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Determination of Mechanical Properties of Al4032 with Reinforcement SiC Fabricated through Stir Casting

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Abstract- *The present work is focused on the determination of mechanical properties of aluminum alloy Al4032-Silicon carbide(sic) metal matrix composites fabricated through the stir casting method. Using this method, varied weight percentages of 1%, 2%, 3%, and 4% of Sic particles are successfully introduced in the aluminum 4032 alloy to produce castings through stir casting. The mechanical properties of the composites were determined and are increased with an increase in the percentage of reinforcement. The microstructure reveals the uniform dispersion of SiC particles in the aluminium alloy matrix.*

I. INTRODUCTION

Because of their excellent strength-to-weight ratio, good resistance to wear and corrosion, and prospective uses in the automotive, aerospace, and marine industries, metal matrix composites based on aluminum have attracted a lot of attention recently. High specific stiffness, low density, regulated coefficient of thermal expansion, high specific strength, and enhanced dimensional stability at high temperatures are all desirable characteristics of composite materials. The scattered phase exhibits greater strength when juxtaposed with the matrix phase. Thus, the phase is known as the reinforcement phase. The numerous facets of MMC wear behavior have been examined in this paper.In comparison to pure metals and alloys, Metal Matrix Composites (MMCs) often offer notable performance improvements and are resistant to ceramic particles. The best qualities of the two components, like as the matrix's hardness and ductility, are combined to create MMCs. Alloys made of aluminum often have low densities, excellent electrical and thermal conductivities, good flexibility, and good corrosion resistance. Investigating the wear behavior of al 4032 reinforced with SiC is the goal of the current work.

II. LITERATURE REVIEW

Deepak Kumar and Pradeep K [1] present the aluminum-silicon alloys utilized in automotive applications, with an emphasis on examining the mechanical and morphological characteristics of the resulting metal matrix composites. Stir casting is the method used to create the metal matrix composites of silicon carbide-reinforced aluminum alloy (Al-4032). Four distinct compositions: silicon carbide at 0, 3, 6, and 9% (by weight). Over the base metal, it has been observed that all mechanical qualities, including tensile strength, hardness, and impact strength, improve with the reinforcement. Additionally, it has been discovered that these characteristics get better when the reinforcement's weight percentage rises. Pardeep Saini and Pradeep K Singh Mer [2] present work reports the effects of silicon carbide (SiC) reinforcement on the mechanical, microstructural, and physical properties of Al-4032/SiC composites made using bottom pouring stir casting setup and containing 4, 6, or 8% SiC. The American Society for Testing and Materials (ASTM) standards have also been followed in measuring the mechanical properties. The inclusion of ceramic particles has been found to considerably improve the UTS, microhardness, and impact toughness of the AMC samples. Himanshu Kala and K.K.S [3] focus Aluminum matrix composites that are widely produced and used in structural applications, as well as the aerospace and automotive industries, because of their excellent strength-to-weight ratio, low cost, and good wear resistance. Expanding the use of composites also requires a straightforward and affordable manufacturing process. The inexpensive and widely accessible stir-casting technology makes it simple to integrate reinforcements such as fly ash, silicon carbide, graphite, and particulate aluminum. The "smaller-the-better" criterion has been regarded as the objective 12 models for examining the MMC's wear resistance. the analysis of variance and optimization of the operating parameters (ANOVA). The results of the ANOVA analysis show that the tribological behavior is significantly influenced by the applied load and the disc's rotational timeinto the melt.Deepak Kumar and Pradeep K [4] focus This study on examining the impact of silicon carbide (SiC) reinforced Al-4032-based metal matrix composite on tribological behavior (wear characteristics). In this work, the aluminum alloy (Al-4032) matrix was supplemented with silicon carbide particles at a weight percentage of 6% to make a composite utilizing the bottom pouring stir casting technique. Using the metal matrix composite, wear analysis has been attempted for the pin-on-disc configuration. The optimization method proposed by Taguchi has been used to create the test objective 12 model, which looks into the wear resistance of the MMC, has the "smaller-the-better" criterion into consideration. the Analysis of Variance (ANOVA) and operating parameter optimization. The ANOVA investigation shows that the applied load and the disc's rotational time have a major impact on the tribological behavior. Avinash Gudimetla, S Sambu Prasad, and D Lingaraju [5] created a novel Metal Matrix Composite (MMC). The stir-casting method was used to create the MMC. We examined the tribological behavior of Al 4032 with the as-cast MMC with different Si and Si B reinforcements. To examine the wear rate, three reinforcing compositions—1%, 3%, and 5% for each of Si and Si B—were taken into consideration. Using a pin-on-disc apparatus, experiments were conducted to measure the changes in thickness per unit of time to study the influence of varied loads on the wear rate. Al 4032 and Al MMC sliding against a hardened stainless-steel disk were tested for wear behavior. Under the same test settings, it was found that the composite's wear resistance was higher than that of Al 4032 and that the composite constructed of Si B with 3%wt reinforcement performed better at all of the loads that were taken into consideration. When compared to base material, there was a decrease in wear and corresponding load, respectively..S. Dinesh Kumar, M. Ravichandran, and M. Meignanamoorthy [6] explain how the need for aluminum metal matrix's mechanical and physical qualities is growing in the automobile, airplane, and other industries. Particulate reinforced MMCs have drawn a lot of interest lately because of their consistent qualities, inexpensive cost, and distinctive isotropic features. Since most processing parameters are related to the reinforcing particles, the potential of these materials primarily depends on selecting the appropriate combination of reinforcing materials. Deepak Kumar, Pardeep Saini, and Pradeep K. Singh [7] By incorporating the idea of a hybrid metal matrix composite, attention on the pattern of metal matrix composites can be improved to create newer engineering materials with better qualities. Investigations have been conducted into the morphological and mechanical properties of hybrid composites Al-4032/SiC/GP. Using a bottom pouring stir casting setup, hybrid composites based on aluminum alloy (Al-4032) were created by using silicon carbide (SiC) and granite powder ceramic particles as reinforcement at different fraction levels, i.e., 0, 3, 6, and 9 weight% in equal proportion. Utilizing an optical microscope, SEM, and XRD, the hybrid composite samples were microstructurally characterized. The analysis shows that the hybrid particles for reinforcing are dispersed nearly evenly throughout the matrix phase.N.V. Rangasamy, M. Rajkumar and S. Senthil [8] Al 4032 is the subject of an EDM machining process using Zrb2&Tib2 in-situ composite. Composites have increased mechanical qualities, such as strength and hardness. In the EDM process, the Tauchi and ANOVA approach is utilized to determine the ideal process parameter.Pradeep Saini and Pradeep K. Singh [9] shows the wear properties of matrix-based hybrid composites (AMHCs) made of aluminum alloy (Al-4032), which have been studied using a pin-on-disc tribometer. The AMHCs were created utilizing a bottom pouring vacuum stir casting setup and a mixture of equal parts silicon carbide (SiC) and ceramic particles from granite marble powder. The study has selected the 'Smaller-the-Better' criteria as the objective model, with mass loss serving as the response parameter. Using primary effect of means and analysis of variance techniques, the control parameters—composition, normal load, sliding duration, and sliding speed—were optimized. It has been noted that the wear characteristics of the AMHCs are significantly influenced by all four control parameters. Up to 6% more reinforcement results in an increase in the AMHCs' wear resistance. Pradeep Saini and Pradeep K [10] Environmental issues arise when waste granite marble powder (GMP) is disposed of. The influence of using waste GMP as a reinforcement to create composites is reported in the current work. Through stir casting, the Al-4032/GMP composites with 0%, 4%, 6%, and 8% (by weight) GMP were created. For 8% reinforcement, there has been a maximum 5.65% decrease in experimental density and a maximum 0.63% gain in theoretical density. The microstructure of the as-cast samples has been investigated using an optical microscope, x-ray diffraction, and scanning electron microscope equipped with energy-dispersive x-ray spectroscopy. Other properties of the composites, such as ultimate tensile strength, micro-hardness, and impact strength, improved with the inclusion of GMP particles. These properties increased from 69.4 MPa to 115 MPa, 131.4 HV to 174.1 HV, and 22.4 J to 32 J, respectively. Out of all of them, the Al-4032/6%GMP composite appears to have the best mechanical property combination.

III. EXPERIMENTALWORK

A. Materials

Al 4032, which has a density of 2.69 g/cm3, is the matrix material utilized in this investigation. Among its series, it is one of the most well-liked. The table below provides the chemical composition of the aluminum alloy.

Fig 1: Al-4032 (Pure)

Table 1: Chemical Composition of Al-4032

Material	Si	Fe	Mn	Cu	Ag	Ni	Al
Percentages	21.42	0.22	0.04	0.67	0.10	0.82	76.73

B. Reinforcement Material

Carbondium, another name for silicon carbide, is a compound that combines silicon and carbon. Sintering silicon carbide grains together creates extremely durable ceramics that are utilized in a variety of high-durability applications, including ceramic plates, automotive brakes, and clutches.

Fig 2: Silicon Carbide

C. Preparation of Samples of Composites

The temperature of silicon carbide is preheated to 200^0C on an average of 38 microns. Stir casting is a liquid metallurgical process used to create composite materials. A stirrer is coupled to the molten metal, and it is combined with a dispersed phase such as ceramic particles, short fibers, etc.

Table 2: Various Combinations of Castings

Casting	Al4032	Silicon Carbide
1	100%	-
2	99%	1%
3	98%	2%
4	97%	3%
5	96%	4%

Fig 3: Bottom Type Stir Casting Machine

I. RESULTS AND DISCUSSION

II. *Compression Test*

The ability of a material or structure to bear loads that tend to reduce size is known as its compressive strength. It is employed to examine the materials' compressibility. The specimen is subjected to a compressive load, and the materials' compressive strength is determined by how resistant the specimen is to deformation. ASTM guidelines are followed while confining specimens. The specimens' length-to-diameter ratios (L/D) are determined to be 26 mm and 13 mm, respectively. They are subjected to UTM, which compresses because two forces work in opposing directions. The values are summarized and compared in the following graph after being compressed.

Fig 4: Universal Testing Machine

Table 3: Compression Strength of Al4032-SiC

Casting	Composites	Compressivestrength (MPa)
1	Al 4032 (Pure)	153.278
2	Al4032+SiC (1%)	200.704
3	Al4032+SiC (2%)	200.553
4	Al4032+SiC (3%)	306.781
5	Al4032+SiC (4%)	391.915

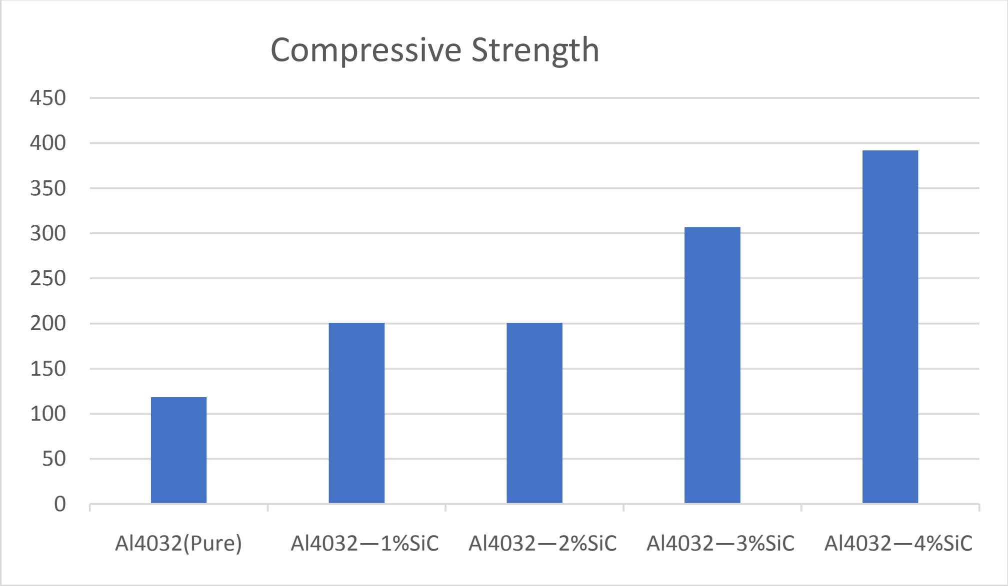


Fig 5: Compressive Strength graph of Al4032-SiC composites

A. *Tensile Test*

The ability of a material or structure to bear strain before breaking is known as its tensile strength. It is employed to examine the materials' tensile properties. The specimen is subjected to a tensile load; the materials' tensile strength is determined by how resistant the specimen is to deformation. ASTM guidelines are followed while confining specimens. The specimens are measured to be 200 mm long and 20 mm wide, respectively. They are subjected to UTM, which causes stretching since two forces act in opposing directions. The numbers are tallied and compared in the following graph after stretching.

Table 4: Tensile Values of Al4032-SiC

Casting	Composites	Tensile Strength(Mpa)
1	Al4032(pure)	77.350
2	Al4032+SiC(1%)	82.585
3	Al4032+SiC(2%)	94.532
4	Al4032+SiC(3%)	106.462
5	Al4032+SiC(4%)	134.769

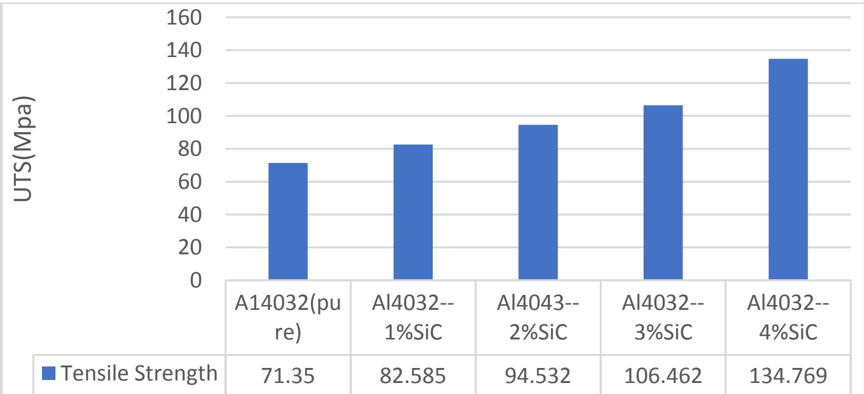


Fig6: Tensile Strength graph of Al4032-SiC Composites

B. *Micro Hardness*

The Vickers Hardness Test can be used to determine the hardness of a substance. The Vickers hardness test measures hardness using diamond indentation. In orderto determine hardness, the Vickers test calculates the depth of an indenter's penetration under load about the penetration caused by a preload. Different scales, each denoted by a single letter, require different loads or indenters.

Fig 7: Vicker's Hardness Testing Machine

Vickers Micro Hardness Tester was used to measure the hardness of Al4032 alloy and composites. Each specimen used for the hardness test measured 10 x 10 mm, and each one was polished and ground to create a smooth, level surface. 500 grams of weight was testedwas applied to the specimen for tens of seconds using a diamond indenter with a square base, and conventional procedures were followed to get the hardness values.

Table 5: Microhardness values of Al4032-SiC

Casting	Composition	MicroHardness Value (HRV)
1	Al4032(pure)	57.80
2	Al4032 +SiC (1%)	60.18
3	Al4032 +SiC (2%)	65.73
4	Al4032 +SiC (3%)	81.55
5	Al4032+SiC (4%)	117.6

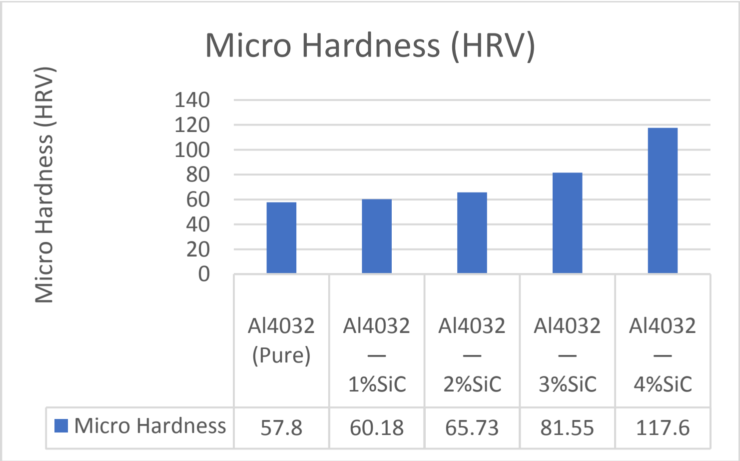


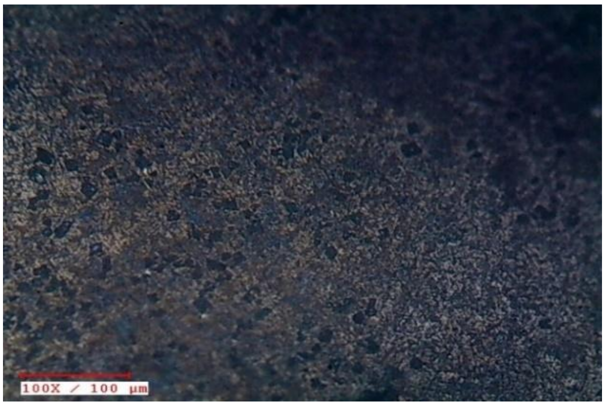
Fig 8: Micro Hardness graph of Al4032-Sic

C. Inverted Metallurgical Microscope

The microscope used in metallurgy A trinocular metallurgical microscope is used to view the microstructure of a metal matrix composite. The different metal matrix composites' microstructures are given below.

Fig 9: Inverted Metallurgical Microscope

Microstructures of composites



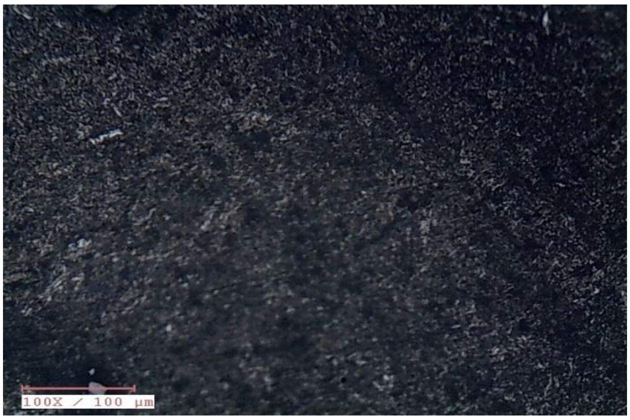


Fig 10: Al4032(Pure)Fig11: Al4032+1% SiC

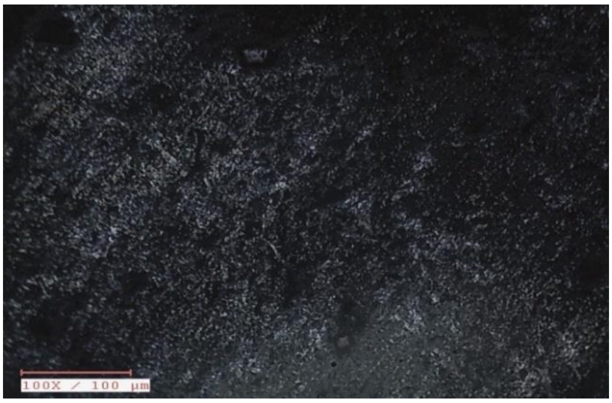


Fig12: Al4032+2% SiCFig13: Al4032+3%SiC

Fig14: Al4032+4%SiC

IV. CONCLUSION

1) A combination of silicon carbide reinforcement with Al4032 base material in varying ratios of 1%, 2%, 3%, and 4%. construction using the stir casting technique.
2) The distribution of reinforcement material is fully distributed in base material as composition increases.
3) As the proportions of SiC grew, so did the mechanical qualities such as tensile, compression, and microhardness.
4) The combination of Al4032 as base material and 4% SiC as reinforcement has the best mechanical characteristics.
5) Since the results shown in the previously mentioned tables fell within an acceptable range, they can be used to forecast the outcomes of unidentified data about Al4032-SiC reinforced composites.

REFERENCES

[1] Pradeep K. Singh and Deepak Kumar "*Mechanical and Microstructural Analysis of Metal Matrix Composites Based on Al-4032*", Materialstoday, Volume 18, Part 7, 2019, Pages 2563–2572.

[2] Pardeep Saini and Pradeep K Singh "*Fabrication and characterization of SiC-reinforced Al-4032 metal matrix composites*", Surface Topography, Volume 10, Number 2, 2022.

[3] Himanshu Kala and K.K.S. Mer "*A Review on Mechanical and Tribological Behaviors of Stir Cast Aluminum Matrix Composites*", Procedia Material Science, volume6,2014, Pages1951-1960**.**

[4] Deepak Kumar and Pradeep K. Singh "*Investigation of Tribological Behaviour of Al-4032 Based Metal Matrix Composite using Taguchi's Optimization Approach*", Materialstoday, Volume 18, Part 7, 2019, Pages 4201-4209.

[5] Avinash Gudimetla, S Sambu Prasad, and D Lingaraju "*Tribological studies of aluminium metal matrix composites with micro reinforcements of silicon and silicon balloons*",Materialtoday, Volume 18, Part 1, Pages 47-56.

[6] S. Dinesh Kumar, M. Ravichandran, and M. Meignanamoorthy "*Aluminium Metal Matrix Composite with Zirconium diboride Reinforcement: A Review*", Materialstoday, Volume 5, Issue 9, Part 3, 2018, Pages 19844-19847.

[7] Deepak Kumar, Pardeep Saini, and Pradeep K. Singh "*A study on Morphological and Mechanical Characterization of Al-4032/SiC/GP Hybrid Composites*", Research Square, March 2022.

[8] N.V. Rangasamy, M. Rajkumar and S. Senthil Kumaran "*An analysis of mechanical properties and optimization of EDM process parameters of Al 4032 alloy reinforced with Zrb_2 and Tib_2 in-situ composites*", Journal of Alloys and Compounds, Volume 662, March 2016, Pages 325-338.

[9] Deepak Kumar and Pradeep K Singh "*Sliding wear characteristics of Al-4032/SiC/GMP hybrid composites using L-16 orthogonal array*" Engineering Research Express, April 2022.

[10] Pradeep Saini and Pradeep K. Singh "*Physical, Morphological, andMechanical Characterization of Al-4032/GMP Composite Fabricated Through Stir Casting*", Springer Link, Volume 74, 2022, Pages 1340-1349.