Light-weight Construction: Robust Simulation of complex loaded cellular Structures

Florian Brenne

In order to reduce the energy consumption of moving parts as well as the total amount of the material used, diverse light-weight strategies are currently in the focus of industry and research. One promising light-weight strategy is the application of additively manufactured cellular structures, which due to their low relative density are characterized by high relative strength. These structures can be adapted to the load by local modification of the strut diameter or strut orientation (Figure 1). Consequently, a more efficient design can be achieved allowing for reducing the structural weight as well as the overall material use. For industrial application a robust and reliable simulation is imperative, as the structural performance in dependence of both the cellular design and the microstructure has to be predictable under complex loading scenarios prevailing in many actual applications. Thus, the establishment of a robust FEA model for complex loaded cellular light-weight structures will be aim of this project.

Preliminary Analysis

Deformation behavior determined by digital image correlation (DIC) and finite elements analysis (FEA)

In a preceding project, the occurring deformation mechanisms of metallic specimens under uniaxial and bending load were investigated. A straightforward simulation of a simple cell geometry under uniaxial load showed a good accordance between the observed and simulated local deformations (Figure 2). Still a simulation under bending load proves difficult and the microstructural condition could not yet be taken into account.

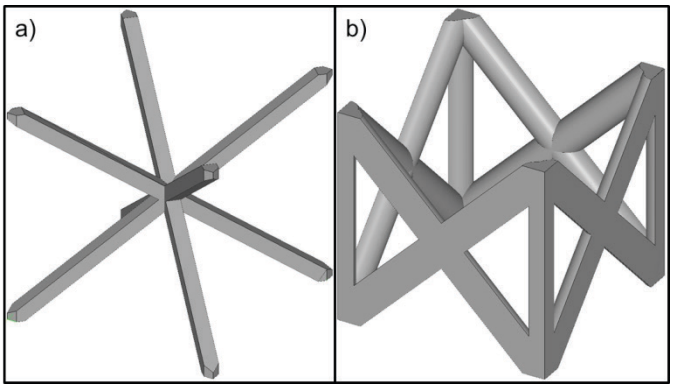

Figure 1: Design of a body- centered base cell a) and face- centered base cell with additional struts in loading direction b)

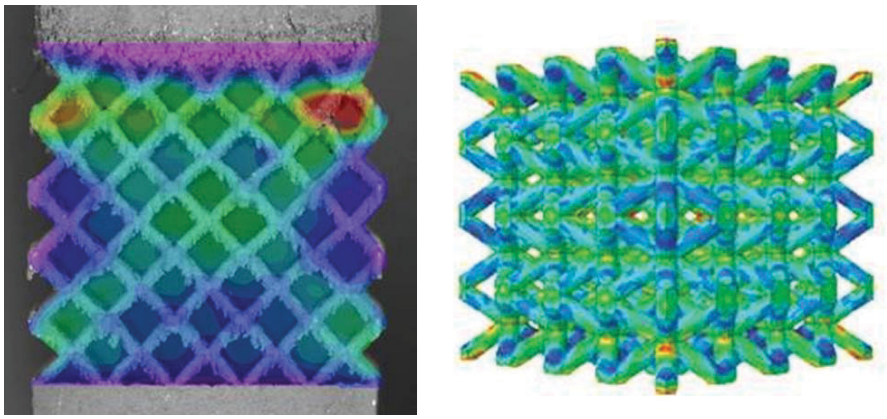

Figure 2: Local strains under compressive force as determined by DIC (left) and FEM (right).

Approach

The key activities in order to obtain a robust FEA model include:

- Design of different base cell types to be investigated
- Microstructural modification by (local) heat treatments
- Mechanical testing and local strains analyses
- Development of different FEA models for simulation
- Verification

Mechanical testing and verification of obtained FEA models for metallic and plastic materials