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Hot oxidation and corrosion behaviour of boiler steel fabricated by wire arc additive manufacturing

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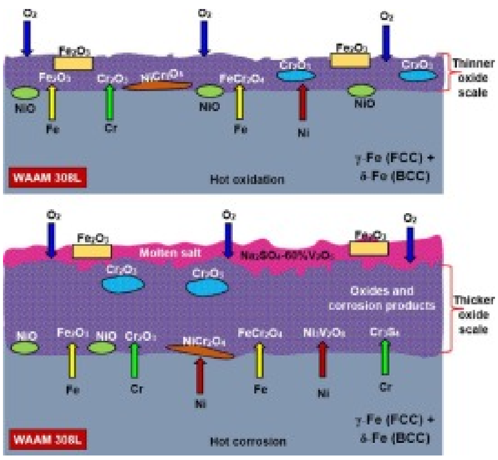
Highlights

- Hot oxidation and corrosion resistance of WAAM 308L was examined for the first time.
- Microstructure composed of austenitic and residual delta-ferrite (2.30 to 4.80 FN).
- Oxides and spinal phases were formed in the WAAM 308L surfaces at 700°C.
- The formation of NiO, Cr_2O_3, and $NiCr_2O_4$ provided good corrosion resistance.
- The formation of $Ni_3V_2O_8$ and the breakdown of Cr_2O_3 reduces the hot corrosion performance.

Abstract

Boiler Steels undergo severe degradation in corrosion resistance due to oxide scale formation at elevated temperatures. In this study, the comparative hot oxidation and hot corrosion resistance of wire arc additive manufactured SS 308L (WAAM 308L) was examined in hot air and Na_2SO_4–60% V_2O_5 molten salt environments at 700 °C. The corrosion resistance at elevated temperature was analysed using thermo-kinetic curves, corrosion products, and morphology of the oxides. The hot oxidation kinetics revealed that WAAM processed SS 308L specimens has excellent resistance and the weight gain reached 3.10 mg/cm^2 with thinner oxide scale formation. Hot corrosion kinetics of WAAM processed SS 308L specimens highlighted the higher weight gain (37.0 mg/cm^2) in molten salt environment and is attributed to the acceleration of oxide scale formation by the salts at elevated temperatures. Also, the development of $Ni_3V_2O_8$ and Fe_2O_3 along with the depletion of Cr_2O_3 significantly influenced the corrosion resistance at elevated temperatures. The findings of this study reveal the potential of WAAM to produce customized parts for high-temperature applications.

Graphical abstract



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Introduction

Wire arc additive manufacturing (WAAM) is a promising and developing technology that offers higher deposition rate, less tooling, higher material efficiency, localized shielding requirements, short lead times and low manufacturing cost [[1], [2], [3], [4], [5]]. WAAM has been highly considered as an alternative to conventional manufacturing techniques for producing medium-to-large near net-shaped structures using stainless steels [6,7] and nickel-based superalloys [[8], [9], [10], [11]] for power generation sectors, aluminium & titanium alloys for aerospace industries [12,13], shape memory alloys [14] and magnesium alloys for biomedical applications [15]. Austenitic stainless steels (ASS), nickel-based superalloys and their welds have been extensively preferred in the power plant applications due to excellent weldability and superior corrosion resistance at elevated temperatures [[16], [17], [18]]. Stainless steels having higher nickel, chromium and molybdenum are employed in oil refineries, energy conversion plants, carbon gasification and pressure vessel industries where structures such as steam pipes, boilers and heat