The effect of solid-state processes and heat treatment on the properties of AA7075 aluminum waste recycling nanocomposite

ABSTRACT

Direct solid-states, such as hot extrusion and equal channel angular pressing (ECAP), are alternative and efficient solid-state processes for use in recycling aluminium scrap. These processes utilise less energy and are eco-friendly. Ceramic particles such as ZrO2 are suggested as alternatives in the production of metal composites. This study investigated and optimised the effects of various parameters of reinforced ZrO2 nanoparticles on the mechanical and physical properties via response surface methodology (RSM). These parameters were the volume fraction (VF), preheating temperature (T), and preheating time (t). The effects of these parameters were examined before and after the heat treatment condition and ECAP. Each parameter was evaluated at varying magnitudes, i.e., 450, 500, and 550 °C for T, 1, 2, and 3 h for t, and 1, 3, and 5% for VF. The effect that process variables had on responses was elucidated using the factorial design with centre point analysis. T and VF were crucial for attaining the optimum ultimate tensile strength (UTS) and microhardness. Reducing VF increased the mechanical properties to 1 vol% of oxide. The maximum hardness of 95 HV was attained at 550 °C, 1.6 h, and 1 vol% ZrO2 with a density of 2.85 g/cm3 and tensile strength of 487 MPa. UTS, density, and microhardness were enhanced by 14%, 1%, and 9.5%, respectively. Additionally, the hot extrusion parameters and ECAP followed by heat treatment strengthened the microhardness by 64% and density by 3%. Compression pressure and extrusion stress produced in these stages were sufficient to eliminate voids that increased the mechanical properties.

Keyword: Aluminium alloy AA7075; ECAP; Heat treatment; Hot extrusion; ZrO2