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Correlation between Crystallographic Texture and Corrosion Behaviour of Directed Energy Deposited Inconel 718

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Extended Abstract

Inconel 718 is a nickel-based superalloy widely used in high-temperature applications (up to ~700 °C) due to its high yield strength, excellent mechanical properties, and corrosion resistance. These properties make it ideal for use in gas turbines, aircraft components, nuclear reactors, pumps, and moulds [1, 2].

To enable the manufacturing of large-scale and complex Inconel 718 structural components, laser-directed energy deposition (LDED) technology has gained increasing attention. LDED is a type of surface cladding and additive manufacturing (AM) process capable of processing both powder and wire as filler materials. This technique is commonly applied for the repair of high-performance components such as jet engine parts, for localized wear protection, and for free-form fabrication [3, 4].

The process parameters involved in DED significantly influence the resulting microstructure during solidification. Notably, a strong correlation has been reported between the functionality and microstructure of metallic components fabricated via AM techniques such as LDED [5].

The objective of this research is to identify which process parameters play the most significant role in inducing texture in LDED Inconel 718 components, and to establish the correlation between process parameters, resulting microstructure, and corrosion behaviour.

For this purpose, Inconel 718 samples with dimensions of 10 mm × 7 mm × 5 mm were deposited on a 316L stainless steel substrate using the LDED technique. The deposition was performed using an AMBIT laser system provided by Hybrid Manufacturing Technologies. Argon gas was employed both as the powder carrier and shielding gas. The Inconel 718 powder used had a nominal chemical composition of Ni: 50–55 wt.%, Cr: 17–21 wt.%, Nb: 4.7–5.5 wt.%, Mo: 2.8–3.3 wt.%, Ti: 0.65–1.15 wt.%, Al: 0.2–0.8 wt.%, Mn ≤ 0.35 wt.%, Si ≤ 0.35 wt.%, with Fe as the balance. Nine different sets of process parameters were investigated to fabricate the LDED Inconel 718 components. Scanning Electron Microscopy (SEM) and Electron Backscatter Diffraction (EBSD) were used to characterize the microstructural features developed during solidification. Additionally, cyclic potentiodynamic polarization tests were performed in a 10 wt.% $NaNO_3$ solution to evaluate the electrochemical behaviour and estimate the corrosion resistance of the samples. All electrochemical measurements were conducted at room temperature using a Gamry Reference 600+ potentiostat/galvanostat (Pennsylvania, USA) in a conventional three-electrode setup.

The results showed that the process parameter with the highest laser power had the most significant influence on the texture of the LDED Inconel 718, leading to the development of a strong preferred crystallographic orientation between the [111] and [001] directions, with a greater tendency toward the [211] direction. In contrast, altering the scanning strategy eliminated the preferred crystallographic orientation and resulted in the formation of finer grains with random orientations.

Electrochemical tests conducted on the strongly textured sample, compared to the sample lacking pronounced texture, revealed a significant improvement in corrosion resistance for the textured component. This finding highlights the influence of crystallographic orientation on corrosion mechanisms and underscores the potential of tailoring DED process parameters to control microstructure and, ultimately, enhance corrosion resistance.

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