Subproject A11

Title
Dimensional and geometrical accuracy in generative laser cladding

Project management/-processing
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Task definition
The challenge and central task in subproject A11 is to increase the geometric precision in laser cladding (LMD). In the period under review, the focus was on edge processing. There, the deviations from the nominal geometry are usually greatest, since the melt forms a bead (edge throw-up, see Figure 1, right) around the edge before solidification. The driving force here is the surface tension (interface: liquid-gaseous).

Procedure
In order to be able to make a prediction about the geometry arising at edges, the existing LMD molten pool model was extended in such a way that the free energy of the surface can be minimized in a triangular network (see Figure 1, left) under the boundary condition of the correct increase in mass or volume (per time step) by the powder mass flow. The LMD process model for the description of the melt pool takes into account particle propagation through the laser beam acoustics, shading of the particles along the beam, modification of the power density distribution transmitted to the component, heat conduction in the component and determination of the curvature of the melt pool surface due to the increase in volume and surface tension.
The results of the model are compared with 3D measurements of fabricated samples to analyze the deviations.

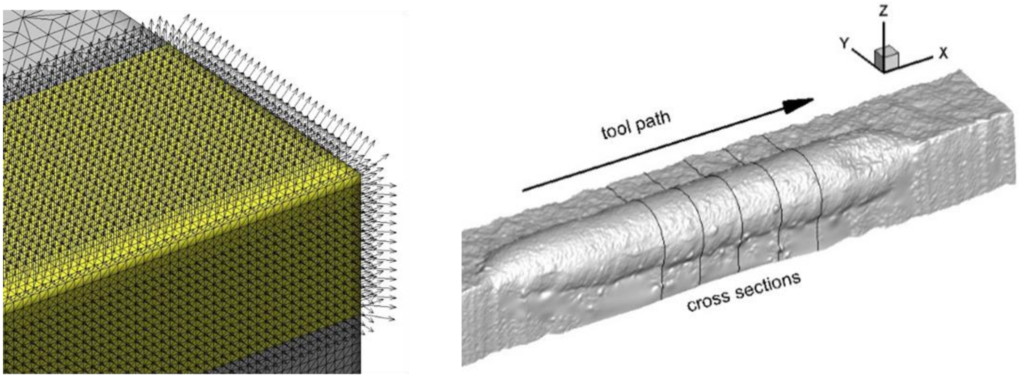

Abbildung 1 Links: Dreiecksnetz einer Kante zur Simulation des Schmelzbadverhaltens, rechts: eingescannter Kantenaufwurf einer LMD Probe nach Bearbeitung

Results

The primary result is the now available model-based capability of calculating the edge throw-up during laser cladding. Furthermore, after extended verification (other systems, variation of process parameters, etc.) the geometry of the edge throw can be predicted. Thus, the processing parameters can be adapted in the experiment in such a way that the desired geometry is produced more precisely. Especially the distance of the processing path to the edge (edge offset) can be adjusted accordingly.

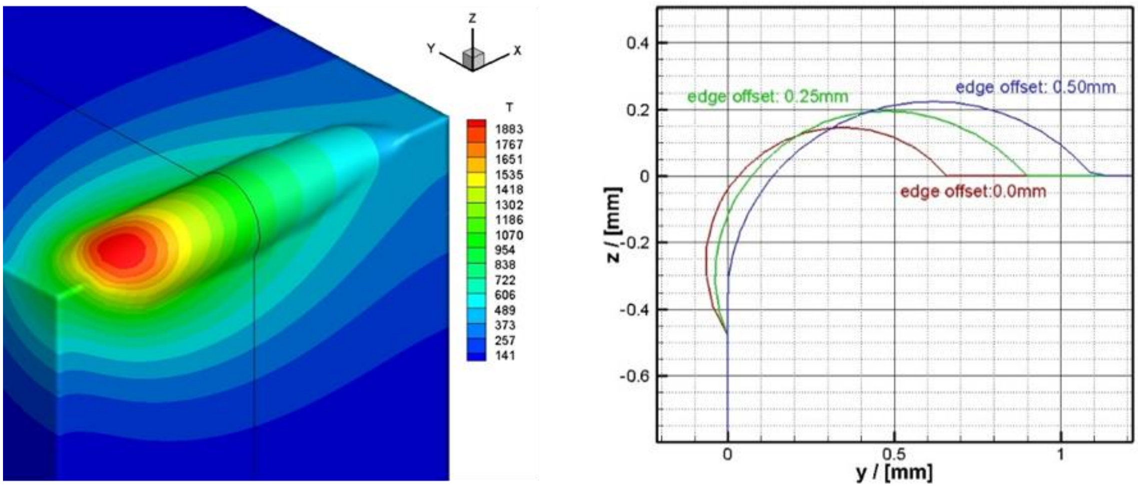

Figure 2 left: Calculated geometry and temperature distribution for LMD, right: calculated edge throw-up as a function of the edge offset (distance of the processing path to the edge)

It is also possible with the model to show the welding around corners (see figure 3).

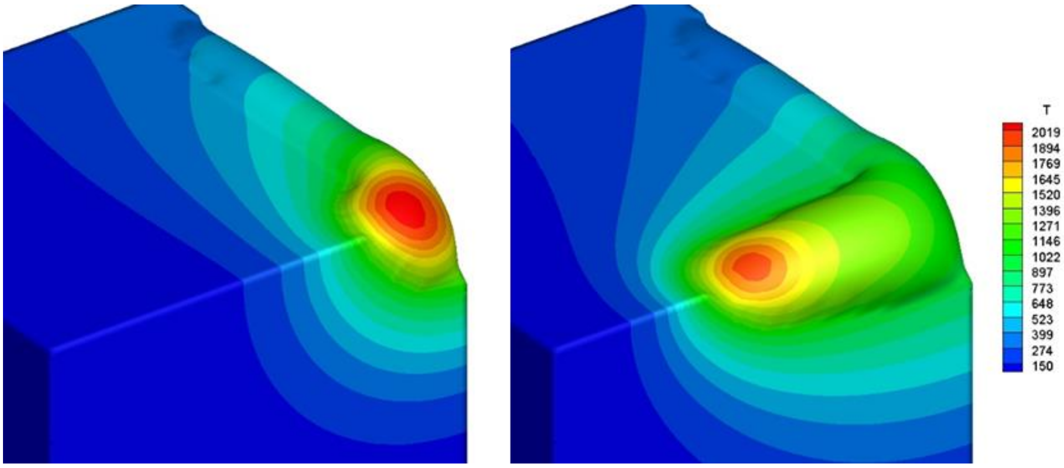

Figure 3 Simulation: Welding around corners

Summary and Conclusion

In the coming reporting period, the developed model will be used to increase the geometric precision of the LMD. One possible approach for corner welding is process control with adapted laser power, which is based on the distance to the corner. The model is to be further validated.
A further research question is the precise filling of trough-like geometries using LMD and the determination of guidelines for optimized offline path planning for the LMD process.

Publication

Pirch, N.; Niessen, M.; Linnenbrink, S.; Schopphoven, T.; Gasser, A.; Poprawe, R.; Schöler, C.; Arntz, D.; Schulz, W., 2018. Temperature field and residual stress distribution for laser metal deposition. In: J. Laser Appl., Vol. 30 (3), 032206 (2018); doi.org/10.2351/1.5040634