Brazing SiC/SiC Composites to Metals

Success depends on suitable process conditions and adequate titanium contents in brazing alloys.

Marshall Space Flight Center, Alabama

Experiments have shown that active brazing alloys (ABAs) can be used to join SiC/SiC composite materials to metals, with bond strengths sufficient for some structural applications. The SiC/SiC composite coupons used in the experiments were made from polymer-based SiC fiber preforms that were chemical-vapor-infiltrated with SiC to form SiC matrices. Some of the metal coupons used in the experiments were made from 304 stainless steel; others were made from oxygen-free, high-conductivity copper.

Three ABAs were chosen for the experiments: two were chosen randomly from among a number of ABAs that were on hand at the time; the third ABA was chosen because its titanium content (1.25 percent) is less than those of the other two ABAs (1.75 and 4.5 percent, respectively) and it was desired to evaluate the effect of reducing the titanium content, as described below. The characteristics of ABAs that are considered to be beneficial for the purpose of joining SiC/SiC to metal include wettability, reactivity, and adhesion to SiC-based ceramics. Prior to further development, it was verified that the three chosen ABAs have these characteristics.

For each ABA, suitable vacuum brazing process conditions were established empirically by producing a series of (SiC/SiC)/ABA wetting samples. These samples were then sectioned and subjected to scanning electron microscopy (SEM) and energy-dispersive x-ray spectrometry (EDS) for analysis of their microstructures and compositions. Specimens for destructive mechanical tests were fabricated by brazing of lap joints between SiC/SiC coupons 1/8-in. (≈3.2-mm) thick and, variously, stainless steel or copper tabs. The results of destructive mechanical tests and the SEM/EDS analysis were used to guide the development of a viable method of brazing the affected materials.

The 1.75-percent-Ti ABA was found to be well suited for joining the SiC/SiC composite with 304 stainless steel. The (SiC/SiC)/Cu joints made by use of the 1.75- and 4.5-percent-Ti ABAs were found to be stronger than were the (SiC/SiC)/Cu joints made by use of the 1.25-percent-Ti. At the time of reporting the information for this article, it was believed that the 1.25-percent titanium content was insufficient for reacting with the SiC/SiC composite; however, it was uncertain whether an observed difficulty in producing joints of acceptably high quality was caused at least in part by surface contaminants that could consume what little titanium was available for reacting with SiC.

The strengths of the (SiC/SiC)/stainless-steel joints tested ranged up to a maximum of 24.5 MPa for joints made with the 1.75-percent Ti ABA. The strengths of the (SiC/SiC)/Cu joints tested ranged up to a maximum of 23.1 MPa for joints made with the 4.5-percent Ti ABA. The preliminary data on the (SiC/SiC)/1.75-percent-Ti ABA/stainless-steel and (SiC/SiC)/4.5-percent-Ti ABA/Cu joints show that the characteristics of the joints are highly predictable — a quality that is desirable for optimization of design.

This work was done by Wayne S. Steffier of Hyper-Therm High-Temperature Composites, Inc., for **Marshall Space Flight Center**. *Further information is contained in a TSP (see page 1).*
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Composite-Material Tanks With Chemically Resistant Liners

Liner materials are chosen for compatibility with reactive and/or unstable fluids.

Marshall Space Flight Center, Alabama

Lightweight composite-material tanks with chemically resistant liners have been developed for storage of chemically reactive and/or unstable fluids — especially hydrogen peroxide. These tanks are similar, in some respects, to the ones described in "Lightweight Composite-Material Tanks for Cryogenic Liquids" (MFS-31379), *NASA Tech Briefs*, Vol. 25, No. 1 (January, 2001), page 58; however, the present tanks are fabricated by a different procedure and they do not incorporate insulation that would be needed to prevent boil-off of cryogenic fluids.

The manufacture of a tank of this type begins with the fabrication of a reusable multisegmented aluminum mandrel in the shape and size of the desired interior volume. One or more segments of the mandrel can be aluminum bosses that will be incorporated into the tank as end fittings.

The mandrel is coated with a mold-release material. The mandrel is then heated to a temperature of about 400 °F (≈200 °C) and coated with a thermoplastic liner material to the desired thickness [typically ≈15 mils (≈0.38 mm)] by thermal spraying. In the thermal-spraying process, the liner material in powder form is sprayed and heated to the melting temperature by a propane torch and the molten particles land on the mandrel.

The sprayed liner and mandrel are allowed to cool, then the outer surface of the liner is chemically and/or mechanically etched to enhance bonding of a composite overwrap. The etched liner is wrapped with multiple layers of an epoxy resin reinforced with graphite fibers; the wrapping can be done either by manual application of epoxy-impregnated graphite cloth or by winding of