INDUSTRIAL PILOT PROJECT

Synchrotron SRµCT and XRD investigations of crack mechanisms in parts produced by laser powder bed fusion additive manufacturing

THE INDUSTRIAL CHALLENGE

Porosity is a critical issue in additive manufacturing (AM) of metals. By modifying the process parameters, the density of printed parts can be varied. However, in certain alloy systems, higher density increases cracking. Low levels of porosity important for good properties but the presence of crack is detrimental. It is therefore important to understand why and when in the process chain these cracks form in order to produce high quality parts.

WHY USING A LARGE SCALE FACILITY

Previous microstructure studies using light optical microscopy have indicated a higher susceptibility to cracking in high-density parts. However, for volumetric quantification of the pores and cracks, SRµCT-data is required. Compared to light optical microscopy, synchrotron radiation sources with high flux and brilliance enables rapid assessment of large volumes, while providing comparable resolutions.

By using synchrotron based XRD, information can be collected from a volume instead of just the surface as in laboratory XRD. This is crucial for an accurate correlation of residual strain with the porosity measurements.

HOW THE WORK WAS DONE

The experiments were performed at the Swedish Materials Science (SMS) beamline P07 by Ulrich Lienert at the Petra III synchrotron in Hamburg, which offers the combination of XRD and SRµCT. In order to investigate the effect of porosity levels on crack initiation and propagation in AM parts, 3x4x10mm samples with various porosity levels was analysed (as-built samples with different densities from 97.7% to >99.9%) as well as stress relived samples and samples still attached to the build plate. The six samples required 8 hours of beamtime for the XRD analysis.

THE RESULTS AND EXPECTED IMPACT

Clear increase and stronger variation in strain was seen as the porosity decreased while samples still attached to the build plate had a different strain profile. After stress relieving, a low and uniform strain profile was found. Together with the SRµCT-data it is possible to better understand the link between porosity, residual strain and strain relaxations due to cracking. However, more work using this methodology is needed to fully understand this link.

With the higher richness of detail and the volumetric data that the large-scale facilities offer, Kanthal gets a new powerful tool for solving future challenges in AM. Rapid implementation of this technology in industry for similar investigations is possible through the methodology developed in the project.

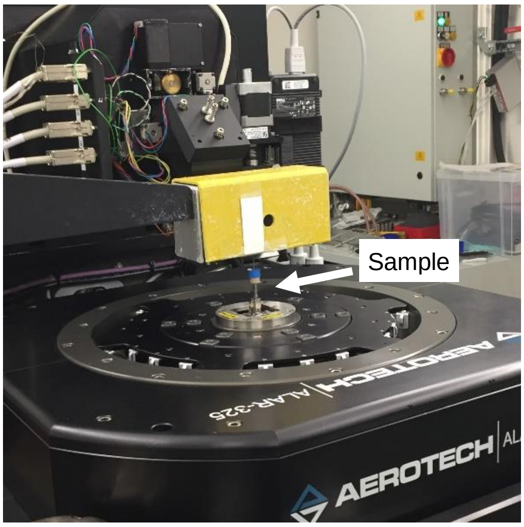

Figure. Experimental setup of the SRµCT.

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