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Investigations on Mechanical Behavior of Al2219Alloy-B4C Particulates Reinforced Composites

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ABSTRACT: In the currentinvestigation, themechanical properties ofAl2219-2 and 4 wt. % of B4C composites were displayed. The composites containing2 and 4 wt. % of B4C in Al2219 alloy were synthesized byliquid metallurgy method. For the composites, fortification particles were preheated to a temperature of 500˚C and afterward added in ventures of two into the vortex of liquid Al2219 alloy compound to improve the wettability and dispersion. Microstructural examination was carried out by SEM. Mechanical properties of as cast Al2219 alloy and Al2219-2 and 4 wt. % of B4C composites were evaluated as per ASTM standards. Microstructural characterization by SEM and EDS confirmed the distribution and presence of micro boron carbide particles in the Al2219 alloy matrix. The hardness, ultimate strength, yield strength and bending behaviour of Al2219 alloy enhanced with the incorporation of 2 and 4 wt. % of micro B4C particles. Further, ductility of Al2219 alloy decreased with the presence of B4C particles. Tensile fractography were studied on the tested samples to know the various fractured mechanisms.

KEYWORDS: Al2219 Alloy, B4C particles, Mechanical Behaviour,Fractography.

I. INTRODUCTION

Requirement of light weight metal matrix composites is increased in recent time, with the requirement of enhanced properties in terms of strength, stiffness with low densities, good wear resistances and reduced thermal expansion coefficient as compared monolithic and pure aluminium [1]. Aluminium Metallic Composites - AMCs are used in numerous industrial applications including automotive, naval, defence and aerospace fields and components.

Structural applications for Aerospace and Automotive require low weights in comparison to high strength requirements. The macro particulate having high melting points and high hardness compared to Aluminium metals such as Aluminum Oxides, Graphites, Carbides, Ceramic are used as alloying additional elements to aluminium base metal. Many particulates of harder metals such as TiC, SiC, Al_2O_3 and B_4C [2, 3] are used as particulate reinforcements to develop aluminium matrix composites and these alloys are used in different nature of applications. The micro boron carbide –B^4C is having lowest density of 2.52 g/cc and is low weight, high hardness and can be used for making an Alloy because of easy mixing characteristics. Hence, micro B_4C along with Aluminium is having lighter weight and high strength and wear resistance and finds application as armour plates [3] and many aerospace parts.

The productions of metal matrix composites must have chemical compatibility between base metal matrix and its reinforcements. Hence various liquid metal products preparing methods by mixing-processes [4, 5] are identified to have better chemical compatibility between matrix and reinforcement and stir casting method is one of them. It is quick and economical method to produce metal matrix composites (MMCs). The melting points of base metal and particulate reinforcements are different and particulate reinforcements can be mixed with molten Aluminum metal. The stir casting method of producing MMC is useful method as it can be done at low cost and can be prepared in foundries at near site. It is used for various selections of materials and is used at different processing conditions.. In order to increase wettability of particulate reinforcements, they are pre-heated or coated before mixing with the molten metal. Flux materials are also added to enhance chemical compatibility of Alloying elements [6].

Potassium Titanium Flouride -K_2TiF_6 is one of such flux material used during casting processes and it helps to increase wettability between Aluminium Al2219 and micro B_4C. It also helps to spread the micro B_4C particles evenly in the molten aluminium. The pre-heated micro-B_4C is properly mixed with K_2TiF_6 and is poured to molten Aluminium metal and mixtures are mixed properly with stir-casting method. The mixture is then poured in to pre-casted and machined metal moulds and reaction phase is avoided by cooling the mixture at atmospheric temperature conditions. Hence, traditional casting process was used during the preparation of micro B_4C metal composite with Aluminium

In the current study, particulate reinforcements of micro B_4C is mixed with molten base metal of Al2219 and metal composites of 0%, 2%& 4% weight of micro-B_4C particulates are prepared for the study of tensile and bendingproperties.

II. EXPERIMENTAL DETAILS

Materials

The experimental set-up of traditional casting process are used to prepare metal matrix composites of micro-B_4C of 0%, 2% and 4% by weight rates into Al2219 by the process of liquid metallurgy. For the preparation of MMCs, an Al2219 alloy was utilized as the base/framework material and micro-B_4C was used as the particulates to give strength. The theoretical density of grid material Al2219 amalgam is 2.80 g/cm^3 and support particulates micor-B_4C is 2.52g/cm^3. The chemical composition of Al2219 composite used for current study is as given in **Error! Reference source not found.**ble 1.

Table 1: Chemical configuration of Al2219 Alloy

Elements	Si	Fe	Cu	Mg	Zr	Zn	Ti	Mn	Al
Weight (%)	0.2	0.3	6.8	0.02	0.20	0.1	0.10	0.02	Bal

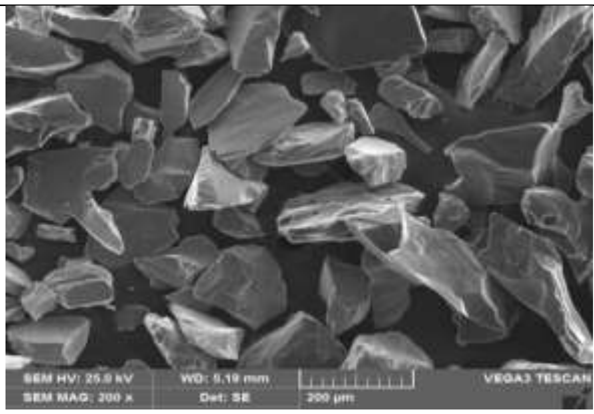


Figure 1: SEM microphotograph of B_4C particles

In the existent work, micro B_4C particulates with 80 to 90 micron size are used as the fortification materials.The density of B_4C is lesser than the matrix material, which is 2.52 g/cm^3.

Preparation of Composites and Testing

The production of Al2219-2 and 4 wt. % of B_4C composites were accomplished by liquid metallurgy route. Determined measure of the Al2219 compound ingots werekept into the heater for liquefying. The melting temperature of aluminumalloy is 660°C. The Al2219 alloymelt was superheated to 750°C temperature. The temperature of the melt was recorded utilizing achrome-alumel thermocouple. The liquid metal is then degassed utilizing solid hexachloroethane (C_2Cl_6) for 3 min [7]. A hardened steel impeller covered with zirconium is utilized to mix the liquid metal to make a vortex. The stirrer will be turned at a speed of 300rpm and the profundity of drenching of the impeller was 60 percent of the height of the liquid metal from the outside of the liquefy. Further, the B_4C particulates were preheated in a heater upto500°C will be brought into the vortex along with the K_2TiF_6 halide salt. Stirring waspreceded until interface connections between the fortification particulates and the Al matrix advances wetting. At that point, Al2219-2 wt. % micro B_4C meltwaspouredinto the cast iron mold having measurements of 120mm length and 15mm width. Further, Al2219-4 wt. % of B_4C particulates composites were fabricated by the same method.

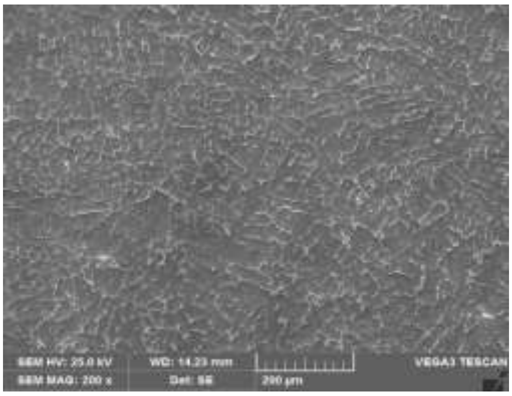
The castings in this way got were sliced to a size of 15 mm diameter across and 5 mm thickness which is then exposed to various dimensions of cleaning to get required example piece for microstructure studies.

Hardness tests were performed according to ASTM E10 [8]. The tensile and bending testswere done on the cut examples according to ASTM E8 and E290 [9] at room temperature to ponder properties like UTS, yield strength, % of elongation and bending strength.Fig. 2 shows the tensile test specimen.

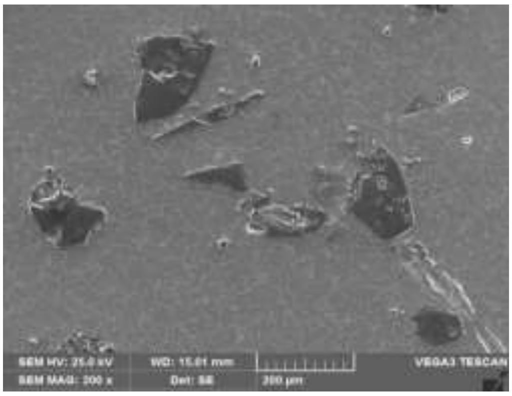
Figure 2: Tensile test specimen

III. RESULTS AND DISCUSSION

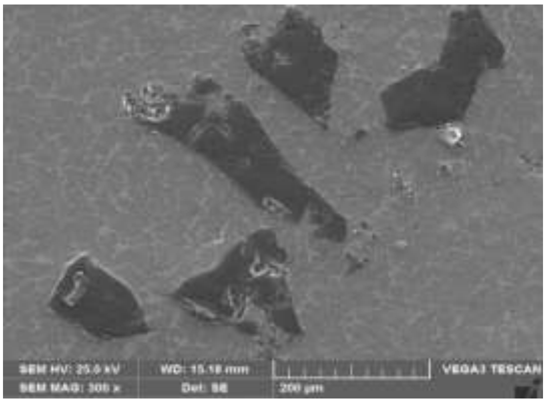
Microstructural Study



(a)



(b)

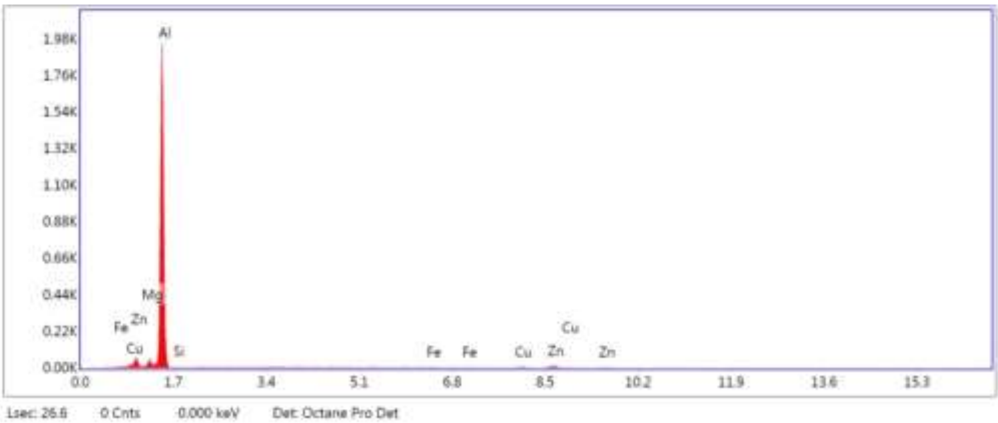


(c)

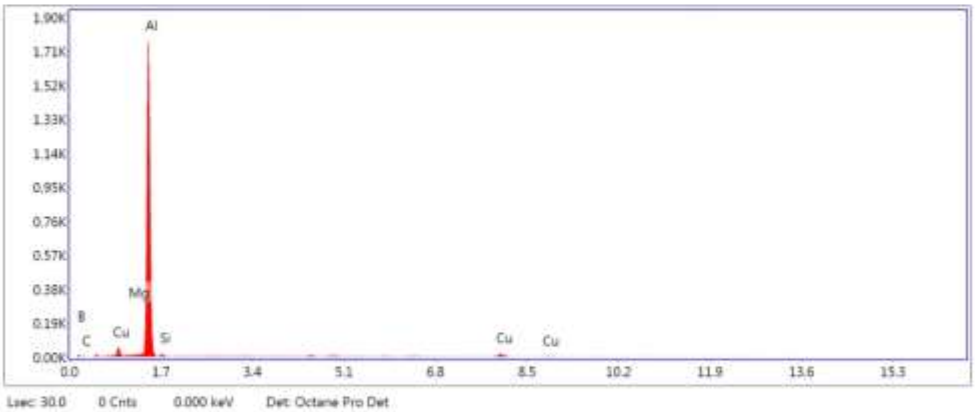
Figure3: Scanning electron micrographs of (a) as cast Al2219 alloy (b) Al2219-2 wt. % B_4C (c) Al2219-4 wt. % B_4C composites

Figure 3a-c shows the SEM micrographs of as cast alloy Al2219 alloy and the composites of 2 and 4 wt. % of micro B_4C reinforced with Al2219 alloy. These two examined samples were chosen from the middle segment from the cylindrical specimens. The microstructure of as cast Al2219 alloy comprises of fine grains of aluminium solid solution with an enough dispersion of inter-metallic precipitates.

Figure 3b-c shows the scanning electron photograph of 2 and 4 wt. % of B_4C particulates reinforced composites. From the SEM photograph, it is revealed that there is uniform distribution of secondary phase of micro particulates in the Al2219 alloy matrix without any agglomeration. It is also observed that there is an excellent interfacial bonding between the B_4C and Al2219 alloy matrix.



(a)



(b)

Figure 4: EDS spectrum of (a) as cast Al2219 alloy (b) Al2219-4% B_4C composites

The presence of B_4C is confirmed using energy dispersive spectroscope analysis carried out at the edge of the B_4C particle and Al alloy matrix. The EDS spectrum also reveals the presence of Zn, Cu, Mg, B and C in the interface reaction layer of Al2219 alloy composites as shown in the Fig. 4a and 4b.

Hardness Measurements

Fig. 5determines the variety in hardness with the expansion of 2 and 4 wt. % of micro B_4C particulates to the Al2219 alloy. The hardness of a material is a mechanical parameter demonstrating the capacity of opposing nearby plastic twisting. The hardness of Al2219-B_4C composite is found to increment with the addition of 2 and 4 wt. % micro B_4C particulates. This expansion is seen from 62.4 BHN to 82BHN for Al2219-4 wt. % of B_4C composites. This can be attributed essentially to the closeness of harder carbide particles in the cross section, and moreover the higher limitation to the restricted framework disfigurement amid space because of the nearness of harder stage [10].

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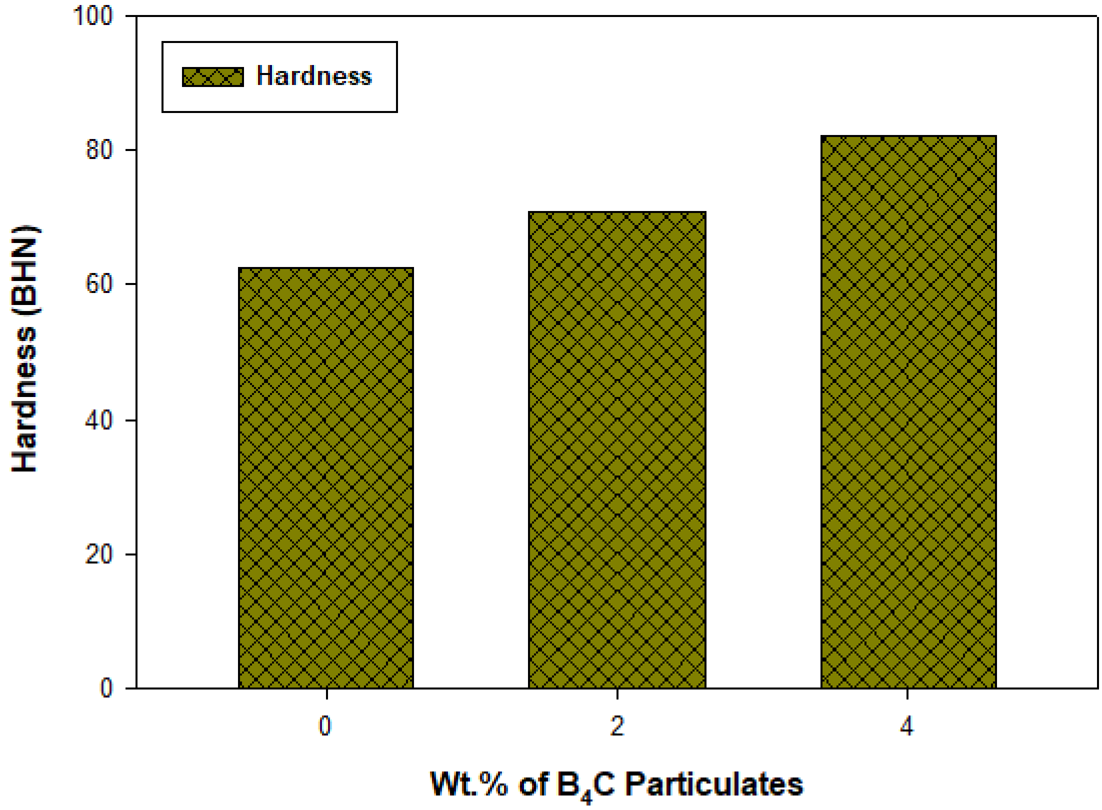
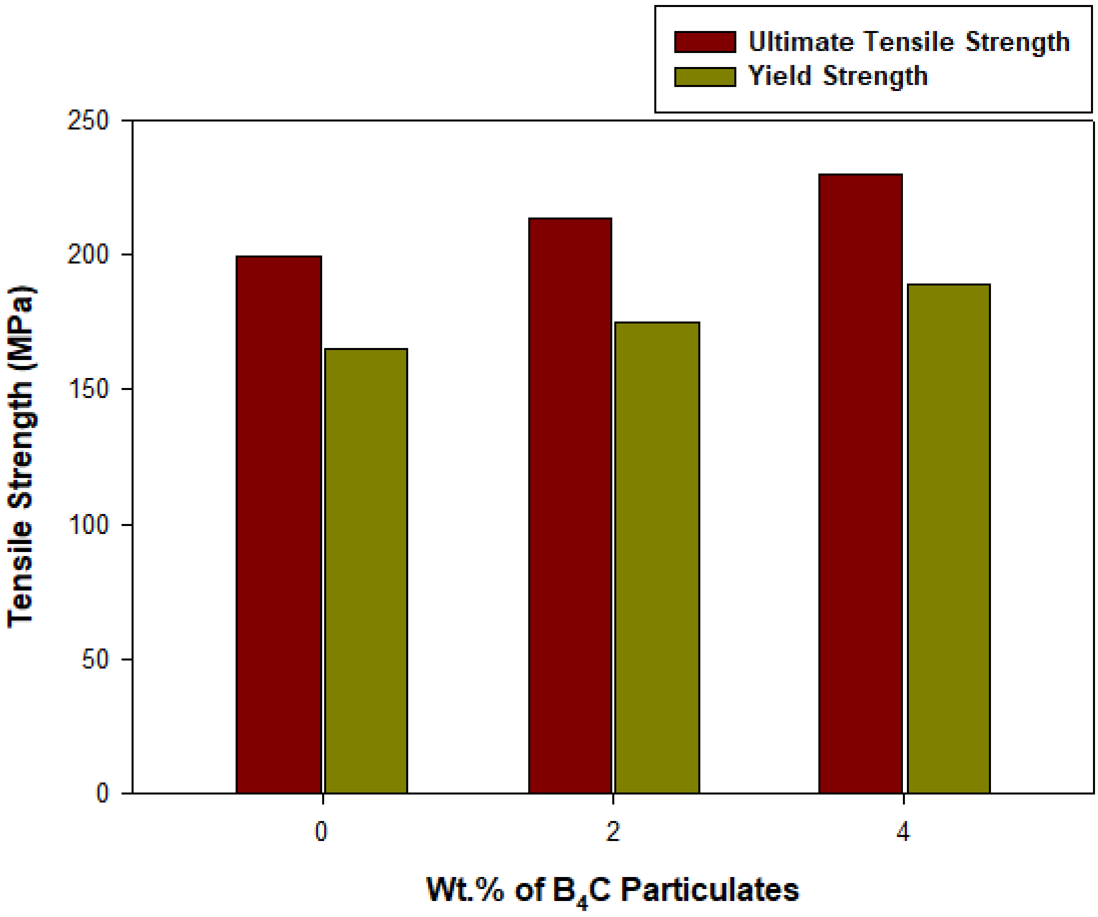


Figure 5: Showing the hardness of Al2219 alloy- B_4C composites



Ultimate Tensile Strength and Yield Strength

Figure 6: Showing the ultimate tensile and yield strength of AL2219 alloy-B_4C composites

The plot of ultimate strength (UTS) and yield strength with 2 and 4 wt. % of B_4C dispersoid in metal grid composite has been presented in Fig.6. The conscious estimations of UTS were plotted as a segment of weight rate of boron carbide particles. The ultimate and yield strength of Al2219 alloy is enhanced with the addition of 2 and 4 wt.% of B_4C particles.The enhancement obtained in the UTS after the addition of 4 wt.% of micro boron carbide particles in the Al2219 alloy is 15.3%. Further, there is an improvement in the yield strength of Al2219 alloy, the yield strength of Al2219 alloy is 165.48 MPa. After the addition of 4 weight percentage of boron carbide particles, it is found 188.66 MPa. The development in quality is credited on account of genuine contact between the matrix structure and materials [11]. Better the grain gauge better is the hardness and nature of composites provoking to upgrade the wear opposition additionally.

Percentage Elongation

Figure 7 showing the effect of micro B_4C content on the elongation (malleability) of the composites. It tends to be seen from the diagram that the adaptability of the composites decreases basically with the 2 and 4 wt. % B_4C sustained composites. This reducing in rate of elongation in connection with the base matrix is a most often happening method in particulate metal cross section composites [12]. The reduced ductility in composites can be credited to the closeness of B_4C particulates which may get broke and have sharp corners that make the composites slanted to confined split begin.

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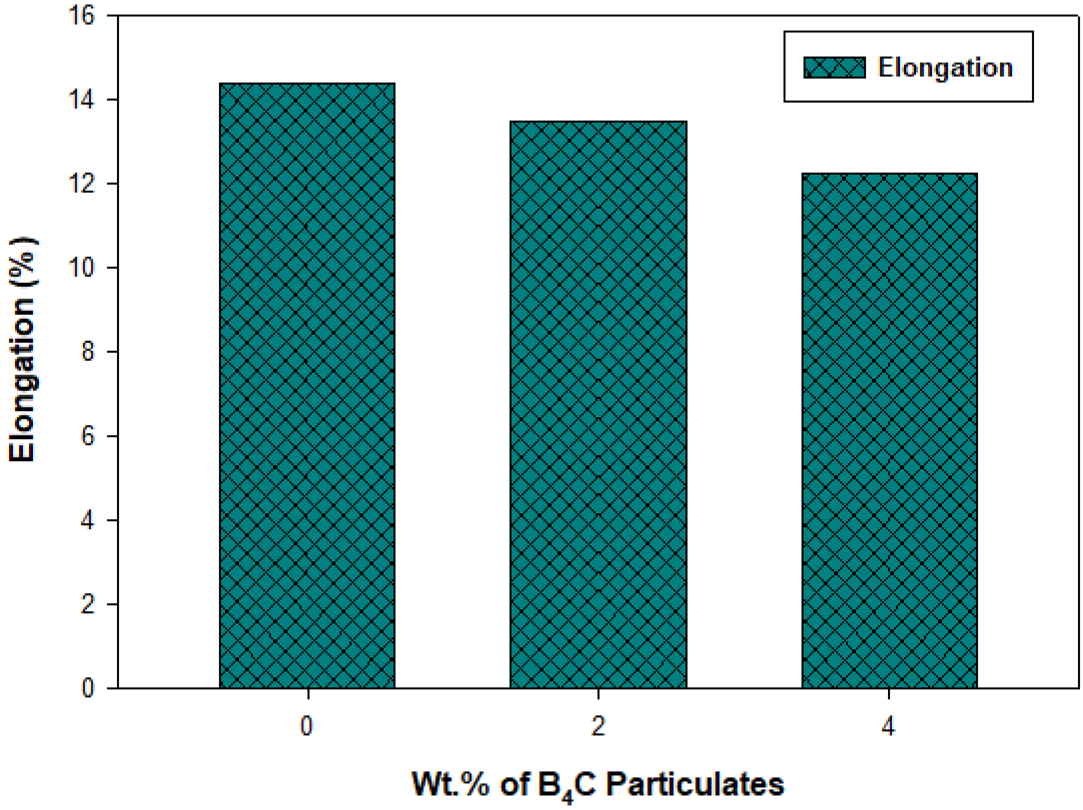


Figure 7: Showing the percentage elongation of Al2219 alloy- B_4C composites

Bending Strength

Fig. 8 is demonstrating the bending strength of Al2219 alloy with 2 and 4 wt. % of B_4C reinforced composites. From the strategy it is revealed that the bending strength of Al2219 alloy upsurges with the addition of micro B_4C particles. The bending strength of as cast Al2219 alloy is 153.1 MPa, the addition of B_4C particles enhanced strength of Al2219 alloy. After the incorporation of B_4C particles in the Al2219 alloy, the bending strength is 181.47 MPa in AA2124-4 wt.% B_4C composites.

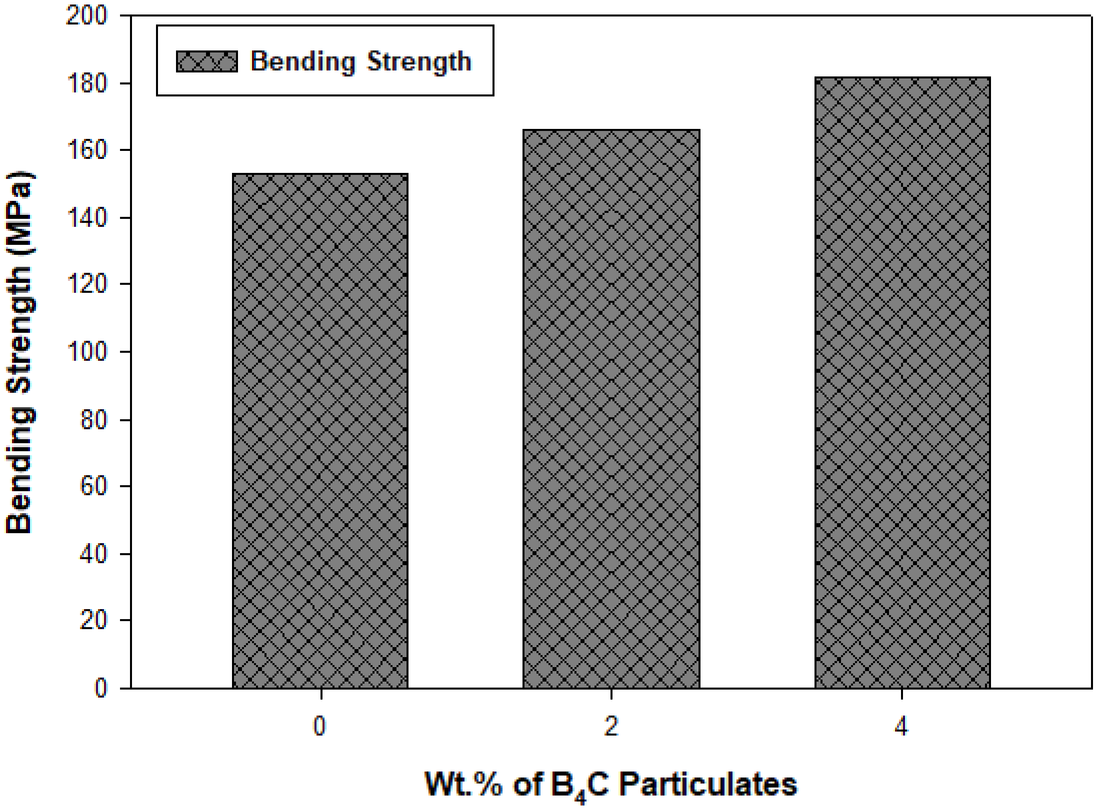
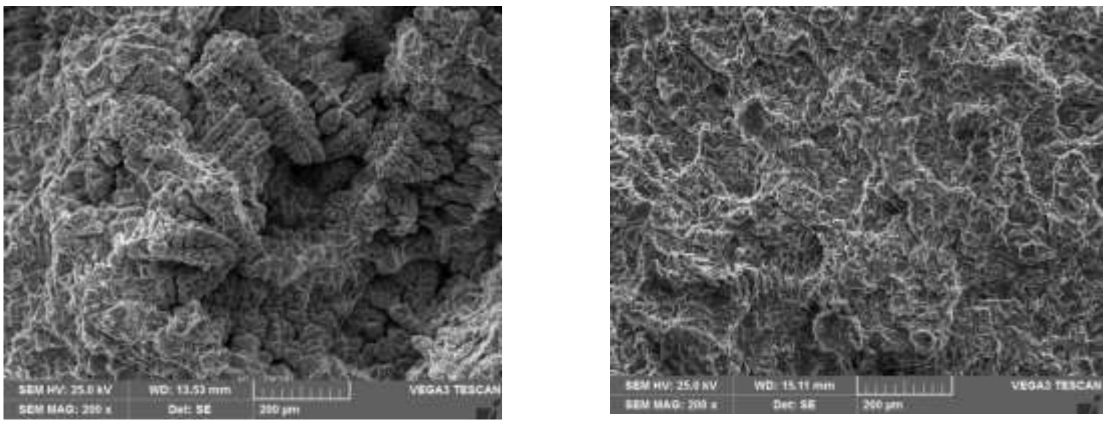


Figure 8: Showing the bending strength of Al2219 alloy-B_4C composites

Fracture Studies



(a) (b)

Fig. 9Showing the tensile fractured specimensof (a) Al2219 alloy (b) Al2219-4 wt.% B_4C composites

Tensile fracture of as cast compound and composite examples after tensile testing were examined by utilizing SEM pictures of crack surfaces (Fig. 9 a-b). The as cast Al2219 compound fracture mode is a ductile crack mode as appeared in Fig. 9-a, which has extensive number of dimple structures with large number of cavities. Fig. 9b demonstrates that 4 wt. % B_4C strengthened MMCs crack structures have less ductile failure.

IV. CONCLUSIONS

In this study, Al2219-B_4C micro composites have been manufactured by stircasting technique by taking 2 and 4 wt. % of B_4C particles. The microstructure, hardness, UTS, yield quality, elongation and bending strengthof Al2219 alloy with 2 and 4 wt. % B_4C composites were examined. The framework or composite is free from pores and uniform dispersion of nano particles, which is apparent from SEM microphotographs; EDS analysis confirmed the presence of B and C elements in the AL matrix. The mechanical properties of Al2219with 2 and 4 wt. % B_4C composites are improved as compared to Al matrix material. The tensile fractured surfaces of the composite material indicate ductile and brittle fracture in Al matrix and its composites respectively.

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