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Integrated topology optimization of multi-component structures considering connecting interface behavior

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Abstract

It is often highly desirable to simultaneously optimize the layout of embedded functional components and the topology of the host structure supporting these components to achieve the best overall performance while still ensuring the structural integrity. We propose a topology optimization framework to account for connecting interface behaviors between the components and the host structure. Here we treat the connecting interfaces with the cohesive zone model to reflect the adhesively bonded interface behaviors. A conforming mesh in conjunction with interface elements is employed to discretize the evolving structure while accounting for the strong discontinuity of displacement field across the material interfaces. To give a clear representation of structural boundaries and the connecting interfaces, we also suggest a multi-material interpolation model in the level set framework, which can conveniently define the connecting interface locations and describe multi-material distribution without redundant phase in the design domain. The objective function is defined as the sum of the strain energy and the work done by the traction on the connecting interface, and the evolution velocities of the level set and the embedded components are treated as design variables. These design variables are updated with the MMA optimizer on the basis of adjoint-variable sensitivity analysis. This optimization formulation allows multiple constraints and mixed design variables (*i.e.* level set design variables and components' design variables) to be easily handled in level set based optimization. The design is advanced by the Hamilton-Jacobi equation with the velocity design variables as input. Numerical examples demonstrate the validity and applicability of the proposed method.

Keywords: Integrated topology optimization; interface; multi-component; multi-material;

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