Manufacturing

Automated Solvent Seaming of Large Polyimide Membranes

Success depends on precise control of all relevant process details.

Marshall Space Flight Center, Alabama

A solvent-based welding process enables the joining of precise, cast polyimide membranes at their edges to form larger precise membranes. The process creates a homogeneous, optical-quality seam between abutting membranes, with no overlap and with only a very localized area of figure disturbance. The seam retains 90 percent of the strength of the parent material. The process was developed for original use in the fabrication of wide-aperture membrane optics, with areal densities of less than 1 kg/m^2, for lightweight telescopes, solar concentrators, antennas, and the like to be deployed in outer space. The process is just as well applicable to the fabrication of large precise polyimide membranes for flat or inflatable solar concentrators and antenna reflectors for terrestrial applications.

The process is applicable to cast membranes made of CP1 (or equivalent) polyimide. The process begins with the precise fitting together and fixturing of two membrane segments. The seam is formed by applying a metered amount of a doped solution of the same polyimide along the abutting edges of the membrane segments. After the solution has been applied, the fixtured films are allowed to dry and are then cured by convective heating. The weld material is the same as the parent material, so that what is formed is a homogeneous, strong joint that is almost indistinguishable from the parent material.

The success of the process is highly dependent on formulation of the seaming solution from the correct proportion of the polyimide in a suitable solvent. In addition, the formation of reliable seams depends on the deposition of a precise amount of the seaming solution along the seam line. To ensure the required precision, deposition is performed by use of an automated apparatus comprising a modified commercially available, large-format, ink-jet print head on an automated positioning table. The printing head jets the seaming solution into the seam area at a rate controlled in coordination with the movement of the positioning table.

This work was done by Robert Rood of **Marshall Space Flight Center** *and James D. Moore, Chris Talley, and Paul A. Gierow of SRS Technologies, Inc. Further information is contained in a TSP (see page 1).*
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Manufacturing Precise, Lightweight Paraboloidal Mirrors

Success depends on the proper selection of materials and process conditions.

Marshall Space Flight Center, Alabama

A process for fabricating a precise, diffraction-limited, ultra-lightweight, composite-material (matrix/fiber) paraboloidal telescope mirror has been devised. Unlike the traditional process of fabrication of heavier glass-based mirrors, this process involves a minimum of manual steps and subjective judgment. Instead, this process involves objectively controllable, repeatable steps; hence, this process is better suited for mass production.

Other processes that have been investigated for fabrication of precise composite-material lightweight mirrors have resulted in "print-through" of fiber patterns onto reflecting surfaces, and have not provided adequate structural support for maintenance of stable, diffraction-limited surface figures. In contrast, this process does not result in "print-through" of the fiber pattern onto the reflecting surface and does provide a lightweight, rigid structure capable of maintaining a diffraction-limited surface figure in the face of changing temperature, humidity, and air pressure.

The process consists mainly of the following steps:

1. A precise glass mandrel is fabricated by conventional optical grinding and polishing.
2. The mandrel is coated with a release agent and covered with layers of a carbon-fiber composite material.
3. The outer surface of the outer layer of the carbon-fiber composite material is coated with a surfactant chosen to provide for the proper flow of an epoxy resin to be applied subsequently.
4. The mandrel as thus covered is mounted on a temperature-controlled spin table.
5. The table is heated to a suitable temperature and spun at a suitable speed as the epoxy resin is poured onto the coated carbon-fiber composite material.
6. The surface figure of the optic is monitored and adjusted by use of traditional Ronchi, Focault, and interferometric optical measurement techniques while the speed of rotation and the temperature are adjusted to obtain the desired figure. The proper selection of surfactant, speed or rotation, viscosity of the epoxy, and temperature make it possible to obtain the desired diffraction-limited, smooth (1/50th wave) parabolic outer surface, suitable for reflective coating.
7. A reflective coat is applied by use of conventional coating techniques.
8. Once the final figure is set, a lightweight structural foam is applied to the rear of the optic to ensure stability of the figure.

This work was done by Frederick Thomas Herrmann of **Marshall Space Flight Center**. *Further information is contained in a TSP (see page 1).*

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-31595-1.