Modelling the Anisotropy of Additively Manufactured IN718 Using a Gradient Crystal Plasticity Model Considering Grain Boundaries

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ABSTRACT

Selective electron beam melting represents an additive manufacturing process where parts with complex geometries are built in a layer wise manner using metal powders. The powder is fused by the energy of an electron beam that is guided by electromagnetic fields allowing a very fast deflection and thus various scan strategies. Using these scan strategies it is possible to influence the resulting mesostructure in the material which may range from a columnar to an equiaxed grain structure.

For altered grain structures different macroscopic mechanical properties are expected. Long and similarly oriented grains cause highly anisotropic behaviour. In contrary, a uniform grain structure results in isotropic mechanical behaviour. In summary the different orientations and the effects of grainsize and boundaries strongly influence the macroscopic mechanical properties.

In this contribution the macroscopic material behaviour is simulated by means of mesoscopic Finite Element simulations. Like in [1] a Voronoi tessellation based method is used to model the grain structure of columnar grained Inconel 718. On the mesoscale the thermo-mechanical behaviour is modelled using the thermal gradient-crystal-plasticity model from [2], accounting for relative misorientations on the grain boundaries with the formulation in [3]. Computational homogenization is used to identify elastic and plastic temperature-dependent macroscopic mechanical parameters such as the anisotropic Young's moduli or the yield surface. Numerical results are validated with experimental data.

REFERENCES

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