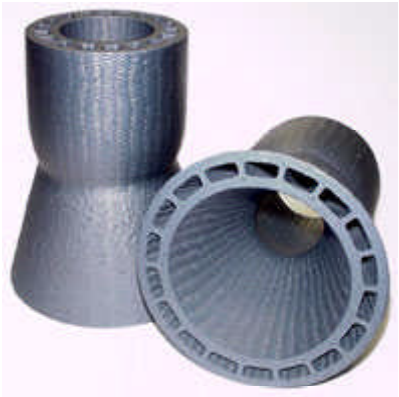
Lightweight, Actively Cooled Ceramic Matrix Composite Thrustcells Successfully Tested in Rocket Combustion Lab

In a joint effort between the NASA Glenn Research Center and the NASA Marshall Space Flight Center, regeneratively cooled ceramic matrix composite (CMC) thrustcells were developed and successfully tested in Glenn's Rocket Combustion Lab. Cooled CMC's offer the potential for substantial weight savings over more traditional metallic parts. Two CMC concepts were investigated. In the first of these concepts, an innovative processing approach utilized by Hyper-Therm, Inc., allowed woven CMC coolant containment tubes to be incorporated into the complex thruster design. In this unique design, the coolant passages had varying cross-sectional shapes but maintained a constant cross-sectional area along the length of the thruster. These thrusters were silicon carbide matrix composites reinforced with silicon carbide fibers.

The second concept, which was supplied by Ceramic Composites, Inc., utilized copper cooling coils surrounding a carbon-fiber-reinforced carbon matrix composite. In this design, a protective gradient coating was applied to the inner thruster wall. Ceramic Composites, Inc.'s, method of incorporating the coating into the fiber and matrix eliminated the spallation problem often observed with thermal barrier coatings during hot-fire testing. The focus of the testing effort was on screening the CMC material's capabilities as well as evaluating the performance of the thermal barrier or fiber-matrix interfacial coatings. Both concepts were hot-fire tested in gaseous O_2/H_2 environments. The test matrix included oxygen-to-fuel ratios ranging from 1.5 to 7 with chamber pressures to 400 psi. Steady-state internal wall temperatures in excess of 4300 °F were measured in situ for successful 30-sec test runs.



Silicon-carbide-fiber-reinforced silicon carbide matrix composites with woven cooling tubes.

Long description

Photograph of actively cooled composite thrustcell fabricated by Hyper-Therm. The thrustcell is a silicon-carbide-fiber-reinforced silicon carbide matrix composite with woven cooling channels. The matrix is formed via chemical vapor infiltration.

Actively cooled carbon-fiber-reinforced carbon matrix composites being hot-fire tested.

Long description

Photograph of hot-fire test of an actively cooled carbon-fiber-reinforced carbon matrix composite thrustcell. This composite thrustcell, which was fabricated by CCI, Inc., was wound with copper cooling coils to contain the water coolant. The tests were run with oxygen fuel ratios up to seven with chamber pressures of 200 psia.

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