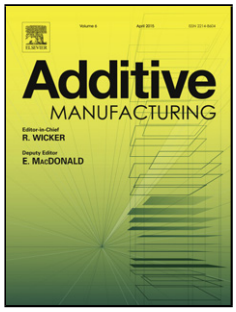

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PII: S2214-8604(18)30275-6
DOI: https://doi.org/10.1016/j.addma.2018.08.002
Reference: ADDMA 460

To appear in:

Received date: 24-4-2018
Revised date: 31-7-2018
Accepted date: 1-8-2018

Please cite this article as: Santos LS, Gupta SK, Bruck HA, Simulation of Buckling of Internal Features during Selective Laser Sintering of Metals, *Additive Manufacturing* (2018), https://doi.org/10.1016/j.addma.2018.08.002

Simulation of Buckling of Internal Features during Selective Laser Sintering of Metals

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ABSTRACT

Additive manufacturing (AM) processes, such as Selective Laser Sintering (SLS), have enabled the fabrication of geometrically complicated designs. However, undesired distortions due to thermally-induced residual stresses may lead to loss of tolerance or failure of the part. One potential failure mode is buckling, particularly when realizing high aspect ratio features, like for infill, to minimize weight. In this paper, we address distortions and part failures due to buckling by using a finite element model to predict residual stress distributions and sintering induced distortions. Initially, we conduct a transient thermal simulation to determine the Heat Affected Zone (HAZ), which is then used in the thermomechanical simulation. In addition, we imposed perturbations on the mechanical mesh based on the buckling eigenmodes. Finally, a thermomechanical viscoplastic analysis was performed layer-by-layer to obtain the final residual stress state and subsequent distortions that occur after cooling down to ambient temperature. A model was used to describe the evolution of porosity due to laser sintering, and then a model of the effects of porosity on the viscoplastic constitutive properties of the sintered material was used in the thermomechanical simulation. Modeling results are compared against experimental specimens using a Durelli (aka, Theta) specimen geometry fabricated with a 3D Systems ProX 200 Selective Laser Sintering (SLS) machine. The geometry of the specimen represents an internal feature with a high aspect ratio that is prone to buckling, and the dimensions were modified based on the simulation results to confirm the ability of the modeling approach to provide accurate mitigation of buckling-induced distortions.

KEYWORDS

Direct Metal Laser Sintering, Selective Laser Sintering, Thermomechanical Finite Element Analysis, Buckling, Thermal Residual Stress