Affordable, Robust Ceramic Joining Technology (ARCJoinT) Given 1999 R&D 100 Award

Advanced ceramics and fiber-reinforced ceramic matrix composites with high strength and toughness, good thermal conductivity, thermal shock resistance, and oxidation resistance are needed for high-temperature structural applications in advanced high-efficiency and high-performance engines, space propulsion components, and land-based systems. The engineering designs of these systems require the manufacturing of large parts with complex shapes, which are either quite expensive or impossible to fabricate. In many instances, it is more economical to build complex shapes by joining together simple geometrical shapes. Thus, joining has been recognized as an enabling technology for the successful utilization of advanced ceramics and fiber-reinforced composite components in high-temperature applications. However, such joints must retain their structural integrity at high temperatures and must have mechanical strength and environmental stability comparable to those of the bulk materials. In addition, the joining technique should be robust, practical, and reliable.

ARCJoinT, which is based on the reaction-forming approach, is unique in terms of producing joints with tailorable microstructures. The formation of joints by this approach is attractive since the thermomechanical properties of the joint interlayer can be tailored to be very close to those of the base materials. In addition, high-temperature fixturing is not needed to hold the parts at the infiltration temperature. The joining process begins with the application of a carbonaceous mixture in the joint area, holding the items to be joined in a fixture, and curing at 110 to 120 °C for 10 to 20 min. This step fastens the pieces together. Then, silicon or a silicon alloy in tape, paste, or slurry form is applied around the joint region and heated to 1250 to 1425 °C (depending on the type of infiltrant) for 10 to 15 min. The molten silicon or silicon-refractory metal alloy reacts with carbon to form silicon carbide with controllable amounts of silicon and other phases as determined by the alloy composition. Joint thickness can be readily controlled through adjustments of the properties of the carbonaceous paste and the applied fixturing force.

Various ceramics and composites joined using ARCJoinT.

The photograph shows various shapes of silicon-carbide-based ceramics and fiber-reinforced composites that have been joined using ARCJoinT. Thermomechanical and thermochemical characterization of joints is underway for a wide variety of silicon-carbide-based advanced ceramics and fiber-reinforced composites under the hostile environments that will be encountered in engine applications. ARCJoinT, which was developed by researchers at the NASA Glenn Research Center at Lewis Field, received R&D Magazine's prestigious R&D 100 Award in 1999.

For more information, visit the Ceramics Branch on the World Wide Web:
http://www.grc.nasa.gov/WWW/Ceramics/homepage.htm

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