Use of Arc-Jet Test Facility for Damage Assessment Tests

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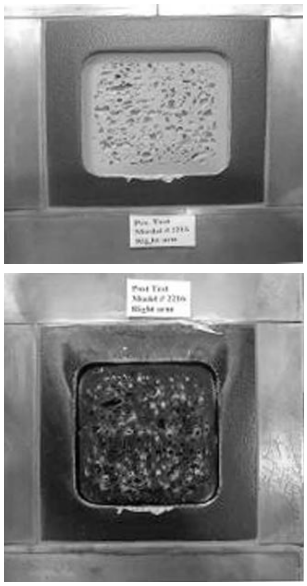
The Johnson Space Center's (JSC's) arc-jet facility, known as the Atmospheric Reentry Materials and Structures Evaluation Facility, completed a great number of tests for the Shuttle Return to Flight effort. These tests fall into four major test themes, including: Reinforced Carbon-Carbon (RCC) damage assessment; RCC Repair; High-temperature Reusable Surface Insulation (HRSI) damage assessment; and HRSI repair.

The RCC damage assessment tests, in concert with analytical tools, determined the maximum allowable crack/hole on the Orbiter wing leading edge for one safe entry. A total of 65 tests were performed in this effort using a modified stagnation holder that allowed for gas penetration and a low-pressure zone behind the specimen. Later tests were performed in a wedge configuration that was more representative of the flowfield angles experienced by the wing leading edge.

In addition, about 68 tests were performed on both crack and plug repair concepts demonstrating the feasibility of both of these concepts. Special test runs were incorporated for the crack repair specimens to include a "soft start." The soft start provided a gradual increase in temperature in an attempt to cure the material in real time using the natural heat from the early portion of the entry profile.

The HRSI damage assessment tests were completed to correlate thermal math models that were required for prediction of the structural and bondline temperatures during entry with a damaged tile. A total of 23 test specimens were run using the channel nozzle to provide a parallel flow so that the cavity heating factors were more representative of flight. Various damage depths, lengths, and ramp angles were tested to bound different parameters for the correlation.

Coupled with the HRSI damage cavity tests were tests that evaluated the STA-54 ablative repair system for damaged tile. A total of 42 tests were completed on the STA-54 to determine the thermal performance and thermal properties under a variety of configurations, test conditions, and material processes. The following photos depict an STA-54 test specimen before and after a single entry profile in the facility. While this specimen was charred by design at the surface, the thermal diffusivity and ablative effects resulted in a heat soak profile that provided lower pre-landing structural temperatures than those of unrepaired/undamaged tiles.



STA-54 Model 2216 – before (top) and after 1700°F laminar test profile.

The JSC arc-jet is expected to be a key component for NASA's effort on the crew exploration vehicle. With spacecraft relative velocities from lunar return on the order of 11 km/sec, the heating rates are high enough to require the use of an ablative heat shield. At these velocities, there is also significant radiative heating from the gas cap or shock layer. As such, the JSC arc-jet will investigate methods to simulate this combined radiative and convective heating environment since there is no facility in the world that can perform a combined test such as this at this time. In addition, the facility will improve heater performance to reach the high enthalpy and pressure test conditions expected from the trajectories of lunar return. It is anticipated that the facility will be used for screening tests, certification material tests, damage assessment tests, repair tests, and penetration tests for the heat shield.