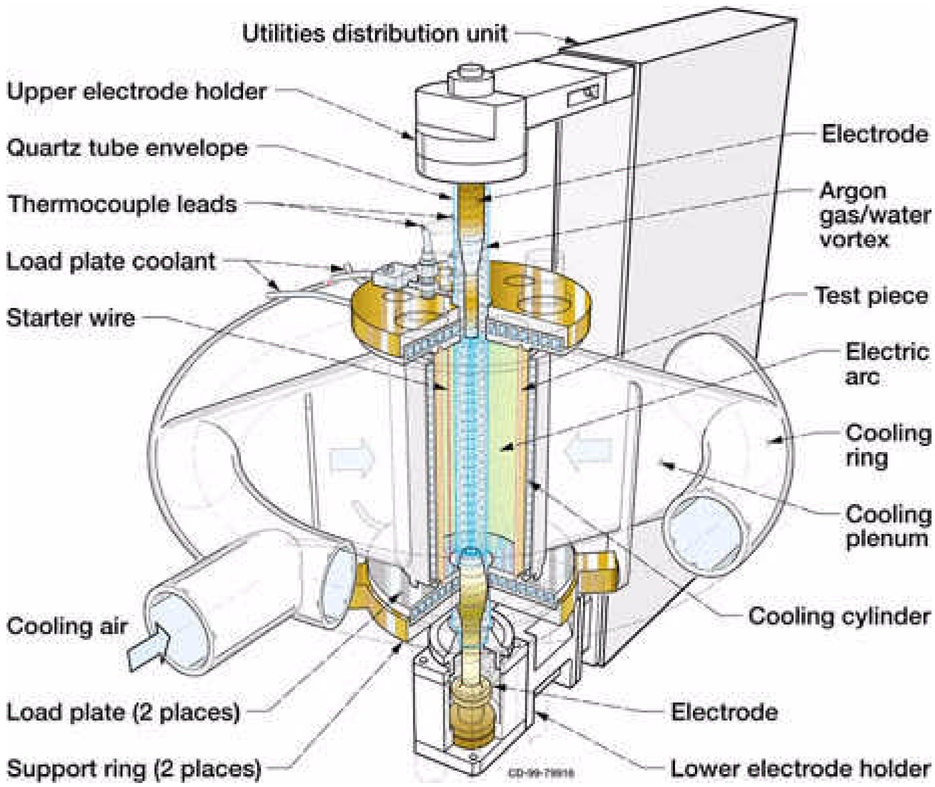
Electric Plasma Arc-Lamp Combustor Liner Durability Test System Developed

Electric plasma arc-lamp combustor liner durability test system.

Silicon carbide matrix composites are candidate materials for high-temperature combustor liners. Because through-the-thickness thermal gradients are the primary cause of stress on combustor liners, a unique test facility was developed at the NASA Glenn Research Center at Lewis Field to simulate in-service pure thermal stress distributions in fiber-reinforced silicon carbide cylinders. It was developed initially under Phase II of the High-Speed Research Program.

This test stand can accommodate 8-in.-long test cylinders that have outer diameters of 4 in. and a wall thickness of about 0.08 to 0.12 in. One cylinder at a time is loaded vertically into the test stand. Water-cooled plates enclose the open ends of the cylinder and provide cooling. Load plates on the exterior side of the water-cooled plates provide support and compression loads.



Test facility for inducing through-the-thickness thermal gradients.

To evaluate a combustor liner material's potential performance, researchers induce thermal gradients with an axisymmetric, direct-current, electric arc within the cylinder while refrigerated air at a rate of 1.5 lb/sec impinges on the outside surface of the cylinder. The achievable through-the-thickness thermal gradient is predicted to be in excess of 200 °C. The 8-in. long, 0.5-in.-diameter plasma arc emits full spectrum visible light; radiant intensity exceeds 300 W/cm^2 to produce temperatures in excess of 1500 °C on materials with emissivity near unity. Because the system does not rely upon the combustion of fuels to achieve the related thermal conditions, ancillary environmental reactions with the sample are eliminated.

The system incorporates a standard mechanical test frame, which can impose constant as well cyclical axial stresses up to 2200 lb upon the test piece. Silicon-carbide-fiber-reinforced silicon carbide matrix composite cylinders were instrumented with thin-film thermocouples to obtain through-the-thickness thermal flux measurements. Inside wall temperatures reached 1200 °C with only 250 A of current. One of the special features of this configuration is the creation of hoop stress states within the cylinder, which up this point have not been obtainable in planar coupon tests.

This facility will allow various operational modes, including accelerated tests of thermal transients simulating the effects of repeated engine ignition as well as prescribed thermal and mechanical histories to simulate various duty cycle profiles. Tests can now be performed on thermal-barrier-coated metallic liners and ceramic composite liners that require a combination of high heat flux and controlled mechanical stresses.

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