the ENERGY lab

PROJECT FACTS

Existing Plants, Emissions & Capture

Coal Direct Chemical Looping Retrofit for Pulverized Coal-Fired Power Plants with In-Situ CO_2 Capture

Background

Pulverized coal (PC)-fired power plants provide nearly 50% of electricity needs, while accounting for a third of the total carbon dioxide (CO_2) emissions in the United States. Proven CO_2 capture technologies, such as the amine-based scrubbing process, can be used to capture CO_2 from the flue gas stream in PC-fired power plants. However, such technologies can consume up to 30% of the total electricity generated in the plant, resulting in an increase of more than 85% in electricity production cost. With expected regulations targeting carbon emissions, novel technologies that efficiently capture the CO_2 generated from existing PC-fired power plants without the need of major modification would be highly desirable for the sustained competitiveness of such power plants.

The Coal Direct Chemical Looping (CDCL) technology under development at the Ohio State University (OSU) splits combustion into separate oxidation and reduction reactions. A metal oxide is used as an oxygen carrier which then releases the oxygen in a reducing atmosphere where the oxygen reacts with the fuel. The metal is then recycled back to the oxidation chamber where the metal oxide is regenerated by contact with air. The advantage of using two chambers for the combustion process is that the produced CO_2 is concentrated, once the water is removed, and not diluted with nitrogen gas. The benefit of the process is that no air separation plant or external CO_2 separation equipment is required for carbon capture.

Description

New CDCL systems will be constructed at both the bench and sub-pilot (25 kWt) scales in order to continue developing a technology that offers efficient and cost-effective CO_2 capture from existing PC-fired power plants. Over the past three years, OSU has researched and developed an oxygen carrier particle that performs well in the CDCL system for power production. This work will continue with the identification and testing of 100 new oxygen carrying candidates culminating in the selection of a single optimum oxygen carrier. This project will operate the CDCL system in an integrated manner and will allow a preliminary techno-economic analysis to be conducted.

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PARTNERS

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PERIOD OF PERFORMANCE

1/1/2009 to 12/31/2011

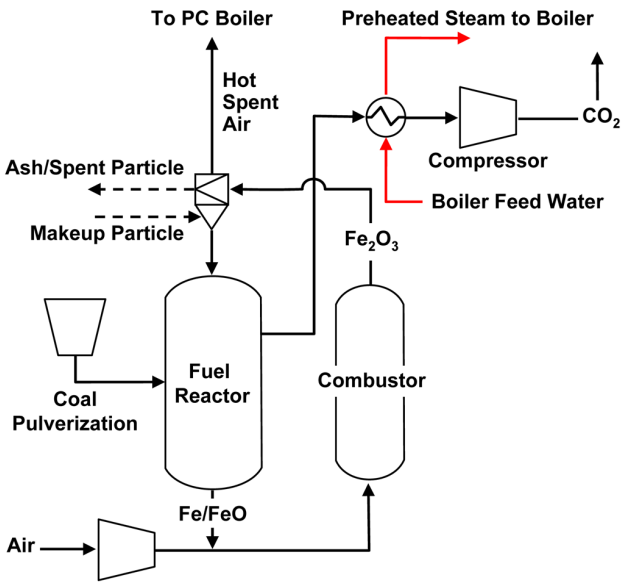
COST

Total Project Value
$1,357,638

DOE/Non-DOE Share
$937,827 / $ 419,811

Primary Project Goal

Develop an efficient, low-cost coal-based power plant system, based upon direct coal conversion via chemical looping, capable of achieving 90% CO_2 removal at no more than a 35% increase in cost of energy services.



The Coal Direct Chemical Looping Process

Objectives

- Improve the oxygen carrying capacity as well as the sulfur/ash tolerance of the currently used metal oxide.
- Demonstrate continuous CDCL operations at sub-pilot scale (25 kW_t) in an integrated mode with greater than 99% coal (bituminous, sub-bituminous, and lignite) conversion as well as the production of a high-temperature exhaust gas stream that is suitable for steam generation in existing PC-fired boilers.
- Identify, via laboratory-scale demonstrations, the fate of sulfur and nitrogen oxides (SO_x and NO_x) in the CDCL system.
- Using laboratory-scale data, conduct a thorough techno-economic analysis that validates the potential for the CDCL system to meet the Existing Plants performance and cost goals.

Benefits

Chemical looping is similar to oxy-combustion in that its flue gas is primarily concentrated CO_2, minimizing the cost and work of CO_2/N_2 separation. In addition, chemical looping has the added advantage of not requiring a costly and energy intensive oxygen plant. This technology utilizes a conventional steam cycle and can be designed to co-capture SO_x along with CO_2. Systems analyses conducted by Alstom Power, have indicated that CDCL power systems could provide significant efficiency improvements and cost reductions. This specific project will, for the first time, advance the technology to the 25 kWt scale.

Upon completion, this project will benefit the Existing Plants Program and chemical looping technology development by identifying oxygen carriers that have potential for multi-pollutant control (CO_2, SO_x); using testing results to identify potential barriers and optimize the CDCL technology; demonstrating CDCL at the sub-pilot scale; and providing more realistic process engineering data for future techno-economic analyses.

Accomplishments

The project began on January 1, 2009.

Planned Activities

- Develop improved metal oxide particles with greater sulfur tolerance and reactivity.
- Identify and develop approximately 100 metal oxide candidates with varying dopants and support materials.
- Identify optimum fuel reactor operating conditions including flow rates, operating temperatures, and enhancer types.
- Design and construct a larger bench scale unit.
- Hold monthly industrial review committee meetings to evaluate the progress of the project and provide recommendations.