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Abstracts

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A Computationally Efficient Process Modelling Approach for Selective Laser Melting

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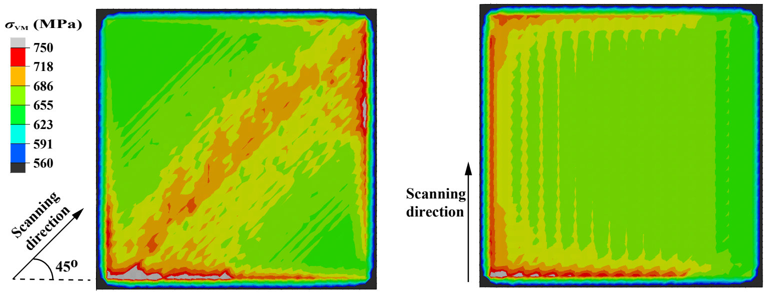
Selective laser melting (SLM) is one of the main additive manufacturing methods suitable for metallic parts. Since SLM has nearly no limitation in terms of geometrical complexity, it enables manufacturing products which cannot be produced by traditional manufacturing techniques. However, a critical issue in SLM is the undesired deformations and residual stresses which arise due to the non-uniform thermal gradients introduced by the laser scanning process.

We present a computationally efficient thermo-mechanical model to investigate the development of deformations and residual stresses during the build for a range of SLM process parameters and various scanning strategies. A semi-analytical thermal model is used to predict the temperature evolution, in which an analytical solution is utilised to capture the steep temperature gradient in the vicinity of the laser, and a complimentary temperature field solved numerically is used to account for the boundary conditions. Since the steep temperature gradient around the laser is accounted for using an analytical description, a coarse spatial discretisation can be used for the numerical solution of the complimentary temperature field.

The temperature field is then used to calculate the thermal strain induced on the SLM product. Corresponding elastic and plastic deformations and stresses are calculated using a temperature dependent elastic-plastic material model with kinematic hardening. The melting behaviour is taken into account by setting the stress and strain to zero when the temperature exceeds the melting point. The mechanical analysis is assumed to have little effect on the temperature field, thus the thermal and mechanical models are one-way coupled. The proposed model is able to describe the development of temperature, associated deformation and stress-strain state within the product during the SLM process.

Case studies for building one layer and multiple layers are investigated. For the one-layer-building process, the influence of different scanning strategies on the residual stresses distributions are studied. The thermal and mechanical simulations are compared with experiments and other simulation results in literature [1]. Next, a block built by multiple layers is simulated and the predicted residual stresses are compared with the experimental results in literature [2]. Good agreements in both cases validate the accuracy of the proposed model.



(a) (b)

Figure 1: The von Mises stress distribution after building one layer with two different scanning directions. (a) The scanning direction is 45^o degrees with respect to the horizontal direction. (b) The scanning direction is along the vertical direction.

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