**ADVANCED THERMAL BARRIER
COATING SYSTEM DEVELOPMENT**

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TECHNICAL PROGRESS REPORT

to the

U.S. DEPARTMENT OF ENERGY

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Advanced Thermal Barrier Coating System Development

Program Objectives

The objectives of the program are to provide an improved TBC system with increased temperature capability and improved reliability relative to current state of the art TBC systems. The development of such a coating system is essential to the ATS engine meeting its objectives.

The base program consists of three phases:

- Phase I: Program Planning - Complete

- Phase II: Development

- Phase III: Selected Specimen - Bench Test

Work is being performed in Phase II and III of the program.

Technical Progress Report

Task II.2 Bond Coat Development

New Bond Coat Chemistries

- Coatings consisting of LPPS bond coats with APS and EB-PVD TBC have been ordered for three of the new bond coats.
- In the previous report, it was mentioned that two new bond coat chemistries were identified for HVOF deposition. Powder resizing to accommodate HVOF equipment requirements is complete, and HVOF deposition trials are in progress. The spray parameter effects on coating microstructure are being evaluated in order to maximize coating density and surface roughness. Delivery of coated test samples is expected in early October at which time furnace testing will begin.

Diffusion Barriers

- Metallographic examination of all diffusion barrier samples ultimately failed with the diffusion barrier going into solution in the MCrAlY and base alloy. This is not surprising given the temperature of the accelerated test.
- The 755 series provided a significant improvement in bond coat performance. This was attributed to 1) maintaining a continuous diffusion barrier longer and 2) forming stable compounds with deleterious substrate elements preventing their diffusion to the thermally grow substrate

Task II.3 Analytical Lifting Model

- The final set of High Heat Flux test data has been analyzed by Southwest Research Institute using the TBC life prediction model (TBCLPM). Due to the limited number of additional data, the fit is not significantly improved from that reported previously, i.e., predicted vs. actual number of cycles to failure show a correlation of the order of 3X.
- Southwest Research Institute's involvement in this program is now complete. Siemens Westinghouse will continue to update model as additional data becomes available.
- This task is complete.

Task II.4 Manufacturing Process Development - Task Complete

Task II.5 NDE, Repair and Maintenance

- Cyclic furnace testing of TBC patch repairs under nominal conditions continued throughout the quarter. During the reporting period, all repaired and unrepaired (control) samples remained in test.

- The evaluation of coating refurbishment effects on CMSX-4 single crystal was completed. Metallographic analysis of creep bar samples indicates that substrate machining is a major contributor to recrystallization. Low stress grinding of the creep samples resulted in recrystallization over the entire range of heat treatments considered. Recrystallized grains were limited to the depletion zone near the outer surface. The results suggest that machining or grinding on single crystal components should be avoided in areas where recrystallization could compromise alloy performance.

Task II.6 New TBC Concepts

- Lab scale evaluation of ceramics for TBC applications is completed. Eight new chemistries have been identified as potential candidates for TBC applications. These new chemistries are expected to be phase stable at temperatures greater than 1400 C and do not sinter excessively. These chemistries are being evaluated for the ease of deposition by EB-PVD. EB-PVD trials are directed towards identifying melt pool stability, coating chemistry and microstructural features. Process parameters specific to each chemistry will be determined. The coating with the best thermal cycling life will be followed up with rigorous process optimization.
- Howmet has been identified as the best facility for the EB-PVD trials. One of the eight chemistries has already been deposited on to test pins and the coatings are being evaluated by various materials characterization techniques. Further deposition trials are planned in the next 2 months. It is expected that the feasibility of deposition of the new chemistries will be determined by end of November.
- New TBC concepts have been developed during the development program which are potentially very attractive for TBC applications up to very high temperatures. These concepts include low thermal conductivity TBCs which are expected to maintain their strain tolerance to very high temperatures. Preliminary results in the lab have confirmed the potential of these new systems. Further work is planned for reproducing the results and identifying new directions for development.

Phase III Bench Test

No work was performed on this task during the reporting period.

III.6 Blade and Vane TBC Monitor - Feasibility Study

- A host engine has been identified for demonstrating the blade TBC monitor. A detailed statement of work is being prepared and quotes obtained for the necessary engineering and hardware modifications. During the remaining quarter of 1998, it is

expected that the necessary modification will be made and demonstrated in the laboratory. This will then be presented to the host and a window identified for the on-line demonstration.