NAPLES, ITALY 30 JUNE - 4 JULY
ACEX2025 NAPLES
18th International Conference on Advanced Computational Engineering and Experimenting

ABSTRACT

Hybrid Development and Characterization of Vibroacoustic Metamaterials

W. Kaal[1,2], M.M. Becker[1,3], S.C.L Fischer[1,3,*]

[1] Fraunhofer Cluster of Excellence Programmable Materials,
Wöhlerstraße 11, 79108 Freiburg, Germany.
[2] Fraunhofer Institute for Structural Durability and System Reliability LBF,
Bartningstraße 47, 64289 Darmstadt, Germany.
[3] Fraunhofer Institute for Nondestructive Testing IZFP,
Campus E3.1, 66123 Saarbrücken, Germany.

* Corresponding author: sarah.fischer@izfp.fraunhofer.de

Metamaterials leverage their internal architecture to achieve functional integration and targeted property changes.A sub-class of metamaterials, namely vibroacoustic metamaterials (VAMM), enable interaction with acoustic waves in different applications and induce damping of specific frequency regimes through their geometrical architecture.In order to increase the functionality and flexibility of these materials, methods to actively trigger and shift regions of high damping are being developed.
To expedite the transition of these materials from the laboratory to the commercial sector, and to curtail innovation cycles, there is a necessity for bespoke characterisation techniques to be integrated at the outset of the development cycle, in conjunction with numerical methods that encompass the extensive parameter space.This hybrid development approach, which integrates numerical simulations and the characterisation of prototypes at the commencement of the development process, is imperative in order to create industrially relevant and scalable novel material systems with integrated functions. [1]
In the present talk, recent advances in the design and characterisation of active vibroacoustic metamaterial unit cells for different applications will be presented, with special focus on hybrid development. Two designs of programmable VAMM (PVAMM) will be discussed: one with a priori tunable range (passive VAMM) and the other with a range varying based on an external trigger, such as a change in the internal pressure of the cell (active VAMM).In order to fully understand the potential of the VAMM, characterisation was performed regarding vibroacoustic properties. To this end, the samples under scrutiny in this study have been subjected to excitation through the utilisation of an electrodynamic shaker or a loudspeaker.The overarching objective of this research endeavour is to

furnish novel concepts for metamaterials that have the potential for noise reduction applications, with the aspiration of attaining scalability from the confines of laboratory experiments to the domain of industrial implementation. [2]

[1] Kollmannsperger, L.S., Kaal, W., Becker, M.M. and Fischer, S.C.L. (2024), Identifying Factors Influencing the Properties of Vibroacoustic Metamaterials Using Three Different Acoustic Methods. Adv. Eng. Mater., 26: 2302137. https://doi.org/10.1002/adem.202302137
[2] Kaal, W., Becker, M.M., Kollmannsperger, L.S. and Fischer, S.C.L. (2025), Design and Testing of Vibroacoustic Metamaterials for Active Damping of Traffic Noises. Proceedings of IMAC 2025