the ENERGY lab

R&D FACTS

Innovations for Existing Plants/ CO_2 Emissions Control

Oxy-Fuel Combustion

Objective

This project aims to measure fundamental combustion data such as gas radiative properties and validation data needed for detailed simulation tools required for development of oxy-fuel combustion systems.

Background

The U.S. Department of Energy's Innovations for Existing Plants program goals for carbon capture include developing technologies that are capable of 90 percent CO_2 capture with an increase in cost of electricity of less than 35 percent. Oxy-fuel combustion is an approach that is being explored to meet these goals. In the oxy-fuel approach, nitrogen is removed from the supply air, and is replaced by another diluent, such as steam, CO_2 or recycled flue gas, in order to control the flame temperature. The oxy-fuel combustion approach results in an exhaust stream more easily separated for carbon capture and storage. Detailed simulation tools such as CFD can be used to develop designs to achieve these performance goals. However, experimental measurements of important fundamental flame and property data, such as gas radiative properties at the conditions relevant to these oxy-fuel combustion systems, are not available in the published literature to extend and validate these simulation tools. The high steam loadings anticipated in oxy-fuel systems are expected to produce significant differences in flame properties relative to conventional combustion systems, but experimental data is needed to verify the predictions. In response to this need, NETL has recently designed and built an oxyfuel-steam apparatus to perform combustion tests using flames with high levels of steam or CO_2 dilution, representative of oxy-fuel systems. The apparatus will be used for measurements of radiative properties of these flames, which are needed to accurately simulate and design advanced power systems for carbon sequestration.

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Project Description

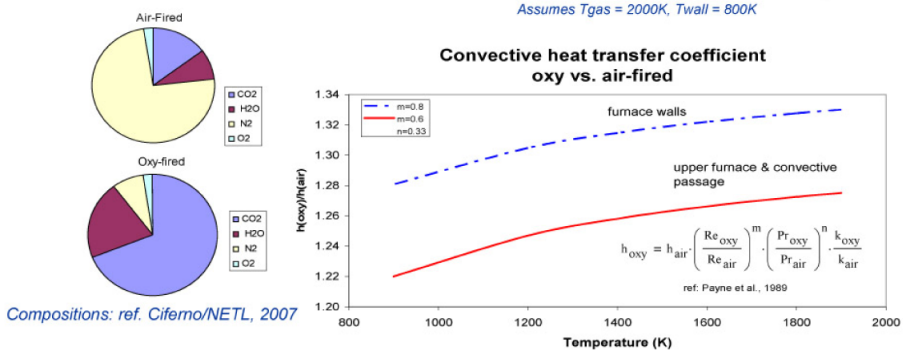
ORD researchers have developed a unique, lab scale oxy-fuel combustion facility designed to study fundamental combustion processes and properties that are relevant to the high steam and CO_2 dilution found in oxy-fuel combustion concepts. The system includes a boiler capable of delivering 18 pph steam at up to 90 psig and precision mass flow controllers for the relevant gases (H_2, CO, O_2, CO_2, and steam). The high steam loadings in these flat flame burner experiments (up to 70% by volume of the supply gas flow to the burner) require heating all the fuel and oxidant gas supply lines to the burner to maintain adequate superheat temperatures. In addition, the flat flame burner is oil-cooled to allow operation with superheated steam without condensation. For planned measurements of optical properties of the oxy-fuel combustion products, a fast imaging spectrometer has been purchased. This instrument can measure the spectral radiation intensity in the mid-infrared region (1.3 to 4.8 jam), a region where the radiative properties are expected to be important to the analysis of heat transfer in oxy-fired pulverized coal boiler systems.

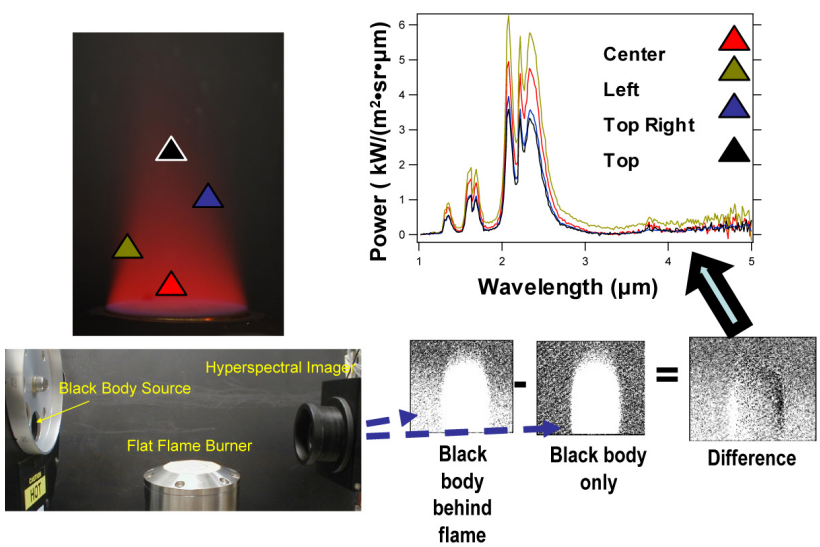
- **Changes in gas composition for oxy- vs. air-fire cases mean changes in heat transfer behavior - radiative and convective components**

Changes in Radiative Properties
Air-fired vs. oxy-fired

L (m)	Total emissivity ratio (oxy/air)	Total absorptivity ratio (oxy/air)
0.5	1.63	1.81
5	1.33	1.44

Assumes Tgas = 2000K, Twall = 800K





Radiative Property Measurements of an Oxyfuel Steam Flame