



## OXY-FUEL/HYDROGEN-FIRED TURBINES

### *Advanced Material and Component Development*

### Program Description

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For advanced combustion systems, such as the oxy-fuel reheat cycle, low pressure turbine expansion sections are projected to encounter temperatures of ~1200 °C. Specifications for hydrogen-fueled combustion turbine systems target mean gas inlet temperatures of 1700 °C for stator blades, and 1570 °C for rotor blades. Similarly, advanced Brayton cycles for highly efficient zero emission systems target increasing the turbine rotor inlet temperature to 1700 °C or higher. Since these elevated temperatures are typically higher than the melting temperatures of alloys used in the construction of the hot gas structural components, the components are cooled by air extracted from the turbine compressor and directed through the cooling passages designed into the component. Additionally, thermal barrier coatings (TBCs) are routinely applied to the surface of the components.

The stability of the TBCs during service operation is a principal concern for use in not only current gas turbine applications, but even more importantly for use in future advanced combustion designs and cycles containing high concentrations of steam. The mechanisms by which TBCs fail are varied, and numerous factors are responsible, such as: (1) the thermal-expansion mismatch stresses; (2) the oxidation of the metal substrate; (3) and the continuously changing compositions, microstructures, interfacial morphologies, and properties of the TBC system.

Since October 2005, program efforts at NETL are being focused on (1) development of advanced bond coat and TBC material systems, (2) projection of the heat flux through the TBC-coated airfoil for oxy-fuel applications, and (3) demonstration of extended TBC durability under simulated process conditions. Post-test characterization of the TBC coupons is planned to address microstructural, compositional and phase changes that result as a function of extended operating time, as well as the overall stability and adhesion of the bond coat/top coat interface, and possible diffusion and/or oxidation layers formed at the bond coat/single crystal or superalloy substrate interface. Characterization techniques include optical, scanning electron, confocal, laser fluorescence microscopy, and elemental microprobe and x-ray diffraction analyses. Nondestructive techniques such as thermal imaging and micro-indentation are being assessed to identify possible point defect locations and stress-strain relationships within the TBC matrix.

