TITLE: ENHANCED HIGH TEMPERATURE CORROSION RESISTANCE IN ADVANCED FOSSIL ENERGY SYSTEMS BY NANO-PASSIVE LAYER FORMATION

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GRANT NO.: DE-PS26-04NT41898-02

PERFORMANCE PERIOD: October 2004 to March 2007

1. ABSTRACT

Objectives

Changes to federal environmental regulations have limited the amount of nitrous oxide (NO_x) compounds that my be released from fossil fuel fired power plants. In order to meet the NO_x emission levels, several plant operators have turned to the practice of staged combustion, wherein the combustion atmosphere is initially starved of oxygen (fuel rich) in the lower stages of the furnace. This leads to the conversion of any nitrous oxide compounds to stable N_2 (thereby lowering NO_x emissions) but also creates a more corrosive, reducing environment in these regions. As a result, typical chromium/molybdenum waterwall tubes are experiencing unacceptable wastage due to the reducing environment, and a current solution is to weld overlay a more corrosion resistant alloy on top of the existing tubes. Nickel based super alloys, such as alloy 622, have been used for overlays, but these alloys were not originally designed for this application and are considered expensive to deposit.

Recent research has shown that Fe-Al alloys with chromium additions offer excellent corrosion resistance in typical low NO_x environments. These alloys present several advantages over the nickel based superalloys currently being used in service, including low cost, improved corrosion resistance, and similar coefficient of thermal expansion

with tube material. The corrosion resistance of the alloys is derived from the development of a nano-passive layer that acts as a barrier between the underlying alloy and the corrosive environment.

This project aims to characterize the structure and chemistry of the nano-passive layer that forms on model FeAlCr alloys in simulated low NO_x environments. Specifically, the mechanisms of passive layer formation and breakdown will be analyzed using various microscopy techniques. These analyses and subsequent diffusion studies on long term exposure samples will permit the creation of a lifetime prediction model for these alloys.

ACCOMPLISHMENTS TO DATE

Preliminary characterization has been carried out on select Fe-Al-Cr alloys exposed to a simulated low NO_x environment. XPS studies of the passive layer on these alloys have shown the existence of an aluminum oxide layer. This technique is being explored to determine it's feasibility for analyzing the passive layer's properties. Additionally, equipment for the long term corrosion tests is being assembled.

FUTURE WORK

- Continue the corrosion studies in simulated low NO_x environments
- Analyze the passive layer that forms on the alloys, including the chemistry and structure of the oxide and the alloy/oxide interface
- Perform long term corrosion studies and analyze underlying metal to determine diffusion rates and alloy depletion.
- Develop lifetime prediction model for FeAlCr alloys in low NO_x environments.

STUDENTS RECEIVING SUPPORT FROM THIS GRANT

- Ryan Deacon