FLORIDA TURBINE TECHNOLOGIES, INC.

HADES TEST SYSTEM

HADES – Hyperbaric Advanced Development Environmental Simulator

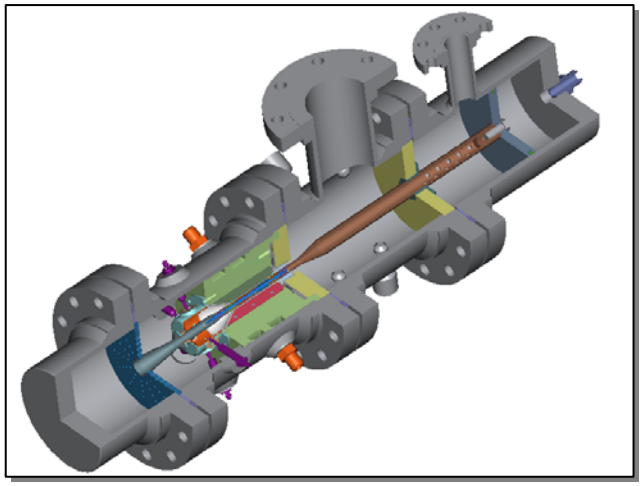
For Testing Advanced Turbine Materials under Representative Conditions

THE HADES SYSTEM

The HADES test rig was developed in response to needs expressed by the Department of Energy, the U.S. Air Force, and advanced turbine engine producers. These groups need a low-cost test method to demonstrate and test advanced turbine and nozzle materials in an environment accurately representing the hot gas environment in advanced turbine engines used for power production and aircraft. Such a system was not available until FTT's HADES rig.

Benefits of the HADES Test Rig

- Low cost: <20% of other methods on a per hour basis
- Low-risk: enables representative conditions without risk to engine hardware
- Natural gas, syngas or jet-fuel combustion environment
- Actual turbine conditions of temperature, pressure, heat flux, and mechanical loads
- Production rig temperatures to 4000°F (2200°C) and pressures to 735 psi (50 bar)
- Long hot time accumulation possible



Isometric cutaway of FTT's HADES rig.

HADES utilizes a small multipoint jet combustor to produce a hot gas stream.

The hot gas is accelerated into the test section which consists of a cooled inner pipe containing the test material coupons and coatings and includes enough testing surface area to accommodate several test specimens concurrently.

Future versions of HADES will incorporate axial fatigue loading using a pneumatic system.

Temperature and pressure are carefully maintained within this annular passage by control of the combustor air supply pressure, the air flow rate, and the fuel flow rate. Note that the test specimens can include film cooling if desired.

Up to 32 strategically placed sensors measure the pressure and temperature at critical locations within the test section. Computer-controlled software allows monitoring of conditions in real-time. HADES' innovative cooling design enables the specimen surface temperature to be accurately controlled throughout the course of the test.

PROOF-OF-CONCEPT TESTING COMPLETE

The HADES System has completed the Proof-of-Concept testing stage and a production rig is anticipated in mid 2008.

Today's capability - offsite facility

	Range of Capability
Combustor	
Exit Temperature:	2,000°F (1,000C) to 3,500°F(1927C)
Gas Pressure:	Atmospheric to 150 psi (10 bar)
Coolant Temperature:	100°F(40C) to 775°F(413C)
Specimen	
Gas Temperature:	3,200°F (1,760C)
Surface Temperature:	2,741°F (1,505C)
Diameter:	0.5 inches (12 mm)
Wall Thickness:	0.035 inches (0.9mm)
Length:	1 inch (25mm) to 6 inches (150mm)
Heat Flux Density:	322,469 BTU/hrft2 (1 MW/m2)

Production Rig - mid 2008

	Range of Capability
Combustor	
Exit Temperature:	2,000°F (1,000C) to 4,000°F(2,200C)
Gas Pressure:	Atmospheric to 735 psi (50 bar)
Coolant Temperature:	100°F(40C) to 1,100°F(600C)
Specimen	
Gas Temperature:	up to 3,900°F(2,150C)
Surface Temperature:	up to 3,200°F (1,750C) (depends on material and cooling conditions)
Diameter:	0.5 inches (12 mm)
Wall Thickness:	0.035 inches (0.9mm)
Length:	1 inch (25mm) to 6 inches (150mm)
Heat Flux Density:	300,000 to 1,500,000 Btu/hr/ft^2 (100 to 5,000 kW/m^2)

HADES CAN REPLACE EXPENSIVE ENGINE TESTS

HADES supports turbine designers by providing the most affordable and comprehensive data in a timely manner. Low operating cost, no risk to engine hardware, adaptable testing setup, and the ability to accurately reproduce engine conditions enable HADES to overcome the technical, cost, and schedule barriers associated with full engine testing.

Material System Failure Mechanism	Test Method			
	Engine Test	Burner Rig	Advanced Plasma and Laser Systems	FTT HADES
Coating Spallation due to High Thermal Gradients	YES	NO	YES	YES
Erosion due to High Velocity Flow	YES	NO	NO	YES
Corrosion Degradation due to Trace Elements in Fuel at Operating Temps and Pressures	YES	YES (partial)	NO	YES
Ability to Apply Axial Loading in addition to Thermal Loading	YES	NO	NO	YES
Low Risk-to-Cost Before Engine Design	NO	YES	YES	YES

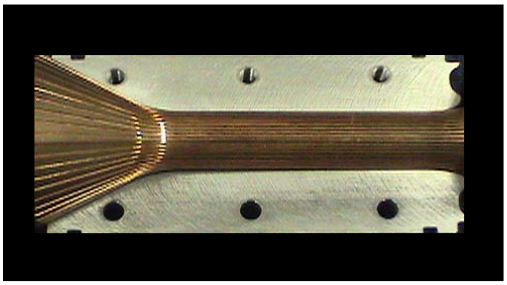
HADES offers many advantages over alternative test methods.

HADES is the only system capable of reproducing a majority of all important material system failure mechanisms.

HADES HELPS U.S. ENERGY PLAN

The United States' long-term energy plan includes the development of technologies that enable low-cost and environmentally acceptable use of its large reserves of indigenous coal. The U.S. Department of Energy's (DOE) Office of Fossil Energy is addressing this need by investigating technologies and systems that can produce fuels or power at high efficiencies with virtually no emissions. Advanced Integrated Gasification Combined Cycle (IGCC) plants, as opposed to today's coal-burning steam turbine plants, operate at higher turbine inlet temperatures and provide a more efficient energy source with reduced CO_2 emissions per kilowatt-hour.

These IGCC plants need advanced combustion turbines (CTs) that operate at higher firing temperatures while being significantly more tolerant of the contaminants that erode, corrode, and deposit onto combustor and turbine hot parts. Synthesis gas (syngas) fueled CTs with advanced coating/material combinations must be developed which can tolerate the more aggressive combustion byproducts while still maintaining high turbine inlet temperatures, increased power output, and power plant efficiency, which all improve the economics of power generation.



HADES test vessel uses innovative technology to obtain a very high heat flux across the specimen

HADES will provide the ability to evaluate coating/material combinations prior to costly engine testing which is critical to industry's (i.e. customers, lenders, and insurance) acceptance of advanced CTs for IGCC plants in the future.

HADES WILL ENABLE TESTING AT EXTREME EXPOSURES FOR ADVANCED U.S. MILITARY AIRCRAFT

Emerging missions such as those supported through the U.S. Air Force's Versatile Affordable Advanced Turbine Engine (VAATE) program, are being designed to operate at high overall pressure ratios, high turbine temperatures, and for extended periods of time. Current engine technologies and other test methods do not extend to these conditions. HADES will provide the ability to test advanced materials and cooling schemes required by next-generation military aircraft engines.

FLORIDA TURBINE TECHNOLOGIES

Florida Turbine Technologies, Inc. (FTT) provides full service gas turbine component design, manufacture and support to the industrial and aircraft gas turbine and rocket industries.

For more information on Florida Turbine Technologies, Inc. and the HADES test system, please contact:

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