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Mechanical Behavior of AA2124 Alloy with 12 wt. % of B_4C Particulates Reinforced Composites

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***Abstract:** In the current investigation, the mechanical properties of AA2124-12 wt. % of B_4C composites were displayed. The composites containing 12 wt. % of B_4C in AA2124 alloy were synthesized by liquid metallurgy method. For the composites, fortification particles were preheated to a temperature of 400˚C and afterward added in ventures of two into the vortex of liquid AA2124 alloy compound to improve the wettability and dispersion. Microstructural examination was carried out by SEM. Mechanical properties of as cast AA2124 alloy and AA2124-12 wt. % of B_4C composites were evaluated as per ASTM standards. Microstructural characterization by SEM confirmed the distribution and presence of micro boron carbide particles in the AA2124 alloy matrix. The hardness, ultimate strength, yield strength and bending behaviour of AA2124 alloy enhanced with the incorporation of 12 wt. % of micro B_4C particles. Further, ductility of AA2124 alloy decreased with the presence of B_4C particles. Tensile fractography were studied on the tested samples to know the various fractured mechanisms.*

***Keywords:** AA2124 Alloy, B_4C particles, Mechanical Behavior, Fractography*

I. INTRODUCTION

Different types of composite materials are available and these are increasing with time as a result of new advancements and good enhanced properties. Performance oriented demands on materials has naturally resulted in revival of the age old concept of combination of various materials for optimum performance unattainable by individual constituent to meet specified user requirement with an added advantage of a flexible tailor made material as per specifications required for optimum use. Today technological development very largely depends on the advance in the field of material. To this end, a very large leap in optimum use of constantly endeavoring materials is composite [1, 2]. Composite technology, an interdisciplinary approach, encompasses fields like physics, engineering, chemistry, polymer science, material science, engineering, etc.

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Composite contains a phase called matrix that holds together and gives form to stronger, stiffer reinforcement constituent [3] resulting in a material with perfect blend of structural properties far better than its constituent parts alone. Combination of properties that make composites superior over conventional structural materials are good design flexibility, high specific strength and specific modulus, high fatigue endurance limit, corrosion and wear resistance, thermal cycling tolerance, tolerable coefficient of thermal expansion [4], etc. Relative amount and properties of constituent phases, geometry of dispersed phase including particle size, shape, and orientation in the matrix directs properties of composites [5]. There are several fabrication techniques available to process composites. The prepared composites are usually evaluated for enhanced properties by conducting experiments like hardness, tensile, compression, fatigue, and tribological tests as per ASTM standards [6].

AMMCs can be fabricated in many tested methods, but no one unique procedure. The fabrication technique depends on matrix material and types of reinforcement used [7]. Of all manufacturing processes that are available for short fiber metal matrix composite, stir casting is commonly acknowledged promising route on account of its simplicity, flexibility, large scale production of applications [8].

With the collective need of lightweight constituents in the emerging applications, the Al-B_4C composites play a significant role. In view of the above observations, it is projected to develop AA2124-B_4C composites with 12 wt. % of B_4C particulates. In this study, it is intended to examine mechanical properties of AA2124-B_4C composites by using un-coated B_4C particulates.

Hence the aim of present study is to synthesize AA2124-B_4C particulate MMC using stir casting method, by taking uncoated B_4C particulates as the reinforcement material. As cast AA2124 and AA2124-12 wt. % of B_4C particulates reinforced composites were subjected to metallographic studies, hardness, ultimate tensile, yield strength, ductility and flexural strength studies have been carried out at room temperature.

II. EXPERIMENTAL DETAILS

A. Materials Used

In the existing study AA2124 amalgam is utilized as the matrix substantial, most of the solicitations in areas such as aerospace, auto, marine make use of 2xxx series, aluminium-copper alloys.

AA2124 normally has 4.9% of copper and 1.8% of magnesium. The theoretical density of AA2124 alloy is taken as 2.80 g/cm^3. Table 1 is demonstrating the elemental analysis of AA2124 alloy and Fig.1 is representing the SEM image of B_4C particles used in the study.

Table I: Chemical composition of AA2124 Alloy

Elements	Content wt. %
Si	0.20
Fe	0.30
Cu	4.90
Mg	1.80
Mn	0.90
Zn	0.25
Cr	0.10
Ti	0.15
Al	Bal

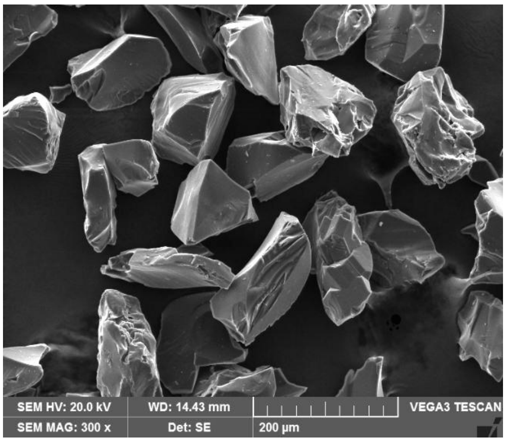


Figure 1: SEM microphotograph of B_4C particles

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.

B. Preparation of Composites and Testing

The production of AA2124-12 wt. % of B_4C composites were accomplished by liquid metallurgy route. Determined measure of the AA2124 compound ingots were kept into the heater for liquefying. The melting temperature of aluminum alloy is 660°C. The AA2124 alloy melt was superheated to 750°C temperature. The temperature of the melt was recorded utilizing a chrome-alumel thermocouple. The liquid metal is then degassed utilizing solid hexachloroethane (C_2Cl_6) for 3 min [9]. 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 upto 400°C will be brought into the vortex. Stirring was proceeded until interface connections between the fortification particulates and the Al matrix advances wetting. At that point, AA2124-12 wt. % micro B_4C melt was poured into the cast iron mold having measurements of 120 mm length and 15 mm width.

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 [10]. The tensile and bending tests were done on the cut examples according to ASTM E8 and E290 [11] at room temperature to ponder properties like UTS, yield strength, % of elongation and bending strength. Fig. 2 shows the tensile test specimen.

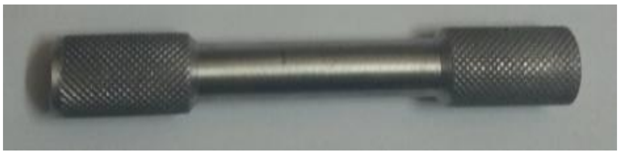
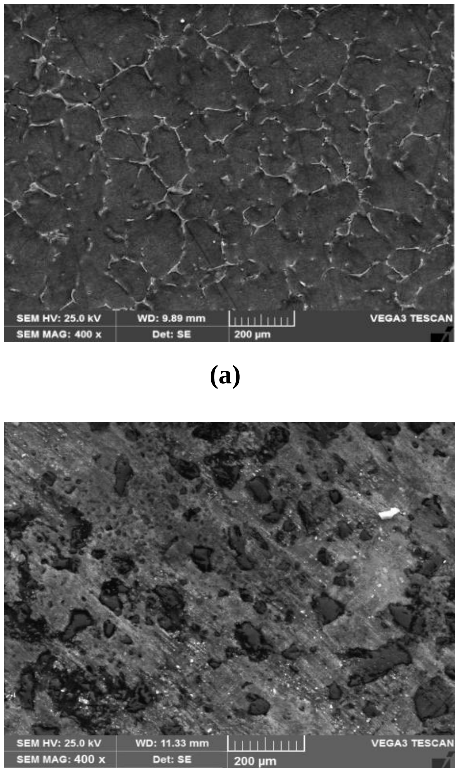


Figure 2: Tensile test specimen

III. RESULTS AND DISCUSSION

A. Microstructural Analysis



(a)

(b)

Figure 3: Scanning electron micrographs of (a) as cast AA2124 alloy (b) AA2124-12 wt. % B_4C composites

Figure 3a-b shows the SEM micrographs of as cast alloy AA2124 alloy and the composites of 12 wt. % of micro B_4C reinforced with AA2124 alloy. These two examined samples were chosen from the middle segment from the cylindrical specimens. The microstructure of as cast AA2124 alloy comprises of fine grains of aluminium solid solution with an enough dispersion of inter-metallic precipitates.

Figure 3a shows the scanning electron photograph of 12 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 AA2124 alloy matrix without any agglomeration.

It is also observed that there is an excellent interfacial bonding between the B_4C and AA2124 alloy matrix.

B. Hardness Measurements

Fig. 4 determines the variety in hardness with the expansion of 12 wt. % of micro B_4C particulates to the AA2124 alloy. The hardness of a material is a mechanical parameter demonstrating the capacity of opposing nearby plastic twisting. The hardness of AA2124-B_4C composite is found to increment with the addition of 12 wt. % micro B_4C particulates. This expansion is seen from 65.76 BHN to 108 BHN for AA2124-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 [12].

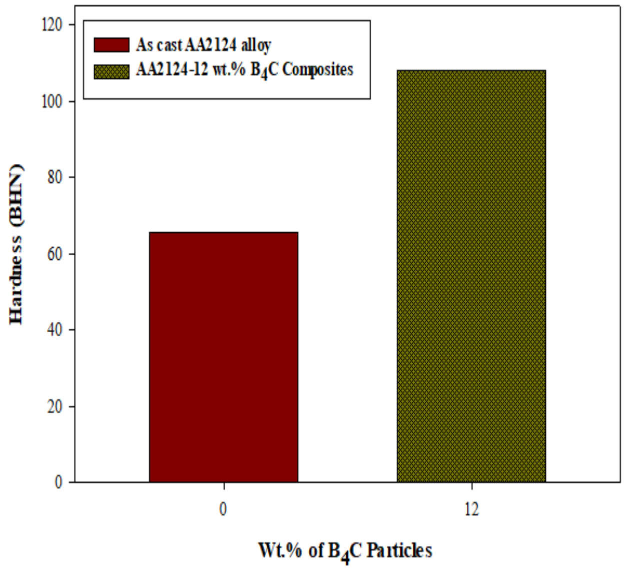


Figure 4: Showing the hardness of AA2124 alloy- 12 wt.% of B_4C composites

C. Ultimate Tensile Strength and Yield Strength

The plot of ultimate strength (UTS) and yield strength with 12 wt. % of B_4C dispersoid in metal grid composite has been presented in Fig.5. The conscious estimations of UTS were plotted as a segment of weight rate of boron carbide particles. The ultimate and yield strength of AA2124 alloy is enhanced with the addition of 12 wt.% of B_4C particles. The enhancement obtained in the UTS after the addition of 12 wt.% of micro boron carbide particles in the AA2124 alloy is 46.3%. Further, there is an improvement in the yield strength of AA2124 alloy, the yield strength of AA2124 alloy is 150.33 MPa. After the addition of 12 weight percentage of boron carbide particles, it si found 221.47 MPa. The development in quality is credited on account of genuine contact between the matrix structure and materials [13, 14]. Better the grain gauge better is the hardness and nature of composites provoking to upgrade the wear opposition additionally.

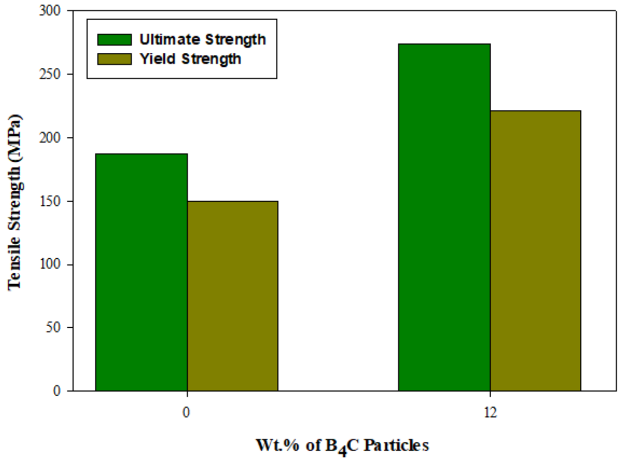


Figure 5: Showing the ultimate tensile and yield strength of AA2124 alloy- 12 wt. % B_4C composites

D. Percentage Elongation

Figure 6 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 12 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 [15, 16]. 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.

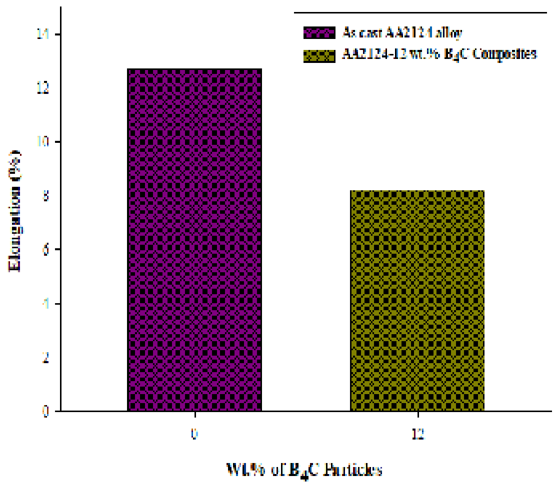


Figure 6: Showing the percentage elongation of AA2124 alloy- 12 wt.% B_4C composites

E. Bending Strength

Fig. 7 is demonstrating the bending strength of AA2124 alloy and 12 wt.% of B_4C reinforced composites. From the strategy it is revealed that the bending strength of AA2124 alloy upsurges with the addition of micro B_4C particles. The bending strength of as cast AA2124 alloy is 126.1 MPa, the addition of B_4C particles enhanced strength of AA2124 alloy. After the incorporation of B_4C particles in the AA2124 alloy, the bending strength is 190.3 MPa in AA2124-12 wt.% B_4C composites.

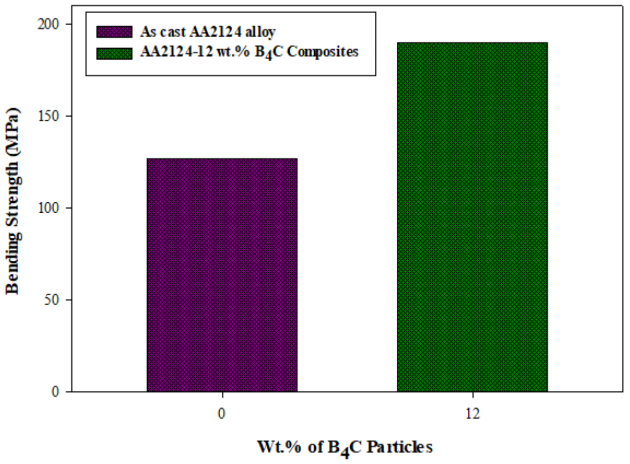
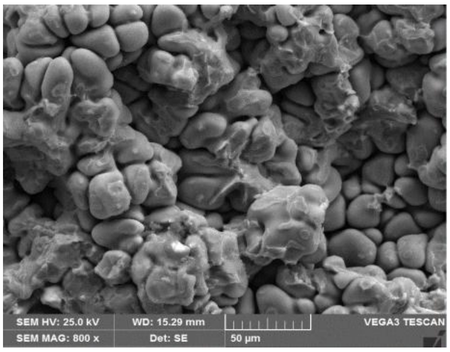
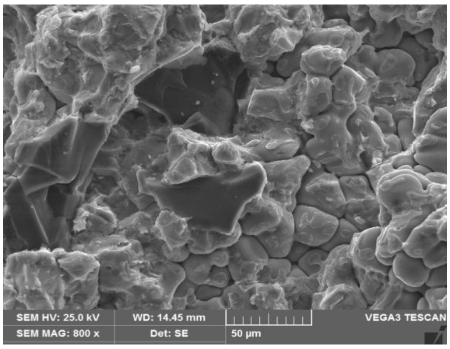


Figure 7: Showing the bending strength of AA2124 alloy and 12 wt.% B_4C composites

F. Fracture Studies



(a)



(b)

Fig. 8 Showing the tensile fractured specimens of (a) AA2124 alloy (b) AA2124-12 wt.% B_4C composites

IV. CONCLUSIONS

In this study, AA2124-B_4C micro composites have been manufactured by stir casting technique by taking 12 wt. % of B_4C particles. The microstructure, hardness, UTS, yield quality, elongation and bending strength of AA2124 alloy and 12 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. The mechanical properties of AA2124 and 12 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.

REFERENCES

1. Amir Pakdel et al., Materials Science and Engineering Materials A, 2018.
2. Sajjadi et al., Journal of Alloys and Compounds, 511, 2014, pp. 226-231.
3. Zhang et al., Materials Science and Engineering A, 433, 2006, pp. 70-82.
4. Sathyashankara et al., Journal of Mechanical Engineering and Sciences, 12, 3, 2018, pp. 3866-3875.
5. Wei Wang et al., Tribology International, 120, 2018, pp. 369-375.
6. Sekar et al., Applied Mechanics and Materials, 592-594, 2014, pp. 968-971.
7. Radhika et al., International Journal of Applied Engineering Research, 9, 26, 2014, pp. 8770-8773.
8. Akhil et al., Materials Today Proceedings, 4, 2017, pp. 7202-7207.
9. Sener Karabulut et al., Composites Part B, 93, 2016, pp. 43-55.
10. T H Manjunatha, et al., Emerging Trends in mechanical Engineering, Lecture Notes in mechanical Engineering, Springer.
11. Madeva Nagaral et al., Journal of Mechanical Engineering and Sciences, 13, 1, pp. 4623-4635, 2019.
12. G Pathalinga Prasad, Structural Integrity and Life, 19, br. 3, 2019, pp. 231-236.
13. Shashidhar S, International Journal of Applied Engineering Research, 14, 5, pp. 1075-1080, 2019.

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