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FULL RESEARCH ARTICLE

Microstructure and nanomechanical behaviour of wire-arc additive manufactured nickel-based superalloy C276

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Abstract

The Hastelloy C276 superalloy is one of the versatile and promising alloys considered for high-temperature applications. In the present work, the crystallographic properties and nanomechanical behaviour of Hastelloy C276 superalloy manufactured via gas metal arc welding (GMAW) based wire-arc additive manufacturing (WAAM) were evaluated. The WAAM-processed C276 superalloy mainly comprises columnar dendrites with the predominant <100> and <111> textures at the middle region. Also, p phases rich in Mo and W were noticed within the interdendritic regions of the austenitic matrix. Small-scale mechanical testing revealed that the WAAM-processed Hastelloy C276 superalloy exhibited a reduced elastic modulus compared to its wrought counterpart. The average nanohardness (H) and reduced elastic modulus (Er) in the horizontal direction were 5.40 ± 0.51 GPa and 192.42 ± 4.50 GPa, and 4.28 ± 0.14 GPa and 122.26 ± 2.0 GPa in the vertical direction. From the nanoindentation responses, the dendritic cores have a reduced nanohardness than that of the interdendritic regions due to the localized segregation of Mo and W in the interdendritic regions, resulting in solid solution hardening. The H^3/Er^2 ratio revealed the comparable plastic deformation resistance of WAAM-processed Hastelloy C276 in the horizontal and vertical directions at the nanoscale level.

Keywords WAAM · Hastelloy C276 · EBSD · Nanoindentation

1 Introduction

Nickel-based superalloys are preferred for fabricating critical components subjected to extreme temperature environments with high-level stresses including power generation, aircraft engines, turbines, and nuclear industries because of their excellent creep resistance, improved fatigue strength, and outstanding hot corrosion and oxidation performance [1, 2]. The mechanical properties of these alloys are considerably influenced by two primary mechanisms: (a) solid solution and (b) precipitation strengthening. Hastelloy C276 is a solid solution strengthened austenitic alloy widely employed for harsh corrosive atmospheres due to its excellent resistance in oxidizing and reducing environments up to 1038 °C [3].

Additive manufacturing (AM) is a promising and widely adopted technique to manufacture complex metallic structures for various applications because of its design freedom and comparable mechanical properties that can substitute traditional subtractive manufacturing processes [4, 5]. AM makes it possible to produce complex components in a fast and cost-effective manner with distinctive microstructures

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