Built-in vibration control may help soundproof spaces

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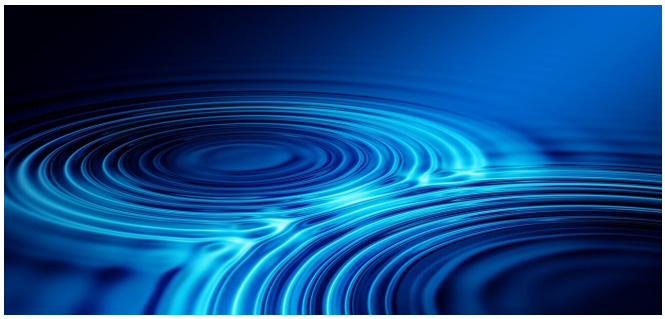

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A different kind of design for absorbing vibrations could help better soundproof walls and make vehicles more streamlined, a new study shows.

The study tested how well built-in resonators handled vibrations under a variety of scenarios. Resonators are devices that help manage vibrations—some vehicles have them to limit the sound emitted from a car's muffler, and some bridges and buildings use them to limit noise and movement from those structures. Resonators use spring-like oscillation to control and change vibrations—some absorb and neutralize them, others amplify and direct them to specific places. (The chamber inside an acoustic guitar is a resonator, for example.)

Prior studies have examined how to use resonators to control sound that is passed through walls or to reduce the vibrations of moving vehicles. Those studies have focused on adding a resonator to an existing structure or vehicle part. But this study found that cutting resonators directly into the wall or vehicle material suppressed the vibrations that could spread.

"We wanted to create and test a design that would reduce vibration," said Ryan Harne, senior author of the paper and former associate professor of mechanical engineering at The Ohio State University. "Vibration is integral to a lot of problems in engineering, both in how we construct buildings and in how we make better airplanes and other vehicles."

Harne, who maintains an adjunct position at Ohio State, has since joined the faculty at Penn State University. The experiments for this study were conducted in his former lab at Ohio State. That lab contains equipment that lets researchers control the force and frequency of vibrations during scientific experiments.

For this study, Harne and former Ohio State doctoral student Sih-Ling Yeh, lead author of the study, cut resonators into rectangular acrylic plates. Their study, published in the October 2021 volume of the journal *Thin-Walled Structures*, was the first to consider what might happen if resonators were cut directly into a material, rather than added on later.

The study did not directly compare cut-in resonators to those that are added on. Harne said that cut-in resonators are more streamlined than those that are added on and would be better options for applications where space matters—in the construction of an airplane or a wall, for example.

The researchers held the plates in place using different mechanisms—some were clamped tightly, some were suspended in air, and some were held up by supports. Then they used a mechanized hammer to strike the plates and measured the force of the vibrations created by each plate after the hammer's impact. They kept one plate unaltered as a control.

They found that vibrations traveled farther on the unaltered plates than on those with built-in resonators. The resonators, their experiments showed, helped the plates flex and absorb the

vibrations from the hammer.

The experiments were built to test a design that could have multiple real-world applications and be used to soundproof walls, but also could be used to build airplane frames that automatically lessen the sound that enters the cabin.

"You can imagine a sandwich-like construction, where you put a lightweight panel with a built-in resonator between two panels of sheetrock, or layer it inside the walls of an airplane," Harne said. "And you could use this to reduce vibration of the whole system without reducing the aerodynamics or efficiency since mass is eliminated. It controls that vibration, and vibration affects what we hear, and it affects how streamlined an airplane or an automobile is."

The resonators also were able to absorb vibrations regardless of how the plates were held in place, something that surprised Harne, who has been studying vibrations and frequencies for years.

"I was also surprised at how effective this was because we aren't adding mass to the plates—usually, resonators are added after the fact," Harne said. "But here, we showed that by building them in, you can achieve even better vibration control."

More information: Sih-Ling Yeh et al, Cut-out resonators for tuned vibration suppression of plates, *Thin-Walled Structures* (2021). DOI: 10.1016/j.tws.2021.108200

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