THE EFFECT OF AGING TREATMENT ON THE FRACTURE TOUGHNESS OF INJECTION MOLDED 625 SUPERALLOY PARTS

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Abstract:
In this study, the effect of the aging treatment on fracture toughness of the powder injection molded 625 superalloy parts was investigated. Gas atomized 625 superalloy powder was mixed with polymeric binder system to obtain feedstock. The feedstock was granulated and then shaped by injection molding. Following this operations the samples were subjected to debinding and sintering operations respectively. The sintered samples were solution treated at 1150°C for 2 hours and cooled down in water. After solution treatment the aging operation was performed at 745°C for 22 hours. The results of fracture toughness tests which applied to both the sintered and the aged samples showed that, the aging operation give way to some carbide, and TCP phases in microstructure. Depending on these phases the fracture toughness of the samples has been decreased while the hardness of samples has been increased.

Keywords: Superalloy, Aging treatment, Fracture toughness.

Introduction

Nickel-based superalloys are unusual group of metallic materials with their unusual combination of high temperature strength, toughness and surface stability in corrosive or oxidative environments [11]. The nickel-based 625 superalloy [12], which is one of the most successfully applied superalloys in engineering applications, is mostly used in aeronautics, chemistry and marine applications thanks to its good corrosion resistance, high stress and strain resistance [13]. Although the superalloy 625 was initially designed to make it gain strength with solid solutions, it was observed that intermetallic and/or carbide depositions may be formed in its structure after an aging process applied at 550-750 °C of temperature [13-18]. It is known that the aging process affect hardness, stress and tensile strength of the nickel-based superalloys positively [19]. However, an increase in hardness of the material affects the ductility and toughness of the material [20].

In this study, nickel-based Superalloy 625 powders were used to produce parts by means of the PIM method. The parts produced were subjected to heat treatment, and tested against fracture toughness with and without heat-treatment, in order to analyze the effects of the changes in the microstructure caused by the heat treatment of the aging process on the fracture toughness values of the material. The results from the fracture toughness experiments were supported by the scanning electron microscope (SEM), transmission electron microscope (TEM) and energy dispersive spectrometry (EDS) inspections.

EXPERIMENTAL PROCEDURE

In Figure 1 SEM image of superalloy powder used in experiments is seen. Chemical composition of 625 superalloy powder is given in Table 1 and some physical characteristics of this powder are given in Table 2. For preparing feedstock superalloy 625 powders were mixed with a multicomponent binder system which consists of 69% paraffin wax, 20% polypropylene, 10% carnauba wax and 1% stearic acid by weight percentage. The volume fraction of superalloy powder in feedstock is 60% vol. The