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Novel Approach in Topology Optimization of Porous Plate Structures for Phononic Bandgaps of Flexural Waves

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Abstract

This paper presents a novel multiobjective optimization strategy for topology optimization of single material phononic plates (PhPs), where the achieved topology can be produced by perforation of a uniform background plate. The primary objective of this optimization study is to exploit the widest relative bandgap of fundamental flexural guided wave modes for maximized phononic controllability. Principally, the optimum topology of such porous structure favors isolated scattering domains leading to maximized interfacial Bragg reflections. Hence, the widest achievable bandgap depends on assumed topology resolution and relevant topology generally has low structural worthiness. Therefore the homogenized in-plane stiffness of phononic unitcell is also incorporated in topology optimization as the second objective to explore the gradient of optimum bandgap topology with respect to its in-plane stiffness. Consequently, structurally worthy bandgap topologies with desired relative bandgap-stiffness performance could be taken from the obtained spread of optimized topologies. Moreover, functionally graded PhP with maximized bandgap efficiency and multiscale functionality could be designed through integration of optimized PhP unitcells of different stiffness. Nondominated sorting genetic algorithm (NSGA-II) is adopted for this multiobjective problem and fitness evaluation of topologies is performed through finite element method. Specific topology assessment is performed for convergence of the solution towards optimum feasible bandgap topology without penalizing the efficiency of genetic algorithm (GA). A set of Pareto topologies is selected and variation of bandgap width and in-plane stiffness across the two Pareto extremes is studied. Arbitrarily selected intermediate Pareto topology shows superior bandgap efficiency as compared with the relevant optimized topologies reported by other researchers. Moreover, the frequency response of a finite phononic plate structure of selected intermediate Pareto topology confirms high attenuation of flexural waves within its calculated bandgap frequency.

Keywords: Phononic; Bandgap; Plate; Topology Optimization.