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Geometric Imperfections in Lattice Structures: A Simulation Strategy to Predict Strength Variability

Authors : Xavier Lorang, Ahmadali Tahmasebimoradi, Chetra Mang, Sylvain Girard

Abstract : The additive manufacturing processes (e.g. selective laser melting) allow us to produce lattice structures which have less weight, higher impact absorption capacity, and better thermal exchange property compared to the classical structures. Unfortunately, geometric imperfections (defects) in the lattice structures are by-products results of the manufacturing process. These imperfections decrease the lifetime and the strength of the lattice structures and alternate their mechanical responses. The objective of the paper is to present a simulation strategy which allows us to take into account the effect of the geometric imperfections on the mechanical response of the lattice structure. In the first part, an identification method of geometric imperfection parameters of the lattice structure based on point clouds is presented. These point clouds are based on tomography measurements. The point clouds are fed into the platform LATANA (LATtice ANAlysis) developed by IRT-SystemX to characterize the geometric imperfections. This is done by projecting the point clouds of each microbeam along the beam axis onto a 2D surface. Then, by fitting an ellipse to the 2D projections of the points, the geometric imperfections are characterized by introducing three parameters of an ellipse; semi-major/minor axes and angle of rotation. With regard to the calculated parameters of the microbeam geometric imperfections, a statistical analysis is carried out to determine a probability density law based on a statistical hypothesis. The microbeam samples are randomly drawn from the density law and are used to generate lattice structures. In the second part, a finite element model for the lattice structure with the simplified geometric imperfections (ellipse parameters) is presented. This numerical model is used to simulate the generated lattice structures. The propagation of the uncertainties of geometric imperfections is shown through the distribution of the computed mechanical responses of the lattice structures.

Keywords : additive manufacturing, finite element model, geometric imperfections, lattice structures, propagation of uncertainty
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