On the effect of distributed embedded resonators in curved sandwich panels loaded by turbulent boundary layer

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ABSTRACT

Composite laminates and sandwich panels are more and more used, even for primary structures, due to their high stiffness-to-weight ratio. However, these are known for having also poor vibroacoustic performance. The resulting strong vibrations and radiated noise, while affecting the internal and pass-by acoustic comfort in transport means, might even cause damages to the payloads in the case of spacecraft fairings.

While it is hard to renounce to their lightness, proper counter-measures must be adopted to avoid these high vibrational levels.

Here, the effects of embedded resonators on the sound transmission loss of sandwich curved structures is investigated. The simulated loading is aerodynamic (turbulent boundary layer excitation), to simulate in-flight operational conditions for fuselages and nacelle fairings. The study is conducted numerically on double wall panels, auxetic and honeycomb cored sandwiches, with periodic embedded resonant elements.

A two-dimensional wave finite element method is used to model the metamaterial with a single periodic cell. The dispersion curves of the structure are investigated and the effect of the induced band-gaps discussed. Then, a set of aleatory helical waves are implied to simulate the random excitation on the curved shells and, through a wavenumber integration, the final transmission loss of the curved panels is retrieved.

The resonant elements are analysed in different tuning combination to investigate the effect on the aerodynamic and acoustic coincidences, as for the ring frequency of the shells. Due to the anisotropy of the structures, the effect of the resonance-induced band gap is strongly affected by the way elastic waves propagate in the different directions. For this reason, in coincidence regions, the efficiency is reduced by the random nature and diffusiveness of the load, while is high when tonal issues need to be covered, as for the ring frequency resonance conditions.

The advantages regarding the sound transmission and the cost associated to the added-masses of the periodic resonators, are also discussed.