Multifunctional textile structural composites for acoustic applications

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Acoustic materials work in two broad principles: sound absorption and sound insulation. Textile structures are lightweight and porous, which make them a decent choice for sound absorption, even though they are not particularly effective materials for sound barrier solutions. While fibrous structures are considered suitable for sound absorption, the fiber-reinforced composite materials can be used as a barrier to sound transmission. In addition, fiber-reinforced composite materials are well known for their load-bearing properties. Therefore, the acoustic properties of composites are significantly important when used in automobiles, aerospace, buildings and civil structures as they must effectively insulate against noise and heat along with high strength to weight ratio.

Textile structures in three dimensions are one of the least researched possibilities for acoustic insulation. Using textile structural composites with reinforcements such as nonwoven, 3D woven, and hybrid structures can fulfil dual load bearing and sound insulation purposes. The sound absorption properties of composite materials can be improved by incorporating nanofillers, allowing these composites to be used as both sound-insulating and sound-absorbing materials. Nanomaterials/nanofillers are good at absorbing acoustic energy due to their large surface area and effective airflow resistance.

This lecture demonstrates a comprehensive and exhaustive research work on the acoustic performance of nonwovens, unidirectional textile structures, two-dimensional structures, three-dimensional structures, 3D woven honeycomb structures, 3D woven spacer fabrics and composites of some of these structures. Efforts have been made to investigate acoustic behaviour of composites incorporating nanoparticles, blowing agents and micro pores in the structure. It is demonstrated that addition of nanoparticles and other fillers can greatly improve the acoustic behaviour of composite materials in the higher frequency ranges due to the damping characteristics of nanofillers. The different sound propagation models such as the Delany-Bazley model, Garai Pompoli model, Delany-Bazley-Miki model, Wilson's model, and Johnson-Champoux-Allard-Lafarge model are used to justify the behaviour of sound absorption in porous media based on airflow resistivity, porosity, and thermal characteristics.