Consistent Transient Thermomechanical Process Modeling for Additive Manufacturing

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ABSTRACT

The added benefit of Additive Manufacturing (AM) is undeniable in terms of increased design freedom, product customization and small batch production. These benefits come with the challenges of part distortion, internal stresses and process dependent material properties. To improve print quality and increase yield in the printing process, accurate prediction of part deformations, residual stresses, material properties, temperature distribution and history as a function of the printing parameters is desired. The aim for this contribution is to develop a generic Multi-physics AM process simulation framework based on element addition in a Finite Element Method context to simulate the AM process with Fused Deposition Modeling (FDM) as the main AM process.

The proposed generic simulation framework is based on a coupled transient thermomechanical model with a timestepping solution procedure. In contrast to the commonly used quiet and dead/alive element activation method [1] this model utilizes a novel element addition strategy. This strategy takes into account the kinematics and initial conditions of the newly added material to model the increasing simulation domain characteristic for AM processes. For the development of this framework small strains are assumed and simple material models are being utilized. The same GCode machine instructions, as typically used in 3D printers, are used as an input to determine the trajectory for the addition of voxel elements such that no prior knowledge of the intended geometry is required. This is schematically shown in Figure 1. In allow for the application of convection and radiation boundary conditions on the continuously changing simulation domain, a boundary detection algorithm is implemented.

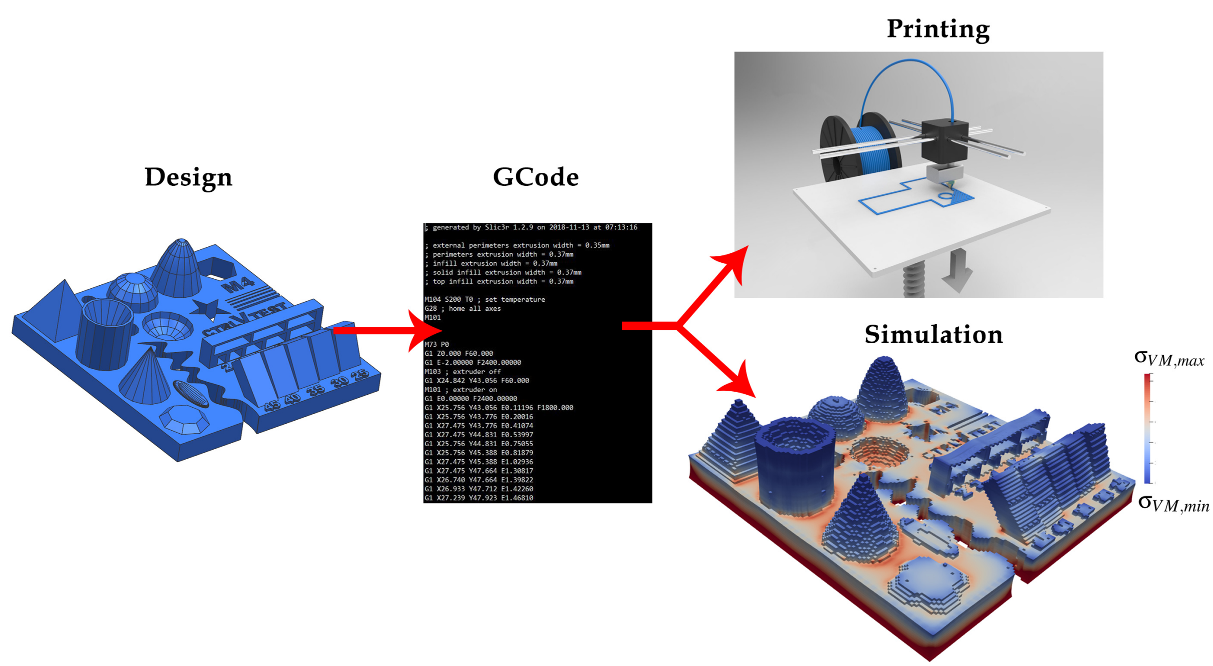

Figure 1: Schematic representation of the GCode implementation to the simulation framework, that allows to use the same input as being used in the printing process

The AM process model framework is validated with a number of smaller experiments, in order to compare temperature field and part deformation after printing.

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REFERENCES

[1] Gouge, M. and Michaleris, P., (2018), Thermo-mechanical modeling of additive manufacturing, Kidlington, Oxford, United Kingdom: *Butterworth-Heinemann*