Simulation of additive manufacturing of alloy 625 with a physically based material model

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ABSTRACT

Additive manufacturing (AM) is a hot topic in the manufacturing industry. The process offers numerous of advantages, such as the ability to create complex shapes and optimized geometries and thus reduce the size, weight and material consumption. However, the additive manufacturing process results sometimes in undesirable distortions and in elevated residual stresses in the final component. To keep these to a minimum, good process parameters must be developed.

Modeling the manufacturing process using e.g. the finite element method can assist the development of the process parameters for different AM processes. Also, modeling the process of AM increases the knowledge and can thus be an aid to develop it, for example in minimizing the distortions and the residual stresses. A common way to model the materials plasticity in finite element simulations is by elastoplastic models with temperature and strain dependent yield stress. These models are simple and do not include e.g. strain rate dependency and stress relaxation.

In the following, a coupled thermo-mechanically finite element model applicable for additive manufacturing simulations are presented. A physically based – or mechanism based – material model for alloy 625 has been developed and is applied in the simulation process. Since the material model is based on the physically mechanisms that are present during plasticity, it is believed that the validity range becomes larger than for a purely empirical elasto- plastic model. The model is calibrated and validated against various temperature and strain rate stress- strain results for powder bed fusion manufactured specimens.