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Microstructure, mechanical analysis and optimal selection of 7075 aluminum alloy based composite reinforced with alumina nanoparticles

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HIGHLIGHTS

- Injection Al/Al_2O_3 powder is benefit way for improving nanoparticles distribution.
- Nanocomposites present superior mechanical properties.
- Extrusion process improved significantly mechanical properties of nanocomposites.
- Preference Selection Index is a simple and benefit method in material selection.

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ABSTRACT

Aluminum metal-matrix nanocomposites (AMMNCs) fabricated by conventional stir-casting process usually show high porosity and poor distribution of nanoparticles within the matrix. In the current study, for the improvement of nanoparticles distribution in the aluminum matrix and enhancement of the mechanical properties, a mixture of Al/nano-Al_2O_3 powders were injected by pure argon gas into the molten 7075 aluminum alloy and this mixture was extruded at high temperature. Mechanical behavior of the final product was investigated by tensile and compression tests, hardness measurements, Scanning Electron Microscopy (SEM), High Resolution Transmission Electron Microscopy (HRTEM) and Optical Microscopy. This nanocomposite exhibited some superior properties such as a fine grain microstructure and a reasonable uniform distribution of nanoparticles in the matrix. Mechanical experiments results confirmed that the addition of Al_2O_3 nanoparticles and the extrusion process effectively improved ultimate tensile strength, compression strength and hardness. In next step, we used a Preference Selection Index (PSI) materials selection method to select best combination of strength and workability of Al7075−Al_2O_3 nanocomposites. By this method, extruded Al7075/0.4 and 0.8 wt % Al_2O_3 has best combination of strength and workability.

1. Introduction

Aluminum alloy 7075, a cold finished aluminum wrought product, has the highest strength of all aluminum screw machine alloys. Because of its extremely high strength, this alloy is used for highly stressed structural parts including aircraft fittings, gears and shafts and various other commercial aircraft, aerospace and transportation equipment [1]. Therefore, mechanical behaviors of this class of materials under constant and spectrum loadings are becoming considerably remarkable in the selection of appropriate alloys for industrial purposes [2]. Furthermore, there are still several attempts and researches in order to improve the mechanical strength of AA 7075 by different methods such as the addition of additives [3]. Typically most of the additives considered in this sphere are ceramics such as oxides, nitrides and carbides, due to their stability at high temperatures and the unique strength and

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