Fabricating Composite-Material Structures Containing SMA Ribbons

Repeatable, predictable structures can be fabricated.

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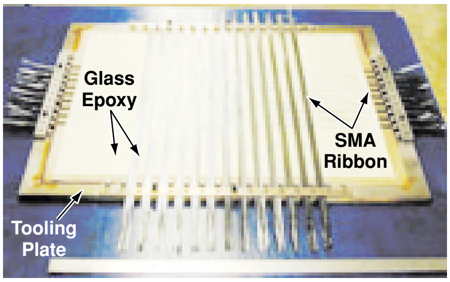
An improved method of designing and fabricating laminated composite-material (matrix/fiber) structures containing embedded shape-memory-alloy (SMA) actuators has been devised. Structures made by this method have repeatable, predictable properties, and fabrication processes can readily be automated.

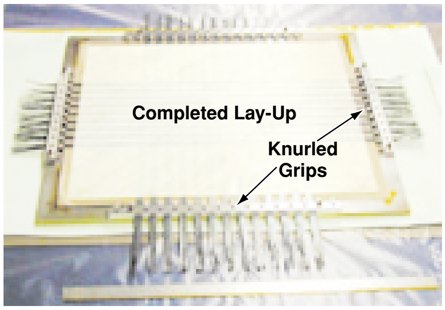
Such structures, denoted as shape-memory-alloy hybrid composite (SMAHC) structures, have been investigated for their potential to satisfy requirements to control the shapes or thermoelastic responses of themselves or of other structures into which they might be incorporated, or to control noise and vibrations. Much of the prior work on SMAHC structures has involved the use SMA wires embedded within matrices or within sleeves through parent structures. The disadvantages of using SMA wires as the embedded actuators include (1) complexity of fabrication procedures because of the relatively large numbers of actuators usually needed; (2) sensitivity to actuator/matrix interface flaws because voids can be of significant size, relative to wires; (3) relatively high rates of breakage of actuators during curing of matrix materials because of sensitivity to stress concentrations at mechanical restraints; and (4) difficulty of achieving desirable overall volume fractions of SMA wires when trying to optimize the integration of the wires by placing them in selected layers only.

In the present method, one uses SMA ribbons instead of SMA wires. This reduces the number of actuators that must be embedded, thereby making it possible to simplify fabrication processes and to exert better control over the locations and volume fractions of actuators.

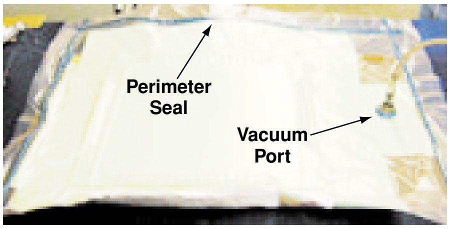
In a typical application of this method, one seeks to fabricate one or more structure(s), each comprising an epoxy-matrix/fiber laminate containing one or more embedded SMA ribbons. First, SMA ribbon, as received from the manufacturer packaged on a spool, is removed from the spool and treated to remove the packaging strain. Then by use of a tensile testing machine operating in stroke-control mode, the SMA ribbon is stretched to the amount of prestrain required by the design of the structure. To save time, several parallel lengths of ribbon, separated by spacers and held by grips designed specifically for the purpose, can be stretched simultaneously on the machine.



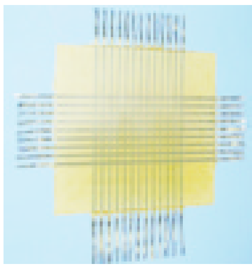
Intermediate Stage of SMAHC Panel Lamination



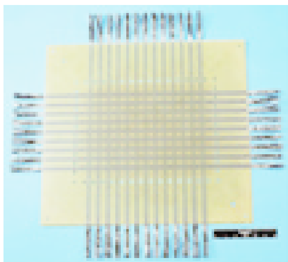
Completed Layup With SMA Ribbon Ends Secured



Vacuum-Bagged Laminate Assembly



Consolidated SMAHC Laminated Panel



SMAHC Panel Specimen After Final Machining

SMA Ribbons Were Incorporated into an epoxy/fiberglass laminate panel. The panel was then machined to obtain SMAHC beam specimens for testing.

The figure shows several stages of fabrication of a panel-type structure following elongation of the SMA actuators. Fabrication of the SMAHC laminate proceeds by incorporating lengths of the SMA ribbon at the specified locations during the lamination process. Depending on the design of the specific structure, either the SMA ribbons can be laid up between laminae, or else precisely dimensioned portions of the laminae can be removed and SMA ribbons inserted in the resulting voids to incorporate the SMA ribbons within the laminae. Upon completion of the layup, the free ends of the SMA ribbons are constrained within the knurled mechanical grips to maintain the preset elongation during elevated temperature cure. The entire assembly is then vacuum bagged and subjected to autoclave cure. Subsequent to consolidation, the free ends of the SMA ribbons are released from the grips and the SMAHC structure is machined to final dimensions.

This work was done by Travis L. Turner, Roberto J. Cano, and Cynthia L. Lach of **Langley Research Center**. *Further information is contained in a TSP [see page 1].*
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