Spectroscopic In-Situ Non Destructive Evaluation to monitor the Health of Thermal Barrier Coatings

FACT SHEET

I. PROJECT PARTICIPANTS

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II. PROJECT DESCRIPTION

A. Objectives

Develop in-situ non-destructive evaluation method to monitor the health of TBC using emission spectroscopic analysis.

B. Background

Early detection of TBC degradation and failure is critical to prevent catastrophic engine failure as advanced gas turbine engines depend on TBC for higher operating temperature. TBC inspection is costly because it requires skilled labor and interruption of service. An in-situ non-destructive evaluation of TBC health will provide significant savings in engine maintenance.

C. Relevancy

Developing self-sensing smart high-temperature coating for critical gas turbine engine components that can allow in-situ monitoring of its own mechanical health during operation of the engine will result in significant cost saving, as compared with the present invasive inspection techniques that require the engine to be shut down and partially disassembled for inspection. This research, if successful, will not only benefit the land based power turbines but will also be useful for aircraft engine applications

C. Period of Performance. July 1, 2003 –November 30, 2006.

D. Project Summary

Under the University Turbine Research (UTSR) program, Cleveland State University is developing self-sensing high-temperature coating for nickel-based superalloy gas turbine engine components that can allow in-situ monitoring of its own mechanical health during operation of the engine. Results, if successful, will yield significant cost saving, as compared with the present invasive inspection techniques that require the engine to be shut down and partially disassembled for inspection. Following are the various tasks proposed under this research.

1. Process doped YSZ and determine the optimum range of Li_2O content.
2. Optimize TBC design in terms of location and thickness.
3. Evaluate the effect of Li_2O on TBC durability.
4. Demonstrate in-situ spectroscopic monitoring with burner rig.
5. Prepare the final report and future recommendations.

III. PROJECT COSTS

$391,615.

IV. MAJOR ACCOMPLISHMENTS SINCE BEGINNING OF PROJECT

1. Examination of lithium spectra obtained from the Lithium Oxide mixed at concentrations of 5, 3, 1, and 0.3 wt.% in the respective cases YSZ showed that a two layer design with doped layer at the bottom and the TBC on the top will be optimum.
2. Li_2O- YSZ coatings showed strong lithium emission at the temperature range investigated with the intensity increasing with increasing temperature and the lithium oxide concentration.
3. A flat flame burner having much improved temperature stability compared with a welding torch was set-up and used for most of the research.
4. The correlation between intensity of Li emission and degree of TBC degradation was confirmed on slurry-processed dual layer TBC coated superalloy coupons.
5. The effect of Li_2O dopant on TBC durability was determined. Optimal Li_2O dopant concentration is 1 ~ 3 wt%. Li_2O-doped inner YSZ layer does not cause a debit in TBC thermal cycling life if the thickness is kept within ~1mil.
6. Emission detection set-up was miniaturized and tested. It easily detects lithium emission signals even in the very bright exhaust-gas environment of the burner rig.
7. Preliminary results show that plasma-spraying process may be producing a porous and highly pervious TBC layer which is not conducive for this NDE technique.

V. MAJOR ACTIVITIES PLANNED DURING THE NEXT 6 MONTHS

Following two activities were not planned in the original proposal. But they are important for a successful conclusion of this project. A three month no-cost extension is being requested for this purpose.

1. Establish that the Li_2O dopant loss observed during recent burner rig testing of plasma spray coated superalloy cylindrical samples is due to the porous nature of the "plasma-sprayed coating".
2. Investigate if the YSZ coating deposited by electron beam physical vapor deposition is impervious and hence suitable as a self-sensing TBC coating.

3. Prepare final project report.

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

N.A.

VII. ISSUES

None

VIII. ATTACHMENTS

No more than one or two figures describing project results, photos/schematics of rigs, or photo of project participants.