Identification of characteristic parameters of auxetic foams

Matthieu Gravade[a], Fabrizio Scarpa[b], Morvan Ouisse[a], Manuel Collet[a]

a. FEMTO-ST - Département de Mécanique Appliquée – 24, rue de l'Epitaphe – 25000 Besançon - FRANCE
b. Department of Aerospace Engineering, Advanced Composites Centre for Innovation and Science (ACCIS), Queens Building, Room # 011, BS8 1TR Bristol – UNITED KINGDOM

Corresponding author: morvan.ouisse@univ-fcomte.fr
Oral presentation preferred, poster otherwise
No special requirement for oral presentation

Porous materials are widely used in vibro-acoustics for many reasons. Their low cost and good performances in terms of noise attenuation or energy impact dissipation, justify its use in many sectors like transportation and housing. In this context, this work is related to the analysis of an auxetic foam, material that have the particularity to exhibit a negative Poisson's ratio. An analytical model and some experimental measurements were conducted for auxetic and non-auxetic foam samples issued from the same source material, in order to compare their performances. Then a sensitivity analysis (FAST method) was done with the purpose of facilitating the optimization of parameters by readjusting analytical results over experimental measurements. Our hope is with a quite simple method of characterization to be able to take the necessaries information for the practical utilisation of this material in models, noise controls studies and other kind of studies that require knowledge about the parameters values found here.

The particular hinge-like structures of auxetic materials justify their negative Poisson's ratio. Such materials are expected to have mechanical properties such as high energy absorption and fracture resistance been able to be used for a variety of applications (personal protection clothing, packing material, robust shock absorbing material, sponge mops and filtration). The isotropic theory allows the utilization of Poisson's ratio between -1 and 0,5. Some anisotropic configurations reach a coefficient value less than -1. The material used in this work has been obtained from conventional foam that becomes auxetic after a specific forming process. This process allows the foam to exhibit a negative Poisson's ratio in all directions, while foams used in previous works [3] had only one negative Poisson's ratio among all ones.

The objectives of this work are first, to illustrate the effects of negative Poisson's ratio of foams on acoustic properties of samples, and secondly, to investigate the ability of a simple procedure to identify the parameters of the material, including the negative Poisson's ratio.

In order to illustrate the effects of negative Poisson's ratio, both numerical and experimental approaches are considered. Analytical 1D and finite-elements based 3D analyses [1, 2] are used to simulate the behaviour of conventional and auxetic foams made from the same base material, in order to understand the effects of the negative Poisson's ratio on global

acoustic performances. Some experimental analyses are then conducted using conventional and auxetic samples made from the same base material, together with classical melamine foam for comparison purpose. Absorption, transmission loss and transmission loss with parallel incident field are investigated. Depending on the kind of test being involved, improvements of acoustic performances are observed in specific frequency ranges.

In order to identify some parameters values including de Poisson's ratio, a simple procedure allowing identification from simple measurements has been tested: a preliminary sensitivity study of parameters is made in order to find the best optimization strategy. The FAST technique (Fourier Analysis Sensitivity Test [4, 5]) has been used for that purpose. The optimization step is then conducted in order to efficiency identify the parameters from experimental measurements. The particular case of the Poisson's ratio is considered in details. Aspects related to visibility of the parameter, anisotropy of the material and confidence of the identification are finally discussed.

References:

[1] J. F. Allard et N. Atalla, Propagation of sound in Porous Media, Modelling Sound in Absorbing Materials, Wiley ISBN: 978-0-470-746615-0, 2009,

[2] F. Sgard, Modélisation par éléments finis des structures multi-couches complexes dans le domaine des basses fréquences, Habilitation a diriger des recherches en sciences, Université Claude Bernard Lyon 1, Lyon, France, 2002

[3] M Bianchi; F Scarpa; C W Smith; F.-X. Bécot; L Jaouen; Identification of poroelastic parameters for conventional and auxetic foams using a Fast Fourier Transform one dimensional spectral element approach; submitted to Journal of Sound and Vibration, 2011.

[4] A. Saltelli, S. Tarantola and K. Chan, A quantitative, model independent method for global sensitivity analysis of model output, Technometrics 41, 1999; 39-56

[5] M Ouisse, M Ichchou, S Chedly, M Collet, On the sensitivity of porous materials models to coupling parameters; submitted to Journal of Sound and Vibration, 2011.