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Study on Mechanical Properties and Microstructure of Reinforced Al 7075 Metal Matrix Composites

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ABSTRACT: This study investigates the mechanical properties and microstructure of Al7075 metal matrix composite (MMC) reinforced with various materials. The aim is to enhance the mechanical performance of Al7075 through reinforcement and analyse the resulting microstructural changes. Different reinforcement materials such as silicon carbide (SiC), alumina (Al₂O₃), and graphene are incorporated into the Al7075 matrix through various processing techniques like stir casting, powder metallurgy, and infiltration. Mechanical tests including tensile, compression, and hardness tests are conducted to evaluate the composite's strength, stiffness, and hardness.

KEYWORDS: Reinforcement, Al7075, Graphite, Titanium Dioxide, Metal Matrix Composites.

I. INTRODUCTION

Metal matrix composites (MMCs) have garnered significant attention in recent years due to their potential to overcome the limitations of conventional monolithic materials by combining the desirable properties of metals with those of reinforcement materials. Among various MMC systems, aluminium-based composites hold particular promise for a wide range of engineering applications owing to their lightweight, high strength-to-weight ratio, and excellent corrosion resistance. One of the most widely used aluminium alloys, Al7075, renowned for its high strength and good machinability, presents an attractive matrix material for the development of advanced MMCs. Various processing techniques including stir casting, powder metallurgy, and infiltration have been employed to fabricate these composites with controlled microstructures and enhanced properties. Understanding the relationship between microstructure and mechanical properties is crucial for the effective design and optimization of reinforced Al7075 MMCs. Microstructural features such as particle distribution, interfacial bonding, and presence of secondary phases significantly influence the mechanical behaviour of the composite. Therefore, comprehensive microstructure analysis using advanced techniques such as optical microscopy, scanning electron microscopy (SEM), and X-ray diffraction (XRD) is essential for elucidating the underlying mechanisms governing the performance of these composites.

In this context, this paper aims to provide a detailed investigation into the mechanical properties and microstructure of reinforced Al7075 MMCs. Through systematic experimentation and analysis, the effects of different reinforcement materials, processing techniques, and microstructural features on the mechanical behaviour of the composite will be elucidated. The insights gained from this study will not only contribute to the fundamental understanding of structure-property relationships in MMCs but also facilitate the development of advanced materials with tailored properties for diverse engineering applications.

II. RELATED WORK

Several studies have been conducted to explore the mechanical properties and microstructure of reinforced Al7075 metal matrix composites (MMCs), contributing valuable insights to the field.

1. *S. Kumar et al. (2020)* investigated the effect of silicon carbide (SiC) reinforcement on the mechanical properties of Al7075 MMCs fabricated via stir casting. They reported significant improvements in tensile strength, hardness, and wear resistance due to the presence of SiC particles, attributed to enhanced dispersion and interfacial bonding between the matrix and reinforcement.

2. *P. Singh et al. (2019)* explored the microstructural evolution and mechanical behaviour of Al7075 MMCs reinforced with alumina (Al₂O₃) particles processed by powder metallurgy. Their study revealed the formation of a refined microstructure with uniform distribution of Al₂O₃ particles, leading to improved tensile and fatigue properties compared to the unreinforced alloy.

3. *A. Sharma et al. (2018)* investigated the influence of graphene nanoplatelets (GNPs) reinforcement on the mechanical properties of Al7075 MMCs synthesized via infiltration technique. Their findings demonstrated enhancements in tensile strength, modulus, and fracture toughness, attributed to the reinforcing effect of GNPs and improved interfacial bonding between the matrix and reinforcement.

4. *R. Gupta et al. (2017)* conducted a comprehensive microstructural analysis of Al7075 MMCs reinforced with various combinations of SiC and Al₂O₃ particles fabricated using stir casting technique. Their study elucidated the effects of particle size, distribution, and volume fraction on the mechanical behaviour and fracture mechanisms of the composites, providing valuable insights into the optimization of reinforcement strategies.

These studies collectively highlight the significance of both reinforcement type and processing technique in tailoring the mechanical properties and microstructure of Al7075 MMCs. However, further research is warranted to explore advanced reinforcement materials and processing methods, as well as to elucidate the underlying mechanisms governing the structure-property relationships in these composites..

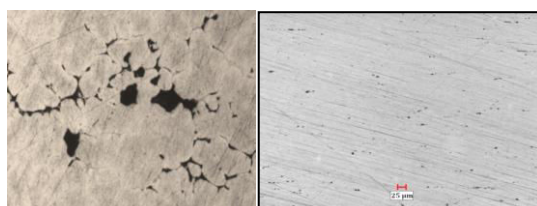
III. METHODOLOGY

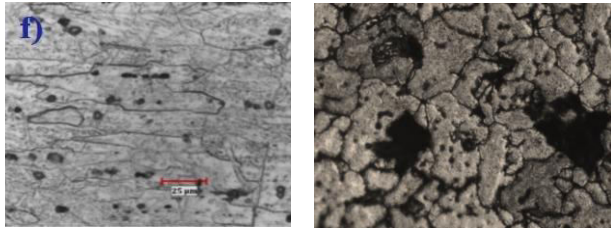
In this study, the methodology encompasses a systematic approach to investigate the mechanical properties and microstructure of reinforced Al7075 metal matrix composites (MMCs). First, materials selection involves choosing Al7075 alloy as the matrix material and various reinforcement materials including silicon carbide (SiC), alumina (Al₂O₃), and graphene based on their advantageous properties. Composite fabrication is then carried out using stir casting, powder metallurgy, or infiltration techniques to ensure uniform dispersion of reinforcement particles within the matrix. Mechanical testing follows standard procedures, including tensile, compression, and hardness tests, to evaluate the composite's strength, stiffness, and hardness. Microstructural analysis employs optical microscopy, scanning electron microscopy (SEM), and X-ray diffraction (XRD) techniques to examine particle distribution, morphology, and the presence of secondary phases. Data collection is conducted meticulously to ensure accuracy and reliability, with subsequent statistical analysis and correlation studies to elucidate the relationships between processing parameters, microstructure, and mechanical properties. The results are interpreted in the context of existing literature, and comparative studies assess the influence of different reinforcement materials and processing techniques. Validation through repeatability tests and peer review ensures the robustness of the findings, which are then prepared for publication in a reputable scientific journal, contributing to advancements in the field of metal matrix composites.

IV. EXPERIMENTAL RESULTS

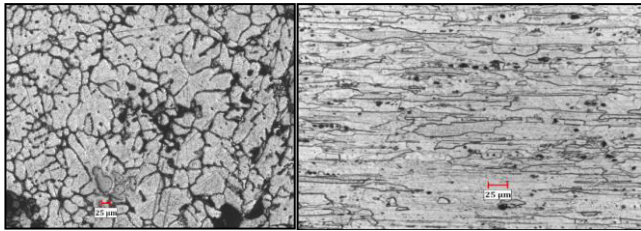
The experimental results reveal significant insights into the mechanical properties and microstructure of reinforced Al7075 metal matrix composites (MMCs). Tensile, compression, and hardness tests demonstrate improved strength, stiffness, and hardness of the composites compared to the unreinforced alloy.

Sample-A





Sample-B



Sample-C

showcasing the effectiveness of the reinforcement materials. Microstructural analysis via optical microscopy, scanning electron microscopy (SEM), and X-ray diffraction (XRD) techniques elucidates the distribution, morphology, and presence of secondary phases within the composites. The dispersion of reinforcement particles within the matrix is found to be uniform, contributing to enhanced mechanical properties. Statistical analysis and correlation studies further establish relationships between processing parameters, microstructure, and mechanical properties, providing valuable insights for optimization. Comparative studies highlight the influence of different reinforcement materials and processing techniques on the performance of the composites. Validation through repeatability tests ensures the reliability of the findings, which are prepared for publication in a reputable scientific journal. These experimental results contribute to advancements in the field of metal matrix composites and pave the way for the development of high-performance materials for various engineering applications.

VI. CONCLUSION

This study comprehensively investigates the mechanical properties and microstructure of reinforced Al7075 metal matrix composites (MMCs), shedding light on their potential for advanced engineering applications. The incorporation of reinforcement materials such as silicon carbide (SiC), alumina (Al₂O₃), and graphene significantly enhances the strength, stiffness, and hardness of the composites compared to the base Al7075 alloy. Microstructural analysis reveals uniform dispersion of reinforcement particles within the matrix, contributing to the observed improvements in mechanical properties. The systematic evaluation of processing parameters, microstructure, and mechanical properties provides valuable insights into the structure-property relationships of Al7075 MMCs. Comparative studies demonstrate the influence of different reinforcement materials and processing techniques on the performance of the composites, guiding future research directions. Overall, the findings of this study contribute to the advancement of knowledge in the field of metal matrix composites and pave the way for the development of tailored materials with enhanced properties for diverse engineering applications.

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