring. In the present work the two step addition used to helps from the problem of clustering of reinforcing particles. In Al molten melt,pre-heated mix containing B4C particles and ADflux was added to improve wettaility during the composite preparation. Further, the evaluation of mechanical properties of prepared composites were subjected to note the extent of improvement achieved thereby.

II. EXPERIMENTAL DETAILS

The following section highlights the material, its properties and methods of composite preparation and testing.

A. Materials Used

The matrix material for present study is LM24. Table.1 gives the chemical composition of LM24. The reinforcing material selected is B4C of particle size 10µmm.

Table 1: Chemical Composition of LM24 by wt%

Element	Al	Si	Fe	Cu	Mn	Mg	Cr	Ni	Zn	Ti	Trace
% Min	-	7.5	-	3.00	-	-	-	-	-	-	-
% Max	-	9.5	1.00	4.00	0.50	0.30	-	0.50	2.90	-	0.50
% Normal	-	8.5	-	3.50	-	-	-	-	-	-	-

B. Fabrication Process

The Compo casting technique is used to prepare the cast composites as described below. A batch of 200g of LM24 was melted to 750°C-800^{0}C in a graphite crucible using furnace. With the help of stirrer the melt was disturbed to form a fine vortex. 3g of degassing tablet was added to the vortex and slag was removed from the molten metal. At the temperature of 800°C the preheated B4C particles of 8vol.wt% was added into the vortex with mechanical stirring at 300rpm for 5mins. 2g of ADflux was added to the molten metal to reduce the atmospheric contamination Before pouring the molten metal to mould. The molten metal at a temperature of 850°C was then poured into mould preheated to 300°C and allowed to solidify. The Aluminium metal matrix composites of LM24 with different weight percentage (1, 2, and 3wt %) of B4C were fabricated by the same procedure.

C. Microstructure and Testing

The microstructural characterization of prepared composites were Examined by using Scanning Electron. In the SEM analysis we observed the distribution of reinforcement throughout the composite. In the entire composite B4C and Aluminium matrix uniform distribution is clearly seen. It is observed that white area is aluminium matrix and remaining grey area are the B4C reinforcement particles. The better interfacial bonding between the matrix and reinforcement particles is observed because of less porosity. XRD analysis of the prepared composite was done using XRD Machine. The experimental density of the prepared composite was determined using Archimedes's principle and compared with the theoretical densities of LM24 (2.7 g/cm3) and B4C particles (2.52g/cm3). Using Brinells hardness tester machine the hardness measured on the prepared composite at different locations on the specimens. The mechanical properties of tensile strength of the prepared composites were measured using a Universal Testing Machine as per ASTM E08-8 standards under tension. Tensile tests were conducted on three specimens for each composition and average value is reported.

III. RESULTS AND DISCUSSIONS

A. Evaluation of Microstructure

Aluminium reinforced with B_4C particulate composites are successfully fabricated by compo casting process. The optical micrographs of the fabricated AMCs with particle sizes of B_4C and different 1,2,3 wt% of reinforcement of 10µm size are shown in Figure.1 a and 1 b respectively. It is observed from the figure that B_4C particles are dispersed uniformly in the aluminium matrix for particle size and for all wt%. This can be attributed to the effective stirring action and the use of appropriate process parameters.XRD analysis confirms the presence of B_4C reinforcement within the matrix.

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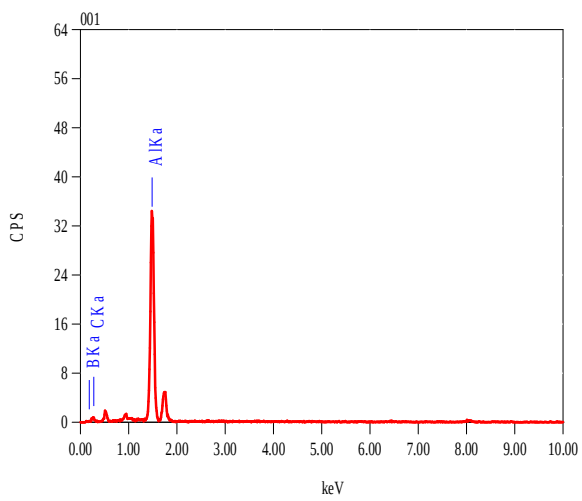
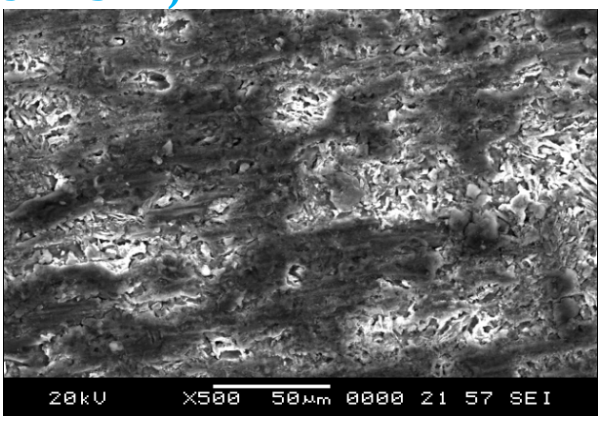


(a)



(b)

Figure 1: Optical micrographs of the as Cast LM24-B_4C, (a) XRD Pattern of 10µm of B_4C
(b) SEM image of Al- 3 wt% of B_4C

B. Evaluation of Mechanical Properties

1) Hardness Test Results: From Figure.2 it was observed that, with increase in wt% of reinforcement the hardness of AMCs has increased.. The brinell's hardness of AMCs was found to be maximum (88 BHN) for the particle size of 10µm of 3 wt%. There is increased in hardness compared to the base alloy. The presence of B_4C particle covered surface area of such hard particles offers more resistance to plastic deformation which leads to increase in the hardness of composites.

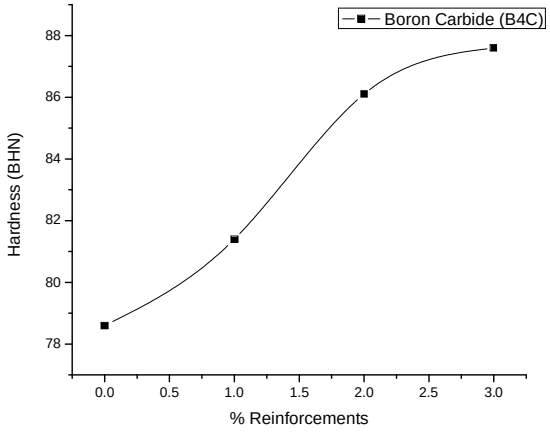


Figure 2: Hardness of the as Cast LM24-B_4C with different wt%

2) Tensile Test Results: The incorporation of B4C particles in alloy of LM24 which improves the mechanical properties of metal matrix composites. Figure.3 and Figure.4 shows the tensile strength and elongation of the fabricated composites and varying different wt% of B4C particles respectively.

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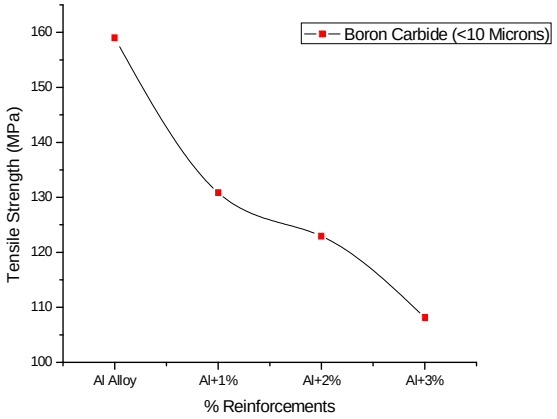

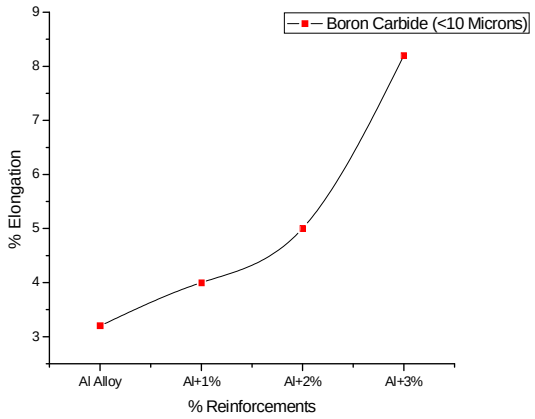

Figure 3: Tensile Strength of Al+B_4C Composites material
Figure 4: % Elongation of Al+B_4C Composites material

It shows that the tensile strength of the composite material are very effectively improved by adding B4C particles. With increase of weight percentage the tensile strength of metal matrix composites are also increases. The tensile strength of aluminum alloy LM24 is found to be maximum (160.16 MPa) for the particle size of 10µmm. But the tensile strength decreased gradually with the increase in wt% of reinforcement by varying wt%. At 1%, 2% and 3% of B4C the tensile strength found as 132.94 Mpa,124.91 Mpa and 108.63 Mpa respectively. The addition of B4C particles in the matrix induces less strength to matrix alloy by offering less resistance to tensile stresses. Decrease in the strength is due to the increase in hardness of the composite.

IV. CONCLUSIONS

The Al-B4C composites were produced by compo cast route with particle size 10µmm of reinforcement and the microstructure, mechanical properties are evaluated. From the study, the following
conclusions are derived.
Production of LM24-B4C composites was completed successfully.
The microstructural study and XRD analysis revealed the presence of B4C particles in the composite with homogeneous dispersion.
The Brinell's hardness of Aluminium Metal Matrix was found to be maximum for the 3 wt% of B4C particles in case of varying wt% of the reinforcement.
The tensile strength of AMCs was found to be maximum for the base material LM24.

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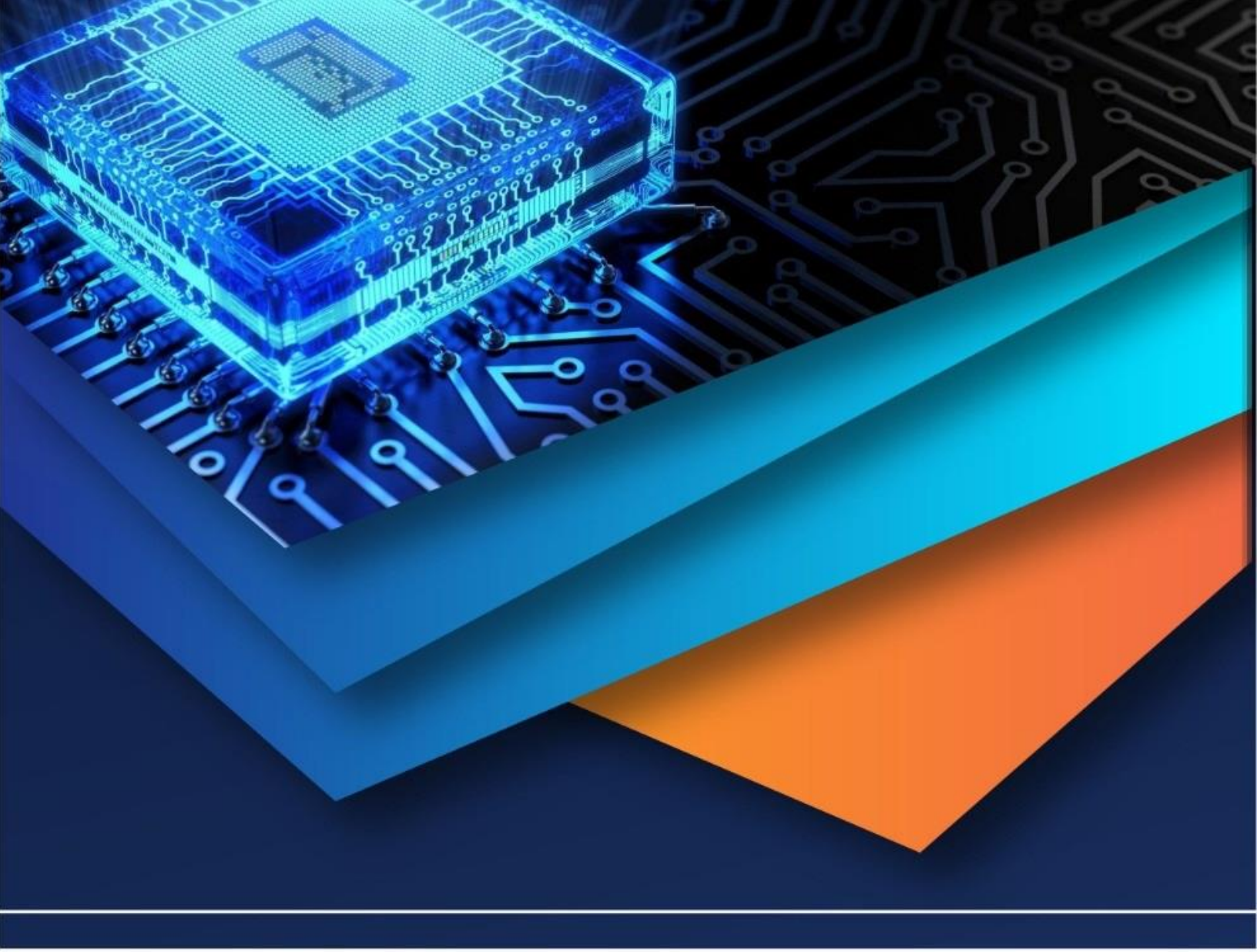

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