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# A Thermo-mechanical Finite Element Model to Predict Thermal Cycles and Residual Stresses in Directed Energy Deposition Technology

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**Abstract :** In this work, a numerical procedure is proposed to design dense multi-material structures using the Directed Energy Deposition (DED) process. A thermo-mechanical finite element model to predict thermal cycles and residual stresses is presented. A numerical layer build-up procedure coupled with a moving heat flux was constructed to minimize strains and residual stresses that result in the multi-layer deposition of an AISI 316 austenitic steel on an AISI 304 austenitic steel substrate. To simulate the DED process, the automated interface of the ABAQUS AM module was used to define element activation and heat input event data as a function of time and position. Of this manner, the construction of ABAQUS user-defined subroutines was not necessary. Thermal cycles and thermally induced stresses created during the multi-layer deposition metal AM pool crystallization were predicted and validated. Results were analyzed in three independent metal layers of three different experiments. The one-way heat and material deposition toolpath used in the analysis was created with a MatLab path script. An optimal combination of feedstock and heat input printing parameters suitable for fabricating multi-material dense structures in the directed energy deposition metal AM process was established. At constant power, it can be concluded that the lower the heat input, the lower the peak temperatures and residual stresses. It means that from a design point of view, the one-way heat and material deposition processing toolpath with the higher welding speed should be selected.

**Keywords :** event series, thermal cycles, residual stresses, multi-pass welding, abaqus am modeler
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