Paper ID: 13175
oral
student

MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Smart Materials and Adaptive Structures (5)

Author: Mr. Ryan Orszulik
York University, Canada, orszulik@yorku.ca

Prof. Jinjun Shan
York University, Canada, jjshan@york.ca

# SHAPE CONTROL OF A MEMBRANE STRUCTURE WITH SHAPE MEMORY ALLOYS

**Abstract**

Membrane structures are currently attracting interest from the space community for future missions such as antennae, solar sails, membrane mirrors, and spacecraft sunshields. This is due to the fact that they are lightweight, provide a large surface area to weight ratio, and can be folded into a small volume, greatly reducing launch costs. An application of particular interest for the membrane structure is that of a synthetic aperture radar antenna, which requires a large surface area for increased resolution. However, membranes have very little resistance to compressive stress and as a result they will wrinkle due to mechanical or thermal loading. For a well-designed membrane structure, wrinkling is most likely to occur on a space mission when the membrane is thermally loaded by some type of heat source. This causes thermal expansion of the membrane material, and since there is no resistance to compressive stresses, wrinkles will be induced. This can substantially degrade the performance of an antenna, where a flat surface is required for optimal resolution. As a result, the membrane shape must be controlled through boundary tensions, supplied in this case by shape memory alloys (SMA's).

Shape memory alloys are materials that contract when an electrical current is applied to them due to the Joule heating effect. SMA's offer suitable actuation forces and relatively fast response times, unfortunately, SMA's themselves suffer from nonlinear effects in the form of hysteresis. Thus, the SMA's themselves require their own controller if they are to be used for shape control of the membrane structure. The previous controller used showed good performance, but only within certain force limits. Here, a discrete incremental proportional-integral controller is implemented and shows much better tension tracking than before within the actuator's saturation and actuation limits.

Results are presented on an experimental system consisting of a boundary cut membrane attached to a frame by twenty Nitinol SMA actuators. Their applied tension is measured by strain gauges for feedback in a real-time control system through Matlab's xPC target. The tension tracking performance of the SMA's is shown to be quite good within their saturation and actuation limits while they are attached to the membrane structure. Then, with the SMA controllers, some illustrative results are presented for the shape control of the membrane structure under varying thermal loading conditions. With the SMA's supplying the desired boundary tensions, membrane flatness can be maintained effectively through a master control loop.