Evaluation of Mechanical Properties of Aluminium 6061 Alloy Reinforced With Sic & B4c Particulate Hybrid Metal Matrix Composites

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Abstract- *Recent researching in a material science has been directly towards the inversion if new engineering materials. The new engineering materials having high strength to weight ratio, high stiffness, good thermal conductivity, good creep, fatigue and wear resistance. It is a most required in the all industry. In this paper the various mechanical properties was evaluated by conducting Hardness test and tensile test. Material used for this work was Al6061 Reinforced with Sic (2.5%, 5%, 7.5%) & B4C (2.5%). The maximum tensile strength and hardness has been obtained at SiC (7.5%) and B4c (2.5%) ratio. Mechanical and Corrosion behavior of Al6061/Sic/B4C alloys are also studied.*

Keywords- Metal Matrix Composites, Silicon Carbide, Boron Carbide, Tensile and Hardness strength

I. INTRODUCTION

Metal matrix composites (MMCs) are increasingly becoming smart materials for advanced aerospace and automobile applications but their properties can be modified through the addition of selected reinforcement [1]. The Applications of Aluminum-based MMCs have improved in recent years as engineering materials. The invention of a ceramic material into a metal matrix produces a composite material that outcome in an striking combination of physical and mechanical properties which cannot be obtained with monolithic alloys [2-3]. In particulate reinforced MMCs have recently found unique interest for the reason that of their specific strength and stiffness at room or elevated temperatures [4]. Among the various matrix materials available aluminium and its alloys are widely used in fabrication of Metal Matrix Composites and have reached the industrial production stage. [5] Infrequently reinforced aluminum matrix composites have emerged from the need for light weight, high stiffness materials which are desirable in many applications, mainly on automobile and aeronautical products such as piston, cylinder, liner, brake drum, air craft wings etc [6-9]. It is acknowledged that the elastic properties of the metal matrix composite are powerfully influenced by micro-structural parameters of the reinforcement such as shape, size, orientation, distribution and volume or weight fraction [10].As revealed in the so far performed research, the particulate B4C increases wear resistance and using a hybrid performance of Sic contributes to improvement of mechanical properties [11].In the present investigation, aluminum based metal matrix composite containing 2.5% ,5%,7.5% of Sic and 2.5% of B4C were successfully synthesized using stir casting method. Evaluating the mechanical properties of produced composites.

II. EXPERIMENTAL DETAILS

2.1 Material

The matrix material used in the experimental investigation was an aluminum alloy (6061) whose chemical composition is listed in Table 1.

Table.1 Chemical composition of Aluminum Alloy 6061 by wt%

Cu	Mg	Si	Fe	Mn	Cr	Zn	Aluminum
0.4	1.2	0.80	0.70	0.15	0.35	0.25	Balance

2.2 Reinforcement Material

The reinforcement material used in the investigation was Silicon Carbide and Boron Carbide. The grain size of Silicon Carbide and Boron Carbide is 25µm and 50µm.

2.3 Composite Preparation

The Al6061/Sic/B4C composite material used for the present research is fabricated by using the stir casting method as it ensured the uniform distribution of the reinforcements. The fabrication procedure followed for making of Al6061/Sic/B4C composites is presented as follows. In the process of preparing the composites, the Al6061/Sic/B4C aluminium alloy in the form of ingot was cut into small pieces to accommodate in the silica crucible. The aluminum alloy was melted in an electric muffle furnace with crucible. B4C and SiC preheated at about 675°C were added to the molten metal at 800 °C and stirred continuously. The stirring was done at 575 r/min for 7−9 min. Magnesium was added in small quantity during stirring to increase the wetting. The melt with reinforcement was poured into permanent metallic mould to get the required shape and size of the work piece. The composites were fabricated with 2.5 % (mass fraction) B4C. The silicon carbide particles used for fabricating the composites was 2.5%, 5%, 7.5%. The microstructure of the work piece is presented in Figure 1

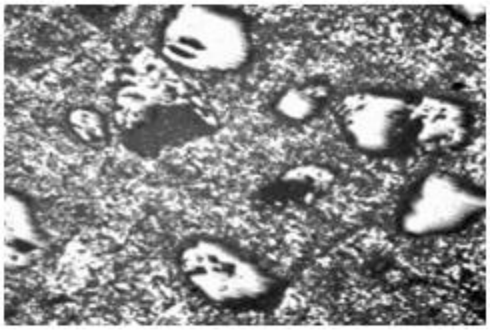

Fig.1: Microstructure of fabricated Al6061/Sic/B4Ccomposite.

2.4 Testing of Composites

To study the mechanical behavior of the composites the tensile and hardness tests were carried out using Krystal model UTK-60 tensile testing machine as per ASTM standards.The Micro-Vickers hardness values of the samples were measured on the polished samples using diamond cone indentor with a load of 150gms and 20 seconds as a holding time. Hardness value reported is the average value of 100 readings taken at different locations on the polished specimen. For tensile results, test was repeated three times to obtain a precise average value. The ASTM Standared size of the specimen as shown in fig.2 wt% Sic composite and also hybrid composites containing varying weight percentages of 2.5%, 5%, 7.5% of Boron Carbide. The Micro-Vickers hardness was measured on the polished samples using diamond cone inventor with a load of 150gms and the value reported is average of 50 readings taken at different locations. A significant increase in hardness of the alloy matrix can be seen with addition of Sic particles. The maximum value of hardness of composites indicates that the existence particulates in the matrix have improved the overall hardness of the composites.

Table 2: Micro Hardness Measurement Results of as Cast Al6061, with Addition of 2.5 wt% of Sic and 2.5, 5 &7.5 wt% of B4C

Sl. No	Composition	Mean Micro Hardness No. (VHN)
1.	Al6061 alloy	85.24
2.	Al6061 alloy +2.5% of Sic + 2.5% of B4C	91.51
3.	Al6061 alloy +2.5% of Sic + 5% of B4C	96.42
4.	Al6061 alloy +2.5% of Sic + 7.5% of B4C	102.94

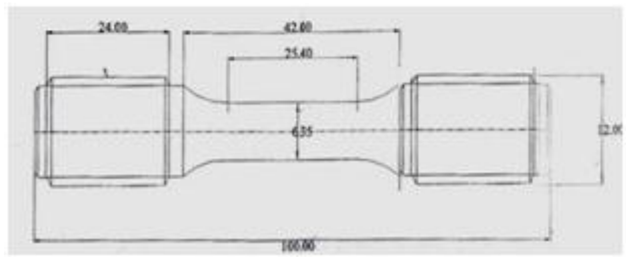

Fig.2. Tensile Specimen as per ASTM standard

III. RESULTS AND DISCUSSIONS

3.1Hardness Measurements

Table 2 and figure 3 shows the results of micro hardness tests conducted on matrix and the Al6061/ 2.5

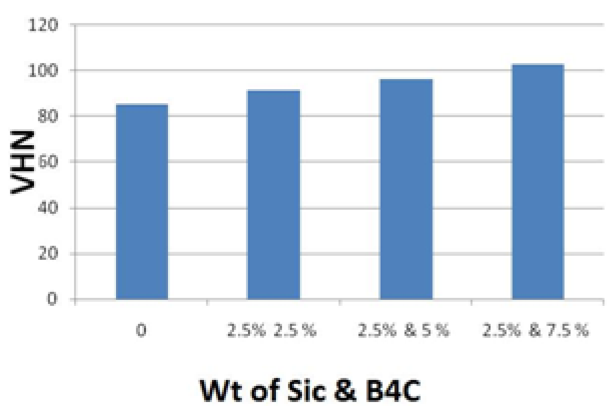

Fig. 3: Variations in Hardness of Al6061/Sic/B4C

3.2Tensile Properties

To investigate the mechanical behavior of the composites the tensile tests were carried out using Krystal model UTK-60 tensile testing machine as per ASTM standards. Three specimens were used for each test and average value is reported. The tensile properties, such as, tensile strength, yield strength and % elongation were extracted 3 and Figure 4, 5, 6. It is clear that tensile strength of composites containing 7.5 wt% of SiC particulates is higher when compared to as cast Al6061. Increase in strength is possibly due to the thermal inequality between the metal matrix and the reinforcement materials, which is a major mechanism for increasing the disorder density of the matrix and therefore, increasing the composite strength. In this reinforced composite materials exhibited lower elongation than that of unreinforced specimens. This obvious that plastic deformation of the mixed soft metal matrix and the non-deformable reinforcement is more difficult than the base metal itself.

Table 3: Tensile Strength Measurement Results of as Cast Al6061, with Addition of 2.5 wt% of Sic and 2.5, 5 &7.5 wt% of B4C

Sl. No	Composition	Tensile Strength (MPa)
1.	Al6061 alloy	132.46
2.	Al6061 alloy +2.5% of Sic + 2.5% of B4C	140.21
3.	Al6061 alloy +2.5% of Sic + 5% of B4C	158.25
4.	Al6061 alloy +2.5% of Sic + 7.5% of B4C	160.24

Table 4: Yield Strength Measurement Results of as Cast Al6061, with Addition of 2.5 wt% of Sic and 2.5, 5 &7.5 wt% of B4C

Sl. No	Composition	Yield Strength (MPa)
1.	Al6061 alloy	136
2.	Al6061 alloy +2.5% of Sic + 2.5% of B4C	137.25
3.	Al6061 alloy +2.5% of Sic + 5% of B4C	140.21
4.	Al6061 alloy +2.5% of Sic + 7.5% of B4C	160.24

Table 5: Elongation Measurement Results of as Cast Al6061, with Addition of 2.5 wt% of Sic and 2.5, 5 &7.5 wt% of B4C

Sl. No	Composition	Elongation (%)
1.	Al6061 alloy	21.23
2.	Al6061 alloy +2.5% of Sic + 2.5% of B4C	23.46
3.	Al6061 alloy +2.5% of Sic + 5% of B4C	22.21
4.	Al6061 alloy +2.5% of Sic +7.5% of B4C	20.41

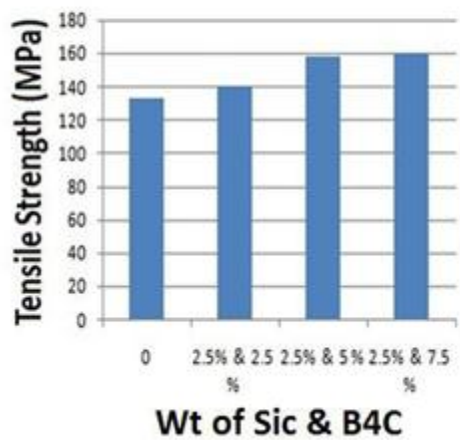

Fig. 4: Variations in Tensile Strength of Al6061/Sic/B4C

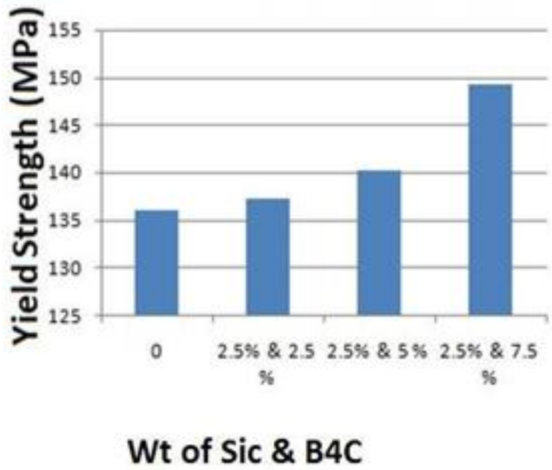

Fig. 5: Variations in Yield Strength of Al6061/Sic/B4C

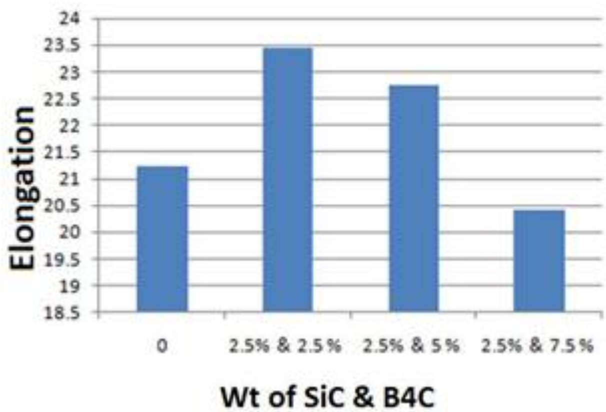

Fig. 6: Variations in Elongation of Al6061/Sic/B4C

IV. CONCLUSION

- Aluminium hybrid MMC was successfully fabricated by using stir method.
- It was conducted that mechanical properties of MMC was carried out with several combinations (Al6061 alloy +2.5% of Sic + 2.5% of B4C , Al6061 alloy +2.5% of Sic + 5% of B4C, Al6061 alloy +2.5% of Sic + 7.5% of B4C).Among the combinations Al6061 alloy +2.5% of Sic + 7.5% of B4C this combination having which yields more hardness.
- For the yield strength the combination Al6061 alloy +2.5% of Sic + 7.5% of B4C is obtained more yield strength.
- For the tensile strength the combination Al6061 alloy +2.5% of Sic + 7.5% of B4C is obtained more tensile strength.
- For the elongation the combination Al6061 alloy +2.5% of Sic + 2.5% of B4C is obtained more Elongation.
- Ductility increases with the addition of SiC particles, which causes increases in percentage elongation as compared to base alloy.
- Addition of B4c content decreases the percentage of elongation compared to composites containing SiC particles.

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