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Experimental Investigation of Aluminium Metal Matrix Composite with Silicon Carbide and Boron Carbide Reinforcement

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Abstract: Composite materials have been introduced into almost every industry in various forms. Composite materials generally have high strength and modulus to weight ratio than traditional engineering material. This feature reduces the weight of the system by 20-30 percent. The Aluminium hybrid metal matrix composites has increased in recent times due to their enhanced mechanical properties for satisfying the requirements of advanced engineering applications. The performance of these materials is greatly influenced by the selection of an appropriate combination of reinforcement materials. The ceramic particles, such as silicon carbide and aluminium oxide, are the most widely used reinforcement materials for preparing these composites. The Aluminium 6061 hybrid MMC reinforced with particulates with different weight fractions of Silicon carbide and Boron carbide by a stir-casting process. The experimental study has been carried out on the prepared composite to investigate the mechanical properties due to the addition of multiple reinforcement materials. Testing carried out in this project are Tensile test, Hardness test. The purpose of this project is to analyse the Tensile Strength and hardness of the material.

Keywords: MMC – Metal matrix composites, Tensile Test, Hardness Test, Stir casting.

I. INTRODUCTION

The field of materials science has seen significant advancements in recent years, leading to the development of modern materials with unique properties and capabilities. These advancements have revolutionized various industries and opened up new possibilities for technology, engineering, and manufacturing. Modern materials are designed to overcome limitations of traditional materials and offer improved performance, sustainability, and functionality. Composite materials are designed to overcome the limitations of traditional materials by leveraging the strengths of each constituent. The reinforcing material in a composite can provide high strength, stiffness, and toughness, while the matrix material can provide durability, corrosion resistance, and other desired properties. The Metal matrix composite (MMC) is composite material with at least two constituent parts, one being a metal. The other material may be a different metal or another material, such as a ceramic or organic compound. MMCs are nearly always more expensive than the more conventional materials they are replacing. The matrix is the material which the reinforcement is embedded, and is completely continuous this means that there is a path through the matrix to any point in the material, unlike two materials sandwiched together. Here Aluminium is used as the matrix metal. The reinforcement material is embedded into the matrix. The reinforcement does not always serve a purely structural task (reinforcing the compound), but is also used to change physical properties such as wear resistance, friction coefficient, or thermal conductivity. Here the reinforcement materials are boron carbide and silicon carbide.

II. LITERATURE REVIEW

G. Venkatachalam et al studied that Aluminium (Al) based metal matrix composite can be an efficient and effective braking material compared to cast iron and matrix alloy. In the present investigation, Al6082 composites were fabricated by stir casting method by varying weight percentage of reinforcements for Samplel (Al 90% + SiC 10%),

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Sample 2 (Al 90% + SiC 5% + fly ash 5%) and Sample 3 (AI 90% + SiC 5% + basalt 5%). Chemical compositions, micro hardness, wear test and tensile test were performed to study the mechanical behavior of all the test specimens. The surface morphology was studied using microscopic inspection to indicate the distribution of reinforcement particles and bonding between the matrixes. Composites containing hard oxides (like SiC) are preferred for high wear resistance along with increased hardness and high temperature oxidation resistance. The result reveals that wear rates of the composite materials is lower than that of the matrix alloy and friction coefficient was minimum.

Ch Hima Gireesh et al studied that A16061 hybrid metal matrix composite (HAMMC) reinforced with particulates with different weight fractions of Sic and Al2O3 and a constant weight fraction (5%) of fly ash by a stir-casting process. The experimental study has been carried out on the prepared composite to investigate the mechanical properties due to the addition of multiple reinforcement materials. The density and mechanical properties, such as ultimate tensile strength, yield strength, impact strength, and the hardness and wear characteristics of the proposed composite, are compared with those of unreinforced A16061. The experimental investigation is also aimed at observing the variation of properties with a varying weight percentage of the reinforcement materials Sic and Al2O3 simultaneously with the fly ash content maintained constant. The outcome of the experimental investigation revealed that the proposed hybrid composite with 20% of total reinforcement material exhibits high hardness, high yield strength, and low wear rate but no considerable improvement in impact strength.

Poovazhagan.L et al Hybrid nanocomposites based on Aluminium alloy 6061 reinforced with different hybrid ratios of SiC (0.5, 1.0 and 1.5 vol.%) and BC (fixed 0.5 vol. %) nanoparticles were successfully fabricated using ultrasonic cavitation-based solidification process. The fabricated cast specimens were characterized using SEM study with EDS analysis, hardness test, tension test and impact test. The results indicate that, by the ultrasonic cavitation effects namely transient cavitation and acoustic streaming, the nano reinforcements were successfully incorporated in the Aluminium matrix. SEM study with EDS validates the presence of Sic and B.C nanoparticles in the Aluminium matrix. Compared to the un-reinforced alloy, the room temperature hardness and tensile strength of the hybrid composites increased quite significantly while the ductility and impact strength reduced marginally.

III. MATERIALS AND METHODS

Matrix Material:

It is a popular alloy of aluminium, which is a composition of aluminium (Al), magnesium (Mg), and silicon (Si). It belongs to the 6xxx series of aluminium alloys, which are known for their excellent combination of strength, weldability, and corrosion resistance. Aluminium 6061 is often referred to as a general-purpose alloy and is widely used in various applications due to its favourable mechanical properties. Due to its excellent combination of strength, machinability, and weldability, Aluminium 6061 is used in a wide range of applications, including aerospace components, automotive parts, marine equipment, bicycles, sporting goods, electrical enclosures, and structural components in buildings and bridges. It is a versatile and widely used alloy in many industries due to its desirable properties and performance.

Element	Al	Mg	Si	Fe	Cu	Mn	Cr	Zn	Ti
Composition	96.85	0.9	0.7	0.6	0.30	0.05	0.25	0.20	0.10

Table 1: Composition of Al6061

Boron carbide (B4C):

It is a ceramic material that is known for its high hardness and excellent wear resistance. Boron carbide has a Mohs hardness of 9.3, making it one of the hardest materials known. This property makes it an excellent choice for applications that require high wear resistance. Boron carbide has a density of 2.52 g/cm^3, which is lower than most other ceramics. This property makes it useful in applications where weight is a concern. Boron carbide has a high compressive strength of up to 4 GPa, which makes it ideal for applications that require high strength. Boron carbide has a melting point of 2763°C, which makes it suitable for use in high-temperature applications. Boron carbide has good thermal stability, which means it can withstand high temperatures without significant degradation or loss of properties.

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Silicon carbide (Sic):

Silicon carbide (Sic) is a popular reinforcement material used in composite materials due to its unique combination of properties. High Strength: Sic has exceptional strength and stiffness, making it an ideal reinforcement material for composites that require high strength-to-weight ratios. Sic has a low density, which makes it an ideal reinforcement material for lightweight composites. Sic is a semiconductor material, which means it has some electrical conductivity. Silicon carbide has a very high melting point of approximately 2,830°C (5,126°F), which makes it suitable for high-temperature applications. It remains stable and retains its mechanical strength even at elevated temperatures, making it ideal for use in harsh environments, such as in aerospace, automotive, and industrial applications.

IV. METHODOLOGY

Development of composite:

Commercial-grade Aluminium Al6061 was used as the matrix material and boron and silicon carbide were used as reinforcing elements in this study's stir casting process to manufacture composite composites. To obtain the desired composition, each component is independently measured using weighing equipment. The measured mixture is added and thoroughly spun in a crucible. The Aluminium basic materials are heated in the furnace to 900 °C, followed by 60 minutes of alternate stirring at a frequency of 20 to 25 kHz, and the finished composite is cast into three rods that are each 30 mm in diameter and 300 mm long.

Sample composition:

Using the fundamental composite material from the early experiment, we included reinforcement to compute the various compositions. And that concludes the data. The total weight of a newly developed alloy had been calculated utilizing reinforcement at 1, 3, and 5% of the total weight. The composition will be more clearly displayed in the table below.

The Compositions we have made are,

Metal / Composition	Aluminium 6061	Boron carbide	Silicon carbide
1st composition	97% (730g)	2%(15g)	1% (8g)
2nd composition	95% (715g)	2%(15g)	3%(23g)
3rd composition	93% (700g)	2%(15g)	5%(38g)

Table 2: Composition of the materials

Machining Process

The machining has been performed to obtain the required shapes of specimen for testing purpose from all three moulded material made. It was carried out in manual lathe machine to prepare tensile test specimen and hardness test specimen in ASDM standards.

Tensile test

The tensile strength of Al6061/ B4C/ SiC was tested using a UTS (Ultimate Tensile Strength) machine. The above-mentioned composites were used to create specimens for tensile testing with dimensions of 160 mm in length and 25 mm in diameter.

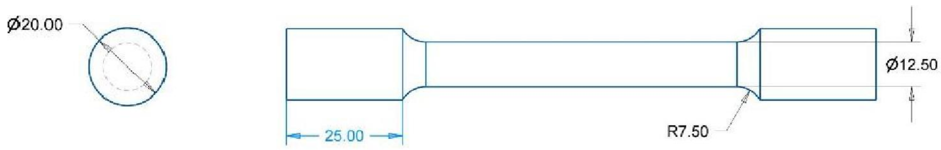

Fig 1: Dimension of tensile test specimen

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Hardness test

Vickers hardness tests use a material's resistance to distortion or penetration through abrasion and scrape to determine how hard it is. Hardness is a function of how long-lasting solid substances transform under compression into different permanent states.

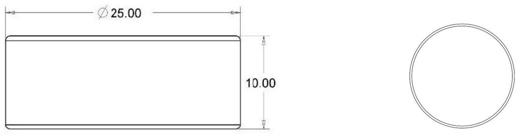

Fig 2: Dimension of hardness test specimen

V. Result and Discussion

Tensile test:

A Universal Testing Machine was used to carry out the tensile test for all three samples. During the test, the tensile strength and elongation of the component is determined. From the result of the test, sample 2 has more tensile strength and more elongation in sample 1.

SI. No	Tensile Load [kN]	Tensile Strength [N/mm²]	Elongation %
1st composition	11.11	95	5
2nd composition	13.25	110	3
3rd composition	13.38	105	1

Table 3: Results of tensile test

Load vs Displacement graph

Sample 1,

From this graph we can conclude that maximum load of the sample falls in between 10,000 N and 12,000 N.
The Displacement is the elongation that falls between 18 mm and 21 mm. So it has the high elongation.

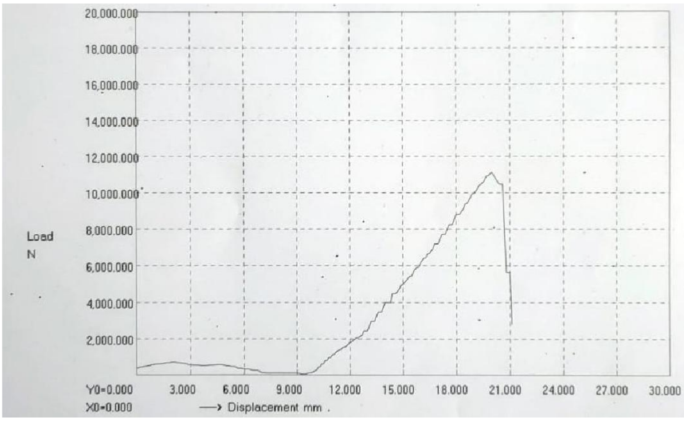

Fig 3: Load vs displacement curve of composition 1

Sample 2,

From this graph we can conclude that maximum load of the sample falls around between 12,000 N and 14,000 N.
The Displacement is the elongation that falls around 9 mm .

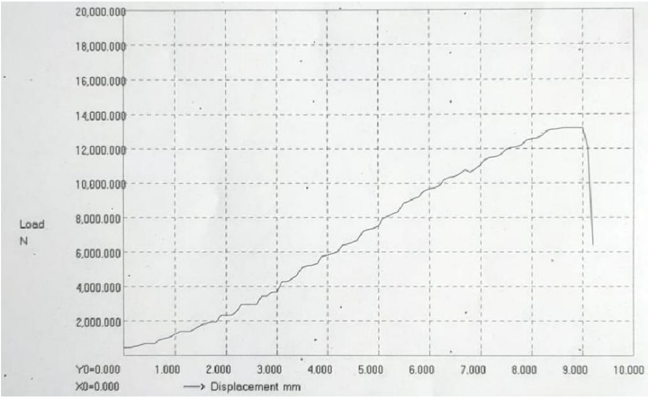

Fig 4: Load vs displacement curve of composition 2

Sample 3,

From this graph we can conclude that maximum load of the sample falls around between 12,000 N and 14,000 N it has the highest Tensile load.

The Displacement is the elongation that falls in between 8 mm and 10 mm. It has the least Elongation of 1% of its total length.

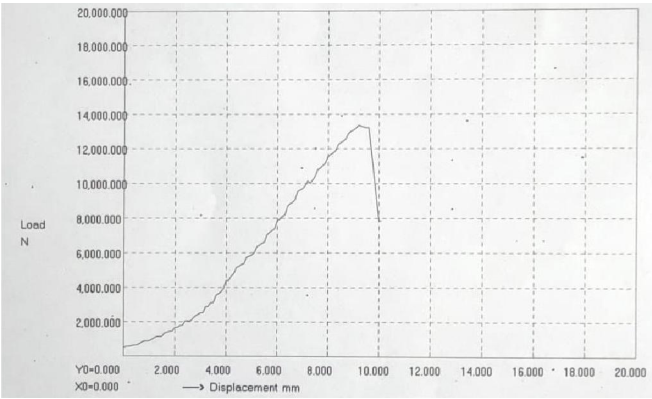

Fig 5: Load vs displacement curve of composition 3

Fig 6: Tensile specimen before testing

Fig 7: Tensile specimen after testing

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Hardness test

A Vickers hardness tester was used to evaluate hardness. Totally three different locations were taken into consideration for determining the hardness value of the samples.We can see that sample 2 has a harder surface, with a hardness of around 67.53 HV10. causing us to get the conclusion that sample 2 is harder than the other two samples.

SI. No	1st Indentation	2nd Indentation	3rd Indentation	Average
Sample - 1	60.5 HV10	60.3 HV10	60.0 HV10	**60.3 HV10**
Sample - 2	67.8 HV10	67.3 HV10	67.5 HV10	**67.53 HV10**
Sample - 3	66.8 HV10	67.0 HV10	67.3 HV10	**67.03 HV10**

Table 4: Hardness test results

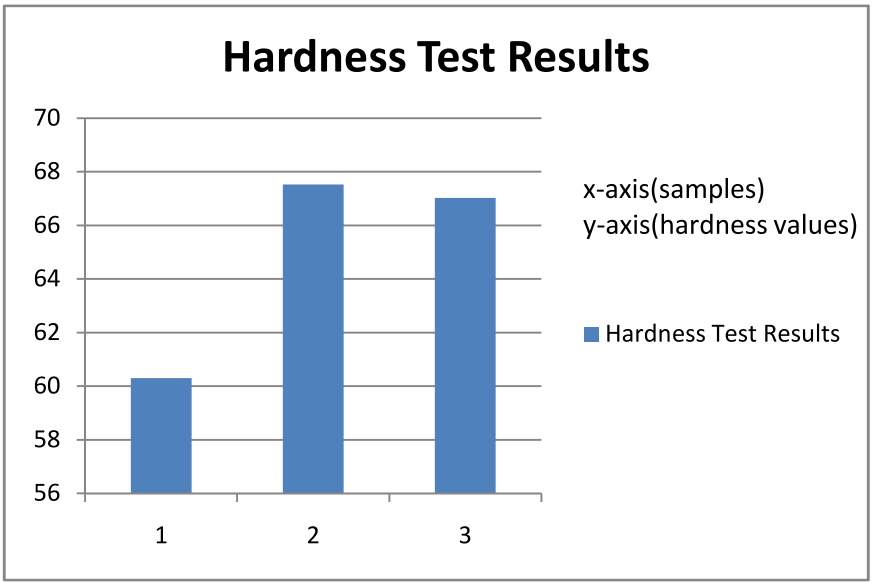

Fig 8: graph showing hardness test result

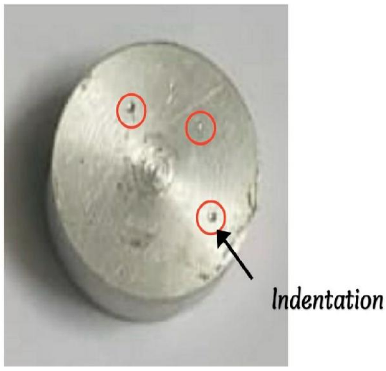

Fig 9: Hardness test specimen

VI. CONCLUSION

During Tensile Test in Universal Testing Machine the highest Tensile Strength is witnessed in Sample 2 of 111 N/mm²
The Highest Elongation is witnessed in Sample 1 of 5%.
The Highest Strength obtained due to balanced composition of Sic and B_4C in the Sample 2 of 3 and 2% and the highest elongation in sample 1 is because it only has 1 % of Sic and more Aluminium (basically it has good elasticity).
During Hardness Test in Vickers Hardness Tester sample 2 has been witnessed the highest Hardness of 67. 53HV10.Overall, the Sample 2 has the best properties improvement. It is witnessed in Both tensile and Hardness Tests.

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REFERENCES

[1]. G,Venkatachalam and A.Kumaravel , Mechanical Behaviour of Aluminium alloy Reinforced with Sic/Fly ash/ Basalt Composite for Brake Rotor.

[2]. Rianti Dewi Sulamet-Ariobimo , Johny WahyuadiSoedarsono, Tensile properties analysis of AA1100 Aluminium and SS400 steel using different JSI tensile standard specimens

[3]. Ramanujam N, Krishnamohan S, Influence of SiCp on wear of AZ91 composites fabricated through Diffusion Bonding.

[4]. K. S. Tun, P. Jayaramanavar, Q. B. Nguyen, J. Chan, R. Kwok and M. Gupta, Investigation into tensile and compressive responses of Mg-ZnO Composites.

[5]. Shaik Karimulla, S. Madhu, S.A.K.Jilani , Wear Characteristics And Mechanical Properties Of Az91 Magnesium Alloy Surface Hybrid Composite Of (Sic+Al203) Fabricated By Friction Stir Process.

[6]. Naveen Kumar, Ajaya Bharti, Hariom Tripathi, Investigation of Microstructural and Mechanical Properties of Magnesium Matrix Hybrid Composite.

[7]. Sadanand Sarapure, B M Satish, B M Girish and Basawaraj, Microstructure and Mechanical Behavior of Magnesium Alloy AZ91 Hybrid Composites.

[8]. Ch Hima Gireesh , K. G. Durga Prasad and Koona Ramji, Experimental Investigation on Mechanical Properties of an A16061 Hybrid Metal Matrix Composite.

[9]. Poovazhagan.L, Kalaichelvan.K, Rajadurai. A andSenthilvelan.Vb, Characterization of Hybrid Silicon Carbide and Boron Carbide Nanoparticles-Reinforced Aluminum Alloy Composites.

[10]. I. Aatthisugan*, A. Razal Rose, D. Selwyn Jebadurai, Mechanical and wear behaviour of AZ91D magnesium matrix hybrid composite reinforced with boron carbide and graphite.