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Studies on Mechanical Behavior of 9 wt.% of 90 Micron Size B_4C Particulates Reinforced LM29 Alloy Composites

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ABSTRACT: - In the present examination the LM29 alloy composites containing 9 wt. % of B_4C (90 micron) particulates were made for the examination. The microstructure of the composite was dissected by checking electron microscopy; micrographs were taken to perceive the proximity of B_4C particulates in the aluminum grid. Further, mechanical conduct of as cast LM29 combination and LM29 composite 9 wt. % of B_4C composites were inspected. Mechanical properties like hardness, UTS, yield quality, ductility and compression quality were evaluated by ASTM benchmarks. Microstructural investigation uncovered the uniform scattering of particles in the LM29 composite system. From the examination, it was found that hardness, extreme, yield and compression quality estimations of composite was extended because of essence of B_4C particles in the composite. Further, from the examination ductility of the composite decreases with the extension of B_4C particulates.
KEYWORDS: - LM29 Alloy, B_4C, Microstructure, Stir Casting, Mechanical Behavior

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I. INTRODUCTION

Metal Matrix Composites (MMCs) are a wide group of materials went for accomplishing an upgraded mix of properties. While the lattice can be any metal or composite, most intrigue has been appeared in the lighter basic metals, much of the time, change in mechanical properties has been the essential goal. To date, the accomplishment of higher quality and strength has been the prime intention behind the advancement of MMCs [1, 2]. Other vital changes in parameters, for example, damping limit, segment weight, wear resistance, warm extension and high temperature capacities can be accomplished by appropriate blends of filler materials in metallic networks. In the meantime, the attractive properties of metals, for example, simplicity of manufacture, pliability, high thermal and electrical conductivity ought to ideally keep up. Besides, the sought mix of properties should be gotten at least part cost.

Metal Matrix Composites (MMCs) are progressively getting to be distinctly appealing materials for cutting edge aviation applications yet their properties can be custom-made through the expansion of chose fortification. Specifically particulate strengthened MMCs have as of late discovered unique intrigue on account of their particular quality and particular firmness at room or raised temperatures. It is notable that the flexible properties of the metal matrix composite are unequivocally affected by small scale auxiliary parameters of the fortification, for example, shape, size, introduction, circulation and volume or weight [3-5].

Among the different matrix materials accessible, aluminum compounds are promising materials because of their high particular quality and firmness. Be that as it may, their applications are limited as a result of their poor wear resistance. Particulate strengthened aluminum lattice composites are currently being considered for their better mechanical and tribological properties over the customary compounds, and in this way, these composites have increased broad applications in car and aviation businesses. The accentuation has been given on creating reasonable Al-based MMCs with different hard and delicate fortifications like SiC, Al_2O_3, B_4C, Zircon, Tungsten Carbide, Graphite and Mica [6].

The essential capacity of the reinforcement in MMCs is to convey a large portion of the connected load, where the matrix ties the fortifications together, and transmits and circulates the outside loads to the individual support [7]. Great wetting is a fundamental condition for the era of a tasteful security between particulate fortifications

and fluid Al metal framework amid throwing composites, to permit exchange and appropriation of load from the lattice to the fortifications without disappointment [8].
It is demonstrated that the micro particles are viable fortification materials in aluminum compound to improve the mechanical and different properties. The support in MMCs is more often than not of earthenware materials; these fortifications can be partitioned into two noteworthy gatherings, continuous and discontinuous.
As revealed in the so far performed research, the particulates B_4C contributes to improvement of mechanical properties, also at elevated temperatures. The presence of micro B_4C could effectively prevent the matrix deformation, to carry the load and lock the micro cracks that often develop along the friction direction [9].
However, meager information is available as regards to the mechanical properties of LM29 alloy reinforced with micro B_4C particulates MMC's processed by stir casting method. With the increasing demand of light weight materials in the emerging industrial applications, the aluminum– B_4C composites play an important role. Keeping the above observations in view, it is proposed to develop LM29 micro B_4C composites with 9 wt. % of B_4C particulates. In this study, it is planned to investigate mechanical properties of LM29 alloy based composites with micro sized B_4C particulates by using liquid metallurgy technique.

II. EXPERIMENTAL DETAILS

Materials Involved

Aluminium has been the choice of material for most of the researchers as it finds suitable in most of the applications due to its light weight and good corrosion resistance. The direct quality of the aluminum can be improved by hard particles and that has made aluminum composites to accomplish higher firmness modulus at bring down densities. From the detailed literature survey, it was comprehended that LM29 has not been abundantly engaged by the analysts and there is sufficient extension to utilize this material as grid material because of its characteristic great properties. Therefore, in the present investigation LM29 casting alloy is been selected as the matrix material. The chemical composition o LM29 alloy is shown in table 1.

Table 1: Chemical composition of LM29 alloy

Elements	Si	Cu	Mg	Ni	Al
Wt. %	24.0	1.0	1.0	1.0	bal

Table 2: Physical Properties of Boron Carbide

Physical Property	Specification
Crystallography	Rhombo-hedral
Color	Black
Specific Gravity	2.52
Knoop100 Hardness	2800
Shape	Blocky – Angular
Melting Point	2350° C

Boron Carbide is one of the hardest man-made materials accessible in business amounts. Boron carbide earthenware production have astounding physical and mechanical properties, for example, a high liquefying point, hardness, great scraped spot obstruction, high effect opposition and superb obstruction towards consumption. As a remarkable in borne mechanical property, the boron carbide as a clay material have pulled in consideration over wide assortment of uses that involves light-weight protective layer plating, impacting spouts, mechanical seal faces, granulating apparatuses, cutting instruments and neutron retention materials. The physical and mechanical properties of Boron Carbide are appeared in Tables 2 and 3 individually.

Table 3: Mechanical Properties of Boron Carbide

Density (gm /cm^3)	2.52
Melting Point (°C)	2445
Young's Modulus (GPa)	450 – 470
Thermal Conductivity (at 25°C - W/m-K)	30 – 42
Hardness (Knoop 100g) (kg/mm^2)	2900 – 3580

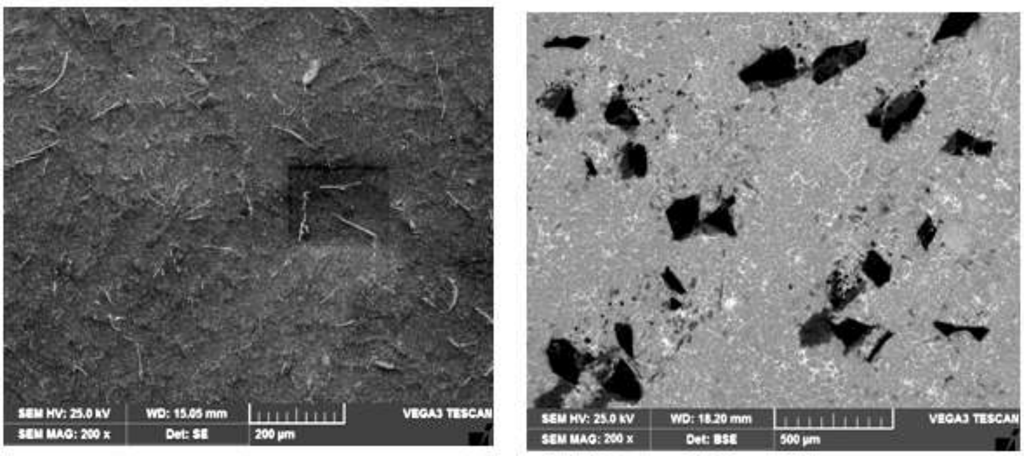
Composites Fabrication

The fabrication of LM29 - B_4C composites were set up by melt stirring technique. Boron carbide particles (90 microns) were preheated to 600ºC for 45 minutes to guarantee their surfaces are totally oxidized. LM29 Al composite ingots are sliced in to little bits of around 0.5kg each and ascertained amount of it is taken in a graphite crucible and set in the electric softening heater. The heater is warmed to the required temperature where softening of the ingots begins to happen and the strong ingots totally dissolve and liquidifies with timeframe.

The preheated 9 wt. % boron carbide particulates were included and blended with stirrer at appraised speed. The warming is proceeded for longer periods to keep up the slurry in the liquid state. The uniform appropriation of the particles in the slurry is guaranteed by mechanical blending through a stirrer at a normal blending pace of 300 rpm for around 15 minutes. Finish liquefying of the combination happens at a temperature of around 750ºC. The soften installed with B_4C support is moved utilizing graphite in to the extraordinarily beyond words have pockets of diameter15mm and length 120mm.

III. RESULTS AND DISCUSSION

Microstructural Analysis



(a) (b)

Figure 1: Scanning Electron Microphotographs of (a) as cast LM29 alloy (b) LM29-9% B_4C with 90 micron B_4C particles

Figure 1 (a-b) shows the SEM microphotographs of LM29 alloy as cast and LM29 with 9 wt. % of B_4C particulate composites. This reveals the uniform distribution of B_4C particles and very low agglomeration and segregation of particles, and porosity.

Fig. 1 b clearly show and even distribution of B_4C particles in the LM29 alloy matrix. In other words, no clustering of B_4C particle is evident. 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

LM29 alloy matrix also retards the movement of the B_4C particles, thus, the particles can remain suspended for a long time in the melt leading to uniform distribution.

Hardness

Brinell hardness test was led on the examples of LM29 combination and 9% B_4C composites, with ball of 5mm diameter, load 250kg and the hardness values got are in the range 61.9 to 94.8 BHN clear from the chart 2. The qualities demonstrate that there is gradual increment in the hardness as a result of the hard boron carbide incorporation. As the level of particulates expanded the hardness likewise expanded parallel.

In the hardness test, severe plastic flow has been concentrated in the localized region directly below the indentation, outside of which material still behaves elastically. Directly below the indentation the density of the particles increased locally, compared to regions away from the depression [10-11]. Although plastic deformation itself has not been responsible for volume change, the existence of very large hydrostatic pressure under the indentation can contribute to volumetric contraction of the metal matrix. As the indenter moves downward during the test, the pressure has been accompanied by non uniform matrix flow along with localized increase in particle concentration, which tends to increase the resistance to deformation.

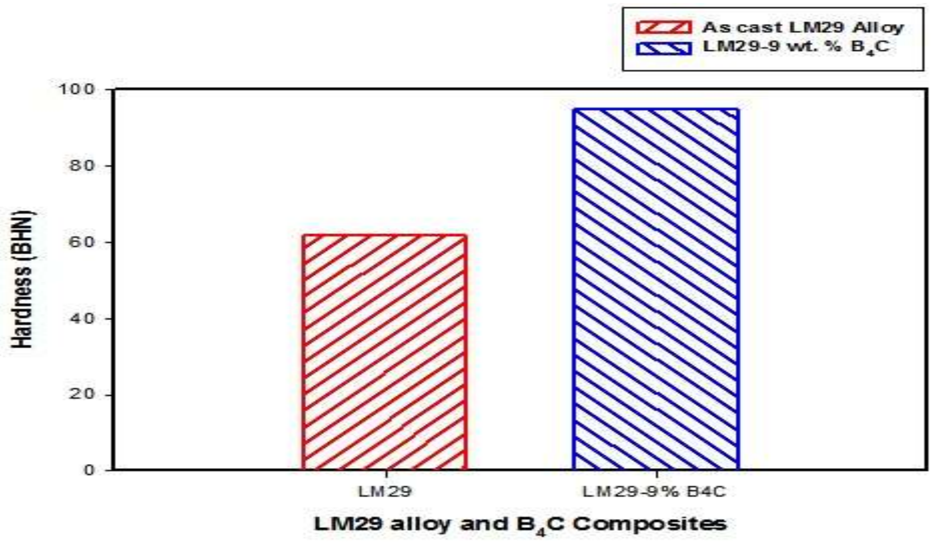


Figure 2: Hardness of LM29 alloy and its B_4C composites

Ultimate Tensile and Yield Strength

Figure 3 shows there is gradual increase in the UTS with 9 % wt. addition of B_4C due 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.

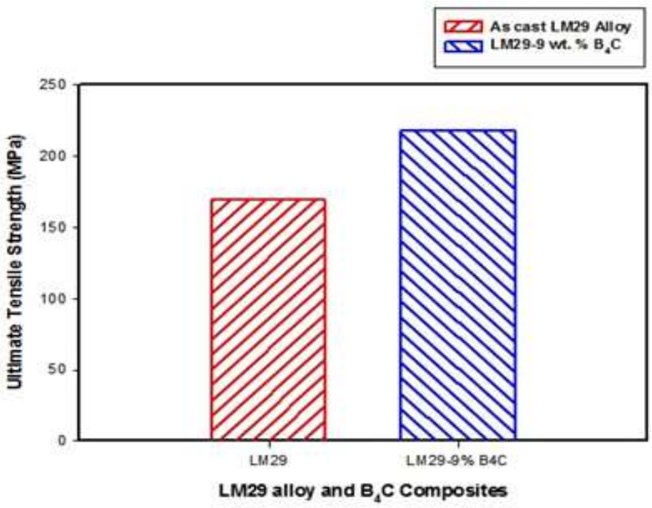


Figure 3: Ultimate tensile strength of LM29 alloy and its B_4C composites

Figure 3 shows variation of ultimate tensile strength (UTS) with 9 wt. % of B_4C particulates. The ultimate tensile strength of LM29 - 9 wt. % B_4C composite material increases by an amount of 24.04% as compared to as cast LM29 alloy matrix. The microstructure and properties of hard ceramic B_4C particulates control the mechanical properties of the composites. Due to the strong interface bonding load from the matrix transfers to the reinforcement exhibiting increased ultimate tensile strength [11]. This increase in UTS mainly is due to B_4C particles acting as barrier to dislocations in the microstructure. The improvement in UTS may be due to the matrix strengthening following a reduction in LM29-B_4C grain size, and the generation of a high dislocation density in the LM29 alloy matrix a result of the difference in the thermal expansion between the metal matrix and the B_4C reinforcement.

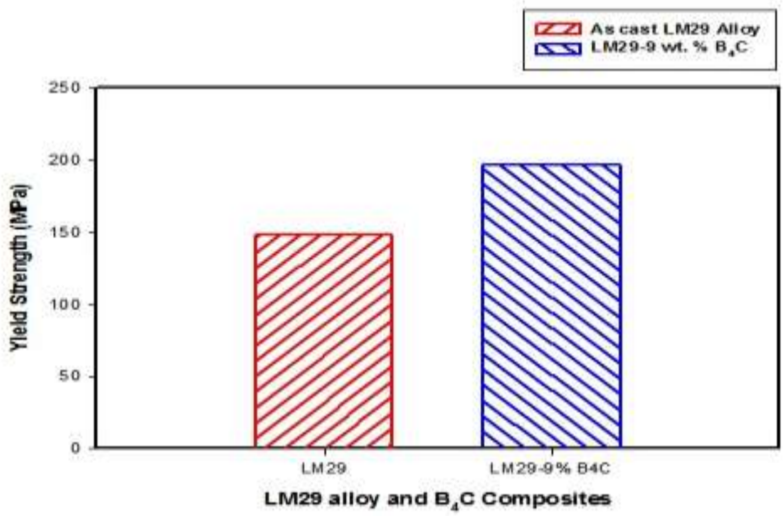


Figure 4: Yield strength of LM29 alloy and its B_4C composites

Figure 4 indicates yield strength improved from 148 MPa to 196 MPa with addition of 9 wt.% of B_4C. The enhancement in the yield strength is due to the close packing of B_4C particles providing molecule strength with the aluminum lattice in turn composite [12, 13]. This increase in yield strength is in agreement with the results obtained by several researchers [14], who reported that the strength of the particle reinforced composites is more strongly dependent on the volume fraction of the reinforcement. The increase in YS of the composite is obviously due to presence of hard B_4C particles which impart strength to the soft aluminium matrix resulting in greater resistance of the composite against the tensile stress. In the case of particle reinforced composites, there is a restriction to the plastic flow due to the dispersion of the hard particles in the matrix, thereby providing enhanced strength to the composite.

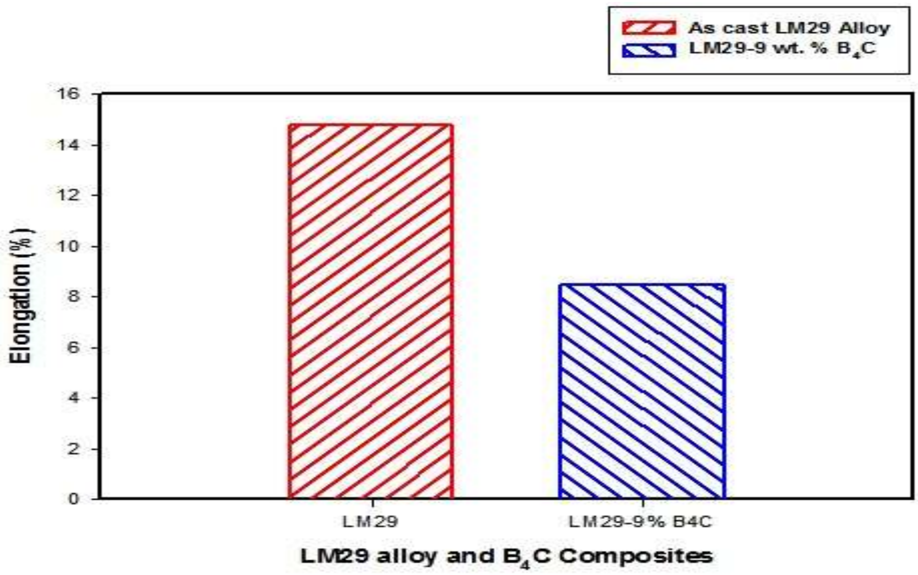


Figure 5: Percentage Elongation of LM29 alloy and its B_4C composites

Figure 5 illustrates the impact of B_4C with reference to malleability of the composite. It can be observed that the graph is falling down with addition of 9 wt.% of B_4C particulates but the rate of diminishing is less by 9 wt.% addition. This is due to the strength acquired by the composite with addition of B_4C owing to its properties. The reduced ductility in LM29-9 wt. % composites can be attributed to the presence of B_4C particulates which may get fractured and have sharp corners that make the composites prone to localised crack initiation and propagation. The embrittlement effect that occurs due to the presence of the hard ceramic particles causing increased local stress concentration sites may also be the reason.

Compression Strength

Figure 6 and indicates the compression strength of the test specimens with 9 wt. % of B_4C in LM29 alloy. It is clearly evident that the compression strength is varied from 567.4 to 782 MPa. This increase in compression strength is mainly due to high hardness and the compression strength of B_4C particulates. This ceramic particulate acts as the barrier for the deformation when the compression load is applied [15].

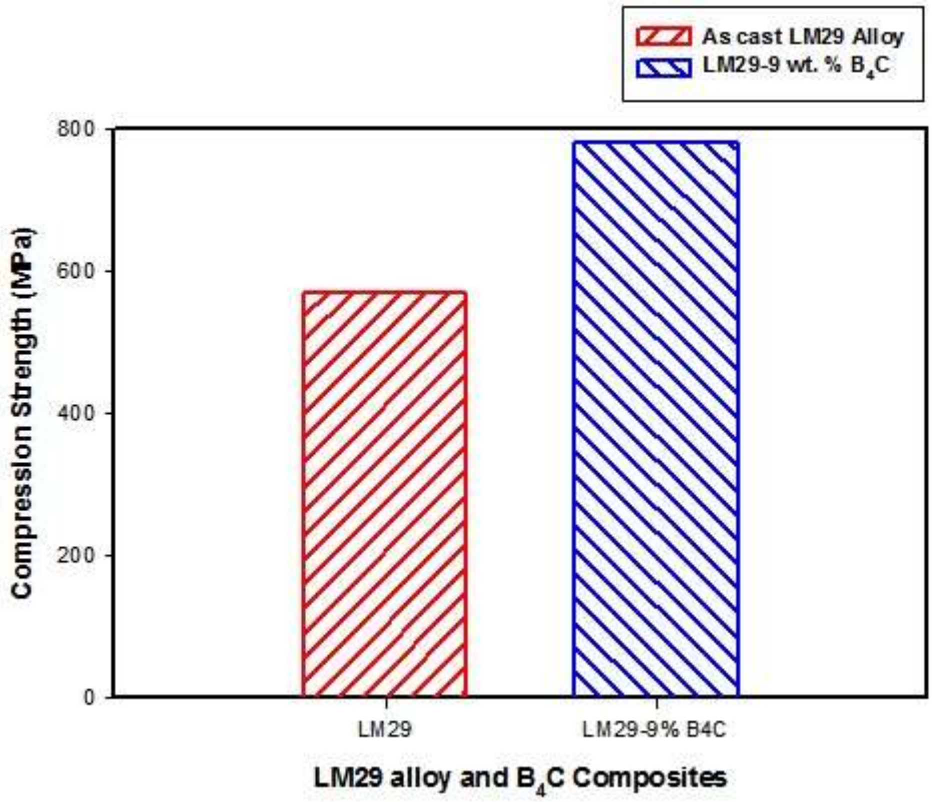


Figure 6: Compression strength of LM29 alloy and its B_4C composites

IV. CONCLUSION

This present research is centered on the development and characterization of the microstructure and mechanical behavior of LM29 alloy and B_4C composites containing 9 wt. From the above results and discussion the following conclusions are made:

1. From the liquid metallurgy techniques LM29-9 wt. % of B_4C composites were prepared successfully.
2. The scanning electron micrographs revealed the uniform distribution of B_4C particulates in the LM29 base alloy.
3. The hardness of LM29 base alloy increased with the addition of 9 wt. % of B_4C particulates.
3. The ultimate tensile strength of LM29 alloy with 9 wt. % of B_4C particulates addition increased from 169.3 MPa to 217.7 MPa.
4. The yield strength of LM29 alloy with 9 wt. % of B_4C particulates addition increased from 148.3 MPa to 196.2 MPa.
5. Compression strength of LM29 base alloy was enhanced with the addition of B_4C particulates.
6. The ductility of base alloy LM29 reduced with the addition of 9 wt. % of B_4C particulates.

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