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Tailoring Structural and Material Topologies under Thermal and Mechanical Loads Using Level Set Topology Optimization

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Structures in advanced applications may simultaneously sustain multiple types of loads, e.g. mechanical and thermal loads, rather than single physics. This presentation will introduce topology optimization under a thermo-mechanical environment for multiscale structural-material systems, where design optimization is applied at two scales, namely macroscale for find the optimal structure and microscale for the material architecture. To achieve this, the principle in [1] is adopted to decompose the two-scale optimization problem into macro- and microscale design problems and to solve the decomposed problems simultaneously for the overall optimum solution. The asymptotic homogenization method is used to bridge the two scales through the effective elastic properties for simulation and optimization. This approach allows any number of unique microstructures, e.g. finding optimal microstructures in specific regions of the macroscopic structure, to be designed. In the present study, we employ level-set topology optimization to provide smooth and well-defined structural boundaries. The optimization problem e.g. compliance minimization is first linearized with respect to design variables using the standard Taylor series expansions, and optimal updates of design variables are determined by a gradient-based method. Several optimization problems are solved to illustrate the performance of the proposed approach. For instance, the figure below show the optimal micro- and macro-structures under a mechanical load with and without the presence of a thermal load are obtained for the minimal compliance.

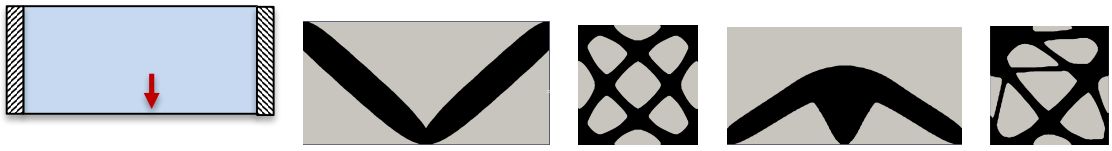

Figure 1. A clamped beam (a) boundary conditions, (b) and (c) optimal macro- and micro-structure without a thermal load, (d) and (e) optimal macro-micro-structures with a thermal load.

REFERENCES

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