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Topology optimization for coated structures and material interface problems

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Abstract

Coating is commonly used to enhance functional properties or to reduce component cost. A cheap polymer which is easily processed into complex shapes can be used as a substrate to create a base structure. Coating such a structure with a superior material combines the processing and cost advantages of the substrate with the performance benefits of the coating material. Based on a recent paper [1] a novel method for including coated structures and prescribed material interface properties into the minimum compliance topology optimization problem is presented. The original study [1] was limited to 2D applications. Here, the method is extended to 3D.

Several elements of the method are applicable to a broader range of interface problems. The approach extends the standard SIMP method by including the normalized norm of the spatial gradient of the design field into the material interpolation function, enforcing coating material at interfaces by attributing particular properties. The length scales of the base structure and the coating are separated by introducing a two-step filtering/projection approach.

An alternative interpretation of the model is to perform single-material design for additive manufacturing. Optimized components will have a solid outer shell. Infill is assumed to be constituted of an isotropic porous microstructure satisfying the Hashin-Shtrikman bounds and is modeled using the homogenized material properties.

References

[1] A. Clausen, N. Aage, O. Sigmund, Topology optimization of coated structures and material interface problems, Computer Methods in Applied Mechanics and Engineering, Available online 2015, (DOI: 10.1016/j.cma.2015.02.011)