RESEARCH PROJECT

IMPACT OF THE 3D PRINTING PROCESS ON THE ACOUSTIC PROPERTIES OF POROUS MATERIALS

It is popularly known that porous materials are effective acoustic absorbers. They possess superior damping properties due to a specific internal structure consisting of a solid skeleton and 'voids' (pores) filled with fluid. Nowadays, continuously evolving additive manufacturing techniques allow forming porous samples with a definite microgeometry. However, their measured acoustic performance is usually different from designed because of some production flaws and other imperfections. Thus, adopting appropriate modelling enhancements that will accommodate computer simulations of wave propagation and sound absorption in such media to reality should eventually lead to substantial benefits from the practical point of view.

It has been shown that the acoustic wave attenuation in fabricated rigid porous layers is eminently underestimated by numerical calculations using standard models. Based on this observation, the major postulate that will be put forward in the project concerns the impact of the additive manufacturing technology on the acoustic properties of produced samples, and may be stated as follows: *the three-dimensional (3D) printing process yields rough surfaces of a material skeleton so that some enhancements to the existing models of wave propagation in porous media are indispensable to get reliable simulations*. According to another hypothesis, however, *the substantial discrepancies may come from an extra microporosity*, much smaller in characteristic dimensions of 'voids' than the main porous network, that has been unintentionally created within the skeleton at the forming stage. These two possibilities will be essentially checked in the course of the investigation comprising four main parts, namely: 1. Generation and re-design of periodic porous structures with open porosity; 2. 3D printing of material samples using various additive manufacturing technologies; 3. Evaluation of the fabricated specimens in terms of their effective acoustic properties (experiments in the impedance tube) and geometrical accordance to the corresponding computer-aided design model; and 4. Numerical studies based on existing (to a large extend recent) mathematical models and procedures for single- and dual-porosity materials. These activities will be carried out more or less simultaneously. First of all, the measurement data should be confronted with the results obtained from multiscale, microstructure-based modelling to validate and perhaps correct the implementation of original theoretical developments and scientific hypotheses. Secondly, the dimensions and shapes of the constructed periodic cells representative for the particular morphology of the investigated porous media need to be compared under a microscope with their manufactured equivalents.

There are at least threefold reasons for choosing this research topic. First, the accomplishment of the project objectives, especially those concerning the confirmation of the versatility and robustness of the utilised modelling, will definitely entail prompt further scientific developments within the framework of 3D-printed noise reducing materials, but not only. Invention of advanced goal-oriented sound absorbers with optimised microgeometry and of a moderate thickness (i.e. weight) being marked by an excellent performance at some considered frequency ranges still seems to be the subject of keen interest in the aviation and automotive industries. If the manufacturing of such modern porous structures will eventually meet with success, an invaluable positive social and environmental impact related to the overall noise attenuation appears quite self-evident. Last, but by no means least, some of the macroscopic material characteristics fed into the models for sound propagation and absorption in porous media (permeability, tortuosity, etc.) can also be relevant for other theories in applications different from acoustics, for instance in biotechnology, medicine, or geotechnics.