Numerical simulation of large DED structures

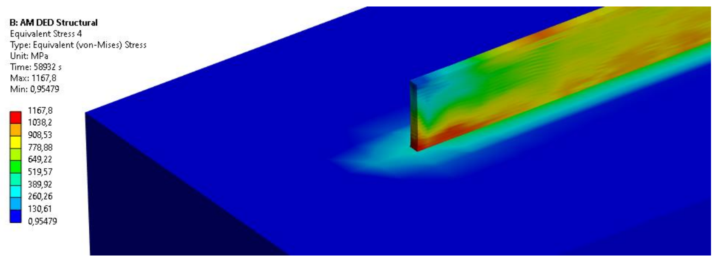
Author/s

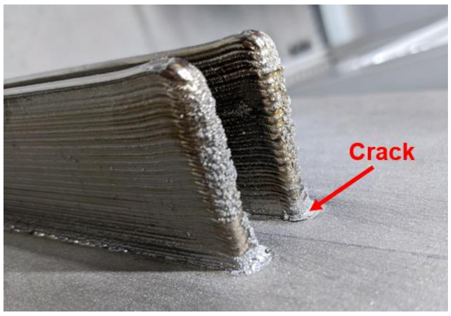
M. Sc. Reza Kaboli, Dipl.-Ing. Moritz Greifzu
Fraunhofer-Institut für Werkstoff- und Strahltechnik IWS, Winterbergstr. 28, 01277 Dresden, Germany

Contact: reza.kaboli@iws.fraunhofer.de; Phone +49 351 83391-3878,
Fax +49 (351) 83391-3300, www.iws.fraunhofer.de

Abstract

3D printing is a cost-effective method for creating complex designs and single-step assemblies. The directed energy deposition (DED) technique uses lasers or electron beams to melt solid material and add either powder or wire.
This technique can lead to overheating, warping, and residual stress, particularly in larger components. The Fraunhofer Institute IWS, commissioned by the European Space Agency (ESA), creates an optical bench from TIAl6V4 alloy with a diameter of 3m, using a combined approach of laser powder welding and precision machining. Due to the size of the bench, simulations are crucial for quality assurance.
The Direct Energy Deposition (DED) manufacturing simulation closely mirrors the actual print process. Given the weak linkage between thermal and structural behaviors, the thermal events are initially modeled, and the derived temperature data is incorporated into the subsequent structural analysis. As the simulation advances, new elements are introduced. The established "birth and death" technique activates clusters, symbolizing weld track portions, guiding the construction simulation. The process concludes when all these clusters are operational.
The calculations were conducted in the ANSYS Additive Wizard, based on the approach described above. To calibrate the model, a simulation model for calculating temperature and distortion was developed based on experimental results. The findings indicate that the maximum inherent stresses occur at the end and beginning of the deposition line close to the substrate. These maximum inherent stresses nearly reach the material's maximum yield stress of approximately 1.2 GPa, which promotes crack formation. In the experiments, cracks were also observed at the exact same location.





After verifying the simulation model on a basic geometry, the simulation was extended to a simplified version of the original component. The maximum stresses were observed on the deposition body, particularly at the circumference of the circle and along the radial connection lines. Contrary to the previous model, the inherent stresses in this case were primarily evident on the substrate and around the circumference. Research indicates that the nature and placement of supports significantly affect the magnitude of these inherent stresses.

Literature

[1] Max ANSYS Inc.: ANSYS Additive Help. In: ANSYS Documentation. 2023