Combustion Turbine (CT) Hot
Section Coating Life Management
EPRI

FACT SHEET

I. PROJECT PARTICIPANTS

1. Prime Participant: EPRI

A. Sub-Award Participants: Southwest Research Institute
Turbine Technology International

II. PROJECT DESCRIPTION

A. Objectives

The objective of this project is to improve the reliability, availability and maintainability (RAM) of combustion turbines (CTs) by developing advanced technology for assessing and managing the life of protective coatings on CT blades and vanes.

B. Background

Degradation of protective coatings represents a major profitability challenge for combustion turbine owners. Coating life dictates blade refurbishment intervals and the need for costly replacement. A proper life management system for coatings represents a major step in preventing such major losses to the CT owner and to society at large.

Relevancy

The life management activities covered in this project for coatings directly impacts the objectives of increasing RAM of CTs. Accurate life management techniques enable optimization of refurbishment intervals and operating practices, thereby avoiding unplanned outages. The new technology developed in this project will enable machine-specific calculations of coating remaining life and direct measurements of the same using non-destructive evaluation (NDE) techniques.

C. Period of Performance

The project was initiated October 2001 and scheduled for completion by September 2004

D. Project Summary

The project will develop improved analytical and nondestructive evaluation techniques to assess the consumed life and/or estimated life of protective coatings on CT blades and vanes, and then integrate these techniques with economic risk-based decision-analysis tools to optimize run/repair/replace decisions. The project is defined along five major technical tasks including:

- Task 1: Refinement and Validation of Hot Section Life Management Platform (HSLMP)
- Task 2: COATLIFE for Advanced Metallic Coatings and TBCs
- Task 3: NDE of Coatings
- Task 4: Field Validation of COATLIFE and NDE
- Task 5: Economic Risk-based Decision Analysis

III. PROJECT COSTS

A. DOE Share of Total Approved Budget--$2,455,560.00
B. EPRI Share of Total Budget--$819,191.00

IV. MAJOR ACCOMPLISHMENTS SINCE THE BEGINNING OF THE PROJECT

1. The completed aero-thermal and stress analyses demonstrate how creep governs the reliability of the model 7FA+ 2nd stage bucket as the predominant life limiting damage mechanism *thus confirming field experience.*

2. Analysis showed that the creep strain was comparable or lower for equiaxial (EA) than for directionally solidified (DS) material at the critical locations in the transverse direction within the shroud *and hence the less expensive equiaxed material can be used.*

3. A 3-D finite element model including a thermal barrier coating (TBC) and a bond coat has been developed using the W501FC 1st stage blade.

4. Thermal mechanical fatigue (TMF) at the blade platform was determined to be the primary damage mechanism and the life limiting issue for W501FC 1st stage blades. This is *confirmed by field experience.*

5. For the 1st stage W501FC blades, *the effect of thermally grown oxide (TGO) growth on potential de-lamination or spallation appears to be less significant than fatigue damage*. Bond coat oxidation may be a long-term performance issue for machines operating in as base load providers.

6. The COATLIFE computer model for advanced MCrAlY bond coating has been validated. Also, a preliminary TBC lifing model for thermal barrier

coatings (TBC) has been developed using a GTD111 substrate and a NiCoCrAlY bond coating. The TBC values produced are in good agreement with the test results.

7. Assembly and selection of a swept-frequency eddy current system in the frequency range of 0.5-10 MHz has been completed and the system's *capability to detect and discriminate between coating degradation and cracking has been demonstrated.*

8. For aged duplex coatings, the application of eddy current NDE provides a qualitative assessment of coating conditions by separating a normal coating, a beta phase depleted coating, and defective coating. Quantitative assessment was also completed by calculating conductivity values for the topcoat, bond coat, and GTD111 substrate.

V. MAJOR ACCOMPLISHMENTS PLANNED DURING THE NEXT 6 MONTHS

1. Refinement and validation of TBC model.

2. Upgrading the three-layer inversion eddy current software program to allow TBC coating assessment.

3. Validate the predictive capabilities of the COATLIFE program and the eddy current NDE methodology on field-operated coated turbine buckets.

VI. MAJOR ACCOMPLISHMENTS PLANNED IN OUTYEARS (6 – 18 MONTHS)

1. Extend the aero-thermal model to refine the existing TBC life prediction model developed by SwRI.

2. The TBC life model validation will be completed using the laboratory and field test results.

3. Correlate eddy current NDE results with COATLIFE program on field-operated buckets coated with TBCs and MCrAlYs.

4. Develop an Economic Risk-based Decision Analysis Spreadsheet.

VII. MAJOR MILESTONES FOR ENTIRE PROJECT

1. GE 7FA+ 2nd stage blade analysis – (*Completed*) (12/02)
2. Siemens-Westinghouse 501FC 1st stage blade analysis – (*Completed*) (09/03)

3. COATLIFE software for life prediction of advanced Metallic coating, GT33 —(*Completed*) (8/03)
4. COATLIFE for thermal barrier coatings (TBC)—*in progress* (6/04)
5. Secure new and aged blade samples (*Completed*) (6/02)
6. Assemble, test, and select a suitable swept-frequency eddy current system (*completed*) (6/02)
7. Perform destructive sectioning to obtain volume fraction of beta-phase particles from aged samples. Establish correlation curves of conductivity values versus volume fraction of beta-phase particles remaining—*in progress* (12/03)
8. Field trials on simple/duplex metallic coatings—*in progress* (8/04)
9. Integration of COATLIFE software for estimating remaining coat life (*Completed for MCrAlY, TBC in progress*) (6/04)
10. Evaluation of eddy current system's capability to test and characterize blades with ceramic TBC coatings—*in progress* (10/04).

VIII. ISSUES

None.

IX. ATTACHMENTS

None.