COMBINED EFFECT OF B₄C PARTICLES ADDITION AND ARTIFICIAL AGING ON AL2218 ALLOY COMPOSITES

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ABSTRACT
In the present investigation synthesis, microstructure and mechanical behavior of 0, 2, 4, 6 and 8 weight percentage of nano B₄C particulate reinforced and artificially aged Al2218 alloy composites has been reported. Al2218 matrix composite containing nano B₄C were fabricated by conventional stir casting method. The composites were solution treated at 520 degree Celsius and artificially aged at 175 degree Celsius for 10 hours. The microstructures of the composites were examined by scanning electron microscopy. Further, mechanical behavior of Al2218 alloy and Al2218 alloy with 2, 4, 6 and 8 wt. % B₄C composites were studied. Mechanical properties like hardness, ultimate, yield strength and percentage elongation were evaluated as per ASTM standards. From the analysis, it was found that the hardness, ultimate tensile strength and yield strength of composites were increased due to addition of nano B₄C particles and effect of aging on the AA7475 alloy matrix. Percentage elongation of the composite decreased in nano B₄C reinforced composites.

Keywords: Al2218 Alloy, Nano B₄C Particulates, Stir casting, Artificial Aging, Ultimate Tensile Strength.

I. INTRODUCTION
Metal Matrix Composites (MMCs) are a wide group of materials pointed toward accomplishing an upgraded blend of properties. While the network can be any metal or compound, most interest has been appeared in the lighter auxiliary metals, as a rule, improvement in mechanical properties has been the essential target. Until this point, the fulfillment of higher strength and solidness has been the prime thought process behind the improvement of MMCs [1, 2]. Other significant upgrades in boundaries, for example, damping limit, segment weight, wear obstruction, warm development and high temperature capacities can be accomplished by appropriate blends of filler materials in metallic networks. Simultaneously, the alluring properties of metals, for example, simplicity of creation, flexibility, high warm and electrical conductivity ought to ideally keep up. Moreover, the ideal blend of properties should be acquired at least segment cost [3].

Metal Matrix Composites (MMCs) are progressively turning out to be appealing materials for cutting edge aviation applications yet their properties can be custom fitted through the expansion of chose support. Specifically particulate fortified MMCs have as of late discovered uncommon interest on account of their particular strength and explicit solidness at room or raised temperatures [4]. It is notable that the versatile properties of the metal network composite are unequivocally affected by miniature auxiliary boundaries of the support, for example, shape, size, direction, appropriation and volume or weight [5].

Among the different network materials accessible, aluminum amalgams are promising materials because of their high explicit strength and firmness. In any case, their applications are limited as a result of their helpless wear obstruction. Particulate fortified aluminum grid composites are presently being considered for their boss mechanical and tribological properties over the traditional combinations, and in this way, these composites have increased broad applications in car and aviation enterprises. The accentuation has been given on creating moderate Al-based MMCs with different hard and delicate fortifications like SiC, Al₂O₃, B₄C, Zircon, Tungsten Carbide, Graphite and Mica [6].
The essential capacity of the support in MMCs is to convey the vast majority of the applied burden, where the lattice ties the fortifications together, and sends and disperses the outside burdens to the individual support. Great wetting is a basic condition for the age of a palatable connection between particulate fortifications and fluid Al metal grid during projecting composites, to permit move and circulation of burden from the framework to the fortifications without disappointment [7].

It is proven that the nano ceramic particles are effective reinforcement materials in aluminium alloy to enhance the mechanical and other properties. The reinforcement in MMCs is usually of ceramic materials; these reinforcements can be divided into two major groups, continuous and discontinuous [8].

However, meager information is available as regards to the mechanical properties of Al2218 reinforced with nano B4C particulates MMC’s processed by stir casting method. With the increasing demand of light weight materials in the emerging industrial applications, the aluminum− B4C composites play an important role. Keeping the above observations in view, it is proposed to develop Al2218 nano B4C composites with 2 to 8 wt. % of B4C particulates. In this study, it is planned to investigate mechanical properties of artificially aged Al2218 alloy based composites with nano sized B4C particulates by using liquid metallurgy technique.

II. EXPERIMENTAL DETAILS

Materials Used

In the present experimental investigation aluminium alloy 2218 is used as the matrix material and its chemical composition is shown in Table 1. Al2218 alloy is one of the wrought aluminium alloy containing copper as the major element. The density of Al2218 is 2.8 g/cm³ and the melting point is considered as 660°C.

<table>
<thead>
<tr>
<th>Element</th>
<th>Si</th>
<th>Cu</th>
<th>Mg</th>
<th>Mn</th>
<th>Fe</th>
<th>Zn</th>
<th>Ni</th>
<th>Al</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wt. (%)</td>
<td>0.90</td>
<td>4.5</td>
<td>1.8</td>
<td>0.20</td>
<td>1.0</td>
<td>0.25</td>
<td>1.5</td>
<td>Balance</td>
</tr>
</tbody>
</table>

In the present work, nano B4C particulates are used as the fortification materials, 500 nm particulates were used, which were obtained from Reinste Nano Ventures Ltd., Delhi. The density of B4C is smaller than the matrix material, which are 2.52 g/cm³.

Preparation of Nano Composites

In this creation cycle, nano composites were readied utilizing Al2218 amalgam alongside 2 to 8 wt. % of nano B4C particulates by mix giving strategy a role according to ASTM principles. The pre-gauged Al billet was cut into little lumps and acquainted with the graphite pot in the electrical opposition heater. The Electrical opposition heater is warmed to the temperature of 750˚C. Support particulates of nano B4C were preheated to a greatest temperature of 400˚C. A computerized temperature regulator is utilized to check the temperature of the liquefy in an electrical obstruction heater. Hexa chloro-ethane (C2Cl6) a degassing specialist was added to eliminate undesirable gases present in the liquid metal. 5 to 10 grams of magnesium was added to expand the wettability of the fortified particles to the metal network. Mechanical blending of the liquid metal to the speed of 300 rpm for around 2 minutes was done prior to adding the fortified particles to frame vortex. Preheated fortified particles were included little augmentations at equivalent stretches into the liquid metal in two stage expansion measure. The cast iron kick the bucket was preheated to a temperature of 200˚C to which liquefy is poured and permitted to cool to get the necessary examples. The same procedure is adopted to prepare the remaining weight percentages of composites. Further, these prepared samples were solution treated at 520˚C for 1 hour and artificially aged at 175˚C for 10 hours.

Testing of Specimens

The castings in this way acquired were sliced to suitable size of 15 mm width and 5 mm thickness which is then exposed to various degrees of cleaning to get required example piece for microstructure study.
first, the cut examples were cleaned with emery paper up to 1000grit size followed by cleaning with Al₂O₃ suspension on a cleaning plate utilizing velvet material. This was trailed by cleaning with 0.3 microns precious stone glue. The cleaned surface of the examples scratched with Keller’s reagent lastly exposed to microstructure concentrate under the filtering electron magnifying lens.

Hardness tests were performed on the cleaned surface of the examples utilizing Brinell hardness testing machine letting loose indenter of 5 mm measurement and 250 kg load for a stay time of 30 seconds, three arrangements of readings were taken at better places of the cleaned surface of the example and normal was thought of. The ductile examination was done on the cut examples according to ASTM E8 [9] norms using Universal Testing machine at room temperature to contemplate properties like tensile, yield strength and level of prolongation.

III. RESULTS AND DISCUSSION

Microstructural Study

Figure 1a and b shows the SEM micrographs of as cast alloy Al2218 and the composite of 8 wt. % of nano B₄C reinforced with Al2218. These two examined samples were chosen from the middle segment from the cylindrical specimens. The microstructure of as cast Al2218 alloy comprises of fine grains of aluminium solid solution with a sufficient dispersion of inter-metallic precipitates due to solution and artificial heat treatment process.

It additionally demonstrates the great holding between the framework and the fortification alongside the uniform homogenous circulation of nano estimated B₄C particulates with no agglomeration and bunching in the composites. This is essentially because of the viable mixing activity accomplished all through the expansion of the fortification by two phases. The nano particles everywhere throughout the grain limit of the lattice obstruct the grain improvement and oppose the separation development of grains amid stacking.

Fig. 1: Scanning electron micro photographs of artificially aged (a) Al2218 alloy (b) Al2218-8 wt. % B₄C composites
Fig.-2: Showing EDS analysis of Al2218-8wt. % B₄C composite

EDS pattern of the Al2218-8 wt. % nano B₄C is shown in figure 2. The presence of Al and B₄C phase are clearly seen in the form of Al, B and C elements.

Hardness

Figure 3 shows the variety in hardness with the expansion of 2 to 8 wt. % of nano B₄C particulates to the Al2218 compound and furthermore with the impact of warmth treatment. The hardness of a material is a mechanical boundary showing the capacity of opposing neighborhood plastic twisting. The hardness of Al-B₄C composite is found to increment with the expansion of wt. % nano B₄C particulates alongside heat treatment. This expansion is seen from 77.47 BHN to 131.4 BHN for Al composites. This can be ascribed essentially to the presence of harder B₄C fortification stage in the lattice, and furthermore the higher imperative to the restricted network twisting during space because of the presence of harder stage [10]. Likewise, B₄C, as different fortifications fortifies the network by making of high thickness separations during cooling to room temperature because of the distinction of coefficients of warm extensions between the B₄C and lattice Al2218 amalgam. Bungle strains created between the support and the network deters the development of disengagements, bringing about progress of the hardness of the composites.

Fig.-3: Hardness of Al2218 alloy and nano B₄C composites with heat treatment
Ultimate Tensile Strength and Yield Strength

The plot of ultimate tensile strength (UTS) with changing wt. % of nano B₄C dispersoid in metal grid composite has been introduced in figure 4. The deliberate estimations of UTS were plotted as an element of weight level of nano B₄C particles. The expansion in strength is ascribed because of legitimate holding between the framework and fortification materials. Better the grain size better is the hardness and strength of composites prompting improves the wear obstruction too. The expansion in UTS is credited to the presence of hard nano B₄C particulates, which gives solidarity to the network combination, along these lines giving upgraded rigidity [11]. The expansion of these particles may have offered ascend to enormous remaining compressive pressure created during cementing because of contrast in coefficient of development between bendable network and fragile clay particles. The improvement of solidarity is likewise ascribed to nearer pressing of fortification and subsequently little between molecule dividing in the network.

![Ultimate tensile strength of Al2218 alloy and nano B₄C composites with heat treatment](image1)

**Fig.-4:** Ultimate tensile strength of Al2218 alloy and nano B₄C composites with heat treatment

Figure 5 shows variation of yield strength (YS) of Al2218 alloy matrix with varying wt. % of nano B₄C particulate reinforced composite and with heat treatment. It can be seen that by adding 8 wt. % of B₄C particulates yield strength of the Al alloy increased from 200.7 MPa to 297.6 MPa.

![Yield strength of Al2218 alloy and nano B₄C composites with heat treatment](image2)

**Fig.-5:** Yield strength of Al2218 alloy and nano B₄C composites with heat treatment
This expansion in yield strength is in concurrence with the outcomes acquired by a few specialists, who have revealed that the strength of the molecule fortified composites is profoundly reliant on the weight or volume division of the fortification. The expansion in YS of the composite is clearly because of essence of hard B₄C particles which confer solidarity to the delicate aluminum lattice bringing about more noteworthy opposition of the composite against the applied pliable burden. On account of molecule fortified composites, the scattered hard particles in the lattice make limitation to the plastic stream, accordingly giving improved solidarity to the composite [12-14].

**Percentage Elongation**

![Percentage Elongation Graph](image)

**Fig.-6:** Percentage elongation of Al2218 alloy and nano B₄C composites with heat treatment

Figure 6 exhibiting the effect of nano B₄C substance and warmth treatment on the prolongation (malleability) of the composites. It very well may be seen from the diagram that the adaptability of the composites decrease basically with the 2 to 8 wt. % B₄C invigorated composites with heat treatment. This reducing in rate prolongation in connection with the base blend is a most ordinarily happening disservice in particulate braced metal grid composites. The reduced malleability in composites can be attributed to the closeness of B₄C particulates which may get broke and have sharp corners that make the composites slanted to limited split beginning [15, 16]. The delicate effect that happens as a result of the closeness of the hard aesthetic particles welcoming on extended area stretch center regions may similarly be the explanation.

**IV. CONCLUSIONS**

In this research, nano B₄C with Al2218 composites have been fabricated by stir casting method by taking varying wt. % of reinforcement. The combined effects of artificial aging and B₄C particles addition on the mechanical behavior of Al2218 alloy composites have been studied. The microstructure, hardness, ultimate tensile strength, yield strength and percentage elongation of prepared samples are studied. The matrix is almost pore free and uniform distribution of nano particles, which is evident from SEM microphotographs. The EDS analysis confirms the presence of B₄C particles in the Al alloy matrix. The mechanical properties of Al2218 alloy with varying wt. % nano B₄C composite is enhanced with the dual effect of artificial aging and nano particles.

**V. REFERENCES**


