Computational procedure for optimal design of acoustic metamaterials

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ABSTRACT

Local resonance effects arising in the so-called locally resonant acoustic metamaterials (LRAM) have the ability of effectively stopping waves from propagating in certain frequency ranges, typically known as bandgaps. This can be used, for instance, in the design of insulation panels capable of attenuating acoustic waves in the low-frequency region, i.e. around 1kHz, where more conventional solutions consist of using thick designs with very dense materials.

In this context, a computational procedure, aimed at the design of optimized LRAM-based insulation panels for a targeted frequency ranges, is presented. The method is based on: (a) a multiscale homogenization framework, (b) modal projection-based techniques for model order reduction and (c) topological optimization methods. The procedure consists of optimizing the metamaterial topology at the lower scale (unit cell), for a set of target frequencies, maximizing their associated bandgaps. The effective properties characterizing the resulting metamaterial design are obtained by means of a multiscale homogenization model capable of accounting for local resonance and viscoelastic dissipation effects, which are then used to study the transmission loss achieved with a panel made of such material [1, 2].

The results show the impact of LRAM-based panels for acoustic insulation applications in the low-frequency regime, as well as validating the potential in using computational tools in the design of metamaterial-based devices with enormous industrial applications.

REFERENCES

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