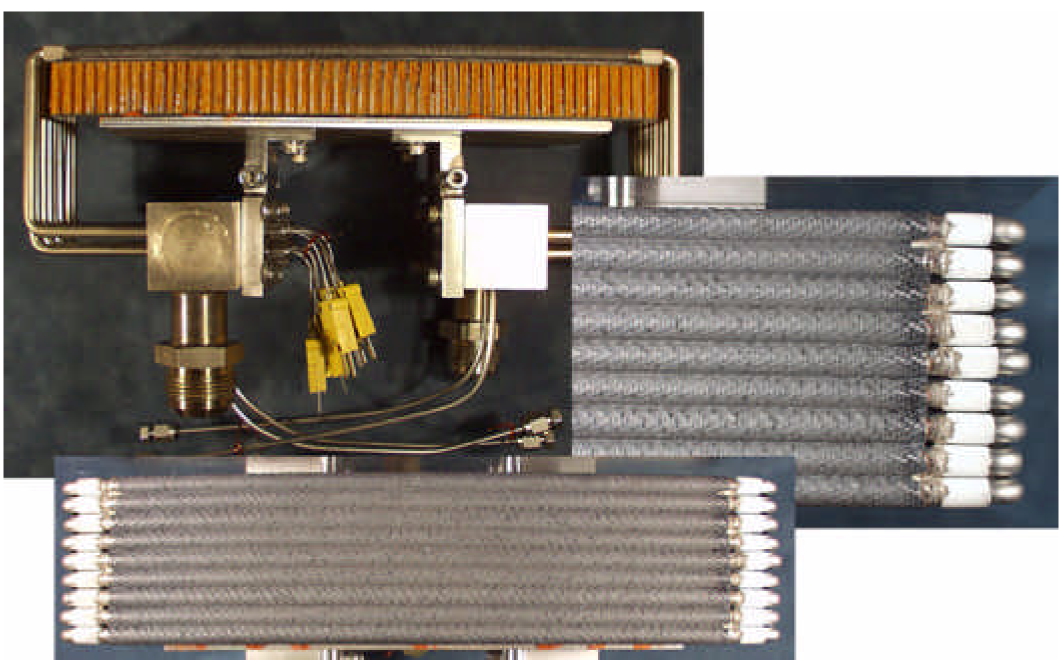
# Cooled Ceramic Composite Panel Tested Successfully in Rocket Combustion Facility

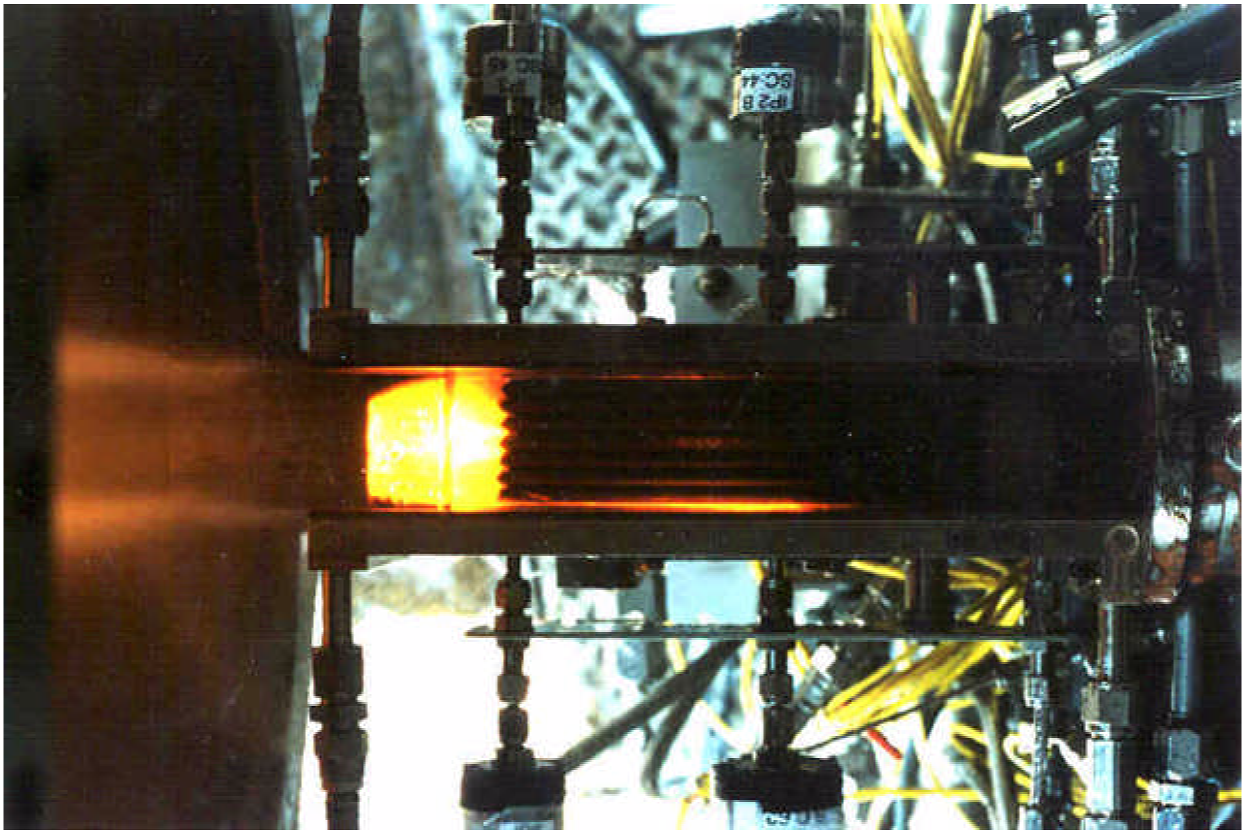
Regeneratively cooled ceramic matrix composite (CMC) structures are being considered for use along the walls of the hot-flow paths of rocket-based or turbine-based combined-cycle propulsion systems. They offer the combined benefits of substantial weight savings, higher operating temperatures, and reduced coolant requirements in comparison to components designed with traditional metals. These cooled structures, which use the fuel as the coolant, require materials that can survive aggressive thermal, mechanical, acoustic, and aerodynamic loads while acting as heat exchangers, which can improve the efficiency of the engine.

A team effort between the NASA Glenn Research Center, the NASA Marshall Space Flight Center, and various industrial partners has led to the design, development, and fabrication of several types of regeneratively cooled panels. The concepts for these panels range from ultra-lightweight designs that rely only on CMC tubes for coolant containment to more maintainable designs that incorporate metal coolant containment tubes to allow for the rapid assembly or disassembly of the heat exchanger. One of the cooled panels based on an all-CMC design was successfully tested in the rocket combustion facility at Glenn. Testing of the remaining four panels is underway.



*Cooled CMC panel with woven coolant channels before test firing.*

The all-CMC cooled panel, developed by Rockwell Science Center, consists of a woven coolant channel design that increases heat exchanger efficiency by employing thin CMC walls to maximize heat transfer and by eliminating metal coolant tubes, which can lead to increased thermal contact resistance at the tube-to-CMC interface. The CMC material used in this design consists of carbon-fiber-reinforced silicon carbide. Thin wall tubes were fabricated by a combination of fiber-preforming and polymer-impregnated pyrolysis techniques. The cooling channels were formed during the weaving process. This process results in an array of integrally woven tubes with greater structural integrity at the tube-to-tube connections. Metal tubes brazed at either end of the CMC panel serve as a coolant delivery system. The 2.5- by 10-in. cooled CMC panels were tested under rocket combustion conditions with gaseous hydrogen and gaseous oxygen as the propellants. A rectangular nozzle was designed for the engine to simulate two-dimensional flow over the panels. For these subscale ground-based tests, water was used as the coolant. The cooled CMC structure survived the test without any coolant leakage and without any visible structural damage. Testing of this panel is continuing with increasingly aggressive engine conditions, longer duration runs, and increased cycles.



*Woven CMC coolant channel design being tested in rocket engine with gaseous hydrogen and oxygen.*

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