TITLE: "Enhanced High Temperature Corrosion Resistance in Advanced Fossil Energy Systems by Nano-Passive Layer Formation"

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1. ABSTRACT

OBJECTIVES

The combustion of pulverized coal produces several compounds that have been identified as contributors to environmental problems such as acid rain. In particular, nitrogen-oxygen compounds, collectively termed NO_x, has been targeted for reduction by federal laws, such as the Clean Air Act. One method of reducing NO_x emissions from coal-fired power plants is the practice of staged combustion, wherein the combustion environment is initially starved of oxygen in the lower sections of the boiler. This has proven an effective means of reducing NO_x emissions, but also created a more corrosive (reducing) atmosphere. This has led to accelerated corrosion of waterwall tubes in boilers that utilize staged combustion. A common solution to this problem is to weld overlay a more corrosion resistant alloy on top of existing waterwall tubes.

Recent analyses by several investigators have identified a range of FeAlCr alloys that are both weldable and corrosion resistant in simulated low NO_x environments. These alloys are also attractive because they do not exhibit the microsegregation often observed in some nickel based superalloys, which can lead to preferential corrosion along dendrite cores.

The objective of this project is to understand the mechanism of corrosion resistance of several FeAlCr alloys in simulated low NO_x environments. While the presence of a sub-micron surface oxide layer has been detected in previous studies, a detailed characterization of the oxide layer has not been performed for the environments and temperatures typical of a low NO_x boiler. In

this project, alloy coupons will be corroded for both short and long term exposures, and the surface oxide(s) that form will be characterized using a variety of scanning and transmission electron microscopies (SEM and TEM). In addition, an x-ray photoelectron spectroscopy (XPS) system will be used to analyze as-exposed coupons and also to conduct in-situ oxidation experiments at high temperature. Finally, a model will be developed to predict the lifetime of typical FeAlCr weld overlay coatings in low NO_x boilers.

ACCOMPLISHMENTS TO DATE

Alloy Selection and Corrosion Equipment

A literature search was performed to determine which FeAlCr alloys would be used in this project. Corrosion resistance and alloy weldability were the two confining variables, while alloy cost was also a consideration. Three alloy compositions were selected and cast ingots of these alloys have finally been received from Oak Ridge National Laboratory after considerable technical delay. In addition, equipment for both long and short term corrosion experiments has been obtained. Horizontal tube furnaces and thermogravimetric analyzers have been modified to run in simulated low NO_x environments.

Corrosion Characterization Techniques

FeAlCr alloy coupons have been analyzed using XPS to determine the composition of the native surface oxides. Different techniques have been evaluated to remove the surface oxide, so that a clean metal surface may be obtained for the start of the in-situ experiments. Additionally, heating of the sample in the analysis chamber has been performed to determine the feasibility of running the in-situ tests. A focused ion beam (FIB) will be used to prepare samples for TEM analysis, and the technique of removing samples with the FIB has been practiced.

FUTURE WORK

- Perform corrosion testing in simulated low NO_x environments
- Continue XPS studies of oxide formation
- Characterize the corrosion products that form on the FeAlCr alloys

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