An Experimental Evaluation of the Application of Smart Damping Materials for Reducing Structural Noise and Vibrations

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(ABSTRACT)

This study evaluates the application of smart damping materials for reducing structural noise and vibrations. The primary purposes of this study are to:

1. Explore the feasibility of smart damping materials, such as piezoelectric materials, for augmenting and improving the noise and vibration benefits of passive damping materials and

2. Provide a preliminary evaluation of the noise and vibration benefits, and weight savings of smart damping material as compared to conventional damping treatments.

To achieve the objectives of the study, a special test rig, designed to measure both vibrations and structure-borne noise of a test plate, was constructed and validated in the early stages of the study. Upon validating the test rig and the instrumentation that was set up for data collection and processing, a series of tests were performed. The tests were intended to establish a baseline for the test rig and compare the performance of smart damping materials with a number of passive interior automotive treatments. Further, in order to evaluate the effect of smart damping materials on the sound transmission loss, a series of tests were conducted according to the SAE J1400 test specifications. The tests evaluate the transmission loss for smart damping materials for an undamped and a damped plate.

The passive damping technique used for this study involved attaching piezoelectric patches with resonant electrical shunts. The vibration modes of the plate were determined both analytically and experimentally, using laser measurement techniques, in order to determine effective placement of the piezoceramic materials. Three piezoceramic patches were applied to control four structural resonance frequencies of the plate.

The tests show that smart damping materials have substantial performance benefits in terms of providing effective noise and vibration reduction at a frequency range that is often outside the effective range of passive damping materials. Further, judging by the acceleration and noise reduction per added weight, the test results indicate that smart damping materials can decrease the vibration peak of a steel plate at 151 Hz by up to 16.24 dB with an additional weight of only 0.11 lb. The addition of constrained-layer damping (CLD) can decrease that same peak by 18.65 dB, but it weighs 10 times more. This feature of smart damping materials is particularly useful for solving particular noise or vibration problems at specified frequencies, without adding any weight to the vehicle or changing the vehicle structure.

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