Virtual testing of geometrically imperfect additively manufactured lattice structures

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ABSTRACT

Selective Laser Melting enables the production of lattice structures from AlSi10Mg metal powder. These lattice structures can be used to build lightweight components with high load carrying capacity. The material properties of additively manufactured AlSi10Mg and aluminium alloys produced by other manufacturing processes differ greatly due to process-induced imperfections. Therfore, an experimental and virtual testing approach on two scales for the modeling of these lattice structures is presented.
Tensile tests on the basic material are performed to derive effective material parameters for material modelling. The detailed analysis of fracture surfaces and microstructure leads to information about process-induced properties on the microstructure level.
Geometric imperfections are macroscopic effects of the manufacturing process. Additional material on the struts due to the high energy input into the powder bed is considered through a systematic variation of the geometry of the lattice structure [1]. Porosity due to evaporation within the manufactured component is quantified and considered with a damage model [2]. Those investigations are initially performed on a 2D-model to evaluate parameter sensitivities and derive suitable adjustments for the 3D-model on the second scale.
Test specimens for pressure, tensile, torsion and shear tests are manufactured and tested. To validate the modelling approach and the influence of the identified process-induced imperfections virtual tests of the modelled test specimens are performed and compared to the experiments.

REFERENCES

[1] Liu, L. et al., Elastic and failure response of imperfect three-dimensional metallic lattices: the role of geometric defects induced by Selective Laser Melting. *Journal of the Mechanics and Physics of Solids* (2017) **107**:160-184. Vol. I., (1989), Vol. II., (1991).

[2] Amani, Y. et al., Compression behavior of lattice structures produced by selective laser melting: X-ray tomography based experimental and finite element approaches. *Acta Materialia* (2018) **159**:395-407.