Repairing Chipped Silicide Coatings on Refractory Metal Substrates

Two methods have been demonstrated to be feasible.

*John F. Kennedy Space Center, Florida*

The space shuttle orbiter’s reaction control system (RCS) is a series of small thrusters that use hypergolic fuels to orient the orbiter in space. The RCS thrusters are constructed from a special niobium-based alloy — the C-103. This alloy retains excellent mechanical properties from cryogenic temperature all the way up to 2,500 °F (1,370 °C). Despite its excellent, high-temperature properties, C-103 is susceptible to rapid oxidation at elevated temperatures. Were the naked C-103 alloy exposed to the operational thruster environment, it would rapidly oxidize, at least losing all of its structural integrity, or, at worst, rapidly “burning.” Either failure would be catastrophic.

To prevent this rapid oxidation during thruster firing, the RCS thrusters are coated with a silicide-based protective coating — the R512a. Over time, this protective coating becomes weathered and begins to develop chips. Launch Commit Criteria limit the diameter and depth of an acceptable pit; otherwise, the thruster must be removed from the orbiter — a very costly, time-consuming procedure. The authors have developed two methods to repair damaged R512a coatings on C-103.

For the first repair technique, metal coupons are chemically and structurally adapted to other high-temperature coating/substrate systems. The two repair techniques may be adapted to other geometries of R512a/C-103. Additionally, the two repair techniques may be adapted to other high-temperature coating/substrate systems.

This work was done by Robert Youngquist of Kennedy Space Center and Christopher D. Immer and Francisco Lorenzo-Luaces of ASRC Aerospace. Further information is contained in a TSP (see page 1). KSC-12690/29

Simplified Fabrication of Helical Copper Antennas

From concept to working prototype takes just a few hours.

*Lyndon B. Johnson Space Center, Houston, Texas*

A simplified technique has been devised for fabricating helical antennas for use in experiments on radio-frequency generation and acceleration of plasmas. These antennas are typically made of copper (for electrical conductivity) and must have a specific helical shape and precise diameter.

Such an antenna could be made by bending a single long piece of copper tubing or bending smaller pieces of copper tubing, then welding the pieces to-
gether. It could also be made by machining from a single large piece of copper. It is extremely difficult to bend copper tubing into a helix with a precise pitch and diameter. It is also difficult to create the helical shape from multiple pieces of tubing; moreover, welding separate pieces distorts the shape. Machining a hollow cylindrical helix from a block or cylinder of copper entails the use of a complex, expensive, three-dimensional-milling machine in a process that entails long setup and machining times.

In the present simplified technique, one begins by creating a two-dimensional paper template of a desired helical antenna shape. The template is pasted on the outer surface of a copper pipe that has the desired inner and outer diameters. Holes are drilled at the locations where corners are required to exist in the final helical antenna. Manually, using a hacksaw, diagonal cuts are made in the outer cylindrical surface of the pipe, following the lines on the template. Usually, after hacksawing, only a little filing is needed to smooth the edges of the resulting antenna. If the antenna must be water-cooled, then copper tubing can be brazed onto the outer surface of the antenna. This tubing is not required to follow the precisely defined shape of the antenna.

This fabrication technique would not be suitable for mass production, but it is ideal for a laboratory environment. The advantages of this technique are the following:

- Precise antennas can be made from inexpensive, stock-size copper pipes.
- No welding of separate pieces is needed, and so there is no welding-induced distortion of antenna shapes.
- Prototype antennas can be fabricated fairly rapidly, without the need for complex three-dimensional-milling machines or computer-aided drafting tools.
- Notwithstanding the reliance on handwork, the total fabrication time (as little as a few hours) is competitive with, and probably less than, that of any automated process that could be used for this purpose.

This work was done by Andrew Petro of Johnson Space Center. Further information is contained in a TSP (see page 1).

MSC-24076