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ALUMINIUM 6063 SILICON CARBIDE METAL MATRIX COMPOSITES FOR HEAT SINK APPLICATIONS-A CRITICAL REVIEW

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Abstract
Applications for heat sinks in mechanical and electrical fields are widespread. Superior heat dissipation is necessary due to the ever-increasing performance of electronic devices and their downsizing. As a result, the materials used to make the heat sink should not only be inexpensive, have low densities, and high thermal conductivities, but also have coefficients of thermal expansion that are comparable to those of ceramic substrates and semiconductor chips. New composite materials, with a primary focus on metal matrix composites (MMCs), have been created in response to the shortcomings of existing materials in meeting these requirements. Therefore, many investigations on improving the thermal performance of metallic matrices employing silicon carbide (SiC) and Al 6063 as different types of reinforcements and their combinations to create composites are thoroughly summarized in this study.

Keywords: Heat sink, MMCs, Al 6063, SiC, Reinforcements.

Introduction

Aluminum alloys have become extremely significant in the industrial sector due to their unique combination of mechanical and physical qualities that set them apart from basic metals. These characteristics include low coefficient of thermal expansion, enhanced damping capacity, high stiffness, strong resilience to abrasion and wear, and high strength. However, the current advancements in material science and technology call for the development of advanced engineering materials that are light, strong, and inexpensive, have a good strength to weight ratio, enhanced heat transfer rate and can be used in a variety of engineering applications [1].
It is well known that metal matrix composites (MMCs) provide the customized qualities that are sorely needed in many different engineering applications [1, 2]. One fantastic illustration of a carefully designed amalgamation of metal and hard particles (referred to as Reinforcement) is MMC [3]. Because the matrix contains very thin sized reinforcement particles, MMCs are the most promising materials for achieving improved mechanical properties such yield strength, ultimate tensile strength, Young's modulus, and hardness. Additionally, MMCs have characteristics like reduced weight, low thermal expansion, high thermal conductivity and increased resistance to wear and corrosion [3, 6].
Aluminium Silicon Carbide composites are one type of metal matrix composite (MMC) that is gaining popularity due to its exceptional dimension stability, low expansion coefficient, high specific strength, and stiffness at a lower cost [16, 17].
There are several ways to make metal matrix composites, including chemical vapor deposition, squeeze casting, pressure infiltration, stir casting, and powder metallurgy. Among all the procedures, stir casting is the one that researchers employ the most frequently [18].

Stir Casting
Stir casting is always the best option because it is so cost-effective. Stir casting offers a number of noteworthy benefits. It's a simpler, more adaptable strategy than the others. The stir casting technology works well for big volume production and is ideal for near net form components. The stirring process offers a number of significant benefits, including a large selection of

materials, superior matrix–particle bonding, easier control over matrix structure, low processing costs, flexibility in large-scale production, and exceptional productivity for near-net-shaped components. Nevertheless, there are certain issues with stir casting AMCs, including uneven distribution of the reinforcing ingredient and low wettability. The stir casting technique concept is displayed in Figure 1.

Figure 1: Stir Casting Setup [19]

Literature Review

Mirza Murtuza Ali Baig et al. [4] examined how metal matrix composites affected things. In this paper, MMCs as heat sink materials are reviewed. Studies reveal that conventional materials fall short of these needs; as a result, novel composite materials, with a primary emphasis on metal matrix composites (MMCs), have been developed. In this review paper, base metals are reinforced with carbon-based, metallic, and ceramic materials by combining desirable qualities in different proportions and patterns of distribution. Therefore, many investigations on improving the thermal performance of metallic matrices employing various reinforcement types and their combinations to create composites are thoroughly summarized in this study. According to the paper's conclusion, heat sink materials reinforced with various metals should show acceptable thermal performance, meaning that their thermal conductivities and coefficient of thermal expansion have been significantly enhanced.

Sabuj Mallik et al. [5] have looked into the automotive ECU's thermal performance. ECU thermal management has always been a difficult problem. It was noted that the necessary functionality and operating temperatures have increased dramatically, despite the fact that automobile ECUs have become smaller and less expensive. This report presents the findings from a study on thermal management materials that could be utilized with an automotive electronic control unit. The loss of heat from the ECU may be enhanced by an ECU housing made of a material with higher thermal conductivity (TC) than the aluminum utilized at the moment. This analysis demonstrates that, among the several materials now on the market, Al/SiC composites have the best potential for use in automotive ECU operations.

H.Agilan et al. [6] the several characteristics of composite materials, including their stiffness, strength, wear resistance, and coefficient of thermal expansion, were examined. 15% silicon carbide particles and 5% magnesium were added for reinforcement when aluminum 6063 was created by stir casting. The study's findings indicate that hardness, strength, and heat transfer rate automatically rises with base metals as percentage of silicon carbide and magnesium increases.

K.K.Alaneme et al. [7] using a borax additive and a two-step stir casting process, the tensile and fracture behavior of aluminum 6063 reinforced with silicon carbide particle composites has been

studied. Composites made of Al 6063 and SiC with volumes of 3, 6, 9, and 12 percent SiC were created. The outcomes indicate that adding 9 or 12 volume percent of SiC as reinforcement significantly increases the strength of the Al 6063 matrix composites without negatively affecting their ductility. All things considered, Al 6063 alloy is a good matrix for creating SiC-reinforced aluminum-based composites.
Arulmani Natarajan et al. [8] mechanical properties of silicon carbide reinforced aluminum 6063 were examined, with a focus on the mass fraction of SiC (3%, 5%, and 10%). They discovered that when silicon carbide content rises, toughness naturally rises and machining time falls. Additionally, it enhanced qualities including high thermal conductivity, higher hardness, yield strength, and tensile strength.
Sunday Aribo et al. [9] examined how a high temperature affected the silicon carbide particle-reinforced cast aluminum alloy composite's mechanical characteristics. Stir casting was used to cast silicon carbide aluminum 6063 composite with a 15% volume fraction. Good mechanical qualities are shown by the results at high temperatures. This material may withstand high temperatures, as evidenced by the yield strength, ultimate tensile strength, hardness, and ductility, which all exhibit stability and a minor improvement with increasing temperature.
Abba Green [10] the mechanical behavior of silicon carbide composite-reinforced aluminum 6063 was examined. Silicon carbide made up 5%, 7%, and 9% of the reinforcement. Tensile strength, hardness, and microstructure of aluminum 6063 composite were investigated in relation to varying weight percentages of silicon carbide. Microstructure investigations have shown that as silicon carbide weight percentage increases, so do yield strength and ultimate tensile strength. As silicon carbide weight percentage increases, total elongation decreases. The Al 6063-SiC composite becomes harder as the silicon carbide content rises.
S.A. Balogun et al. [11] investigated how heat treatment and cold rolling affected the ductility and strength of aluminum alloy 6063 reinforced with silicon carbide grains. To create samples for heat treatment and cold rolling, silicon carbides with 100 µm grain sizes were added to 6063 aluminum in volume fractions ranging from 0 to 30%. Increases in SiC volume percentage and particle size led to stronger results compared to the standard 6063 aluminum alloy.
O. Olaoluwayinka et al. [12] a heat sink made of aluminum silicon carbide was created for use in electronics and electrical applications. Using stir casting and 10% aluminum silicon carbide with various grits containing additives, nine samples were created. The created samples' density, electrical conductivity, and thermal conductivity are all extremely appropriate and significantly improved, according to the results.
Senthilkumar Packirisamy et al. [13] examined the mechanical characteristics of silicon carbide reinforcement and aluminum 6063. By using the stir casting method, AMCs with different SiC contents (0, 3, 6, and 9 weight percent) were created. The produced composites' tensile strength, percentage elongation, and hardness were examined. According to the experimental results, the percentage of elongation of the composite reduces as the percentage of silicon carbide increases, while the tensile strength and hardness increase with the addition of SiC reinforcement in the aluminum matrix.
Murlidhar Patel et al. [14] were examined by going over the SiC particle reinforced in Al and Al alloy's mechanical, tribological, and corrosion behavior. Silicon carbide reinforcements range from 0 to 45% of volume fractions in aluminum or aluminum alloys. The density, hardness, tensile strength, sliding wear resistance, and slurry erosive wear resistance of the composite all raise as the SiC content in the Al matrix increases. Additionally, the coefficient of thermal expansion decreases as the SiC percentage increases, indicating superior thermal conductivity.
B. Suresh Babu et al. [15] Al 6063-Silicon Carbide and Al 6063-Silicon Carbide/Graphite hybrid metal matrix composite materials are created and their mechanical and metallurgical characteristics are compared in this research study. The reinforcing content of the composites, which were produced using stir casting processes, ranges from 5% to 15% in increments of 5% weight percentage every sample.

Using a comparative approach, it has been possible to comprehend the tensile behavior and density parameters of the composites constructed of SiC/Gr and SiC reinforced with Al 6063 metal matrix in three different weight fractions manufactured using stir casting procedure. The uniform dispersion of reinforcements across the matrix was examined using optical micrographs and SEM analysis. It has been shown that the composites' mechanical characteristics, such as their tensile strength, have a significant effect.

Conclusion
The experimental and theoretical results of research activity are presented in this review. An overview of the progress made in developing Al6063 MMCs—the materials industries want to replace the traditional materials they are now using and also it is beneficial for other researchers.

1. It is discovered that the hardness, yield strength, and ultimate strength of a base metal automatically increase as the percentage of silicon carbide in the metal increases.
2. Additionally, it is discovered that Al 6063 Silicon Carbide Composites exhibit significantly improved thermal conductivities and coefficients of thermal expansion, making them appropriate for high temperature applications as heat sinks.
3. Research has shown that, when compared to other manufactured MMC, the stir casting process is the most economical approach.
4. The percentage of silicon carbide reinforcement in Al 6063 was limited upto 45%.

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