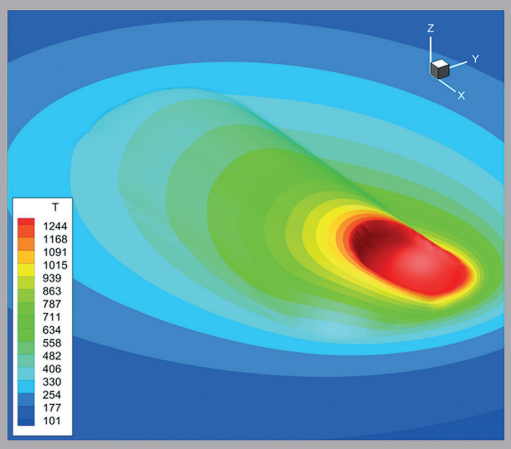
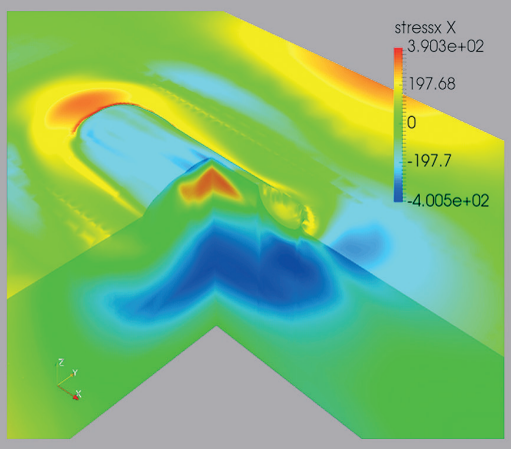


1



2

DISTORTION AND INTERNAL TENSION DURING LASER MATERIAL DEPOSITION

Task

For laser material depositon (LMD), a simulation tool was created with which the user can simulate the process for specific tasks, different process strategies and parameter settings. Adapted process control is intended to reduce stresses and distortion and thus to expand the process limits for LMD.

Method

Mathematically, LMD represents a free boundary value problem whose solution is based on integrating the transient heat conduction equation and the pressure balance equation, while taking into account a mass balance or the powder particles absorbed in the melt per unit time. The simulation is carried out with the finite element method (FEM) on moving network points in order to realize contour-matched networking. For structural mechanics, the melt is extracted from the model at each time increment, so that the stresses are calculated only in the solid phase. The solvent for structural mechanics is massively parallelized and distinguishes itself in large systems of equations by requiring little memory and having high computing speed.

Results

The simulation tool was applied to powder bed-based laser melting and powder-based LMD. Calculated trace geometries (Figure 1) during LMD could be validated by comparison with experiments. The temporally and spatially resolved development of the residual stresses was analyzed for single tracks, overlapping tracks and multilayers for different process strategies (Fig. 2).

Applications

The developed simulation tool can be used to calculate process temperatures and distortion in LMD and Selective Laser Melting (SLM), also known as laser beam melting or Laser Powder Bed Fusion (LPBF). An application is currently being planned for other machining processes such as welding or drilling.

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1 Track geometries and temperature distribution during LMD.

2 Stress distribution during LMD.

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