Materials

Ceramic Paste for Patching High-Temperature Insulation

Repairs can be performed by use of simple techniques.

Lyndon B. Johnson Space Center, Houston, Texas

A ceramic paste that can be applied relatively easily, either by itself or in combination with one or more layer(s) of high-temperature ceramic fabrics, such as silicon carbide or zirconia, has been invented as a means of patching cracks or holes in the reinforced carbon-carbon forward surfaces of a space shuttle in orbit before returning to Earth. The paste or the paste/fabric combination could also be used to repair rocket-motor combustion chambers, and could be used on Earth to patch similar high-temperature structures.

The specified chemical composition of the paste admits of a number of variations, and the exact proportions of its constituents are proprietary. In general, the paste consists of (1) silicon carbide, possibly with addition of (2) hafnium carbide, zirconium carbide, zirconium boride, silicon tetraboride, silicon hexaboride, or other metal carbides or oxides blended with (3) a silazane-based polymer.

Because the paste is viscous and sticky at normal terrestrial and outer-space ambient temperatures, high-temperature ceramic fabrics such as silicon carbide or zirconia fabric impregnated with the paste (or the paste alone) sticks to the damaged surface to which it is applied. Once the patch has been applied, it is smoothed to minimize edge steps as required [forward-facing edge steps must be ≤0.030 in. (≤0.76 mm) in the original intended space-shuttle application]. The patch is then heated to a curing temperature thereby converting it from a flexible material to a hard, tough material. The curing temperature is 375 to 450 °F (≈190 to 230 °C).

In torch tests and arc-jet tests, the cured paste was found to be capable of withstanding a temperature of 3,500 °F (≈1,900 °C) for 15 minutes. As such, the material appears to satisfy the requirement, in the original space-shuttle application, to withstand re-entry temperatures of ≈3,000 °F (≈1,600 °C).

This work was done by Steven J. Adam, James V. Tompkins, Gordon R. Toombs, Pete Hogensen, and Douglas G. Soden of The Boeing Co. for **Johnson Space Center**.

Title to this invention has been waived under the provisions of the National Aeronautics and Space Act {42 U.S.C. 2457(f)}, to The Boeing Company. Inquiries concerning licenses for its commercial development should be addressed to:

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Refer to MSC-23942, volume and number of this NASA Tech Briefs *issue, and the page number.*

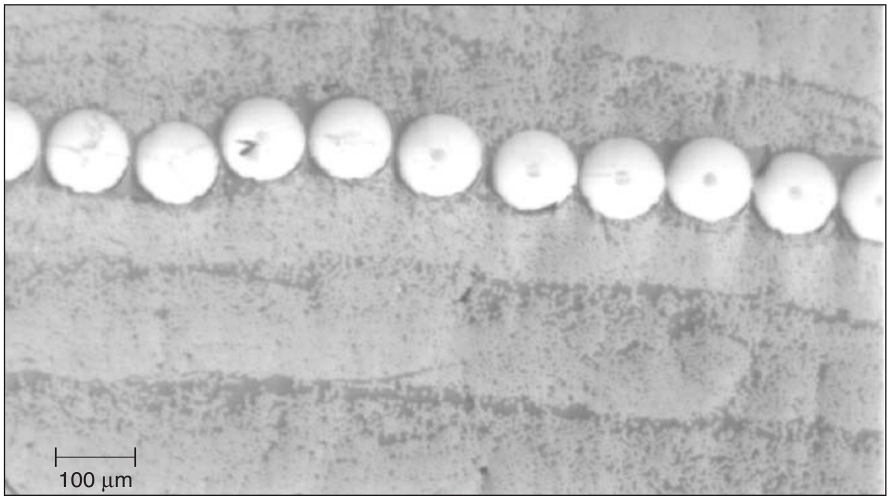
Fabrication of Polyimide-Matrix/Carbon and Boron-Fiber Tape

Production costs can be reduced and compression strengths increased.

Langley Research Center, Hampton, Virginia

The term "HYCARB" denotes a hybrid composite of polyimide matrices reinforced with carbon and boron fibers. HYCARB and an improved process for fabricating dry HYCARB tapes have been invented in a continuing effort to develop lightweight, strong composite materials for aerospace vehicles. Like other composite tapes in this line of development, HYCARB tapes are intended to be used to build up laminated structures having possibly complex shapes by means of automated tow placement (ATP) — a process in which a computer-controlled multiaxis machine lays down prepreg tape or tows. The special significance of the present process for making dry HYCARB for ATP is that it contributes to the reduction of the overall cost of manufacturing boron-reinforced composite-material structures while making it possible to realize increased compression strengths.

The present process for making HYCARB tapes incorporates a "wet to dry" process developed previously at Langley Research Center. In the "wet to dry" process, a flattened bundle of carbon fiber tows, pulled along a continuous production line between pairs of rollers, is impregnated with a solution of a poly(amide acid)



This **Photomicrograph** shows a cross of a specimen containing one layer of boron fibers.