the ENERGY lab

PROJECT FACTS

Existing Plants, Emissions & Capture

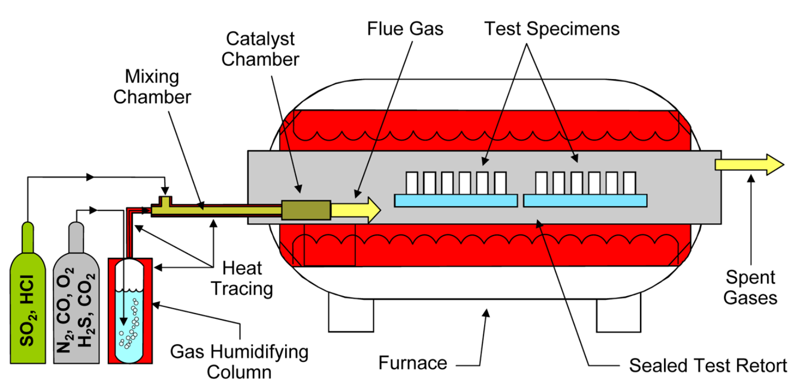
Oxy-combustion Boiler Material Development

Background

In an oxy-combustion system, combustion air (79 percent nitrogen, 21 percent oxygen) is replaced by oxygen and recycled flue gas (carbon dioxide [CO_2] and water), eliminating nitrogen in the flue gas stream. When applied to an existing boiler, the flue gas recirculation rate is adjusted to enable the boiler to maintain its original air-fired heat absorption performance, eliminating the need to derate the boiler output or modify the boiler heat transfer surfaces. Because the recycled flue gas will be mostly CO_2, the levels of boiler CO_2 and carbon monoxide (CO) — a reducing gas that is linked to corrosion of boiler tubes — are increased. With the recycled flue gas also containing small amounts of corrosive gases, such as sulfur dioxide (SO_2) and hydrochloric acid (HCl), corrosive conditions are expected to increase throughout the boiler, as well as in localized wall zones.

Description

This project will evaluate the corrosion characteristics of oxy-combustion relative to air-fired combustion while identifying the corrosion mechanisms involved and, when operating with high- to low-sulfur coals, determining the effects oxy-combustion has on conventional boiler tube materials, conventional protective coatings, and alternative materials and coatings. This project involves the prediction of coal-fired power plant oxy-combustion gas compositions by computational fluid dynamic (CFD) calculations, exposure of approximately 800 coupons of boiler tube materials and coverings, coated with coal ash deposits, to simulated oxy-combustion gases in bench-scale electric furnaces, and evaluation of the coupons to assess the potentially corrosive effects of oxy-combustion. The test conditions and candidate materials for testing will be identified in the design phase of the project.



Typical Electric Tube Furnace Test Arrangement

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PERIOD OF PERFORMANCE

10/1/2008 to 9/30/2011

COST

Total Project Value
$1,991,794

DOE/Non-DOE Share
$1,593,437 / $398,357

Primary Project Goal

The goal of this project is to investigate corrosion in conventional and advanced boiler materials under conditions that replicate oxy-combustion processes used to improve CO_2 capture from coal-fired power plant flue gas.

Objectives

The objectives of this program are to evaluate the corrosion characteristics of oxy-combustion relative to air-fired combustion, identify the corrosion mechanisms involved, and, when operating with high- to low-sulfur coals, determine oxy-combustion's effects on conventional boiler tube materials, conventional protective coatings, and alternative materials and coatings.

Benefits

This project will greatly increase the understanding of corrosion mechanisms and material behavior under oxy-combustion conditions by coating and exposing the materials to representative gases for 1,000 hours in electric tube furnaces, which will allow for direct comparison of air- and oxy-fired corrosion data.

Applying a coating to localized regions is less expensive and more practical than upgrading to higher alloys, and in-situ application of the coatings is less expensive than cutting out wall sections and installing replacement panels with shop-installed protective coatings.

Planned Activities

Foster Wheeler will:

- Assess the corrosion characteristics of oxy-combustion relative to air combustion by conducting analytical and experimental work.
- Predict flue gas compositions by using its CFD boiler design tools throughout oxy- and air-fired boilers, and especially along furnace walls, where localized zones/micro-climates high in corrosive gases can exist; the analyses will also include high- and low-sulfur, coal-fired boilers.
- Use the CFD results to select gas compositions representative of the furnace and superheat/reheat regions of oxy- and air-fired boilers for material corrosion tests.
- Expose coupons of conventional boiler tube materials, conventional tube coatings, and alternative/advanced materials, all of which will be coated with deposits whose corrosive constituents span those of high-, medium-, and low-sulfur coal-fired boilers, to the representative gases for 1,000 hours in electric tube furnaces.
- Parametrically investigate the effect of gas and deposit compositions, temperatures on a range of present day boiler tube materials and higher alloy and advanced materials being developed for use as protective tube weld overlays and coatings.

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