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# Experimental investigation on the impact of mechanical properties of SiC, $Al_2O_3$ and $ZrSiO_4$ particles on AA6063 composites

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## Abstract

In this research, processing temperature and the addition of micro-sized SiC, Al2O3, and ZrSiO4 to AA6063 metal matrix composites affects the mechanical properties investigated. A stir casting technique was used to evenly disperse SiC, ZrSiO4, and Al2O3 particles in an AA6063 matrix composite. Because the bonding between the ceramic and AA6063 interfaces reduced the mobility of the grain and twin boundaries, ceramic/aluminum composites could withstand greater external loads. The results show that reinforcing quantities of AA6063- $ZrSiO_4$ composites were softer than AA6063- $Al_2O_3$ and AA6063-SiC composites. The results reveal a sweet spot for ceramic content in composites where the final tensile strength and hardness are optimal. The numbers proved to be percentages: 6–12% for AA6063-SiC composites, 6–12% for AA6063- $ZrSiO_4$ composites, and 18% for AA6063-$Al_2O_3$ composites. These experiments show that ceramic-reinforced composites have greatly improved tensile strength and hardness. The most beneficial additions are $ZrSiO_4$ and $Al_2O_3$, which boost tensile strength by 53% and hardness by 127%, respectively.

## Introduction

Because of the proliferation of high-tech applications across an extensive range of industries, such as aviation, automobiles, industrial equipment, entertainment, and more, the demand for lightweight, durable engineered materials has continuously expanded over the past three decades [1], [2], [3]. Strength, toughness, rheological characteristics, creep resistance, and exhaustion resistance are only some of the qualities of composites that have been demonstrated to be greatly enhanced by the addition of ceramic reinforcements to a metallic matrix [4], [5]. Due to its unique qualities, composites made of an AA6063 aluminum matrix strengthened with ceramic fibers, whiskers, and particles could find applications in cutting-edge technology[6], [7]. Due to their superior mechanical qualities, these materials are in high demand in the transportation industry (low thermal expansion, high specific strength and stiffness, and matrix-like densities) [8], [9], [10]. Ceramic particles have many desirable qualities, including a high Young's modulus, a high hardness, a low thermal expansion, and a high chemical resistance. Incorporating these reinforcements into metal matrix composites led to improved mechanical properties, including strength, hardness, thermal stability, and wear resistance [11], [12]. Most MMCs are made using casting or powder metallurgy (P/M). P/M is a significant problem with composites due to the homogenous reinforcement dispersion and poor matrix/reinforcement contact, which leads to good mechanical properties[13]. It is preferable to use the metal casting method for mass producing composites because of the material's malleability and the low manufacturing costs associated with this technique[14], [15]. The MMC's enhancing impact is mitigated by the inevitable occurrence of an exaggerated matrix/reinforcement interfacial reaction during solidification and the minute wetting properties of ceramic/metal[16], [17], [18]. As long as the interfacial link is robust, the matrix can pass its weight to the reinforcements without worrying about the reinforcements failing too soon. How the ceramic reinforcements and metal matrix react to one another is a crucial factor in determining the final composite's mechanical and physical properties[19], [20], [21].

In this experiment, Ceramic particles of varying sizes and shapes have been employed as reinforcements in AA6063 and Al matrix composites. Although it has been demonstrated that MMCs benefit from the incorporation of ceramic particles such $ZrSiO_4$, SiC, and $Al_2O_3$, no comparative study has been described. Different compositions are created at different processing temperatures, and it has been reported that B4C reacts with aluminium synthesised using liquid and semi-solid processes. Great wettability of SiC in the AA6063 matrix has been made possible by the creation of a boron oxide coating upon interaction with air. In this investigation, we have used the stir casting technique to make AA6063-$ZrSiO_4$ composites, AA6063-SiC composites, and AA6063-$Al_2O_3$ composites. Authors compared the mechanical as well as physical characteristics of three composites by altering their processing temperature and volume percentage of reinforcement. Using mathematical models, one may accurately predict mechanical qualities without wasting too much time or money.

## Section snippets

### Materials

Ceramic particles used in this study included ZrSiO4 (10μ m, purity 97%), Al2O3 (10μm, purity 99%), and SiC (10μm, purity 99%). The chemical composition of AA6063 is shown in Table 1.…

### Composite sample preparation

AA6063 matrix composite samples were made by melting aluminium billets in an electric furnace. One must use a specialised tool made for the purpose of stir casting. By stirring the aluminum at 350–400rpm with a four-bladed graphite impeller in a stirrer motor device and controlling the heating and cooling…

### X-Ray diffraction

Composites with varying reinforcing levels and casting temperatures are shown in X-ray diffraction (XRD) patterns in Fig. 2. As shown in Fig. 3a, $ZrSiO_4$ is hardly dissolved in the molten metal. This indicates that the manufacturing of AA6063- $ZrSiO_4$ composites did not result in any chemical change. From what can be seen in Fig. 3b, aluminum showed only mild absorption of B4C. Matrix-reinforcement chemical interactions lead to the appearance of several peaks, such as $Al_3C$ $(BC_2)$, $AlB_2$, and $AlB_{12}$ …

### Mechanical properties

Fig. 5a–f displays the variations in hardness between 800°C and 900°C cast AA6063 matrix composites. Addition of ceramic particles increases the MMCs' hardness. It was found that the AA6063-$Al_2O_3$ composite had a higher hardness than the AA6063- $ZrSiO_4$ and AA6063-SiC composites. The composite's hardness at a higher processing temperature (900°C) was highly variable amongst ceramic reinforcing types. Particles in ceramics settle more evenly over time, while in silicon blades settle largely…

## Conclusion

In this investigation, stir casting technique was select to disperse SiC, $ZrSiO_4$, and $Al_2O_3$ particles in an AA6063 matrix composite.

- Ceramic-reinforced AA6063 aluminum matrix composites have been discovered to have greater hardness and tensile strength than pure aluminum.…
- Similar reinforcing quantities of AA6063- $ZrSiO_4$ composites were softer than AA6063- $Al_2O_3$ and AA6063-SiC composites. The results reveal that there is a sweet spot for ceramic content in composites where the final tensile…

…

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.…

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