Session 2aNS

Noise, Physical Acoustics, Structural Acoustics and Vibration, and Architectural Acoustics: Emerging Technologies for Noise Control

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Chair's Introduction—8:00

Invited Papers

8:05

2aNS1. Future trends in noise control technology. J. S. Bolton (Ray W. Herrick Labs., School of Mech. Eng., Purdue Univ., Ray W. Herrick Labs., 177 S. Russell St., West Lafayette, IN 47907-2099, bolton@purdue.edu)

Although acoustics plays an important role in noise control, noise control is arguably more difficult than acoustics owing to the constraints that are usually imposed on noise control solutions by manufacturers. That is, ideally, noise control solutions should occupy no space, weigh nothing, cost nothing, not impact the operation of the device being treated, and remain effective for 20 years without maintenance. Hence, identifying effective noise control solutions is a challenging, multidimensional problem. In this presentation, future trends and opportunities in noise control will be highlighted in four categories: targets, measurement techniques, predictive tools, and noise control methods and materials.

8:25

2aNS2. Noise reduction using metamaterials and metasurfaces. Yun Jing (North Carolina State Univ., 911 Oval Dr., EB III, Campus box 7910, Raleigh, NC 27695, yjing2@ncsu.edu)

We are surrounded by noise. Planes, trains, cars, crowds, cooling fans — just about everything is a potential source of noise. Traditional noise abatement methods have a number of limitations and they are particularly ineffective for low frequency noise. As we are becoming increasingly aware of the noise pollution issue, there is a pressing need to develop novel materials for more effective noise reduction. In this talk, I will give an overview of recent development on noise reduction using metamaterials or metasurfaces. I will cover structures such as decorated membrane resonators, hybrid resonators, and coiled Helmholtz resonators.

8:45

2aNS3. Correlating dynamical properties of organic aerogel with increased sound insulation of sandwich wallboard systems. Ning Xiang, Mathew A. Whitney (Graduate Program in Architectural Acoust., Rensselaer Polytechnic Inst., Greene Bldg., 110 8th St., Troy, NY 12180, xiangn@rpi.edu), Sadeq Malakooti (Mech. Eng., the Univ. of Texas in Dallas, Richardson, TX), Habel G. Churu (Mech. Eng., LeTourneau Univ., Longview, TX), Nicholas Leventis (Chemistry, Missouri Univ. of Sci. and Technol., Rolla, MO), and Hongbing Lu (Mech. Eng., the Univ. of Texas in Dallas, Richardson, TX)

Low thermal conductivity of classical aerogels has long been exploited, while their dynamic properties are yet to be further investigated. This work investigates a new class of acoustic materials based on porous hierarchical three-dimensional assemblies of organic nanoparticles. Primary polymer nanoparticles are formed via chemical reactions in solution and self-assemble to fractal porous secondary particles, which in turn become the fundamental building blocks of larger globular, fibrous or hybrid structures that form the microscopic network of highly porous monolithic materials referred to as polymer-crosslinked (or X-) aerogels. Their low-cost, thin-panel form has found potential applications as constrained damping layers integrated into gypsum wallboards. The standardized chamber-based random-incident tests demonstrate drastically increased sound transmission losses without significantly increasing the board thickness and weight when light-weight X-aerogel panels of less than 1 cm in thickness are integrated into gypsum wallboards in sandwich structure. For better understanding of its excellent effect as constrained damping layers, this paper discusses experimental investigations on broadband dynamic properties of X-aerogels with the intention to correlate their intriguing dynamic properties with increased sound insulations which will have high potentials as emerging building materials for advanced noise and vibration controls and beyond.

9:05

2aNS4. Complex frequency analysis of the scattering matrix for the design of perfect absorbers in reflection and transmission problems. Noé Jiménez (Instituto de Instrumentación para Imagen Molecular (I3M), Consejo Superior de Investigaciones Científicas (CSIC), Edificio 8B, Acceso N, 1[a] Planta, Camino de Vera s/n, Valencia 46022, Spain, nojigon@upv.es), Vicente Romero-Garcìa, Vincent Pagneux, and Jean-Philippe Groby (UMR CNR 6613, Laboratoire d'Acoustique de la Université du Mans, Le Mans cedex 9, France)

The design of deep-subwavelength structures for low frequency sound perfect absorption is challenging. Subwavelength perfect absorption implies increasing of the density of states at low frequency while maintaining impedance matching to the surrounding medium. Therefore, the study of the eigenvalues and eigenvectors of the scattering matrix in the complex frequency plane appears extremely powerful to analyze such systems and derive the critical coupling condition. The latter consists in exactly compensating the leakage of the structure by using the intrinsic losses. Two simple structures, the thicknesses of which are 88 times and 40 times smaller than the perfectly absorbed wavelengths, are presented for reflexion and transmission problems, respectively.

9:25

2aNS5. Are nano-fibers an emerging noise control solution? Kirill Horoshenkov, Alistair Hurrell (Univ. of Sheffield, Mappin St., Sheffield S1 3JD, United Kingdom, k.horoshenkov@sheffield.ac.uk), and Mohan Jiao (Univ. of Sheffield, Sheffield, South Yorkshire, United Kingdom)

This paper presents experimental evidence that laboratory measurements of the acoustical and related non-acoustical data is not a trivial task. This paper also shows that the prediction of the acoustical properties of this seemingly simple material is far from easy. First, there is a problem of characterising the non-acoustical properties of nano-porous membrane with standard laboratory methods. Second, there is a high uncertainty in the value of the membrane thickness which can lead to a substantial change in its predicted acoustical and related non-acoustical properties. Thirdly, there is an argument whether or not sound propagation in a nano-porous membrane can actually be treated as that in a classical porous media. The paper attempts to respond to these questions and to present new evidence that we may not know well yet the true acoustical properties of these fibres. Therefore, the key question is *Are nano-fibres still an emerging noise control solution?*

9:45

2aNS6. Are aerogels an emerging noise control solution or it is just beefed up fiber glass? Kirill Horoshenkov and Hasina V. Begum (Univ. of Sheffield, Mappin St., Sheffield S1 3JD, United Kingdom, k.horoshenkov@sheffield.ac.uk)

Recently, there has been a number of publications which suggested that aerogels can offer high acoustical performance in terms of their ability to absorb or to insulate against sound. It seems that a bulk of these publications report laboratory experiments on the acoustical absorption or transmission loss performance for samples of particular thickness and lateral dimensions. None of these results appear to be rigorously linked to the aerogel's chemistry or micro-structure. This paper attempts to fill in this gap in information by explaining what these materials actually are, why they work acoustically and what is the underpinning physical phenomenon of aerogel. It is shown that the main reason that these materials are used in applications is that they are fire retardant or their elastic modulus is relatively independent of frequency and that they highly hydrophobic. It is also shown that the absorption performance of fibre glass impregnated by aerogel is generally controlled by the fibre diameter of fibreglass and by the density of the composite structure.

10:05–10:20 Break

Contributed Papers

10:20

2aNS7. Is anything radically new in noise control research? Kirill Horoshenkov (Univ. of Sheffield, Mappin St., Sheffield S1 3JD, United Kingdom, k.horoshenkov@sheffield.ac.uk) and Mark Swift (Armacell, London, United Kingdom)

This paper attempts to review the state of art of noise control research globally and answer a key question: *Has anything been radically new in noise control research lately?* There is anecdotal evidence that no radical noise control solution has emerged from noise control research since the invention of active noise control by Paul Lueg in 1936 (U.S. Patent 2,043,416). Among passive noise control solutions used for sound absorption the market is dominated by mineral wool and fibreglass (43% in 2017, Global Insulation Market Report, 2024). Technical foams used for acoustic absorption cover pretty much of the rest. Similar situation is for common solutions used for noise and vibration insulation. Their acoustical properties and *in-situ* performance can be predicted within experimental and material parameter uncertainties using a commercial package such as Comsol or semi-empirical models such as by Delany and Bazley. There seem no radical solutions has emerged recently to challenge this status quo. Metamaterials are one promising solution for the future, but they remain largely in the realm of academic laboratories or fancy theories. Therefore, another key question is: *What has true impact of noise control research been so far and what fundamental ideas need to emerge to radically improve this situation?*

10:35

2aNS8. Destructive interferences in resonators created using additive manufacturing. Umberto Berardi (DAS, Ryerson Univ., 350 Victoria St., Toronto, ON M5B 2K3, Canada, uberardi@ryerson.ca)

The broad absorption of low-frequency noise typically requires the utilization of large thicknesses of sound absorbing materials. As this creates space issues, there is a demand for thin broad low-frequency absorbers. This research aims to develop an acoustic transparent panel for low-frequency broad sound absorption. Destructive sound resonance tubes were created for this scope using modern tools for generating complex geometries in systems of a few centimeters of thickness. The capability of digital fabrication to enable design freedom and to support the production of complex geometries is explored in this paper. Destructive interference means that two interfering sound waves that are in counter-phase, cancel each other. Digital fabrication is shown to play an important role in developing customized sound absorbing components to absorber below 500 Hz, and especially well below 200 Hz. A parametric script using Grasshopper through Rhinoceros to generate automatically the geometric parameters of the 3d resonators is described.