Advanced Hot Section Materials and Coatings Test Rig (rev 12/12/03)

I. PROJECT DESCRIPTION

A. Objective(s)

The overall objective of this project is to develop an advanced materials and coatings test rig for the coal-gas fired turbine industry for the purpose of understanding how hot gas path materials and coatings will perform under advanced combustion turbine operating conditions when fueled by coal-derived synthesis gas (syngas). Resulting test data will provide an understanding of how trace contaminants, particulates, and gaseous species such as SOx or HCl in the syngas interact with the materials and coatings and contribute to the degradation processes of deposition, erosion, and/or corrosion. No data exists on materials exposed to syngas fuel, nor at extreme conditions. This test rig will be capable of thermally and mechanically loading the test specimens, and will simulate actual engine conditions as an affordable alternative to engine testing or other materials testing approaches.

B. Background/Relevancy

A new, affordable, state-of-the-art coating/material test rig to test the interaction of syngas trace contaminants with advanced turbine blade materials and coatings will provide designers with the necessary data to develop advanced Integrated Gasification Combined Cycle (IGCC) plants using combustion turbines at full firing temperatures. This will lead to a less expensive and more reliable energy source, which will reduce the US dependence upon foreign fuels. The United States' long-term energy usage plan includes the development of technologies that enable the low-cost and environmentally-acceptable use of its large reserves of indigenous coal. The DOE's Vision 21 program addresses this need by investigating technologies and systems that can produce fuels or power at high efficiencies and with virtually no emissions. Advanced IGCC plants need advanced combustion turbines (CTs) that operate at the high firing temperatures of gas turbines while being significantly more tolerant of possible contaminants from syngas that can erode, corrode, and deposit onto turbine hot parts. Syngas fueled CTs with more robust hot section materials and coatings would allow for full-life hot parts while still maintaining high turbine inlet temperatures, increased power output, and power plant efficiency, which all improve the economics of power generation. Advanced coating/material combinations must be developed which can tolerate the more aggressive combustion byproducts in IGCC applications. The ability to evaluate coating/material combinations prior to costly engine testing by an advanced test rig is critical to industry's (customers, lenders, and insurance companies) acceptance of advanced CTs for IGCC plants in the future. The proposed rig supports these goals.

C. Period of Performance

9/30/2003 through 9/30/2006

There are three phases with two go/no go decision points. Phase I runs from 9/30/03 through 9/30/04.

D. Project Summary

The project involves design, construction, initial test operation, and evaluation of a materials test facility operating on an actual coal syngas fuel stream. The facility will provide mechanical and cooling constraints on coupon sized test samples, exposed to the syngas combustion exhaust, which will match the thermo-mechanical boundary conditions found in high temperature gas turbines. The project involves initial design and planning work at FTT, followed by construction and testing of the materials test rig at SWPC. Lastly, the test rig will be integrated with a specially designed combustor at the Dakota Gas Co. site. Details are described below:

II. PROJECT PARTICIPANTS

Florida Turbine Technologies (FTT) (Lead)

Siemens Westinghouse Power Corp.

Dakota Gas Co.

III. PROJECT COSTS

$6.17 M DOE, $7.72 M total

(Phase I: $304k DOE, $380k total)

IV. MAJOR ACCOMPLISHMENTS SINCE THE BEGINNING OF THE PROJECT

Conceptual design activity of the rig has started with mechanical arrangement of the overall concept complete. The preliminary design of the rig-unique combustor has been performed and the sizing of the test section to subject the specimens to the required heat flux is being performed.

V. MAJOR ACTIVITIES PLANNED DURING THE PROJECT

Milestones have been identified throughout the three-year project, and are shown in Table below.

Table - Milestones

Phase I	Date	Phase II	Date	Phase III	Date
Test Section Design	Jun-04	Fab Test Section	Dec-04	Test Rig Installation	Dec-05
Facility Req'ts	Mar-04	Validation Testing	Mar-05	Checkout/Calibration	Mar-06
Permitting Plan	Dec-03	**GO/NO-GO Decision**	Mar-05	Demonstration Testing	Jul-06
Implementation Plan	Jul-04	Permits Applications	Oct-04		
GO/NO-GO Decision	Jul-04	Equip. Procurement	Aug-05		

Test Section Design

A conceptual design of a test section incorporating multiple specimens will be completed. The specimen size, configuration, and tolerances will be determined. The chamber dimensions and construction methods will be evaluated. The rig will be designed to allow quick teardown and setup. Following the test rig conceptual design, a detailed design will be initiated to address all aspects of the design and fabrication techniques.

Facility Requirements Definition

The test rig requirements will be studied and incorporated into the host site infrastructure since they are integral. A building to house the test rig will be specified. Fuel handling and delivery systems will be identified and specifications prepared. Requirements and specifications will be prepared for all mechanical and electrical subsystems required for the test rig.

Permitting Assessment and Plan

An assessment of the permitting required for construction and operation of the test facility will be conducted and documented in a permitting plan, and will include any need for National Environmental Protection Act (NEPA) applications.

Implementation Plan

The overall test rig design, fabrication, and setup are multi-faceted and will require logistical coordination. An overall implementation plan will be created outlining the tasks and schedule required to design, build, install, and achieve operational status of the test facility.

After the above described planning stage a go/no go decision will be made.

Fabricate Test Section

The test section will be fabricated and assembled for a validation test. The test section components will be procured wherever possible, or fabricated as necessary.

Conduct Test Section Validation Tests

To demonstrate the ability of the test rig to achieve stated objectives, a validation test will be performed at SWPC in Pittsburgh, PA. An existing combustion test rig will generate the hot gas, and test specimens will be inserted into the test section. Heat flux and thermal gradients will be demonstrated via instrumentation and thermal paint. To verify the test rig controls, coolant supply pressure will be monitored. An intentional specimen burn-through will be performed, followed by safe shutdown, for concept demonstration.

Based on the results of the demonstration test, an FTT team/DOE NETL decision will be made as to whether or not to proceed through the remainder of Phase II.

Permitting

The permitting plan with the state of North Dakota department of health will be performed.

Purchase Test Rig Hardware

All of the major equipment and components of the test rig will be procured during Phase II, and will include the following: combustors, heat recovery steam generators, piping and ducting, fuel delivery skid, additional test sections, instrumentation and controls, and the exhaust systems for each test section. All components and hardware will be delivered to the host site for installation.

Test Rig Installation at Site

The test facility components and hardware will be assembled and installed at the Dakota Gasification Company (DGC) Plant. Utility hookups will be completed, and integration of the test facility steam supply into the existing site infrastructure will be performed.

Full System Checkout and Calibration

Test facility system checkout and commissioning will be performed. Trial tests will be conducted to ensure that the test facility is functioning properly. All operating parameters will be verified during the trial tests, instrumentation will be checked out and re-calibrated if necessary. The overall rig functionality and controls will be validated.

Test Rig Demonstration

After the team is confident that subsystem and overall test rig performance meets design objectives; a test rig demonstration will be carried out. This demonstration will provide the operators and customers with the confidence that the test rig will operate as designed and will meet the technical goals that provide the low cost testing projected.

VI. ISSUES

Currently, there are no issues that may impede the progress or performance of the project.

VII. ATTACHMENTS

No attachments provided at this time.