Optimum selection of A356/Al₂O₃ nano/microcomposites fabricated with different conditions based on mathematical method

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Abstract
Aluminum matrix composites reinforced with micro- and nano-sized Al₂O₃ particles provide desirable characteristics for high-performance applications in aerospace, automobile, and military industries, because of their improved physical and mechanical properties. Selection of the best combination of ultimate strength and formability properties of the composites is a multiple attribute decision making problem where some criteria must be considered. In this study, A356/Al₂O₃ composites were prepared with different conditions such as the fabrication method, size, and weight fraction of reinforcement. These alternatives were ranked by analytic hierarchy process method. Analytic hierarchy process results revealed that the composite with 2 wt% nano-Al₂O₃ fabricated by compo-casting method was the preferred composite material.

Keywords
Metal matrix composite, stir-casting, compo-casting, analytic hierarchy process method

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Introduction
Metal matrix composites (MMCs), as new fabricated materials, provide an opportunity to combine the metallic properties of matrix with the ceramic properties of the reinforcements.¹ Microstructure and mechanical properties of MMCs depend on the size of the reinforcement. Recently, metal matrix nanocomposites (MMNCs) have received considerable attention due to their high strength, high stiffness, high elastic modulus, excellent corrosion resistance, and superior wear resistance. Recent studies have indicated that the microparticles (e.g. Al₂O₃ and SiC and or B₄C) are used to improve yield and ultimate strength of alloys resulting in reduced ductility.¹⁻⁴ It is interesting to note that the nanoparticles as a reinforcement improve yield and ultimate strength of the nanocomposites along with maintaining good ductility.⁵⁻⁸

MMCs are fabricated with different techniques including liquid and semi-solid state processes (casting process) and solid-state processes (powder process). Casting technique is especially attractive for their simplicity, flexibility, and low cost. According to the incorporating temperature of particles into the melt, there are two types of casting methods: (1) the liquid process: the reinforcements are incorporated above the liquid temperature of the molten alloy and (2) the compo-casting method: the reinforcements are incorporated into the semi-solid slurry.⁵ Although casting is known as a commercial and flexible technique for the fabrication of MMCs, there are technical challenges for obtaining uniform distribution of nanoparticles with low agglomeration in matrix because of the low wettablity between matrix and reinforcements.⁶⁻¹⁰

Material selection is an important activity in the design and development of products, and in this process, ranking and choosing the best material is one of the most important stages. A large number of on-hand materials with complex relationships between different selection parameters often makes the material selection process difficult, tedious,