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Coupled heat transfer, fluid flow and solidification kinetics for laser additive manufacturing applications

Khomenko, MD; Makoana, Nkutwane W; Mirzade, FKH; Pityana, Sisa L

Abstract
A new coupled heat transfer and solidification kinetics model is developed for the optimization of microstructure during laser additive manufacturing applications. The Johnson–Mehl–Avrami–Kolmogorov equation is applied in a self-consistent manner for modeling of the rapid phase change on the substrate. The numerical simulations using the OpenFOAM framework are conducted for Ni-based superalloy single track laser cladding. Single track laser cladding experiments were carried out to verify the results of our calculations. A rather good coincidence with the experimental data is shown for the developed model. The influence of processing parameters on the macro and micro parameters of the tracks is analyzed. A method for changing the average crystalline size and simultaneous preservation of the height and width of the track is presented. The possibility of controlling the microstructure of similar tracks gives an opportunity to preserve the scanning strategy for building parts with a defined quality.