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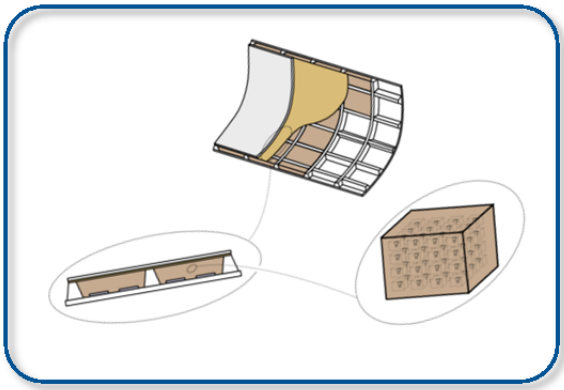
OPEN PHD POSITION 2014-2017

PERIODIC FUNCTIONAL POROUS COMPOSITES FOR BROADBAND VIBROACOUSTIC ABSORPTION



The CARIBOU (adaptive metaComposites: modeling, prototyping, mAnufactuRIng and reliability for viBroacOUstics) has been granted by NSERC. This international project is a collaborative research effort between GAUS (U. Sherbrooke, Canada), LTDS (ECL, France) and FEMTO-ST (U. Franche-Comté, France). This project aims at developing a new concept of "smart meta-composite", namely an active-passive smart composite, designed for sound and vibration applications. This meta-composite combines the natural absorption (passive part) of open cell foams and active inclusions suitably located and controlled to ensure maximum acoustic performance over the entire audible frequency range. The low frequency domain, which represents the major challenge of sound insulation, is more particularly concerned, since in this range conventional treatments are practically inefficient.
The methodology includes: (a) optimization of the microstructure of foam prototype from a new reticulation technology, (b) characterization and correlation of cell morphology of foams to their performance indicators for noise and vibration, (c) addition and control of active components in the foam to control low frequency performance, (d) optimization of process parameters, design and control of foam, and (e) manufacturing and evaluation of the performance and robustness of the foams produced in configurations close to the aeronautical industry. The proposed methodology addresses its objectives through a combination of experimental and numerical methods.

The proposed thesis work will aim to develop the design methodology for periodic composites with foam matrices using functional inclusions: anisotropy effects, nonlinearities, or multiphysics couplings (thermal, electro-active, magnetic) will be particularly investigated. This functionalization will either improve the device performance in terms of broadband absorption, or provide new properties (flexibility, tunability, shock absorption ...).

The design of these structures requires advanced finite element modeling techniques, including multiphysics

phenomena, dissipative effects and taking into account of periodicity relations in multidimensional space, so advanced numerical tools are needed to effectively model the developed structures. Advanced tools for modelling of porous materials are available at GAUS, while FE-based multiphysics tools for periodic structures have been developed at FEMTO-ST, thanks to recent works of the team on the topics of adaptive metacomposites. The first step of the project will be the combination of the tools to handle 3D FE wave propagation in periodic composites with porous PU matrices and arbitrary inclusions. In a second step, a special attention will be paid to the nature of the inclusion. Rigid inclusions will be considered to check the coherence of the results using open literature results. Then, resonant and smart inclusions will allow the designed sound package to dissipate energy in frequency bands in which conventional devices exhibit low performances.

The tools developed will be used in the final phase of the project to conduct sensitivity and reliability analyzes of the systems in order to ensure, on the one hand, the control of parameters and their impact on the quantities of interest (vibroacoustic performances) and second, the quantification of the reliability associated with failure scenarios.

These analyzes, as the entire project, will be completed in the sake of completeness on the various parameters involved in the development of metacomposites devices from conception to vibroacoustic in situ validation, through optimal design.

This work will take place in both countries involved in the project: at within the GAUS at University of Sherbrooke in Canada, under the supervision of Prof. N. Atalla, and within the PoFSI research theme of Applied Mechanics Department of FEMTO-ST, in the scope of the Labex ACTION “Smart systems embedded into matter”, in France, under the supervision of M. Ouisse. The doctorate will be co-awarded by University of Sherbrooke and University of Franche-Comté.

Selection of team’s references:

- Allard J.F. & Atalla N. Propagation of sound in Porous media. 2e. John Wiley & Sons Ltd. (2009)
- Collet, M., Ouisse, M. Ruzzene & M. Ichchou *Floquet-bloch decomposition for the computation of dispersion of two-dimensional periodic, damped mechanical systems*. International Journal of Solids and Structures, 48(20):2837–2848 (2011)
- Collet, M. Ouisse, M. Tateo, F. *Adaptive Metacomposites for Vibroacoustic Control Applications*. IEEE Sensors Journal, doi: 10.1109/JSEN.2014.2300052 (2014)
- Doutres, O., Atalla, N. & Dong, K. *Effect of the microstructure closed pore content on the acoustic behavior of polyurethane foams*. J. Appl. Phys. 110, 064901 (2011)
- Ouisse, M., Doutres, O., Atalla N. and Ichchou, M. *Investigations on the sensitivity of the relationships between sound absorption characteristics and microstructure related parameters for polyurethane foams.* International Congress on Acoustics, Montréal (Canada), 2013
- Doutres, O., Ouisse, M., Atalla N. and Ichchou, M. *Micro-macro modeling of polyurethane acoustic foams and impact of the periodic unit-cell variability*, submitted to Journal of the Acoustical Society of America (2014)

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