FACT SHEET

On-Line TBC Monitoring for Real-Time Failure Protection and Life Maximization

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I. Project Participants

Siemens Westinghouse Power Corporation, Orlando Florida
Siemens Corporate Research, Princeton, New Jersey
Indigo Systems, Santa Barbara, California
Wayne State University, Detroit, Michigan
InterTest, Inc., Olympia, New Jersey

II. Project Description

A. Objectives:

The objective of this proposed work is to design build and install a gas turbine blade and vane thermal barrier coating (TBC) monitor that will monitor, in real time, during turbine operation, the formation and progression of critical TBC defects. The monitor will track and report on the progression of TBC defects, estimate remaining TBC life, and notify operations of impending damage. The program goal is to alleviate unscheduled outages due to TBC failure and engine damage by having a monitor system to assure that irreversible damage does not occur.

B. Background:

As engines are driven to higher efficiencies (or higher firing temperatures), they require ceramic thermal barrier coating (TBC) to protect the thermally challenged base metal of critical components. As a result, the newest engines used today for land based power generation rely heavily on the durability of the thermal barrier coating (TBC). Current operating evidence demonstrates the importance of monitoring the TBC on a frequent basis. The on-line TBC monitor will not only significantly extend critical component lives by advising of the need for repair before the component's failure, but also serve as a guard for the safe operation of a turbine engine. One-hundred percent monitoring, when fully implemented, will allow for better scheduling of maintenance outage and operation of the turbine to meet immediate "call for electricity" demands. It will do this by combining the state-of-the-art real-time infrared (IR) sensor systems, component lifing models, engine operational parameters and expert systems into a supervisory system that will oversee and report on component status and recommend best operating practice. It will therefore significantly escalate the current reliability/availability/maintainability (RAM) standard of electric power generation for gas turbines.

Relevancy:
This program seeks to substantially improve the operating life of high cost gas turbine components using TBC; thereby, lowering the cost of maintenance leading to lower cost of electricity.

C. Period of Performance: 10/01/2001 – 1/31/2003

D. Project Summary:

On-line TBC Blade Monitor
The On-line TBC Blade monitor continues on schedule and meets all milestones. Siemens Westinghouse is currently installing a prototype version in a 501FD gas turbine engine in Berlin. The Siemens Westinghouse manufacturing and test facility has a full scale 501FD Gas Turbine engine for the purpose of development and testing of components and validation engine requirements. This test engine will allow the dual view ports for the purpose of viewing row one blades. The use of this facility and engine will allow the program to have pre distressed blades for the purpose of infrared sensory development, validation of mechanical design and further refine algorithms for the blade monitor supervisory system. Installation of the multi-spectral, dual viewing port assemblies will be installed in December 20003. Validation test will begin January 2004.

III. Project Costs

DOE costs are $5.118M, with $1.280M being cost-shared by Siemens Westinghouse.

IV. Major Accomplishments Since the Beginning of the Project

1. Dow Facility Baton Rouge Louisiana Proof-of-Concept Testing. The proof-of-concept tests profiled key interactions between infrared instrumentation, and absorption characteristic of the engine's hot gas path. Based on the positive outcome of the testing, the program proceeded with a full-based installation in current W501FD gas turbine engine.

2. Characterize emissions from TBC defects (APS)-Infrared emission from TBC and associated progressions of deterioration will be characterized, I.E. debond growth, spall. The relevance of the emissions of TBC defects plays an important role for defect recognition. The deteriorating TBC emission demonstrates a local step change in emissivity.

3. Validation testing of infrared hardware selection was conducted based on spectral response of infrared camera, atmospheric attenuation of hot gas path, mechanical life of instrumentation, emittance characteristics of TBC and optics design of spectral imaging relay scope. This validation of instrumentation and the emission characteristics formulate a solid basis for the TBC blade monitoring system.

4. The Development of the TBC Remaining Life Prediction Model task completed testing May 2003 in Julich, Germany. The initial tests during phase validated the proposed infrared instrumentation. The objectives were (1) monitor failure progression of TBC's under high heat flux conditions and (2) develop a numerical model to describe the failure progression as a function of the loading regime.

5. DOE On-Line Monitor - Using a radial borescope port specifically adapted to real-time viewing access, a 501F row 2 turbine blade was viewed, under operating conditions, with a high-speed IR camera at the Berlin test rig. Both the camera and the software proved the concept by repeatedly indexing to specific blades and imaging them as if they were standing still. The final borescope design will allow viewing of about 75% of the Row 1 blade, any time, as often as practically needed, during operation.

V. Major Accomplishments Planned during the Next 6 Months

1. GT Control /alarming software development - Key elements of software for supervisory system control will be written for artificial intelligence system.
2. Identify available blade test facility – This will be at Siemens Westinghouse Power Corporation maintained power plants will be selected for both blade and vane prototype monitor installation.
3. Prototype installation into a Siemens Westinghouse W501FD gas turbine. The installation of a multi-spectral dual view ports of row 1 blades will start in November 2003 and begin development and validation test in December 2003 and January 2004.
4. TBC Remaining life prediction software implementation - The life prediction model algorithm will be keyed into software.

VI. Major Accomplishments Planned during the Next 6-18 Months

1. Software development at the Real-time Vision and modeling Department of Siemens corporate Research. Phase 1 includes integration of infrared imaging camera, developing algorithms and smart camera based system for defect recognition
2. The artificial intelligence software that will make the real -time or near real time decisions and recommendations regarding eminent pending failure, time to respond, optional operation for extending life, etc. This will be integrated into the software package.
3. Evaluate performance of On-lineTBC Monitor for blades- The first full scale evaluation of the online blade monitor at the select power plant facility will be completed.

VII. Issues : None

VIII. Attachments: None