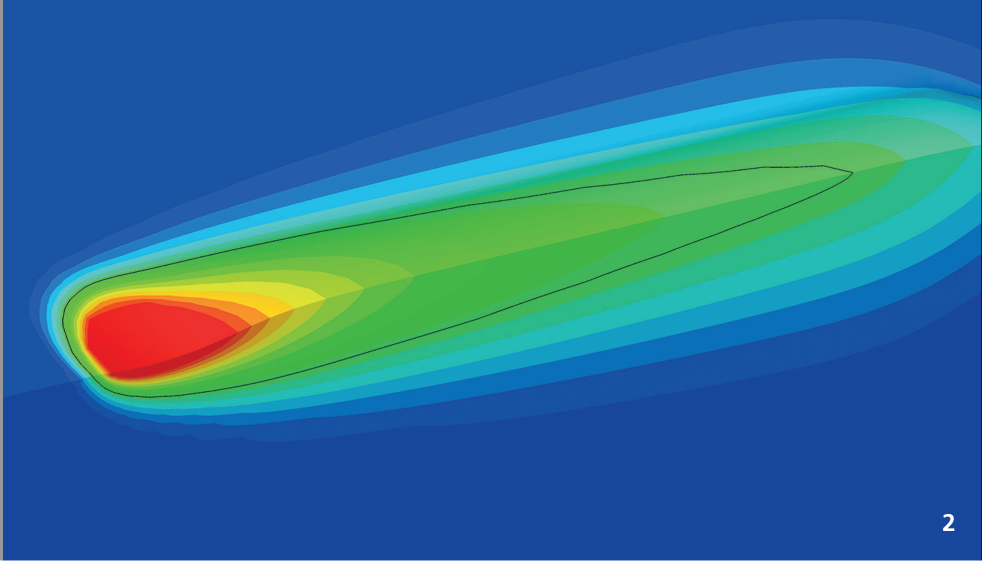

PROCESS SIMULATION FOR SELECTIVE LASER MELTING

Task

When the cause-and-effect relationships during Selective Laser Melting (SLM) need to be systematically analyzed, a Design of Experiment (DOE) is normally used. The experimental costs for a full-factorial DOE in SLM are very high due to the many, partly dependent parameters. In practice, the number of test points shall be reduced by two factors. First, specialized knowledge is used to reduce the DOE and to select test points more skillfully. Second, the (further) developed micro model for SLM serves to simulate the process for various parameter settings and to restrict the possible test points mathematically. Furthermore, the physical phenomena relevant to the process shall be identified and understood from the comparison between model and experiment. A cause-effect relationship shall be derived between the solidification conditions calculated with the model and the structure generated and microstructure resulting in the experiment.

Method

Mathematically, SLM constitutes a free boundary problem. To solve this problem, the transient heat conduction equation and the pressure balance (Young-Laplace) equation need to be integrated, while the vapor pressure and the mass balance of the powder layer melted per time interval are taken into account. In a separate model, Fraunhofer ILT has simulated the interaction of the laser radiation with the powder layer as they depend upon the measured particle size distribution. For these models, the track geometry and the temperature distribution (Figure 2) have been calculated and resolved in time as a function of process parameters and the thermo-physical properties of the materials.

Result

The advanced simulation tool is currently in the validation phase; since melt pool depths were calculated as too small, other physical effects have to be implemented. Once experiment and model agree well with each other, then DOEs will be reduced in size due to the input of the simulation.

Applications

The results obtained by these simulations can be employed to adapt the process control specific to material or component and/or to generate improved process understanding.

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2 Simulated track geometry and temperature distribution.