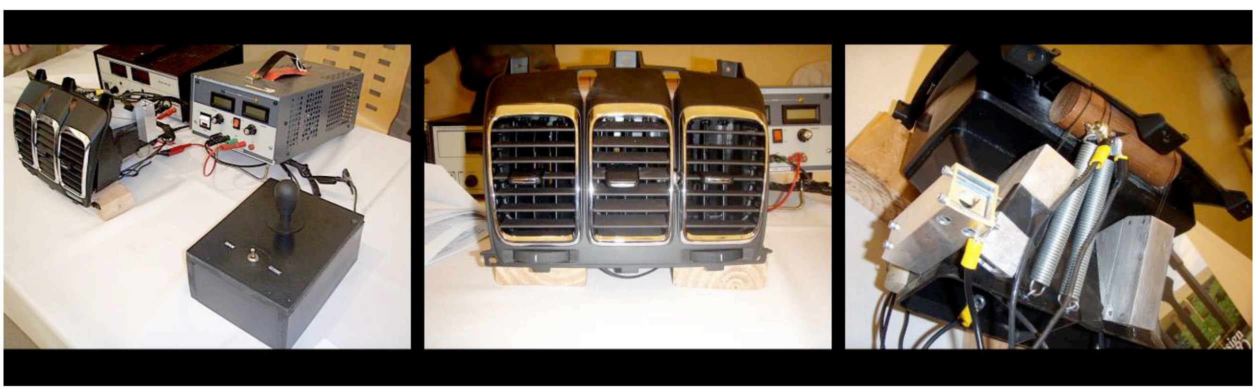
Active Automotive Vents
University of Michigan
Mechanical Engineering 450

Co-Sponsored by:
General Motors and
University of Michigan
SMART Materials and Structures Laboratory



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EXECUTIVE SUMMARY

An active vent system actuated by shape memory alloys has been designed and a functional prototype has been created. This project is being sponsored by General Motors (GM), who has asked for the system to be built onto the center console of a GMC Acadia. Their motivation for sponsoring this project is to explore the feasibility of incorporating this as a luxury feature for their higher end vehicles. Also, an active vent system can reduce heating and cooling time by allowing the driver to close vents not being used and focusing the ones that are. This feature may also be useful for customers with restricted joint motilities. More design drivers include using this device as a demonstration unit and aiding future research of SMA controls for the University of Michigan Smart materials and structures design lab.

During the initial meeting with the sponsors, a list of requirements for a high-quality active vent system design were compiled. GM required that the design be quiet, lightweight, and durable. They also stated that the system must have low power consumption, a fast response time, the same life as the car, and the ability to be manually overridden without damaging the mechanism. The design must also not infringe on any of the current vent system's features. Additionally the SMART lab indicated that the design must be continuous and not a series of discrete positions. A QFD was utilized to convert these customer requirements into engineering specifications and allowed for understanding of the relationships between them.

The process of concept generation was performed using several design and organizational tools. A functional decomposition was created to get a better understanding of the design problem and then all of the concepts were organized in a concept tree, using a separate tree for each function. The task of choosing the final design from these numerous concepts was performed while utilizing selection matrices and concept scoring. Along the way, feasibility calculations were made to ensure that each design that was evaluated was reasonable using the criteria of the length of wire required, ease of manufacturing, and packaging to differentiate between the designs.

From this methodology the final active vent system design was chosen to utilize leveraging for each of the degrees of freedom that must be controlled: vertical, horizontal, and air flow control. It involves creating or extruding pins for these levers to operate on and also the use of low friction corners. Mechanical fuses, in the form of springs sized to trigger before the critical stress is reached, are employed to ensure that the wire is not damaged during operation. The optimal lever ratios were found by a thorough analysis examining the diameter, length, and number of wires as well as the force and voltage required while factoring in losses. A force analysis on the levers was completed to examine the correct material and sizing to ensure that they would not fail and a detailed CAD model was created to illustrate how the mechanism's components would fit and operate in the packaging space available.

After the final design was optimized using an engineering analysis, a prototype was fabricated. This included machining levers, SMA attachment points, mechanical fuses, low friction corners and attaching them to the given vent system. The SMA wire was attached and tuned to achieve the optimal performance. The final prototype was successful in validating the final design by meeting weight, power, and time response specifications while maintaining the ability to be manually overridden.