the ENERGY lab

PROJECT FACTS

Existing Plants, Emissions & Capture

Evaluation of Concentrated Piperazine for CO_2 Capture from Coal-Fired Flue Gas

Background

The mission of the U.S. Department of Energy/National Energy Technology Laboratory (DOE/NETL) Existing Plants, Emissions & Capture (EPEC) Research & Development (R&D) Program is to develop innovative environmental control technologies to enable full use of the nation's vast coal reserves, while at the same time allowing the current fleet of coal-fired power plants to comply with existing and emerging environmental regulations. The EPEC R&D Program portfolio of post- and oxy-combustion carbon dioxide (CO_2) emissions control technologies and CO_2 compression is focused on advancing technological options for the existing fleet of coal-fired power plants in the event of carbon constraints.

Pulverized coal (PC) plants burn coal in air to generate steam and comprise 99 percent of all coal-fired power plants in the United States. CO_2 is exhausted in the flue gas at atmospheric pressure and a concentration of 10–15 percent by volume. Post-combustion separation and capture of CO_2 is a challenging application due to the low pressure and dilute concentration of CO_2 in the waste stream, trace impurities in the flue gas (nitrogen oxides [NO_x], sulfur oxides [SO_x], and particulate matter [PM]) that affect removal processes, and the parasitic energy cost associated with the capture and compression of CO_2. Chemical solvents can be used to capture CO_2 from flue gas by absorbing it into a liquid carrier. Although this method is used commercially to remove CO_2 from industrial gases, it has not been applied to the removal of large volumes of gas as in coal-fired power plant flue gas due to significant cost and efficiency penalities.

University of Texas' SRP Plant

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PARTNERS

University of Texas
Trimeric Corporation

PERFORMANCE PERIOD

Start Date	End Date
10/01/2010	03/31/2014

COST

Total Project Value
$3,866,711

DOE/Non-DOE Share
$3,000,000 / $866,711

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U.S. DEPARTMENT OF ENERGY

Project Description

URS Group, in collaboration with the University of Texas and Trimeric Corporation, will investigate the use of concentrated piperazine (PZ) as a solvent for absorbing CO_2 from coal-fired power plant flue gas. Laboratory research, CO_2 capture process modeling, and preliminary pilot results with synthetic flue gas have shown concentrated PZ to have several advantages over other solvents. When coupled with a novel, high-temperature regeneration system that takes advantage of PZ's enhanced thermal stability, the modeled process has demonstrated significant progress toward meeting the DOE goal of capturing 90 percent of the CO_2 with less than a 35 percent increase in the cost of electricity (COE). This project will investigate the concentrated PZ process for the first time with coal-fired flue gas and at scales of 0.1 MWe and 0.5 MWe to provide data to assess the technical and economic feasibility of a potential future full-scale version of this technology.

The PZ-based CO_2 absorption process will undergo a series of three field tests to gain operational experience with the solvent in coal-fired flue gas, while employing a novel, high-temperature, two-stage flash regeneration design. The tests will be conducted at Commonwealth Scientific and Industrial Research Organization's (CSIRO) Post-Combustion Capture (PCC) facility, University of Texas' Separations Research Program (SRP) plant, and DOE's National Carbon Capture Center (NCCC).

Goal

The project goal is to gain operational experience with the concentrated PZ solvent in coal-fired flue gas while employing the high-temperature, two-stage flash regeneration design. Results will be used to evaluate the technical and economic feasibility of a full-scale implementation of this process.

Objectives

Project objectives are to quantify and demonstrate the robustness of concentrated PZ with coal-fired flue gas in an integrated absorption/stripping system with solvent regeneration at 150°C; optimize the equipment design and energy performance of the innovative, two-stage flash system; and identify and resolve other potential operational and design issues including process control, corrosion, foaming, and solids precipitation.

Planned Activities

- A three-month test of the PZ-based absorption process will be performed in coal-fired flue gas using CSIRO's 0.1 MWe absorption column installed at a power station, coupled with the project team's 0.1 MWe high-temperature, two-stage, flash solvent regeneration system. This test campaign will provide the first operational experience with PZ in coal-fired flue gas so that solvent degradation can be quantified over a three-month operating period, operational problems can be identified and addressed, and energy balance data can be obtained.
- Based on the experience gathered during the CSIRO campaign, the 0.1 MWe regeneration skid design will be modified and then tested at the University of Texas' SRP Plant. A three-week test in synthetic flue gas at 0.1 MWe scale will be conducted using the absorption column at the SRP Plant. This test campaign will verify the operation of regeneration skid modifications, as well as the ability to remove solvent impurities, if applicable, prior to finalizing a design for a 0.5 MWe regeneration skid to be used in the third field test.
- The third field test will be on coal-fired flue gas conducted with the 0.5 MWe absorption column at the NCCC in conjunction with a 0.5 MWe regeneration skid built by the project team. The three-month test will provide useful mass and energy balance data required for scaling up the process for larger-scale testing and future commercialization.
- An engineering feasibility study will be performed on data obtained during the three testing programs to assess the feasibility of using concentrated PZ solvent for post-combustion CO_2 control. This analysis will include estimated capital and operating costs for installing and operating a full-scale system capable of achieving over 90 percent CO_2 removal. Additionally, the next steps for research and development will be defined.

Accomplishments

- Kick-off Meeting conducted on 12/10/2010.

Benefits

The use of concentrated PZ—coupled with two-stage, high-temperature flash regeneration—as a solvent for absorbing CO_2 from coal-fired power plant flue gas offers improved performance when compared to other solvents, including faster CO_2 absorption rate, higher CO_2 capacity, lower volatility, negligible thermal degradation, negligible oxidative degradation when used with an inhibitor, and production of CO_2 at elevated pressure (resulting in lower compression costs). Further development of this solvent process to capture CO_2 from coal-fired power plant flue gas will be an important advancement toward controlling CO_2 emissions for existing coal combustion-based plants.

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