Manufacturing & Prototyping

Radiation-Shielding Polymer/Soil Composites

Radiation shields could be fabricated *in situ* at relatively low cost.

Marshall Space Flight Center, Alabama

It has been proposed to fabricate polymer/soil composites primarily from extraterrestrial resources, using relatively low-energy processes, with the original intended application being that habitat structures constructed from such composites would have sufficient structural integrity and also provide adequate radiation shielding for humans and sensitive electronic equipment against the radiation environment on the Moon and Mars. The proposal is a response to the fact that it would be much less expensive to fabricate such structures *in situ* as opposed to transporting them from Earth.

Prototype polymer/soil composite bricks have been fabricated on Earth. Transport calculations have shown that the addition of polymeric materials to soil significantly improves the radiation-shielding properties of the resulting composites due to the high hydrogen content of the polymeric constituent. Mechanical testing and hypervelocity-ballistic testing of the proposed composites have demonstrated that structural properties can be improved by a factor of 10 when compared to bricks consisting of only the planetary soil.

A typical composite of this type consists of 5-to 95-weight percent polymeric material and 95-to-5-weight percent of the local planetary soil. The polymeric and soil constituents are thoroughly mixed, heated to slightly over the melting point of the polymeric constituent and pressure is applied to ensure complete infiltration of the polymeric material within the pores of the soil particles. Through suitable choice of pressure and temperature, the resulting polymer/soil composite can be made nearly free of voids.

This work was done by Subhayu Sen of BAE Systems for Marshall Space Flight Center. Further information is contained in a TSP (see page 1).

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

BAE Systems
Attn. Subhayu Sen
Subhayu.sen-1@nasa.gov

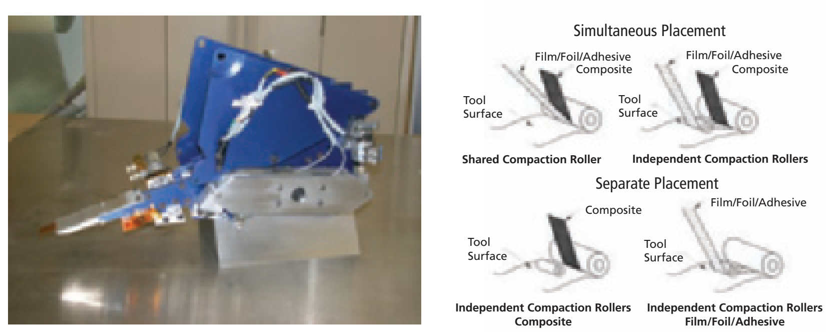
Refer to MFS-32340-1, volume and number of this NASA Tech Briefs *issue, and the page number.*

Film/Adhesive Processing Module for Fiber-Placement Processing of Composites

Films, foils, or adhesives may be interleaved while fiber-placing composite material structures.

Marshall Space Flight Center, Alabama

An automated apparatus has been designed and constructed that enables the automated lay-up of composite structures incorporating films, foils, and adhesives during the automated fiber-placement process. This apparatus, denoted a film module, could be used to deposit materials in film or thin sheet form either simultaneously when laying down the fiber composite article or in an independent step. Examples of materials that may be processed with this device include structural core and joining adhesives, permeation barrier films/foils, surfacing films, lightning-strike materials and IVHM (Integral Vehicle Health Monitoring) arrays. The use of this technology will reduce composite fabrication time and will allow for new concepts/designs to be considered for fiber-placed composite structures.



The **Prototype Film Module** is shown on the left. Materials, as shown on the right, may be placed either simultaneously with to the composite tow/tape, or in an independent step such as in the application of external structural core adhesives.

The film module may be easily designed to fit existing fiber-placement machinery or may be integrally designed into new machines. The film materials may be placed either simultaneously with the fiber composite material as with the case of embedded materials, or in an independent operation as with application of exterior structural core adhesives, as shown in the figure. The device is designed such that it may be made to operate by use of existing fiber-placement lay-up program files. This eliminates the need for additional computer program files to be generated, saving both time and expense.

The film module includes a material supply and feed system, a material preheating system for the tackifying of incoming and substrate materials, and a film-cutting system. The preheating system utilizes an infrared quartz-halogen lamp with a focused parabolic reflector to provide radiant heating of the substrate and incoming materials at the point of application. All prototype device actuators are pneumatic; however, digital servo/stepper motors may be employed for additional control and accuracy.

The prototype device was designed to supply material of width identical to that of the composite material typically processed by the machine that was used as the test-bed during the course of module development. By thus setting the width of the film, use may be made of the same placement files as written for the composite. The device is designed to be portable and easily removed from the host machine. A simple switch allows for the disabling of the device when placement of composites alone is being performed.

This work was done by A. Bruce Hulcher of Marshall Space Flight Center. For further information on this technology, contact A. Bruce Hulcher at (256) 544-5124.

This invention is owned by NASA, and a patent application has been filed. For further information, contact Sammy Nabors, MSFC Commercialization Assistance Lead, at sammy.a.nabors@nasa.gov. Refer to MFS-32008-1.

Fabrication of Submillimeter Axisymmetric Optical Components

Surfaces of components can be arbitrarily shaped to optimize spectral responses.

NASA's Jet Propulsion Laboratory, Pasadena, California

It is now possible to fashion transparent crystalline materials into axisymmetric optical components having diameters ranging from hundreds down to tens of micrometers, whereas previously, the smallest attainable diameter was 500 μm. A major step in the fabrication process that makes this possible can be characterized as diamond turning or computer numerically controlled machining on an ultrahigh-precision lathe. This process affords the flexibility to make arbitrary axisymmetric shapes that have various degrees of complexity: examples include a flat disk or a torus supported by a cylinder (see figure), or multiple closely axially spaced disks or tori supported by a cylinder. Such optical components are intended mainly for use as whispering-gallery-mode optical resonators in diverse actual and potential applications, including wavelength filtering, modulation, photonic generation and detection of microwaves, and research in quantum electrodynamics and quantum optics.

The first step in the fabrication process is to use a brass tube bore with a 30-μm diamond suspension to cut a small cylindrical workpiece from a plate or block of the selected crystalline material. In a demonstration of the process, the cylindrical workpiece was 1.8 mm in diameter and 5 mm long; in general, different dimensions would be chosen to suit a specific application.

The workpiece is then glued to a metal cap that, in turn, is attached to the rotor of an aerostatic spindle. During the rotation of the spindle, a diamond tool is used to cut the workpiece. A computer program is used to control stepping motors that move the diamond tool, thereby controlling the shape cut by the tool. Because the shape can be controlled via software, it is possible to choose a shape designed to optimize a resonator spectrum.

This work was done by Ivan Grudinin, Anatoliy Savchenkov, and Dmitry Strekalov of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

Innovative Technology Assets Management
JPL
Mail Stop 202-233
4800 Oak Grove Drive
Pasadena, CA 91109-8099
(818) 354-2240
E-mail: iaoffice@jpl.nasa.gov

Refer to NPO-42056, volume and number of this NASA Tech Briefs *issue, and the page number.*