Development of a Design Optimization Framework for TPMS-Based Sandwich Structures under Blast Loading

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The demonstrated potential of energy absorption and impact resistance of triply periodic minimal surface (TPMS)-based lattice structures is the motivation of this project. The goal of the project is to develop an efficient framework for finding optimal designs of TPMS-based sandwich structures for blast protection. Optimal grading of the TPMS-based lattice structures is performed by numerical multi-fidelity experiments using Abaqus/Explicit and machine learning supported surrogate models. First, compactly supported radial basis function networks are trained for the low-fidelity data, and then ensembles of surrogate models are generated by minimizing the cross-validation error of the high-fidelity data obtained from the Abaqus/Explicit simulations. The optimization is then performed using these optimal ensembles of surrogate models. The blast pressure on the structure is applied using the empirical ConWep model which is implemented in Abaqus/Explicit. During the development of the framework 316L stainless steel is chosen as material for the sandwich structure, which is modelled using J2-plasticity with isotropic Johnson-Cook hardening. The constitutive Johnson-Cook parameters for the hardening are determined using the method of least squares applied to the Cauchy stress and the logarithmic strain. Additionally, a continuum damage model is activated when the logarithmic failure strain is reached. While strain rate and temperature dependencies will be included in future versions of the framework. Furthermore, the lattice structure is modelled using either shell elements with representative thicknesses, or solid elements with representative constitutive properties obtained from numerical homogenization. Finally, the optimal result is mapped back to the implicit surface geometry, which in turn is converted to a printable STL-file. The workflow of the framework and optimal designs will be presented at the conference.