Prototype Variable-Area Exhaust Nozzle Designed

Ongoing research in NASA Glenn Research Center’s Structural Mechanics and Dynamics Branch to develop smart materials technologies for adaptive aeropropulsion components has resulted in the design of a prototype variable-area exhaust nozzle (see the preceding photograph). The novel design exploits the potential of smart materials to improve the performance of existing fixed-area exhaust nozzles by introducing new capabilities for adaptive shape control, vibration damping, and flow manipulation. The design utilizes two different smart materials: shape memory alloy wires as actuators and magnetorheological fluids as damper locks.

The prototype of the variable-area exhaust nozzle consists of an assembly of eight overlapping leaves, four shape-memory-alloy wire actuators, and four magnetorheological fluid damper locks. Electrical heating is used to actuate the shape-memory-alloy wires from the fully open position shown in the preceding photograph to the 40-percent reduced-area position depicted in the following photograph. The magnetorheological damper locks are subsequently used to hold the exhaust nozzle in the reduced-area configuration. Constant-force springs return the shape-memory-alloy wires to their original length once the electrical heating is removed. A computerized data acquisition and real-time control system has been implemented using a sliding-mode-based robust controller to operate the system.
Reduced-area configuration of the variable-area exhaust nozzle after the shape-memory-alloy wires are electrically heated.

This design represents a novel approach to using adaptive shape-control research to achieve performance benefits from smart materials. This research was conducted under a grant by the University of Houston in collaboration with Glenn researchers and was supported by the Ultra-Efficient Engine Technology (UEET) Project.

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