A Wave-Based Methodology for the Optimization of Finite 1D Metamaterials

R. Boukadia*[,a,b,c], E. Deckers[a,b], C. Claeys[a,b], M. Ichchou[c], W. Desmet[a,b]

[a] Department of Mechanical Engineering, PMA Section, Noise And Vibration Research Group
KU Leuven
Celestijnenlaan 300 - box 2420 3001 Leuven, Belgium
e-mail : regis.boukadia@kuleuven.be, elke.deckers@kuleuven.be, claus.claeys@kuleuven.be, wim.desmet@kuleuven.be

[b] DMMS lab, Flanders Make

[c] Structural Acoustics and Enriched Materials research group, LTDS
École Centrale de Lyon
36 Avenue Guy de Colongue Bat. E6, 69134 Écully, France
e-mail: mohamed.ichchou@ec-lyon.fr

ABSTRACT

Metamaterials are artificial, engineered materials with properties that are not found in nature. They are typically formed by an assembly of reoccurring patterns whose scale is generally smaller than the phenomena they influence. In the vibro-acoustic community, metamaterials are mostly known for their stopband behavior that can be used to reduce noise and vibrations beyond what is dictated by the mass law. This behavior can be predicted during the design stage using unit cell modeling techniques such as the Wave Finite Element Method (WFEM)[1] and the Shift Cell Operator Method [2] to compute the propagation constants of the relevant waves. As a consequence, most design optimization schemes have focused solely on maximizing the spatial attenuation of targeted waves. However, dispersion characteristics alone cannot predict the performance of metamaterial solutions once deployed because they neglect their operating environments, finiteness and boundary conditions applied. This is most observable when edge modes occur as the treatment may result in increased and localized vibration energy [3]. This paper presents a second order optimization scheme based on the 1D WFEM framework enabling the optimization of the response of finite metamaterial solutions. The proposed methodology is validated on a simple model updating case and subsequently applied to the design of a resonant metamaterial.

REFERENCES

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