Isfahan University of Technology

Department of Material Science and Engineering

Mechanochemical Synthesis of Fe_3Al-Al_2O_3 Nanocomposite and Investigation of Its Properties

A thesis

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Abstract

Fe_3Al intermetallic compound is an important class of materials because of a combination of its high tensile strength, low density, good wear resistance, ease of fabrication and low cost. It also has excellent oxidation, sulfidation and corrosion resistance at high temperature. These properties have led to the identification of several potential usages including structural applications and protective coatings in hostile environments. Two major problems that restrict the application of Fe_3Al are poor low-temperature ductility and inadequate high-temperature creep resistance. These limitations can be overcome by introducing ceramic particles as reinforcements. The goal of this work is fabrication of Fe_3Al intermetallic compound with Al_2O_3 reinforcement via mechanochemical process. The phase transformation and microstructural characterization during mechanochemical reaction were investigated by X-ray diffractometery (XRD), scanning electron microscopy (SEM), Transmission electron microscopy (TEM) with an energy dispersive spectrometer (EDS) attached, and thermal analysis (DTA). Mechanochemical behavior of different Fe, Al, and Fe_2O_3 powder mixtures to fabrication of Fe–Al_2O_3, Fe_3Al–57 vol.% Al_2O_3, Fe_3Al–30 vol.% Al_2O_3 was studied according to the calculated adiabatic temperature of reactions, vial temperature measurement during milling, and structural investigations. Fe_3Al–57 vol.% Al_2O_3 and Fe_3Al–30 vol.% Al_2O_3 nanocomposite powders were compacted and then sintered at 1400° C for 1 h. The consolidated Fe_3Al–57 vol.% Al_2O_3 part had an ultrafine and homogeneous structure without "core-rim" feature consisting of Fe_3Al and Al_2O_3 phases. The consolidated Fe_3Al–30 vol.% Al_2O_3 part had a homogeneous and interconnected network of Fe_3Al matrix. In addition, Fe_3Al–30 vol.% Al_2O_3 was also fabricated by mechanical alloying of Fe, Al, and nano-Al_2O_3 in order to compare the effect of the addition route of Al_2O_3 phase in Fe_3Al matrix on sintering behavior and mechanical properties. The results showed that the Fe_3Al–30 vol.% Al_2O_3 fabricated through mechanochemical process had higher three-point fracture stress and hardness than Fe_3Al–30 vol.% Al_2O_3 fabricated by addition of Al_2O_3 nanopowders.