Mixed Integer Optimization for Truss Topology Design Problems as a Design Tool for AM Components

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ABSTRACT

One of the most important advantages of additive manufacturing (AF) in relation to Truss Topology Design (cf. [1]) is that there are fewer manufacturing constraints than in classical manufacturing, which makes it possible to manufacture much more complex and fine-granular unstructured lattices. To use these advantages, it is important that the components are optimized in advance with a design tool. Against this background a mixed integer program (MIP) - based on [2] - is developed, in order to use mathematical optimization and the associated possibility of using powerful standard solvers (e.g IBM ILOG CPLEX) to optimize unstructured lattices. This work consists of three interdisciplinary sub-areas, mathematical optimization, AF as a manufacturing process and a link between these sub-areas in the form of a CAD extension for the automatic construction of optimization results. Intension is to contribute to strengthening the field of Operations Reserach in the engineering sciences, so-called Technical Operations Research (TOR), see [3] as an example for a algorithmic system design of thermofluid systems.
In the presented MIP, instance variables such as the static load case itself, various material specifications and the installation space - ground structure (three-dimensional) with the binary condition to (not) mount a bar - are specified for each load case. The aim is to determine the design holistically using a MIP instead of optimizing an existing design (fixed ground structure, without binary condition) with regard to e.g. bar thicknesses. A topology optimization and a shape optimization (minimization of the necessary material) is modelled. This approach does not lead to any additional effort for the optimization of unstructured lattice structures, as each bar is considered constituent. Subsequently, the optimization results are converted into a assembly by a CAD extension. The assembly can then be subjected to a strength and deformation analysis using numerical methods in order to compensate the disadvantages of the purely static approach from the MIP. Finally, the AF can be used to produce the lightweight structure developed solely with the MIP. We will present the theoretical background of the MIP the workflow to combine mathematical optimization with AF, and first results manufactured with selective laser sintering.

REFERENCES

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