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Influence of SiCp Reinforcement on Al5052 Towards Hardness and Wear Performance: An Experimental Observation

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Abstract: Because of their outstanding wear resistance and corrosion resistance, aluminium alloy-based metal matrix composites (AMMC) are widely employed in the automotive, aircraft, architecture, and marine industries. Stir casting was discovered to be a cost-effective way of fabricating AMMC.In this study, aluminium alloy 5052 was reinforced with different percentages of SiC particles (1, 2, and 3 wt percent). The manufacture and examination of AA5052/SiC AMMC, which was fabricated utilising the stir casting procedure, are the goals of this research project. Optical microscopy was used to investigate the microstructures of AMMC. SiC particles were found to purify the grains and were evenly dispersed in the aluminium matrix. The aluminium matrix was adequately bound to the SiC particles.The constructed samples are machined to the desired dimensions before being tested under controlled conditions. AMMC's hardness and wear resistance were increased by the addition of SiC particles.

Keywords: AMMC, Stir casting, AA5052, SiC, Hardness, Wear Resistance.

I. INTRODUCTION

To improve overall efficiency, the modern automotive, aerospace, and marine industries are turning to lightweight and high-strength materials. Due to their low weight, high strength, wear resistance, thermal resistance, and corrosion resistance features, aluminium metal matrix composites will meet the needs of such industries in the near future. Continuous or discontinuous fibres, as well as particles, may be employed as reinforcements in these composites [1-3]. Metal matrix composites can be made using either a melting or powder metallurgy technique. The melting technique has several critical advantages over powder metallurgy, including better matrix-particle bonding, easier MMC structural control, and lower processing costs [4-8]. Aluminium Metal Matrix Composites (AMMCs) have grown in importance in a variety of technical applications, including cylinder block liners, automobile pistons, and bicycle frames, among others.Metal matrix composites are materials that are appealing for a wide range of engineering applications [9-12] because they combine high specific strength with strong corrosion resistance. The comparatively low-cost stir casting technology was investigated in this research for usage in the manufacture of silicon carbide/aluminum alloy (AA5052) MMC. The purpose of this study was to use the stir casting method to make Al5052 reinforced with varied weight percentages of SiC particles. Increased weight % of SiC particles in the aluminium matrix increased mechanical qualities such as hardness and wear resistance. In 3 wt. percent SiC, the greatest hardness values for casting and sintering samples were found at 850 and 350°C, respectively.

A. *Problem Statement*

Metal matrix composites based on Aluminum Alloy 5052 have found use in the marine environment. Al5052 alloy has high corrosion resistance; however, its hardness is lower which limits its applications. To overcome this problem, Silicon Carbide (SiC) is added as reinforcement particles to enhance the hardness and wear resistance.

B. *Objective*

The construction and investigation of AA5052/ SiC AMMC, which was fabricated utilising the stir casting procedure, are the goals of this research project.

C. *Material Selection*

i. *Matrix Material*: Because of its abundance, low cost, and great corrosion resistance, aluminium 5052 was chosen as the metal matrix for the composite. The selected aluminium alloy Al 5052 bears excellent characteristics for salt water environment. The composition is shown in the Table I.

ii. *Reinforcement Material:* Because of its low density, high strength, high hardness, and wear resistance, Silicon

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Carbide is used as a reinforcing phase. Table II lists the characteristics of Silicon Carbide.

Table I Chemical composition of Al5052.

Chemical Element	% Percentage
Manganese (Mn)	0.02 - 0.10
Iron (Fe)	0.02 – 0.40
Copper (Cu)	0.02 – 0.10
Magnesium (Mg)	2.20 – 2.80
Silicon (Si)	0.02 – 0.25
Zinc (Zn)	0.02 – 0.10
Chromium (Cr)	0.15 – 0.35
Others (Total)	0.02 – 0.15
Others (Each)	0.02 – 0.05
Aluminium (Al)	Balance

Table II Silicon Carbide properties.

Density	3.21 g/cm^3
Melting point	2,730 °C
Hardness	2600 Hv
Thermal conductivity	490 W/mK

II. EXPERIMENTAL WORK

A. *Fabrication of Composite*

Stir casting's experimental setup consists mostly of an electric furnace and a mechanical stirrer. Figure 1 shows a schematic representation of a stir casting machine setup. Stir casting is a method in which the melt is continuously stirred, exposing the melt surface to the atmosphere and causing continuous oxidation of the aluminium melt.The wettability of the aluminium decreases as a result of continual oxidation, and the reinforcing particles stay unmixed. SiC is a chemical compound that cannot be reduced under normal conditions, and its wettability in melt does not change. To totally block the oxidation, an inert atmosphere must be provided, which is fraught with difficulties. As a result, adding wetting agents to the melt, such as TiK2F6, borax, and magnesium, is a common solution to this problem and is commonly employed in the fabrication of AMMCs. Apart from the oxidation issue, another key issue in the stir casting process, which is regulated by stirring parameters, is ensuring homogenous particle dispersion in the melt.Stirring speed, stirring time, impeller blade angle, impeller size, and impeller position are all important factors that influence the distribution of reinforcements in the matrix.

B. *Experimental Plan*

The aluminium alloy Al5052 is employed as the matrix metal for the composites, which are reinforced with SiC of average 30 µm size at 1 wt. percent, 2 wt. percent, and 3 wt. percent. The stir casting technique was used to create the composite. The melting took place in a stir casting furnace at temperatures ranging from 850 to 200 degrees Celsius. Figure 2 depicts the setup of a stir casting machine. The melt was physically agitated with a graphite stirrer and motor, and pre-heated silicon carbide particles were gradually introduced to the molten metal during this time. The stirring operation takes 10 minutes and takes place at a temperature of 7500C with a stirring speed of 600 rpm.To measure the temperature change of the molten metal, one K-type thermocouple has been put into the graphite crucible. Finally, the mechanical characteristics of the Al5052/ SiC composite are compared to those of the Al5052 matrix alloy without reinforcement. The composites' microstructural properties, hardness, and wear resistance are assessed. Figure 3 depicts the experimental strategy.

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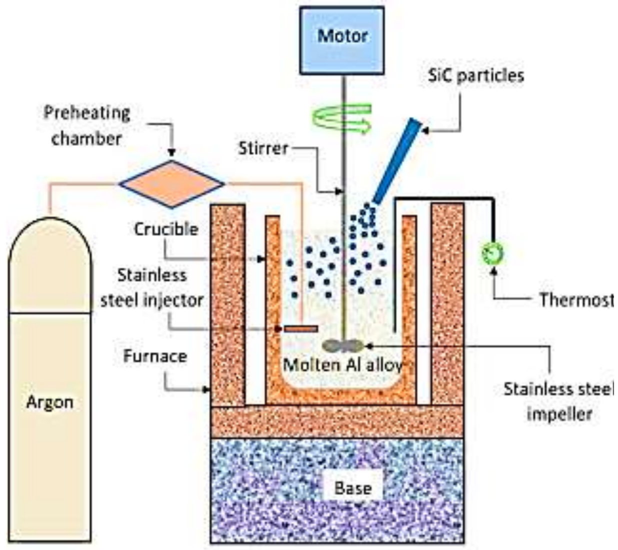

Fig 1 The schematic diagram of stir casting machine set up.

Fig 2 Stir casting machine set up.

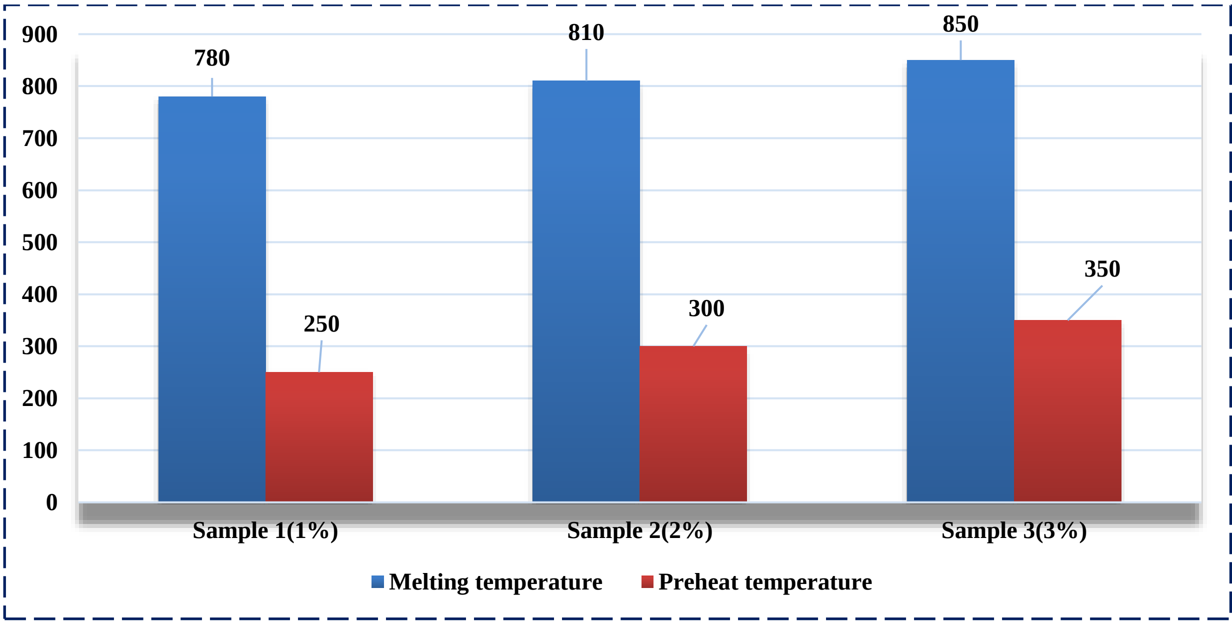

Fig 3 Experimental plan.

III. RESULT AND DISSCUSION

A. *Micro Structural Analysis*

In comparison to the top surface, the micro structure on the side surfaces has finer granules. This could be due to grain reinforcement caused by a slow cooling rate. Heat dissipation is improved since the side surfaces are confined to the walls. As reinforcement increases, these ripple structures become weaker and eventually disappear. The ripples could be caused by laminar flow in the riser region of the die due to the sluggish rising of molten metal. SiC particles are dispersed along grain boundaries in the composites with 1%, 2%, and 3% SiC content, according to optical microscopic pictures. Figure 4 (a-b-c).The alumina particles are well dispersed at the grain boundaries in the samples with 1%, 2%, and 3% silicon carbide particles, according to the elemental mapping of the composites.

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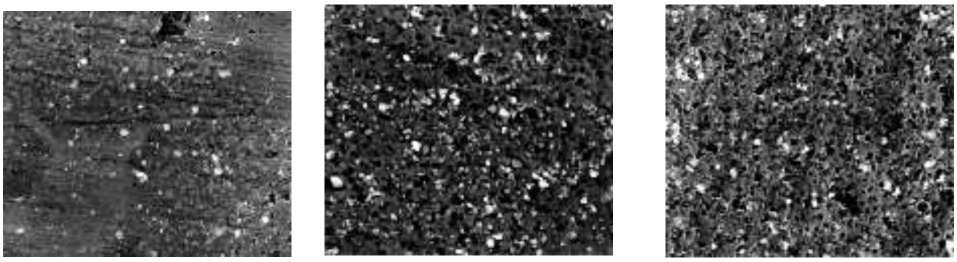

(a) (b) (c)

Fig 4 (a) Microscopic image of 1% SiC (b) Microscopic image of 2% SiC (c) Microscopic image of 3% SiC

B. *Hardness*

Hardness is the property of the metal that resists to deformation usually by penetration or indentation and scratching. Hardness of the material mainly depends on strain, ductility, elastic stiffness, strength, plasticity, viscoelasticity, toughness and viscosity. All samples were subjected to a Vickers hardness test with a load of 100gf and a dwell duration of 10 seconds. It was discovered that as the percentage of additional reinforcement increased, the hardness value increased. The reinforcing of SiC particles with matrix metal increases the toughness of the metal. Each specimen was subjected to a hardness test with a load of 60 kgf and an indenter of a steel ball with a diameter of 2.5 mm. The Rockwell hardness test predicts the size of the indenter impression. The corresponding hardness (HRC) values were determined. The data in Table III show an increasing trend in hardness as the weight % of SiC particles increases. The hardness value increases as the weight percentage of SiC particles in the casting increases, according to the experimental data. At 3 wt% SiC, the greatest hardness value was attained.

Table III Vickers hardness values for Al5052/SiC AMMC.

Sample	Trail 1 (µm)	Trail 2 (µm)	Average (µm)
Base alloy	68	70	69
1% SiC	120.5	121.5	121
2% SiC	121.3	123.7	122.5
3% SiC	124.2	123.6	123.6

C. *Wear Test*

The weight loss method was used to calculate the wear rates. The pin was forced against the counterpart revolving against an EN32 steel disc with a hardness of 65HRC in the wear test. The pin specimen is held vertically in a revolving hardened steel disc by an approximately strain-gauged friction detecting arm. The specimen was removed, cleaned, and weighed after going through a fixed sliding distance at a specific period to assess the weight loss due to wear. The wear of the specimen is determined by the change in weight measured before and after the test. The weight loss method was used to calculate the volume losses. Figure 5 depicts the pin-on-disk wear test machine.

Fig 5 Pin-on-Disk wear testing machine

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The solidified castings were taken from the die, and cylindrical samples were prepared for wear testing on a pin-on-disc wear testing equipment by machining. On the pin on disc wear testing machine depicted in Fig. 1, wear tests were done at various loads. The wear rate and 3.3 were determined by weighing the samples before and after the tests, as indicated in Table IV below.

Table IV Wear rate of Al5052/SiC AMMC.

Sample	Initial weight (g)	Final weight (g)	Weight loss (g)	Volume loss (mm3)	Wear rate (mm3/m)
1% SiC	5.12595	5.11432	0.01163	1.2134	0.003425
2% SiC	6.45592	6.45011	0.00581	2.1518	0.001434
3% SiC	6.21339	6.21028	0.00311	1.1518	0.000768

IV. CONCLUSION

The following results have been drawn from the current research on the stir casting preparation of Al5052-SiC Aluminium metal matrix composites and the examination of microstructural and mechanical properties. SiC particles are dispersed along grain boundaries in composites containing 1%, 2%, and 3% SiC, according to optical microscopic pictures.In comparison to the micro structure of the top surface, the micro structure of the surface near the die wall revealed finer grains. This could be owing to an inefficient cooling rate induced by heat dissipation at the die's side wall. The hardness test reveals a progressive increase in the hardness rating as the proportion of silicon carbide added to the composite increases.73 HV is the maximum hardness value. When we increase the reinforcement of SiC nano particles from 0 to 3 weight percent, the wear rate lowers.

REFERENCES

[1]. Purohit, R., Qureshi, M.M.U. and Dandoutiya, B.K., 2018. Study of tribological properties of Al-Al2O3 nanocomposites developed through ultrasonic assisted stir casting process. *Materials Today: Proceedings*, *5*(9), pp.20492-20499.

[2]. Kumar, A., Lal, S. and Kumar, S., 2013. Fabrication and characterization of A359/Al2O3 metal matrix composite using electromagnetic stir casting method. *Journal of Materials Research and Technology*, *2*(3), pp.250-254.

[3]. Sukumar, M.S., Babu, K.A. and Venkataramaiah, P., 2014. Exploration of mechanical behavior of Al2O3 reinforced aluminium metal matrix composites. *Elixir Mech. Engg.*, *72*, pp.25462-25465.

[4]. Sharma, S. and Sharma, A., 2015. Investigation of wear characteristics of aluminum disc with pin-on-disc tribometer. *Int. J. Sci. Eng. Res*, *6*(1).

[5]. Mugilan, T., Aezhisai Vallavi, S. Santhosh, D. Sugumar, and S. Christopher Ezhil Singh. "Machining of microholes in Ti-6Al-4V by hybrid micro electrical discharge machining to improve process parameters and flushing properties." Bulletin of the Polish Academy of Sciences. Technical Sciences 68, no. 3 (2020).

[6]. Dolatkhah, A., Golbabaei, P., Givi, M.B. and Molaiekiya, F., 2012. Investigating effects of process parameters on microstructural and mechanical properties of Al5052/SiC metal matrix composite fabricated via friction stir processing. *Materials & Design*, *37*, pp.458-464.

[7]. Mugilan, T., S. Santhosh, and N. Sridhar. "Experimental investigation of machinability and microstructure analysis on Inconel 718." International journal of research in advent technology 7, no. 1 (2019): 405-409.

[8]. Gobinath VK, Manju SA, Santhosh S, et al. Fracture analysis and geometrical parameter optimization of bolted composite joints. Material Sci & Eng. 2020;4(6):169-174. DOI: 10.15406/mseij.2020.04.00146

[9]. Kandpal, B.C. and Singh, H., 2017. Fabrication and characterisation of Al2O3/aluminium alloy 6061 composites fabricated by Stir casting. *Materials Today: Proceedings*, *4*(2), pp.2783-2792.Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specification, IEEE Std. 802.11, 1997.

[10]. Mugilan, T., and T. Alwarsamy. "Prediction of Cutting Forces During End Milling using 3D FEM based Simulation Analysis." International Journal of Vehicle Structures & Systems 12, no. 1 (2020): 26-30.

[11]. Lukose, L., Babu, K. and Srinivasan, S.A., 2020. Development of Aluminium 6082 alloy reinforced with Al2O3 by die casting and investigation of microstructural and mechanical properties. *Materials Today: Proceedings*, *27*, pp.2520-2525.

[12]. Mathur, V., Patel GC, M. and Shettigar, A.K., 2019. Reinforcement of titanium dioxide nanoparticles in aluminium alloy AA 5052 through friction stir process. *Advances in Materials and Processing Technologies*, *5*(2), pp.329-337.