PROJECT facts

U.S. DEPARTMENT OF ENERGY
OFFICE OF FOSSIL ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY

High Efficiency Engines and Turbines

12/2002

INTERACTION OF STEAM/AIR MIXTURES WITH AIRFOIL ALLOYS AND COATINGS

PRIMARY PARTNER

University of Pittsburgh

TOTAL ESTIMATED COST

$ 430,636

CUSTOMER SERVICE

800-553-7681

STRATEGIC CENTER FOR NATURAL GAS WEBSITE

www.netl.doe.gov/scng

Description

Under the Advanced Gas Turbine Systems (AGTSR), the University of Pittsburgh (Pitt) is conducting experiments to evaluate how water vapor affects oxidation performance of turbine alloys and coatings. Figure 1 illustrates that air containing steam produces much higher long term degradation of a coated turbine alloy than dry air.

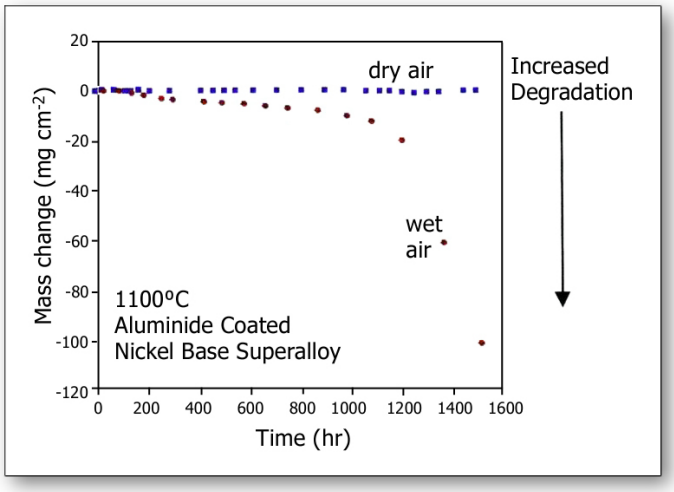

Figure 1. Water vapor (steam) increases turbine materials degradation

Task 1 of the project obtains turbine alloy and coated specimens for oxidation evaluations. Task 2 conducts low-pressure experiments to determine the effects of steam pressure, gas flow rate, and temperature on oxidation of turbine alloys. Task 3 investigates effects of high-pressure steam on oxidation of turbine alloys. Task 4 evaluates effects of high gas velocities on oxidation of turbine alloys in steam-air mixtures. Task 5 analyzes the experimental oxidation results of Tasks 2-4. Task 6 assesses the effects of steam-air mixtures on the degradation of thermal barrier coatings. Task 7 evaluates the effects of steam on oxidation of turbine alloys in the presence of stress. Task 8 coordinates and communicates the research results to the gas turbine industry and government laboratories.

Interaction of Steam/Air Mixtures with Airfoil Alloys and Coatings

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Turbine materials can be classified according to whether they tend to form one or the other of the two most protective scales, alumina or chromia oxides. Oxidation experiments to date in this project have shown that turbine materials that form chromia scales are more protective to steam enhanced oxidation than those that form alumina scales in the 700 C temperature range of downstream turbine airfoils. Conversely, turbine materials that form alumina scales were found to be more protective in steam environments than those that form chromia scales in the 900 C temperature range of upsteam turbine airfoils. The experiments at Pitt also revealed relative oxidation performance of a number of turbine materials in the 700 C and 900 C temperature range.

Duration

36 months

Goals

Commercial experience has shown that use of water or steam injection to control emissions or augment power has produced accelerated oxidation of turbine airfoils. Turbine materials are protected from high temperature combustion products by formation of protective oxide scales that are barriers to further penetration of oxygen to the underlying metal. Without protective scales, turbine materials oxidize at excessive rates, resulting in spallation and excessive material loss. This project evaluates the factors and conditions that control oxidation and formation of protective oxide scales on turbine materials in steam-air environments.

Benefits

The experiments at Pitt will provide data to turbine designers for the selection of airfoil materials for engines that operate with water or steam injection to reduce emissions or increase power.