Advanced Ablative Insulators and Methods of Making Them

Reinforced, filled silicones and carbon phenolics are laser-milled to final shapes.

Lyndon B. Johnson Space Center, Houston, Texas

Advanced ablative (more specifically, charring) materials that provide temporary protection against high temperatures, and advanced methods of designing and manufacturing insulators based on these materials, are undergoing development. These materials and methods were conceived in an effort to replace the traditional thermal-protection systems (TPSs) of re-entry spacecraft with robust, lightweight, better-performing TPSs that can be designed and manufactured more rapidly and at lower cost. These materials and methods could also be used to make improved TPSs for general aerospace, military, and industrial applications.

The ablative materials belong to two families. One family comprises filled, fiber-reinforced elastomeric carbon phenolics with mass densities that range from 12 to 50 lbm/ft³ [192 to 800 kg/m³]; these materials are designed to protect against heating rates from 5 to about 400 Btu/(ft²s) [about 1,300 Btu/(ft²s) = 15 MW/m²]. The other family comprises filled, fiber-reinforced silicones with mass densities that range from 12 to 50 lbm/ft³ [192 to 800 kg/m³]; these materials are designed to protect against heating rates from 5 to about 400 Btu/(ft²s) [about 1,300 Btu/(ft²s) = 15 MW/m²]. The fillers in these materials help to minimize their mass densities, while the fibers help to maximize their strengths.

Design and manufacture of TPSs according to the present approach involve the use of computer-aided design and computer-aided manufacturing (CAD/CAM) methods, including computer numerically controlled (CNC) laser milling. This approach eliminates the labor-intensive steps of machining, fitting, and trimming heat-shield parts in the prior approach to manufacturing. In the present approach, molded panels of the ablative materials are CNC-laser-milled to precise final sizes and shapes and are thus made ready for bonding to heat-shield structures.

This work was done by G. K. Surya Prakash, Qin-Jie Wang, and George A. Olah of the University of Southern California and Marshall C. Smart, Sekharipuram Narayanan, and Subbarao Surampudi, of Caltech for NASA’s Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

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