Cyclic loaded elastoplastic metallic lattices: experiments and simulations

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The explosion of additive manufacturing techniques of the last decades has produced an important number of studies on lattice structures manufactured both out of polymer and metallic materials. Several aspects have been discussed: (i) influence of microstructure on the global material behaviour, (ii) shape and topology optimization of the microstructure, (iii) material microstructure and global material behavior [3, 4].

Our goal is to analyze an elasto-plastic lattice structure under cyclic mechanical loading both from the experimental and the numerical point of view, emphasizing elasto-plastic localization, shakedown and failure and taking into account the real manufactured structure with its variability imposed by the process following [2, 1]. More specifically, we consider a 316L stainless steel lattice structure manufactured by selective laser melting (SLM).

The structures are tested under tensile and compressive regimes with monotonic and cyclic type of loading. Let us remark that the tensile loading of lattice structure is an original aspect of this work, which is utmost importance for applications under cyclic loading in fatigue. The results present strain localization bands where final failure will occur, plastic shakedown and ratcheting. Failure initiates in a small number of struts and then propagates rapidly to the complete failure of the specimen. The structures have been observed pre- and post mortem using SEM and several aspect can be exhibited ranging for texture and microstructure of the grains, surface analysis of the manufactured free surfaces and of the final failure surface.

The computation permit to assess the impact of the geometric variability of the lattice structures in terms of surface waviness, node position and cross-section variation on the global behavior of the structure. For example, it has been shown that taking into account this variability permits to precisely predict the yield plateau of the structure.

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