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Development and Performance of Aluminum Matrix Nanocomposites for Improved Mechanical Properties

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Abstract

Aluminum matrix composites offer superior properties that can substitute traditional materials in the automotive industry. This study aims to investigate the performance of aluminum-based metal matrix composites with nanoparticles used as reinforcement made by stir-squeeze casting for improved mechanical properties. This nanocomposite could be used in many applications, including a brake rotor application where superior mechanical properties are required. The type of reinforcement, particle size, and weight percentages are determined using previous studies. The nanocomposite material is subjected to a standard T6 heat treatment to enhance the performance of the nanocomposite. The nanocomposite is also subjected to a hot extrusion process to enhance its mechanical properties. The characterization includes obtaining materials chemical mechanical properties (using optical and scanning electron microscope (SEM), energy-dispersive X-ray spectroscopy (EDS), X-rd diffraction (XRD)), mechanical properties (hardness and compressive strength), physical properties (density and porosity), and tribological properties (wear rate).

The results show that the presence of nanoparticles affects the nanocomposite mechanical properties (hardness and wear resistance). Furthermore, the presence of porosity and agglomerated particles (confirmed by SEM) also affected the material's strength. Compared to the base alloy, hardness is improved by 19.5 % and 37.55% for cast nanocomposite and heat-treated nanocomposite. Moreover, post processing of stir squeeze casted nanocomposites using hot extrusion refined the grains and improved the hardness by 27.4%. The ultimate compressive strength of the Al 7075 matrix and as-cast nanocomposite were comparable. However, the nanocomposite had lower strength due to the porosity and particle agglomeration. T6 heat treatment showed the best results in terms of hardness and compressive strength, and this is due to the presence of η' (MgZn2) formed during aging. On the other hand, extruded nanocomposite had the lowest strength, and this is due to the T(Al-Zn-Mg-Cu) phase, which is most likely the result of dynamic precipitation caused by hot extrusion formed at a high temperature (400°C) despite the observed grain refinement after hot extrusion.