Development of Aluminum Based Nanocomposites Through Stir Casting Approach

Ziyad Mohammed Ziyad Al Subhi

Abstract

Aluminum-based nanocomposites commonly offer superior properties that can replace conventional steel alloys in many industries such as automotive, aerospace and construction, aiming to reduce the weight and save energy. In this present study, aluminum nanocomposites were successfully produced through stir-squeeze casting process with and without the aid of ultrasound sonication (US). The matrix material was scrap automobile aluminum alloy (A356). About 1% of SiC nanoparticles (15.3 g) with an average particle size of 40 nm were used as a reinforcement material. For the purpose of comparison, A356 aluminum casts were also produced with and without US. The work commonly aimed to develop a suitable aluminum nanocomposite that can withstand highly-wear environment like brake disc and examine the effect of using ultrasonic sonication as an advanced additional mixing technique in the mechanical and tribological properties of the produced material. As a first step, the modified digital logic method (MDLM) was conducted to select both matrix and reinforcement materials for the above-mentioned brake disc application. The analysis of the produced material was conducted based on their microstructure, porosity, hardness, tensile strength, compression strength and wear/tribological performance. In the microstructure characterization, optical microscope, and scanning electron microscope (SEM) were used, revealing different morphologies and grain structures in the cast materials. Energy-dispersive X-ray spectroscopy (EDS) and X-ray diffraction (XRD) were also performed to check the compositions and confirm the presence of SiC nanoparticles in the aluminum matrix. The porosity was greater in the nanocomposite's samples than that of pure matrix samples. This was attributed to the tendency of poreformation when ceramic particles weren't properly distributed throughout the matrix, and hence clusters and agglomerations of nanoparticles took place. That also explain, the significant reduction in porosity when the ultrasonication was applied which helped to break these clusters and agglomerations. In terms of mechanical properties, the A356+SiC sample with US exhibited, the highest hardness with a value of 70.8 HRB, the highest tensile strength (163.25 MPa), and the highest compressive strength (387.2 MPa). It also demonstrated the lowest abrasive wear loss (0.0016 g) among the four produced casts. The IV improvements of mechanical properties and wear resistance were attributed mainly to three factors: Hall-Pitch effect, reduction in porosity, and uniform distribution of the reinforcement particles in the aluminum matrix.