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Coupling Lattice Structure Topology Optimization with Design-Dependent Feature Evolution for Additive Manufactured Heat Conduction Design

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Abstract: Significant advance in additive manufacturing (AM) is leading to a paradigm shift in design-for-manufacturing. The manufacturability concern over geometry complexity has largely been removed by AM, which will greatly promote design creativity. A representative paradigm shift is the increasing focus on lattice structures which can be efficiently manufactured by AM. Specifically, lattice structures have been used to replace conventional solid materials to reduce weight and enhance multi-functional properties. Hence, lattice structure topology optimization (LSTO) has drawn remarkable interest for being an optimal lattice infill design tool. Despite the extensive investigation on LSTO, this paper addresses a novel aspect in the concurrent optimization of lattice infill and design-dependent movable features, on which boundary conditions are prescribed. This type of problem has practical importance, such as cooling channel system (forced convective boundary) design used in different thermal management applications, which is challenging to solve numerically due to the increased complexity in sensitivity calculation. In the proposed method, parametric level set function is used to represent the movable feature geometry and accordingly, the thermal boundary conditions are implicitly applied. A detailed sensivity analysis is performed to provide the effective sensitivity information for design update. Several numerical examples are provided to prove the effectiveness of the proposed method. In particular, the proposed methodology is applied to the concurrent optimization of cooling channels and the optimized design is printed out to demonstrate the manufacturability.

Keywords: Lattice structure topology optimization; Immersed boundary method; Level set method; Additive manufacturing