Simulation for Additive Manufacturing
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Modelling of Stresses, deformations and microstructure evolution during additive manufacturing

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There are many challenges in producing components by additive manufacturing (AM). One of them is to keep the residual stresses and deformations to a minimum. Another one is to achieve the desired material properties in the final component. A simulation model can be of great assistance when trying to reduce the negative effects of the manufacturing process. A model of the process can even be used to tailor the properties such as microstructure in the AM produced component. Finite element models for predicting the thermo-mechanical response during the AM-process will be presented. This work also features a physically based plasticity model coupled with a microstructure evolution model for the titanium alloy Ti-6Al-4V [1]. The microstructure model is thermally driven and is used to derive the evolution of the non-equilibrium compositions of α-phases and β-phase. The FE-model can be used to evaluate the effect of different welding sequences. Validation of the model is performed by comparing measured deformations, strains, residual stresses and temperatures with the computed result. The residual stresses in the component were measured non-destructively using high-energy synchrotron X-ray diffraction on beam line ID15A at the ESRF, Grenoble [2].
Another application that is classified as additive manufacturing is repair welding. An example of modelling of repair welding will be shown. The material in this example is Inconel 718. The material is welded in aged condition. The welding process changes the microstructure vastly, e.g. in this case the precipitates are dissolved. After the repair weld is performed a local heat treatment by induction heating is conducted in order to restore the strength of the material. To better understand the microstructural changes and to be able to predict the mechanical properties of the material a model for the nucleation, growth and dissolution of the γ´´ phase was implemented [3]. The microstructure model is coupled to a physically based flow stress model where the size and volume fraction of the precipitates is one of the main driver for the prediction of the current yield stress.

References

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