THE INFLUENCE OF BOUNDARY CONDITIONS AND INTERNAL CONSTRAINTS ON THE PERFORMANCE OF NOISE CONTROL TREATMENTS: FOAMS TO METAMATERIALS

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ABSTRACT

Theories governing coupled wave propagation in noise control materials are now well-developed. As a result, it is, in principle, possible to design optimal noise control materials, whether sound absorption or barrier performance is the goal. However, it is now understood that details of the external and internal boundary conditions applied to poroelastic materials such as foams have a dramatic impact on the wave propagation within them, and as a result, their performance. It is important to understand these effects if the best performance is to be obtained under particular circumstances and if the opportunity to achieve enhanced performance in particular frequency ranges owing to these sensitivities is to be realized. Here, these effects will be described and demonstrated. First, the impact of front and rear surface boundary conditions on the performance of layers of foams will be demonstrated and the possibility of enhanced low frequency performance will be discussed. Next, the impact of material inhomogeneity will be discussed as will the effects of segmenting poroelastic materials into finite-sized, constrained pieces, hence creating a dissipative metamaterial. It will be shown, for example, that internal constraints can greatly enhance barrier performance, but that a weight penalty is inevitably incurred. Finally, a connection will be drawn with recently developed cellular metamaterials comprising finite-sized panels mounted within a rectangular, elastic frame, whose performance similarly depends on finite length-scales and internal constraints. It will be shown, in particular, that the mass of a homogeneous elastic panel can be redistributed to create such a realistic metamaterial whose low frequency barrier performance is well in excess of that of the original homogeneous panel.