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PROCEEDINGS

Wall-Thickness Dependent Microstructure Evolution of GH4169 Thin-Walled Components Fabricated by Laser Powder Bed Fusion

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ABSTRACT

In the intricate and multi-physical process of Laser Powder Bed Fusion (LPBF), the microstructure significantly influences the performance of the resulting components, particularly evident in the manufacturing of thin-walled structures. In this paper, a prediction model of microstructure evolution coupled with 3D cellular automaton (CA) and finite element (FE) method for thin-walled components of GH4169 fabricated by LPBF is established. In this model, the multi-layer and multi-track temperature field within the interest region of thin-walled parts is simulated by the FE method. Subsequently, the temperature history is transferred to the CA model for predicting the microstructure evolution of samples in varying thickness. The microstructure, as determined by electron backscatter diffraction in a 4 mm-thick sample is statistically compared to the simulation results obtained from the developed FE/CA model, showing a favorable correspondence. The study reveals that grains in the overlap zone of LPBF-fabricated parts are completely columnar, while those in the melt pool center are mixed equiaxed and columnar grains. Grain size at the bottom is coarser than at the top due to epitaxial growth and remelting phenomena. In the multi-layer LPBF process, compared with the initial melting, the metal within the remelting zone experiences a reduced cooling rate and an elevated temperature gradient. This leads to epitaxial growth of grains along the heat transfer direction, resulting in a larger grain size during the solidification process. In the samples with a thickness of 4 mm, the grain sizes with a diameter of 5 μm to 15 μm exhibit the highest proportion. Within contrast to the 4 mm-thick sample, the microstructure of the 1 mm-thick sample shows negligible changes. However, when the sample is reduced to a thickness of 0.4 mm, because of the decreased cooling rate, the grain size of the sample increases, and most grain diameters in the sample falls within the range of 10 μm to 20 μm. For LPBF thin-walled metal structures, there exists a critical thickness threshold. Below this threshold, the grain will exhibit a coarse texture.

KEYWORDS

Laser powder bed fusion; thin-walled parts; cellular automaton; finite element; microstructure evolution

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