the ENERGY lab

PROJECT FACTS

Advanced Research Materials

Influence of Processing on Microstructure and Properties of Iron Aluminides and Coatings

Background

The search for cleaner processes and greater efficiencies in fossil energy power production has generated efforts to conduct fossil fuel based power production processes at higher operating temperatures and pressures. This has created a need for materials capable of withstanding elevated temperatures, pressures, and corrosive environments found in boilers and turbines.

Advanced coatings provide environmental degradation resistance to high-temperature structural alloys that may not otherwise have the corrosion resistance necessary for use in modern, high-efficiency, fossil-energy power plants. Thermal spray application of coatings is relatively inexpensive and rapid compared to conventional means, such as weld overlay application. High-temperature, corrosion-resistant coatings may enable the development of high-temperature, high-efficiency (greater than 50 percent conversion) power production, which can lead to a reduction of total greenhouse emissions, conservation of fossil energy reserves, and a decrease in U.S. dependency on foreign fossil energy sources.

The Idaho National Laboratory's long history in the area of thermal spray coatings has focused on assessing the impact of various thermal spray parameters on coating characteristics (coating porosity, coating microstructure, residual stress in the coating, etc.), the development of coating compositions that resist environmental degradation, and thermal spray diagnostics. Feedback from advanced in situ diagnostics is used to control thermal spray parameters to produce consistent and reproducible coatings. It also allows the residual stress (compressive or tensile) in the coating/substrate system to be controlled and tailored to the desired application.

Project Description

This project will determine the influence of thermal spray processing parameters on the microstructure, stress state, and performance of advanced coatings for high-temperature environmental resistance in fossil energy applications Advanced in situ diagnostics used in the application of coatings are employed to relate thermal spray particle characteristics to the observed coating microstructure and residual stress state. The state of total residual stress in the coating can be controlled by altering the thermal spray process parameters to control the relative importance of peening stress (which is known to be compressive) and the tensile quench stresses. A significant impact of the peening stress on the coating microstructure has also been observed.

CONTACTS

Robert Romanosky
Advanced Research
Technology Manager
National Energy Technology Laboratory
3610 Collins Ferry Road
P.O. Box 880 PO3D
Morgantown, WV 26507-0880
304-285-4721
robert.romanosky@netl.doe.gov

Vito Cedro
Project Manager
National Energy Technology Laboratory
626 Cochrans Mill Road
P.O. Box 10940 922-258 M/S 922-273C
Pittsburgh, PA 15236-0940
412-386-7406
vito.cedro @netl.doe.gov

Thomas Lillo
Principal Investigator
Idaho National Laboratory
P.O. Box 1625
MS 2218
Idaho Falls, ID 83415
209-526-0746
thomas.lillo@INL.gov

PROJECT DURATION

Start Date
10/01/2009

End Date
09/30/2011

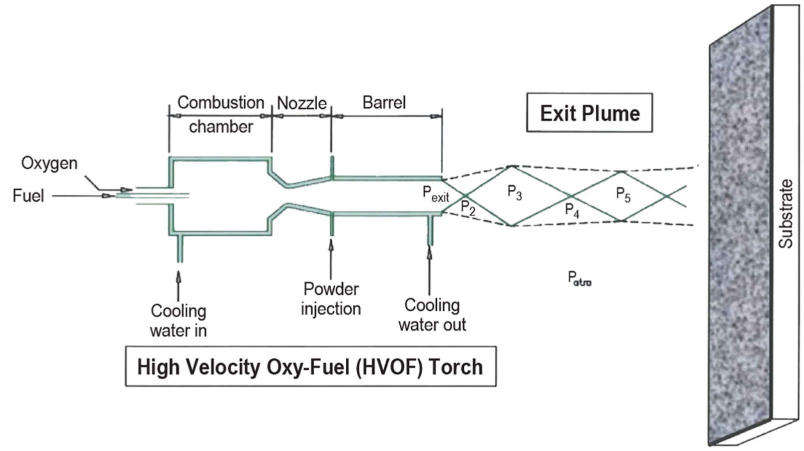
COST

Total Project Value
$305,000

DOE/Non-DOE Share
$305,000/ $0

U.S. DEPARTMENT OF ENERGY

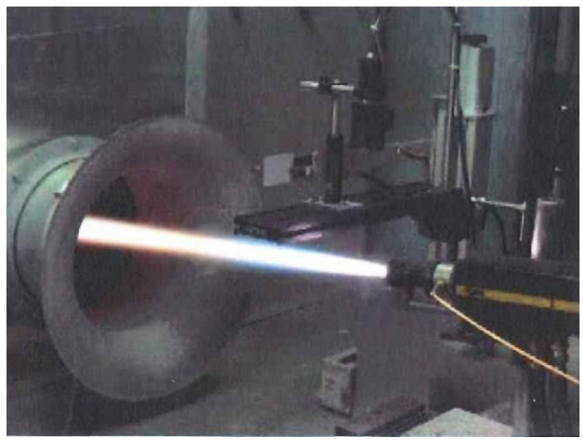
A suite of coating performance tests will measure the effects of microstructure and stress state on important in-service coating characteristics, ultimately enabling selection of optimum coating parameters of a given alloy and application. The coating performance tests will encompass measurements of high-temperature oxidation and corrosion resistance at constant and cyclic temperatures.as well as providing measures of coating adhesion and durability both before and after environmental exposure. Demonstrated performance improvements of thermal spray coatings will lead to field testing. The repair of thermal spray coatings will also be explored.



Schematic of High-Velocity Oxy-Fuel thermal spray device.

Goals and Objectives

The project's goal is to increase the efficiency of power production from fossil fuels by enabling operation at higher temperatures and pressures. Specifically, the project will determine the influence of thermal spray processing parameters on the microstructure, stress state, and performance of advanced coatings for high temperature corrosion and oxidation resistance in fossil energy applications. Coating performance tests will include measures of coating adhesion, durability, and corrosion/oxidation resistance under constant and cyclic temperature conditions.



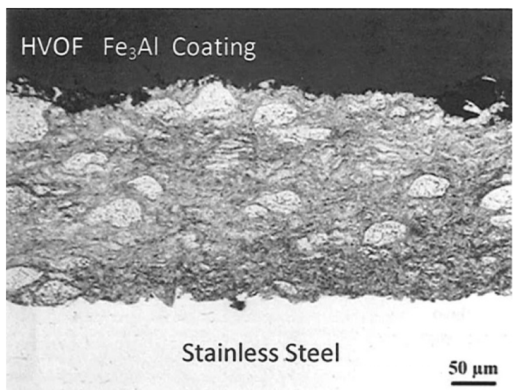
The High-Velocity Oxy-Fuel thermal spray device at work.

Accomplishments

Techniques have been developed to quantify the durability of the coatings and the effect of thermal spray parameters on coating durability. Ultrasonic methods have been developed to detect cracking of the coating during thermal cycling up to the intended operating temperature.

Iron aluminide (Fe_3Al) coatings were deposited on P91 steel, Inconel 600 (In600), and 316 stainless steel (316SS) substrates at a range of thermal spray chamber process parameters.

Thermal cycling cracking resistance tests were conducted on all the coating specimens. Coatings on In600 and 316SS substrates showed good resistance to cracking, with coatings prepared at higher spray chamber pressures having the best resistance to cracking.



Micrograph of iron aluminide coating applied using the High-Velocity Oxy-Fuel thermal spray device.

Benefits

An effective test suite and optimized thermal spray methods and materials will contribute to the use of thermal and environmental barrier coatings in fossil energy power production. These coatings will permit the cost-effective operation of power plants at the elevated temperatures and pressures required to meet DOE's efficiency and emissions targets. Achieving these targets will help to lower power production costs, conserve resources, limit dependence on foreign energy sources, and reduce emissions of greenhouse gases and other pollutants, thereby enhancing environmental management.