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# Effect of Post-Process Heat Treatment on the Microstructure and Tensile Behaviour of Wire Arc Additive Manufactured 13-8 PH Martensitic Stainless Steel

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ABSTRACT

Precipitation hardened (PH) 13-8Mo martensitic stainless steels are well-known for their excellent combination of strength and toughness, in addition to being highly corrosion resistant. The aim of the present study is to examine the microstructural evolution and mechanical response of a wire arc additive manufactured precipitation hardened (PH) 13-8Mo martensitic stainless steel being subjected to various heat treatment cycles, including solution treatment at 950, 1050, and 1150 °C, followed by aging at 400, 450, 500, 550, and 600 °C. Post-printing heat treatment was implemented to remove the columnar structure, homogenize the microstructure, and tailor the mechanical properties of the as-printed part. The experimental results showed that the solution treatment at 950 °C was not sufficient to eliminate the columnar grain structure and undesired δ-ferrite phases formed in the as-printed sample. On the other hand, the solution treatment at 1150 °C resulted in the re-formation of δ-ferrite in the primary austenite grain boundaries. However, solution temperature of 1050 °C was identified as the optimum cycle due to having a fully martensitic microstructure with no preferential texture. Although the subsequent aging process at 400 °C had no considerable influence on the microstructure of the solution-treated sample, further promotion of dislocations annihilation resulted in a slight reduction in hardness. On the other hand, aging at 450 and 500 °C led to the nucleation of fine and coherent β-NiAl precipitates dispersed within martensite laths causing a significant increase in microhardness and ultimate tensile strength of the alloy. However, further increase of the aging temperature to 550 and 600 °C reduced the ultimate tensile strength and hardness due to the formation of Cr-rich carbides and reverted austenite, while the ductility was improved. The observed anisotropic response in the ductility of the as-printed alloy was considerably reduced in the heat-treated condition caused by the removal of columnar grain structure during solution treatment.

Keywords: Wire arc additive manufacturing; PH 13-8Mo stainless steel; β-NiAl; Heat treatment; Microhardness; Anisotropic mechanical properties.