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Research Article

Processing, microstructure, density and compression behaviour of nano B_4C particulates reinforced Al2219 alloy composites

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Abstract
Aluminum metal matrix composites are measured as advanced materials in the field of aerospace, automotive, naval and other industrial applications. In the present work investigations is made on effect of nano B_4C particulates addition on the compression behavior of Al2219 alloy. Nano B_4C particulates of 500nm were used as the reinforcements in the Al alloy matrix. Nano composites were synthesized by using two stage liquid melt stir method in steps of 2, 4, 6 and 8 wt. % of nano B_4C reinforcement in the Al2219 alloy. Samples were tested for microstructural characterization by using scanning electron microscope (SEM) and energy dispersive spectroscope (EDS). Density and compression strength were evaluated as per ASTM standards. Scanning electron micro photographs revealed the uniform distribution of the nano B_4C particulates in Al2219 alloy and confirmed by EDS analysis. Further, the compression strength of base matrix Al2219 alloy is improved with the addition of the nano B_4C reinforcement.

Keywords
Al2219 alloy, Nano B_4C, Melt stirring, Microstructure, Compression behavior.

1.Introduction
In the present situation, there is always a unremitting requirement for the weight and cost effective product designs to remain competitive all time, synthesis of composite materials and its improved material properties is always remained as best practical solution to convince market demand. In metallic materials, aluminum alloy is most preferred for research and development activities for its low density, economical, ease of accessibility and production, good interfacial bonding with reinforcements [1].

The combination of one or more materials, with one being with matrix phase (Al, Zn, Mg, Ti etc) and other being reinforcement phase (SiC, B_4C, TiC, Gr, Al203, etc.), the two phases having different physical properties are combined by different processing techniques to form a new material known as composites with improved mechanical and physical properties [2−4].

From the matrix constituent, composites are categorized as organic-matrix composites, metal matrix composites (MMCs) and ceramic-matrix composites. Among these composites, aluminum metal matrix composites (AMMCs) with reinforcement of nano material possess highly enhanced mechanical properties such as good strength to weight ratio, improved specific modulus, superior damping capacity, stiffness, and good wear resistance. AMMCs have been the advances in materials in the past two to three decades and are widely used for major engineering applications like aeronautical, automotive, naval and civil structures [5, 6].

The reinforcement material is categorized in to four major groups based on the shape and size i.e. (i) continuous fibers (ii) short fibers (iii) whiskers and (iv) particulates. Among these particulates having a nano size reinforced MMCs are more attractive due to their cost-effectiveness, and isotropic properties [7, 8]. Various techniques are evolved for developing particulate reinforced AMMCs such as 1) liquid stage processing; 2) semi-solid manufacturing; and 3) powder metallurgy. From all liquid state processing the stir casting process is preferred because of its

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several advantages like simple process, cost effective, flexibility and help full in the mass production [9].

The significant problem in the procedure is to improve adequate wetting of scattered by the liquid fluid and to get a uniform homogeneous scattering of the nano particles. Interior imperfections, for example, porosity, molecule bunches, oxide considerations and interfacial responses are found because of unsuitable throwing innovation. With all the positive and negative focuses, just couples of researchers have been accounted for accomplishing fruitful throwing of AMMCs.

In current study, Al2219 is reinforced with nano B_4C particulates, by liquid stir metallurgy with two step stirring technique, which is identified to be one of the most potential method for different application under various controlled parameters in stir casting such as constant feed rate, stirring speed and room temperature cooling for the better interface bonding and distribution of the nano particles.

The objective of the current experimental study is to determine the compression properties and density behavior of the nano composites by adding hard nano ceramic particles into the Al2219 metal alloy.

Figure 1 shows the step by step procedure to achieve the objectives.

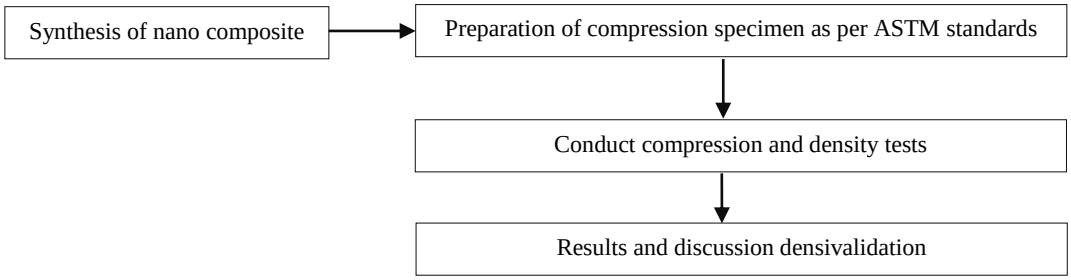


Figure 1 Step by step procedure of objectives

2.Material used

2.1Aluminium

Table 1 Chemical composition of Al2219 alloy by wt.%

AL	CU	FE	MG	MN	SIC	TI	V	ZN	ZR	OTHERS
Bal	6.8	0.3	0.02	0.4	0.2	0.10	0.10	0.1	0.20	0.15

The matrix stage, for the current experimental study depends on Al-Cu composition combination, assigned as aluminum association of Al2219. Aluminum is the third abundant component after oxygen and silicon. This baseline compound has low density 2.8 g/cm^3 among all Al composites and gives superior mix of quality, high erosion resistance, high elasticity, and great machinability and weldability. *Table 1* demonstrates substance structure of Al2219 discovered by Spectro examination strategy.

2.2Nano B4C

Nano B_4C is one of the top order hardest material nano-boron carbide (B_4C) particles have high impeccability, limit run molecule estimate appropriation, and bigger particular surface region with low thickness of 2.52 g/cm^3. It as liquefying point up to 2350˚C, breaking point higher than 3500˚C, hardness up to 2800 BHN, flexural quality ≥ 400MPa; It has great as against oxidation, high temperature safe, high quality, high granulating proficiency, high hardness, high versatile modulus, high wear-safe, and great self-oil attributes alongside warm neutron catch cross segment, with brilliant neutrons retention property and great hostile to radiation execution.

3.Experimental procedure

The preparation of Nano reinforced metal matrix composites (MMCs) is carried out by the liquid metallurgy Stir casting method. By the choose of two stage stir casting process, it is easy to achieve enhanced mechanical properties of the prepared Nano composite and to obtain a good interfacial bonding (wetting) between the nano reinforcement phase and the liquid matrix. In the present experiment, initially

the matrix alloy (Al2219) is kept in the graphite crucible in an electric furnace having a maximum temperature of 1300˚C. The entire matrix alloy is melted at temperature of 750˚C, and then the degassing tablet known as solid hexa chlro ethane was added to the molten melt to remove all the unwanted slag content and volatile gases. At the drop of the temperature during the addition of C2Cl6 to the molten matrix [10], the Nano B_4C particles are preheated to temperature of 600˚C to provide good bonding with the matrix phase and mechanical equipment's such zirconium coated stirrer, and the mold are also preheated at temperature of 350-400˚C to remove all the moisture content. Then the 2% weighted amount of Nano particulates was added in to the melt at a constant feed rate and the continuous vigorous stirring was done for about 10 minutes at stirring speed of 400rpm. Then the entire molten melt was poured into the preheated mould cavity and allowed to cool at a room temperature. Similarly, the same process was repeated for different weight percentage.

4.Testing

The compression test is carried out at room temperature (Instron Universal Testing Machine-1195 machine) according to ASTM-9 standard. Minimum of three specimens were used for each composite sample. For plotting the result graphs, average of all the three readings were considered.

Density of the specimen is calculated to know the porosity in the nano metal matrix composite specimens. The theoretical density is calculated by rule of mixture for the base alloy and composite for the different wt % of reinforcements. Experimental density of the prepared specimens is obtained by the Archimedean method of weighing the specimens in water.

Density: dc = dm*Vm + df*Vf

Where,

- dc, dm, df – densities of the composite, matrix and dispersed phase respectively;
- Vm, Vf – volume fraction of the matrix and dispersed phase respectively.

5.Results and discussions

5.1Microstructural Studies

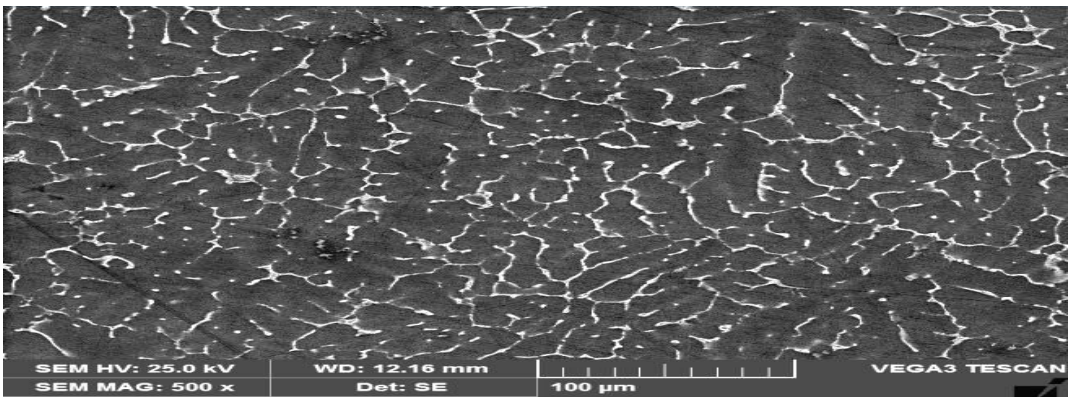
The prepared composites are characterized for microscopic studies. Specimens of 12mm diameter and thickness of 5mm were cut from the central portion of the casting for SEM//EDAX microanalysis studies.

Figure 2 (a, b) demonstrates the SEM microphotographs of Al2219 composite as thrown with 8 wt. % of nano B_4C particulate composites. This uncovers the uniform circulation of B_4C particles and low agglomeration and isolation of particles, and porosity. The *Figure 2 b* unmistakably demonstrates the even conveyance of nano B_4C particles in the Al2219 compound lattice. As it were, no grouping of nano B_4C molecule is apparent. There is no confirmation of giving deformities such a role as porosity, shrinkages, slag incorporation and splits which is characteristic of sound castings. In this, wetting impact amongst particles and liquid Al2219 amalgam network additionally hinders the development of the nano B_4C particles. In this manner, the particles can stay suspended for quite a while in the liquefy prompting uniform dissemination.

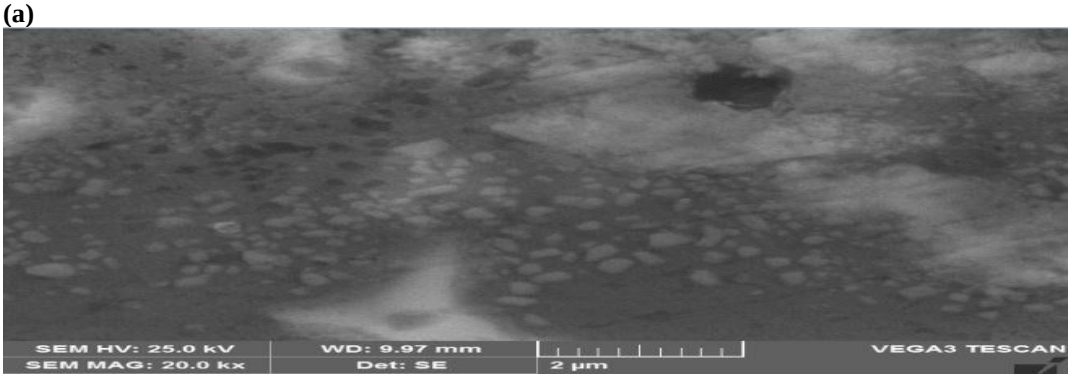
Figure 3 (a, b) shows and reveals the chemical composition of Al2219 alloy without addition of reinforcement and *Figure 2b* revealed the presence of nano B_4C particles in the aluminum matrix in the form of Boron (B) and Carbon (C).

5.2Density measurements

Figure 4 indicates the variation in densities of Al2219 alloy and 2, 4, 6 and 8 wt.% nano B_4C particulates reinforced composites. From the plot it is evident that as weight percentage of B_4C particles increases from 2 to 8 wt.%, there was decrease in the density of the Al2219 alloy composites. The reduction in density is due to lower density of reinforcement particles. Further, experimental densities are almost close to the theoretical densities in all the prepared composites. This indicates the soundness of the castings prepared by the vortex method.

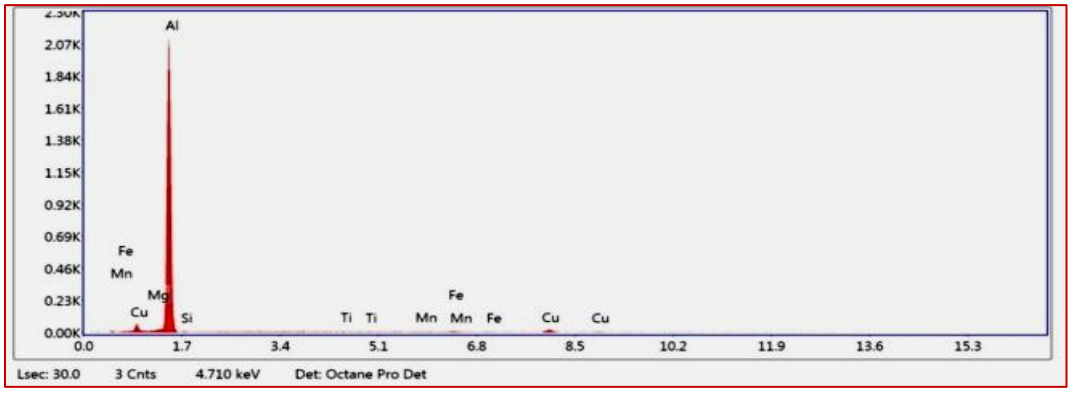


(a)

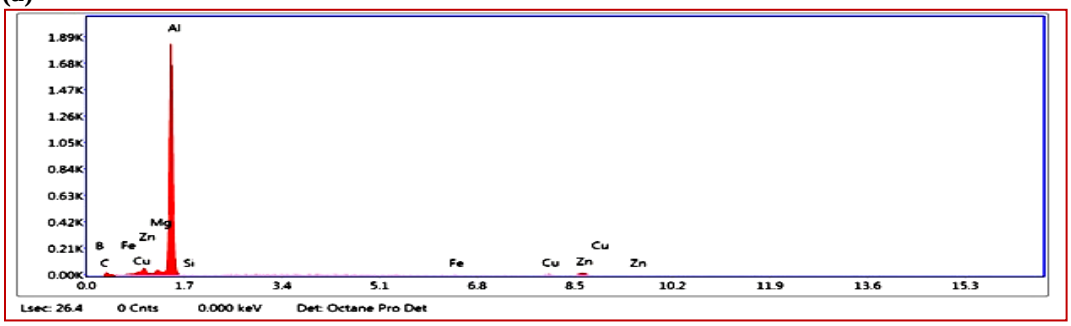


(b)

Figure 2 Scanning electron micrographs of (a) Al2219 alloy and (b) Al2219-8% nano B_4C composites



(a)



(b)

Figure 3 EDS spectrum of (a) Al2219 alloy and (b) Al2219-8% nano B_4C composites

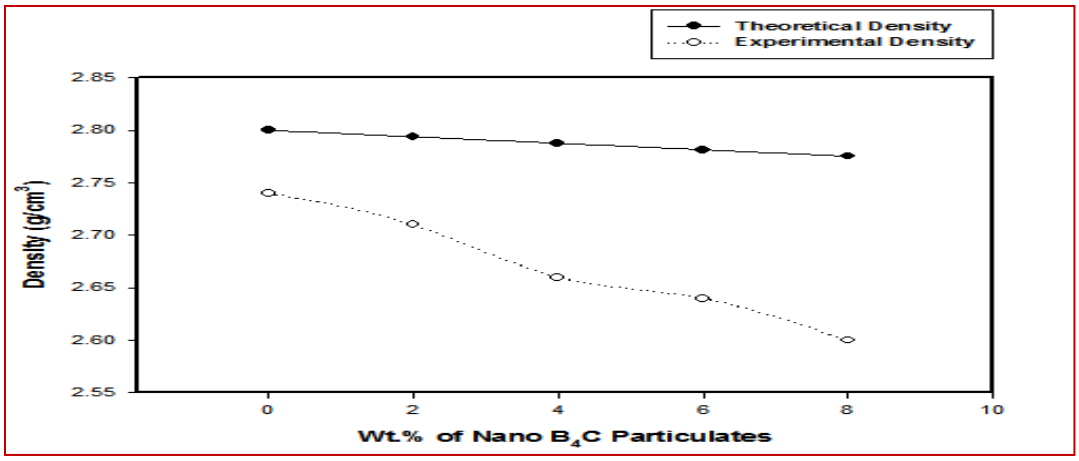


Figure 4 Shows the variation in density of Al2219 alloy and nano composites

5.3Compression strength

The results of compression test for the as-cast and the nano B_4C composites are presented in *Figure 5*. It is shown from the graph, the compression strength of Al2219 alloy enhanced with the addition of nano B_4C particles. Further, as weight percentage increases from 2 to 8 wt.%, it was enhanced to 555.9 MPa to 751.5 as compared to 504.1 MPa in the case of base Al2219 alloy. The improved compression strength is observed in the case of Al2219-B_4C composites, due to high hardness of ceramic particles. Usually, these particles exhibits the high hardness and very strong in the compressive nature [11, 12]. When these high compressive strength particles are added into the base soft matrix helps in the improvement of properties. Further, the enhanced compression strength is mainly due to presence of nano particles and acts as a barrier for the deformation during the compression load.

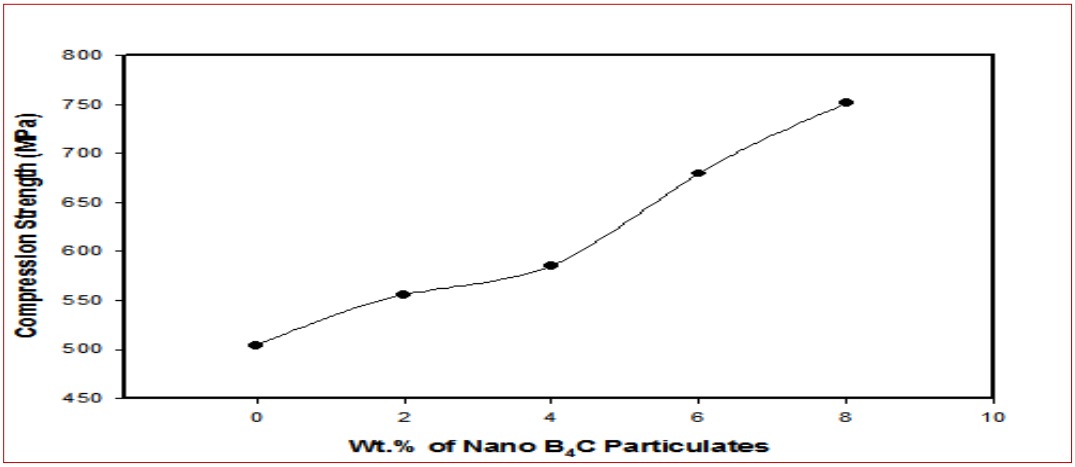


Figure 5 Shows the variation in compression strength of Al2219 alloy and nano composites

6.Conclusion and future work

In this research, nano B_4C/Al2219 composites have been fabricated by stir casting method by taking 2, 4, 6 and 8 wt.% of reinforcement. The microstructure, density and compression strength of prepared samples is 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 nano B_4C particles in the Al alloy matrix. The densities of the composites are decreased with the addition of nano B_4C particles. Also, Theoretical and Practical density measurement shows good correlation with negligible deviation. Compression properties of Al2219- nano B_4C composites are superior to those of unreinforced material. The compression strength of Al2219 alloy is increased from 504.1 MPa to 751.5 MPa for 8 wt. % nano composites.

The future work is to study the tribological and hardness properties of the synthesized nano composites.

Acknowledgment
None.

Conflicts of interest
The authors have no conflicts of interest to declare.

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