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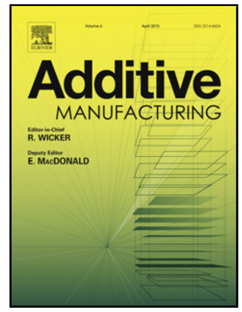

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A Thermal-Mechanical Finite Element Workflow for Directed Energy Deposition Additive Manufacturing Process Modeling

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Abstract

This work proposes a finite element (FE) analysis workflow to simulate directed energy deposition (DED) additive manufacturing at a macroscopic length scale (*i.e.* part length scale) and to predict thermal conditions during manufacturing, as well as distortions, strength and residual stresses at the completion of manufacturing. The proposed analysis method incorporates a multi-step FE workflow to elucidate the thermal and mechanical responses in laser engineered net shaping (LENS) manufacturing. For each time step, a thermal element activation scheme captures the material deposition process. Then, activated elements and their associated geometry are analyzed first thermally for heat flow due to radiation, convection, and conduction, and then mechanically for the resulting stresses, displacements, and material property evolution. Simulations agree with experimentally measured *in situ* thermal measurements for simple cylindrical build geometries, as well as general trends of local hardness distribution and plastic strain accumulation (represented by relative distribution of geometrically necessary dislocations).

Keywords: additive manufacturing; directed energy deposition; residual stress; finite element analysis.

Introduction