Numerical failure locus of micro-lattice structures obtained by SLM: validation of the models and comparison with experiments

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ABSTRACT

The microlattice structures manufactured by 3D printing are increasingly adopted in aerospace components because of their lightweight and thermal exchange properties. If the design is based on simple homogeneized properties [1], then the assessment of the components needs a precise description of the strength of lattice cells. This work presents a detailed study on numerical simulations of the mechanical behavior of microlattice structures obtained by SLM with AlSi7Mg powder, with a particular attention paid to modelling a failure locus.

The mechanical behavior of the lattice body centered cubic, named as BCC, cells in tension and compression have been modeled numerically simulating only one single cell of lattice with periodic boundary conditions (PBC). Simulations have been performed on the ideal geometry, i.e. the one sent to the printing machine, and on the real geometry, extracted from CT scan. The model proposed has been firstly validated numerically comparing the results of the simulations of one single cell with PBC with the results of the simulations of the entire compression specimen with elasto-plastic parent material constitutive law. Then, the Gurson-Tvergaard-Needleman damage model [2, 3] has been implemented, in order to predict failure of the structure. The parameters of this damage model, that was recently used for the failure prediction of aluminum components (lattices and foams) obtained by SLM [4, 5], were calibrated with micro-tensile tests conducted on the parent material obtained with the same SLM process. Good correlation has been found between strain localization predicted by the FE analysis and the one observed by Digital Image Correlation analysis on the specimen during the test. Moreover, the failure localization are well predicted by the numerical models and are in agreement with what observed experimentally.

Finally, for the BCC cell topologies a numerical failure locus has been found imposing bi-axial load condition on the cell with PBC. As a first approximation, the curve identified by the Mohr-Coulomb fracture surface for brittle material can be considered representative of the failure domain of the considered lattice structure.

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