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Integrated design of cellular materials and structures using the topological shape optimization

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Abstract

Integrated design of cellular materials and structures using the optimization methodology shows great significance in both science and engineering. As the homogenization method providing a rigorous way to predict the effective mechanical behavior of the micro-structured materials, the topology optimization approaches are successfully used to design the ultra-lightweight cellular materials to achieve specific multifunctional properties such as energy absorption, anti-impact and thermal isolation. However, the optimal design will never be obtained unless the loading and boundary conditions of the macrostructure are considered. Therefore, this paper presents a systematic method to solve the integrated design problem of material and structure. The optimization process is divided into two levels, in which the first level is macrostructure design by using the SIMP to describe the hierarchical structural layout with intermediate densities, and the second level is material microstructure design by integrating the numerical homogenization approach into a powerful parametric level set method (PLSM). Several numerical cases are given to showcase the characteristics of the integrated design method.