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TOPOLOGY OPTIMIZATION OF MULTI-PANEL STRUCTURES LINED WITH POROELASTIC MATERIALS FOR SOUND TRANSMISSION LOSS MAXIMIZATION

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ABSTRACT

The layout design of multi-panel structures lined with poroelastic materials is investigated to maximize the sound transmission loss by topology optimization. Although the multi-panel structures are popular configurations to reduce sound transmission, no systematic design method such as the topology optimization method has been employed. Therefore, it was difficult to obtain optimal multi-panel structures to yield the best sound isolation capability. Motivated by a recent successful application of the topology optimization in finding optimal sequences of air and poroelastic layers (Lee *et al*. [1]), this investigation aims to extend the method to the optimal sequencing of elastic panels and poroelastic foam layers. In [1], the optimal number and thickness of air and poroelastic material layers were determined in a topology optimization setting to maximize the sound transmission loss at single and bands of frequencies. The specific goal of this research is the topology optimization formulation of the one-dimensional optimal sequencing of panels and poroelastic materials for the sound transmission loss maximization for given single or ranges of frequencies. A main issue in extending the method of Lee *et al*. [1] to the present problem is how to interpolate a material state from a poroelastic material to an elastic panel. To this end, a panel is expressed as a poroelastic material layer having the limiting material properties. Therefore, one set of governing equations for a poroelastic material with design-variable dependent material properties is used to analyze both of the two material states: an elastic panel and a poroelastic material layer. For the acoustical analysis of a system of panel layers and poroelastic material layers, a transfer matrix [2] derived from Biot's equation is used. The transfer matrix for a panel is obtained as the transfer matrix of a

poroelastic layer having the limiting material values. In numerical studies, design cases with different amounts of allowed panel in a design domain and target frequencies are considered. After finding optimal solutions, the transmission loss capabilities of the optimized layer sequences are compared with those of nominal ones. The comparisons are made to confirm the validity and effectiveness of the present design method.

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