N87-11197

THERMAL BARRIER COATING LIFE PREDICTION MODEL DEVELOPMENT

T.E. Strangman
Garrett Turbine Engine Company

Thermal barrier coatings (TBC) for turbine airfoils in high-performance engines represent an advanced materials technology that has both performance and durability benefits. Foremost of the TBC benefits is the reduction of heat transferred into air-cooled components. As indicated in Figure 1, cooling air requirements can be reduced by one-third or the airfoil creep life can be increased by a factor of five with the successful application of a 125μm thick zirconia coating.

In order to achieve these benefits, however, the TBC system must be reliable. Mechanistic thermochemical and thermomechanical life models and statistically significant design data are therefore required for the reliable exploitation of TBC benefits on gas turbine airfoils. Garrett's NASA-Host Program (NAS3-23945) is designed to fulfill these requirements.

This program is focused on predicting the lives of two types of strain-tolerant and oxidation-resistant TBC systems (Figure 2) that are produced by commercial coating suppliers to the gas turbine industry. The plasma sprayed TBC system, composed of a low-pressure plasma spray (LPPS) applied oxidation resistant NiCrAlY bond coating and an air-plasma-sprayed yttria (8 percent) partially stabilized zirconia insulative layer, is applied by both Chromalloy (Orangeburg, New York) and Klock (Manchester, Connecticut). The second type of TBC is applied by the electron beam-physical vapor deposition (EB-PVD) process by Temescal (Berkeley, California).

Key elements of Garrett's TBC life prediction strategy include the following:

- Development of mission-analysis capable TBC life models
- Development of rapid TBC life computation approaches for preliminary and final design analysis
- Calibration of TBC life models with affordable tests
- Establishment of NDE feasibility for TBCs
- Interative engine testing to validate TBC life analysis

Burner rig oxidation and hot corrosion test data will be used to establish the thermochemical life model. Anticipated results are indicated in Figure 3, multi-temperature tests will also be performed to facilitate the development of a cumulative damage model, which is required for an engine mission-analysis capability.

Tensile and compressive spalling strain and fracture toughness test data are being obtained to quantify the width of the TBC's strain-tolerant envelope as a function of flaw size, exposure temperature and time. Anticipated results are provided in Figure 4.

A low-cost modified bond strength test with an artificial penny-shaped flaw at the ceramic-metal interface or within the zirconia layer has been developed to provide a quantitative estimate of the fracture toughness. Post-test examination of the fracture surface provides detailed information with respect to location of the fracture path and elements present on the fracture surface.

Non-destructive evaluation techniques, such as eddy current, photothermal radiometric imaging and scanning photoacoustic microscopy, are also being investigated in this program. These technologies will be assessed for their capability to quantify a TBC's thickness, flaw size and insulative capability.

Lives of all the TBC systems will be predicted for TFE731 high pressure turbine blades for factory engine test, business aircraft and maritime surveillance missions. Complementary engine validation tests are planned.

This program has just been initiated. Specimen procurement is in progress.

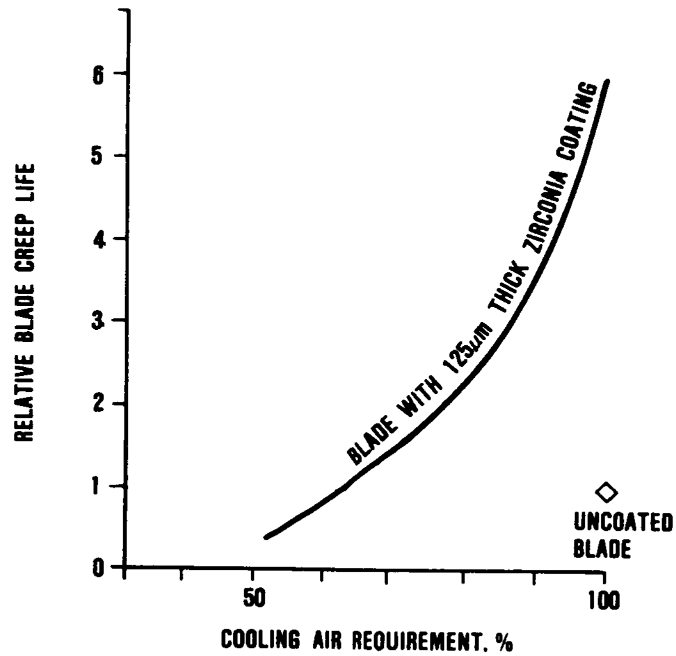

Figure 1. TBCs Improve Creep Life and Reduce Cooling Air Requirements for Garrett High-Pressure Turbine Blade.

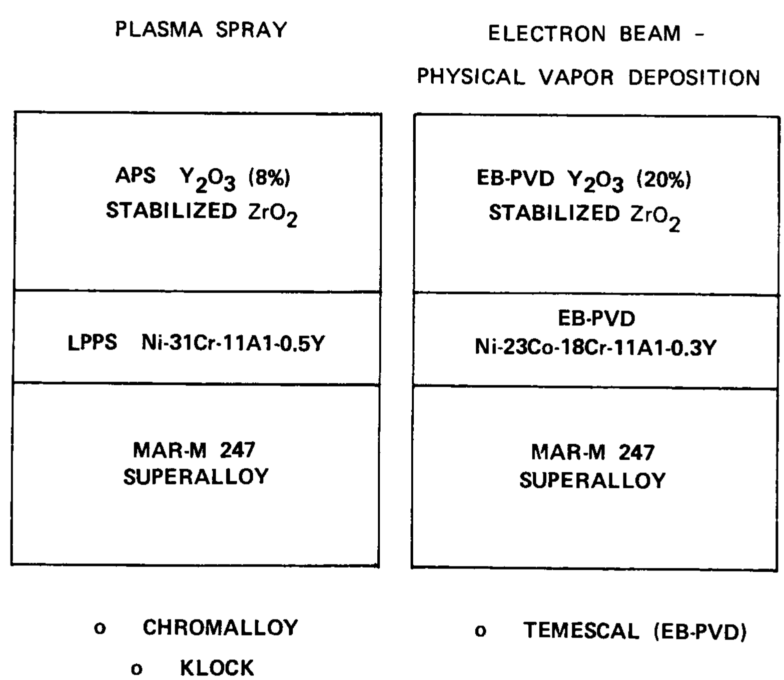

Figure 2. Life Prediction Models Are Being Developed For Plasma-Sprayed and EB-PVD TBC Systems.

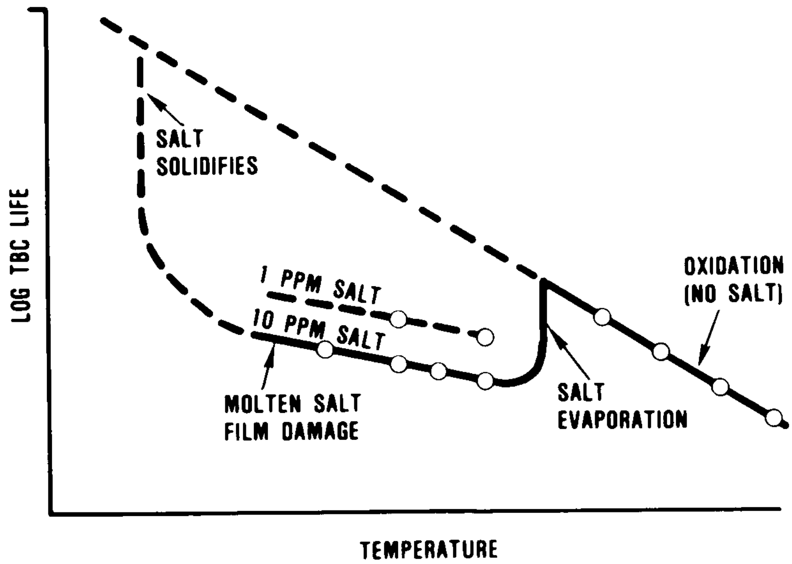

Figure 3. Burner Rig Tests Will Be Used To Develop and Calibrate Thermochemical TBC Life Model.

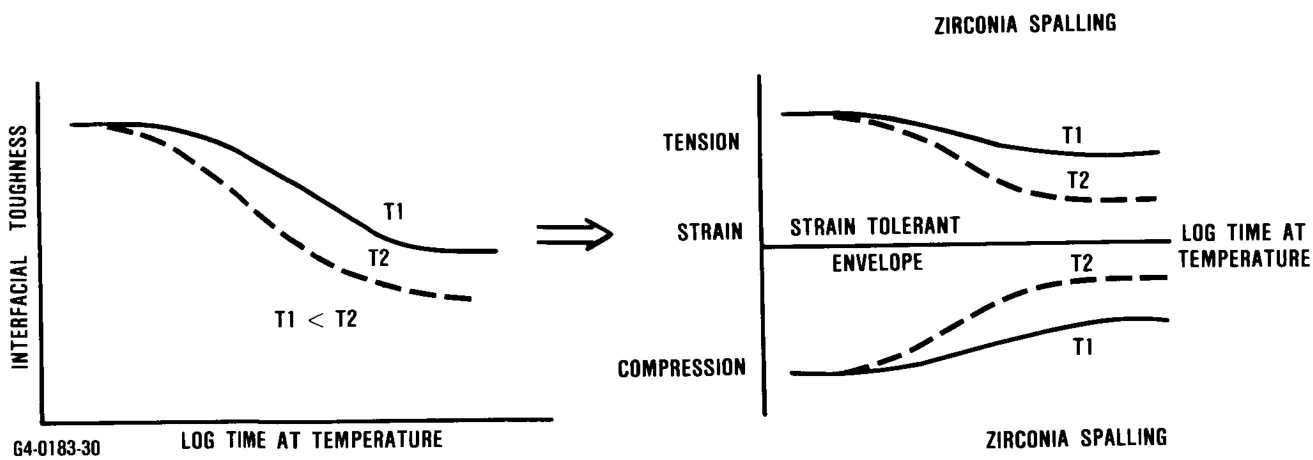

Figure 4. Interfacial Toughness Data Will Be Used To Extrapolate Spalling Strain Data With Respect To Exposure Time and Temperature.