PROJECT facts

U.S. DEPARTMENT OF ENERGY
OFFICE OF FOSSIL ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY

Advanced Research

05/2007

NITROGEN EVOLUTION AND CORROSION MECHANISMS WITH OXYCOMBUSTION OF COAL

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Description

Under a grant from the University Coal Research (UCR) program, Brigham Young University (BYU) is leading a three-year research effort to investigate the physical processes that several common types of coal undergo during oxy-fuel combustion. Specifically, research addresses the mixture of gases emitted from burning, particularly such pollutants as nitrogen oxides (NO_X) and carbon dioxide (CO_2), and the potential for corrosion at the various stages of combustion. The UCR program is administered by the Advanced Research Program at the National Energy Technology Laboratory (NETL), under the U.S. Department of Energy's Office of Fossil Energy (DOE-FE).

Oxycombustion is a promising technology to capture greenhouse gases economically at existing pulverized coal-fired power plants. In an oxy-fuel combustion-based power plant, oxygen-enhanced air and CO_2 from recycled flue gas are used to burn a fossil fuel such as coal more completely, resulting in a highly pure exhaust stream. Oxycombustion is a viable approach to limit and control pollutants such as NO_X, reduce carbon emissions by capturing and storing CO_2, and provide potentially enhanced mercury sorption during combustion.

Significant reductions in the cost of supplying oxygen are a key requirement for making the oxycombustion power plant an option for the electric utility industry. No commercial oxycombustion power plants are operating yet, due mainly to the high cost of producing oxygen using current methods, primarily cryogenic technology. Research is under way on a number of options to advance technologies that will both produce oxygen cost-effectively, and enable plant operators to utilize that oxygen for advanced oxycombustion.

Objectives

The objectives of this research are to: (1) determine the mechanisms by which NO_X reduction occurs during oxycombustion; and (2) measure particles deposited on simulated superheater and water-wall boiler tubes, which indicate the corrosive tendencies of coal when used in and for oxycombustion. These properties and mechanisms are being investigated for three coals: Powder River Basin (PRB) subbituminous; and Illinois #6 and Pittsburgh #8 bituminous. Analysis of these coals has identified various amounts of sulfur and chlorine (both corrosive elements), which are to be measured in various oxycombustion environments in deposits formed after burning.

PROJECT DURATION

Start Date
08/04/05

End Date
08/31/08

COST

Total Project Value
$237,000

DOE/Non-DOE Share
$200,000 / $37,000

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Technical Approach and Accomplishments

An experimental flat-flame burner (FFB) will be used to study nitrogen evolution in coal particle stream devolatilization experiments at elevated temperatures produced by flames that are high in oxygen. A laminar plug flow, premixed, multi-fuel reactor (MFR) has been converted for use to simulate oxycombustion by burning coal in CO_2/O_2 streams supplied from tanks. Nitrogen and other gas species as well as ash deposits will be collected from these experiments, along with temperature and axial profile data, to evaluate the effects of various coals and gas streams on NO_X formation and corrosion potential at various locations and residence times in the MFR.

A schematic diagram of the MFR is shown in Figure 1. Because both the CO_2 and O_2 gases cool down when expanded to lower pressures, the CO_2 requires preheating before the flow is measured and mixed for use in the combustion chamber. Gas and fuel flow rates have been calibrated and initial system testing is under way.

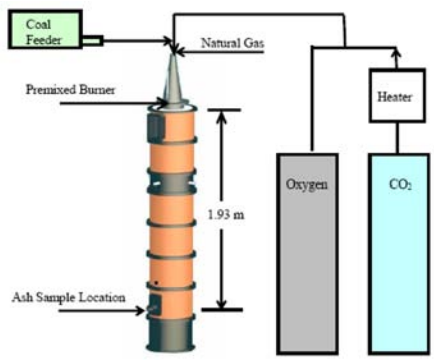

Figure 1. The multi-fuel reactor configured to run on simulated oxy-fuel combustion

Initial work on the FFB also has begun. Flames at elevated temperatures with higher heating rates have been produced, replicating some oxy-fuel combinations. A measurement of the axial distance from the centerline of the burner, corresponding to the temperature profile over time for one of the selected conditions, is shown in Figure 2. The temperature along the axis of the fuel is cooler near the burner because of the lower temperature of the primary gas that enters with the coal particles. The temperature at 0.5 cm from the axis is higher and represents the surrounding temperature produced by the flame. Peak temperatures above 1,800 K (3,272 °F) are seen in the flame.

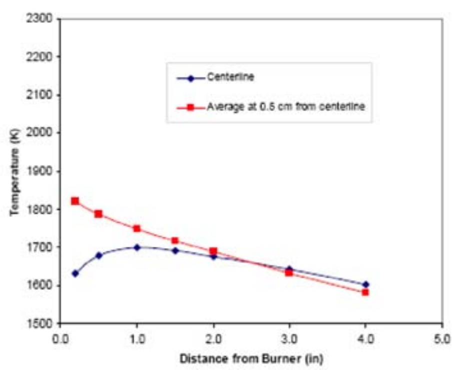

Figure 2. Measured temperature profiles in the flat-flame burner

Benefits

Numerous future experiments are planned using the FFB and MFR combination to identify the evolution of nitrogen and changes in corrosion potential. These experiments are expected to yield results that will help establish oxycombustion as a viable technology for use in existing coal-fired power plants to reduce greenhouse gas emissions. Reducing the cost and technical risk of oxycombustion technology will help move the nation closer to cleaner, more efficient power generation from coal.