Highlight

Aachen,
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Computer simulations of advanced irradiation strategies for the thermally optimized laser welding of thermoplastics

Significant advances in the last decade related to computer simulation software made possible the investigation of complex processes reducing drastically the time needed to set up the underlying equations, material properties, and boundary conditions for a given problem. Therefore, using commercially available simulation software a computer model for advanced irradiation approaches such as of the TWIST® process was developed in order to achieve a better understanding and further development of the process.

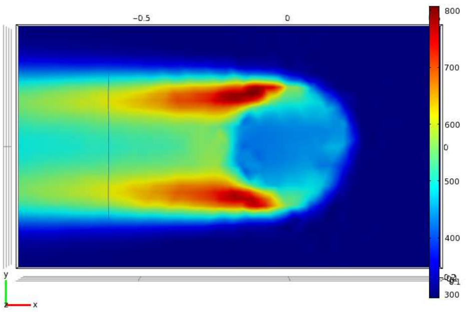

Figure 1: Simulation result for the heat distribution in the welding area from a top view and a circular beam oscillation

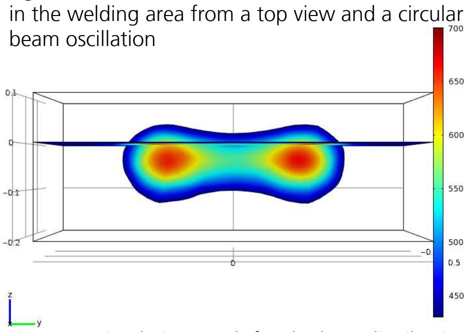

Figure 2: Simulation result for the heat distribution in a cross-section of the weld seam and a circular beam oscillation

Successful experimental results obtained with the TWIST® process over the last years confirmed that the used of advanced irradiation strategies lead to an optimized energy input in the welding area, and finally to an increased process robustness. In order to get a deeper and more detailed process insight and to determine the influence of the process parameters on the welding result a computer model that considers the beam oscillation of the TWIST® approach was developed. Since the laser beam welding of polymers is based on the transformation of the laser beam optical energy into thermal energy (heat) within the welding specimen, the heat transfer module of the COMSOL Multiphysics software has to be used for the computer simulations. COMSOL Multiphysics is an interactive environment for modeling and solving scientific and engineering problems based on partial differential equations (PDEs).

The developed computer model enables the overlap of high dynamic beam oscillations along different patterns such as circular or eight shapes to the feed movement of the laser beam along the desired welding contour. Feeding the model with accurate material and laser beam data high valuable process information can be acquired. For each set of process parameters used for the simulations mainly three data sets are extracted. In a first step the appearance and dimensions of the Heat Affected Zone (HAZ) in a top view of the welding area is analyzed (Figure 1). Based on this information the expected width of the weld seam and an eventual

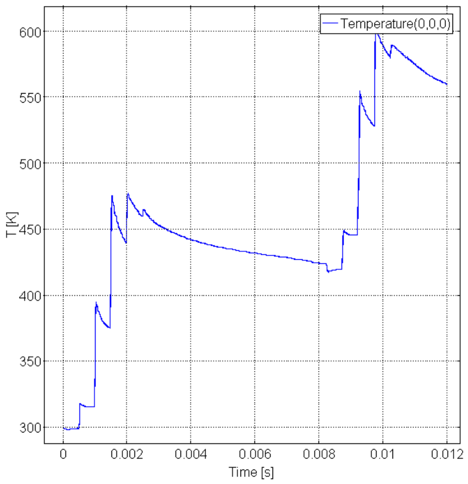

Figure 3: Temperature profile for a fixed point in the middle of the weld seam and a circular beam oscillation

local overheating can be determined. Figure 1 shows such an overheating effect that occurs at the sides of the weld seam for a circular beam oscillation. The next set of data, extracted after each simulation, reveals the appearance of the HAZ in a cross section of the weld seam along its width (Figure 2). Based on this data the depth and width of the HAZ in both transparent and absorbing joining partner can be determined. The shape and the homogeneity of the energy input in the material can be analyzed as well. The last set of key process information is extracted for a point fixed in the middle of the weld seam considering the weld seam width. Monitoring the temperature development for the selected point during the welding process it can be observed that depending on the TWIST® parameters a defined temperature profile can be achieved (Figure 3). Introducing oscillation frequency and amplitude as additional process parameters compared to the conventional laser contour welding the TWIST® process allows the flexible adjustment of the heating and cooling curve for the joining materials depending on the specific requirements of each joining task.

Currently intensive simulation activities are carried out for different oscillation patterns and process parameters in order to fully characterize their influence on the welding result

For any further questions our experts will be pleased to provide you assistance:

Contacts at Fraunhofer ILT

Dipl.-Ing. Andrei Lucian Boglea
Phone +49 241 8906-217
andrei.boglea@ilt.fraunhofer.de

Dr. Alexander Olowinsky
Phone +49 241 8906-491
alexander.olowinsky@ilt.fraunhofer.de

Fraunhofer Institute for Laser Technology ILT
Steinbachstrasse 15
52074 Aachen, Germany
Phone +49 241 8906-0
Fax +49 241 8906-121
www.ilt.fraunhofer.de

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