Abstract for the General Public

Sound-absorbing composites: coupled acoustic energy dissipation mechanisms, multiscale modelling and prototyping

Noise pollution is a growing problem across Europe and all over the world. It is a major problem, both for human health and the environment. However, it is also true that many people may not be aware of the impacts of noise on their health. According to the European Environment Agency twenty percent of Europe's population are exposed to long-term noise levels that are harmful to their health, and that number corresponds to more than 100 million people within Europe. For this reason, fighting noise becomes more and more important.

Sound-absorbing materials are very important in the fight against noise, by themselves and also as the main components of sound insulation solutions. Popular sound-absorbing materials are open-cell foams and fibrous materials. These highly porous materials are lightweight and cheap, but efficient in the medium and high frequency range, while the biggest problem is low-frequency noise. From the point of view of applications other than insulation, they may be of little use, therefore, are often combined with other materials. This is how the so-called composites are made, that is, special materials that consist of other materials, selected and combined in order to obtain better properties than their components and/or a combination of different properties, that is in other words, to obtain multi-functionality.

The general purpose of this project is to develop and construct new types of soundproofing composites. This will require new mathematical models capable of capturing phenomena and mechanisms that can be designed to significantly increase the dissipation of noise energy, especially at low frequencies, without losing broadband efficiency in the medium and high frequencies. However, the project will not be limited to modelling. One of the main goals of the project will be to create prototypes of efficient sound-absorbing composites to fully validate advanced mathematical modelling and experimentally prove their excellent acoustic properties. For this purpose, modern additive manufacturing technologies will be used together with other techniques. These modern technologies allow for rapid prototyping of very complex designs. Finally, other structures and materials, for example membranes, but also more or less conventional sound-absorbing materials can be used as components. For example, the skeleton of an acoustic composite with the complex geometry resulting from optimized design can be relatively easily 3D printed and then filled with organic fibrous material. In addition, one of the research tasks of the project will be the additive manufacturing of microporous elements (e.g. a microporous skeleton), which will further enhance the noise absorption effect.

Achieving the project's objectives for modelling and design of innovative acoustic composites with enhanced and tunable sound energy dissipation mechanisms will form the basis for rapid scientific development in the field of soundproofing solutions. Moreover, manufacturing and testing of prototypes should give a solid confirmation of the theoretical results obtained. Although some techniques used to this end (for example 3D printing) may not be directly suitable for large-scale mass production and low-cost composite soundproofing solutions, this situation should change in the near future. In any case, the development of innovative composites with a refined selection of components and an optimised design, allowing to obtain excellent acoustic insulation parameters in certain intended frequency ranges with a very moderate material volume (thickness), and at the same time with a high potential for multifunctionality, will certainly be of interest to the aviation and automotive industries, which ultimately should have a big social impact.