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Tuning SMA Hybrid composites via patterning and pre-straining

Patterned, pre-strained SMA layers tune composite damping/dynamics for targeted vibration control.

Researchers at Purdue University have developed a method to improve shape memory alloy (SMA) hybrid composite materials through patterning and pre-straining. By embedding SMA materials into composites, either in the form of wires or sheets, the performance of the host materials can be enhanced and potentially adapted to specific operating conditions. Because of their unique properties, SMAs are used in fields such as aerospace engineering, civil engineering, and robotics. Many SMAs undergo a pre-strain process during their manufacturing, in which a known strain is applied and held while precise temperature changes are made to induce the shape memory effect. However, the exact effects of nonlinear tuning of the pre-strain on the dynamic performance of hybrid composites embedded with monolithic and patterned SMA layers was largely unexplored. In addition, all SMAs possess specific through-hole patterning, which impacts their final characteristics and can be manipulated during production. By utilizing a novel mathematical model, Purdue researchers explored the synergistic effects of nonlinear pre-strain tuning and patterning to produce a method for creating uniquely tunable SMA hybrid composites. With this method, these researchers have achieved a significant step towards understanding the development of SMA hybrid composites with highly tailored dynamic properties and optimal damping capacity under specific design constraints.

Technology Validation:

By means of numerical simulations, the nonlinear damping characteristics of hybrid composite plates (HCPs) and SMA layers (either monolithic or patterned) were evaluated. The damping properties of the HCP were assessed via free decay analysis, where the effects of the position, the pre-strain level, and the pattern imprinted on the SMA layer were investigated under different operating regimes. The damping capacity of the HCP was also estimated as a function of the SMA total transformed volume fraction to identify the types of patterns and the pre-strain profiles capable of

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improving the overall damping capacity of the HCP.

Advantages:

-Highly tailored dynamic properties

-Optimal damping capacity

-Tunable to specific design constraints

-Improved understanding of strategic SMA placement in composite materials may contribute to reduced materials cost

Applications:

-Aerospace engineering

-Civil engineering

-Robotics and actuation

-Biomedical engineering

Publications:

Q. Zhang and F. Semperlotti. "Nonlinear damping characteristics of shape-memory-alloy hybrid composite plates: The synergistic role of patterning and pre-straining SMA layers." Mechanical Systems and Signal Processing. 218. 2024. https://doi.org/10.1016/j.ymssp.2024.111545.

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