Kinetic Modelling of Phase Fraction Prediction on an Additive Manufacturing Process

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Although additive manufacturing (AM) is a promising approach in building complex functional lattices and structures, still there is a major challenge in predicting the properties of the fabricated parts that leads to the limited ability of implementation in manufacturing. This difficulty stems from the non-uniform thermal history during a layer-by-layer fabrication manner. In the way of predicting the final properties, developing a robust kinetic model for non-isothermal phase transformation is nontrivial, especially when it comes to multiphase alloy materials, like the super alloy In 625 that undergo simultaneous phase transformations phenomena during the additive manufacturing process. The main aim of this study is to develop a computational microstructure framework to track the non-isothermal phase transformations based on the Johnson-Mehl-Avrami modified model, which is fed from thermal history results. The precise thermal modeling is implemented into finite element commercial software ABAQUS-implicit to mimic the real phenomena details. The transient thermal model associated with a thermodynamically consistent phase field approach is applied by resorting to user subroutines programmed in FORTRAN language. The case study material is super alloy complex multi-components Inconel 625. The phase fraction history interface throughout the building, solidification, and re-melting stages are studied in fabrication of a thin cantilever in order to predict material properties and provide complementary improvements in the material designing concept.

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