NASAFacts

NASA Ames Arc Jet Complex

Providing ground-based hyperthermal environments in support of the Nation's Research & Development activities in Thermal Protection Materials, Vehicle Structures, Aerothermodynamics, and Hypersonics.

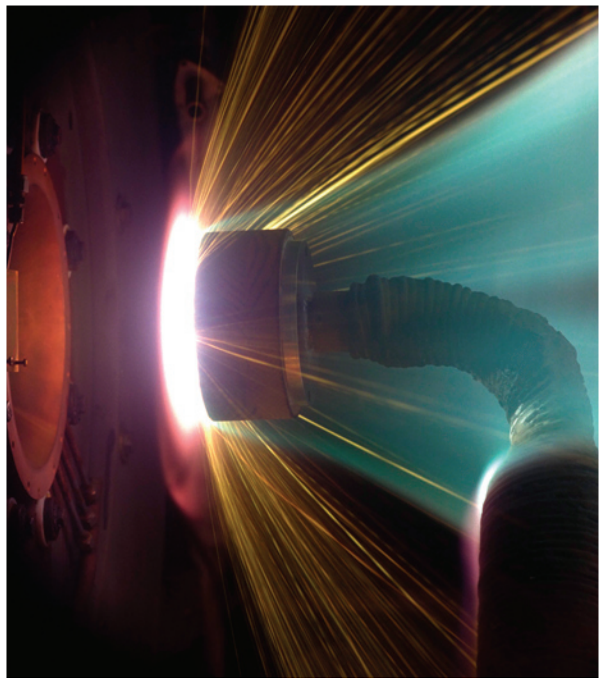
Background

Innovative TPS materials and systems will be required to support the Exploration Initiative. Project Constellation missions, in particular crewed Moon or Mars return missions, will involve high velocity aerocapture or direct entry at Earth. These high stress missions will induce heating environments too severe for existing reusable Thermal Protection Systems (TPS). Qualifying a new TPS material for a crewed mission requires extensive testing to explore the limits of material performance, to validate reliability and repeatability of performance, to investigate the effects of material damage, and to develop a full database of material properties. Arc plasma facilities are critical to such a process, and to any other TPS developments required for Exploration missions, by providing the only ground-based simulation of flight entry conditions.

Wing Leading Edge Repair

The safety of the crew on the Shuttle Orbiter depends on the integrity of the thermal protection system, which shields the astronauts and airframe from the searing heat of re-entry. The harsh re-entry environment can produce temperatures upwards of 3000ºF on the Shuttle's wing leading edge. Repairing damage to a Shuttle's outer shell while on-orbit may be necessary if there is an impact from space debris, micro-meteorites or foam debris (on launch).

NASA and industry have been working on ways to repair damage to the Shuttle's thermal protection system while the Shuttle is on orbit, in the event that damage is discovered. Concepts for fixing cracks or holes include plugs (cover plates), patches (pre-ceramic polymers impregnated cloth) and paste like materials (pre-ceramic polymers).



Thermal Protection test in NASA Ames Arc Jet complex

The engineers and scientists of the Space Technology Division at Ames have been involved, with NASA JSC and Boeing arc jets, in testing these various repair concepts.

A combination of improvements to the designs involving higher temperature materials and thinner more aerodynamic plugs, the new designs are passing the highest temperature condition that the Shuttles wing is expected to experience. The experience of testing in the Ames arc jets has led to the improved design that is planned to fly on the next Shuttle.

Ames Arc Jet Complex

The Ames Arc Jet Complex has seven available test bays. At the present time, four bays contain Arc Jet units of differing configurations, serviced by common facility support equipment. These are the Aerodynamic Heating Facility (AHF), the Turbulent Flow Duct (TFD), the Panel Test Facility (PTF), and the Interactive Heating Facility (IHF). The support equipment includes two D.C. power supplies, a steam ejector-driven vacuum system, a water-cooling system, high-pressure gas systems, data acquisition system, and other auxiliary systems.

The magnitude and capacity of these systems makes the Ames Arc Jet Complex unique in the world. The largest power supply can deliver 75 MW for a 30 minute duration or 150 MW for a 15 second duration. This power capacity, in combination with a high-volume 5-stage steam ejector vacuum-pumping system, enables facility operations to match high-altitude atmospheric flight conditions with samples of relatively large size.

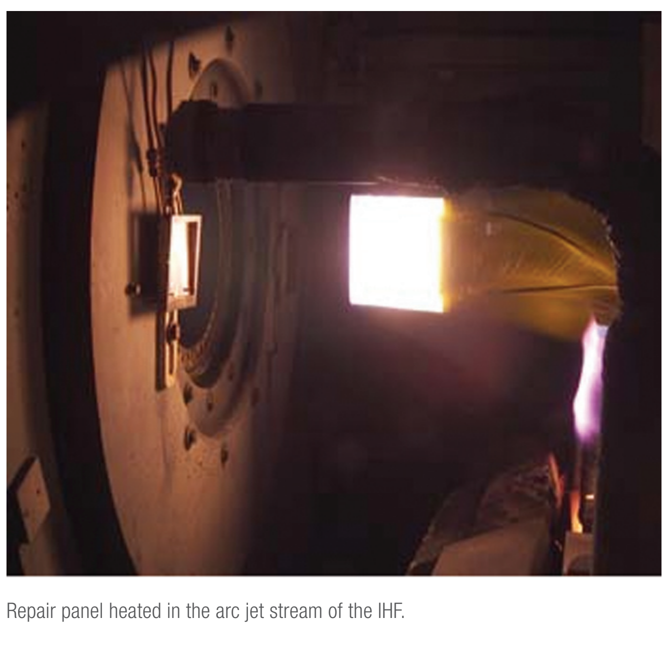
The Thermo-Physics Facilities Branch operates four arc jet facilities. The Interaction Heating Facility IHF), with an available power of over 60-MW, is one of the highest-power arc jets available. It is a very flexible facility, capable of long run times of up to one hour, and able to test large samples in both a stagnation and flat plate configuration. The Panel Test Facility (PTF) uses a unique semielliptic nozzle for testing panel sections. Powered by a 20-MW arc heater, the PTF can perform tests on samples for up to 20 minutes. The Turbulent Flow Duct provides supersonic, turbulent high-temperature air flows over flat surfaces. The TFD is powered by a 20-MW Hüls arc heater and can test samples 203mm by 508mm in size. The Aerodynamic Heating Facility (AHF) has similar characteristics to the IHF arc heater, offering a wide range of operating conditions, samples sizes and extended test times. A cold-air-mixing plenum allows for simulations of ascent or high-speed flight conditions. Catalycity studies using air or nitrogen can be performed in this flexible rig. A 5-arm model support system allows the user to maximize testing efficiency. The AHF can be configured with either a Hüls or segmented arc heater, up to 20-MW.

History

The Ames Arc Jet Complex has a rich heritage of over 40 years in Thermal Protection System (TPS) development for every NASA Space Transportation and Planetary program including Apollo, Space Shuttle, Viking, Pioneer-Venus, Galileo, Mars Pathfinder, Stardust, NASP, X-33, X-34, SHARP-B1 and B2, and most recently X-37 and Mars Exploration Rovers. Such a history has fostered the growth of extensive local expertise in the development and refinement of the arc jet facilities. The facilities of the Arc Jet Complex are used to simulate the aerothermodynamic heating that a spacecraft endures throughout atmospheric entry, and to test candidate TPS materials and systems. The duration of such testing can range from a few seconds to more than an hour, and from one exposure to multiple exposures of the same sample.

An arc jet is a device in which gases are heated and expanded to very high temperatures and supersonic/hypersonic speeds by a continuous electrical arc between two sets of electrodes. The gases (typically air) pass through a nozzle aimed at a test sample in vacuum, and flow over it, producing a reasonable approximation of the surface temperature and pressure and the gas enthalpy found in a high velocity, supersonic flow of the kind experienced by a vehicle on atmospheric entry. The Ames Arc Jets began in the 1950's with the founding of a permanent facility in 1961. A breakthrough patented design in 1964 by Stein, Shepard and Watson of NASA Ames produced a high-enthalpy constricted-arc heater, which enabled TPS development for Mercury and Apollo missions.

Website
http://thermo-physics.arc.nasa.gov



Repair panel heated in the arc jet stream of the IHF.