the ENERGY lab

PROJECT FACTS

Existing Plants, Emissions & Capture

Bench-Scale Development of a Hot Carbonate Absorption Process with Crystallization-Enabled High Pressure Stripping for Post-Combustion CO_2 Capture

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 produce 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.

Solvent-based CO_2 capture involves chemical or physical sorption of CO_2 from flue gas into a liquid carrier. Although solvent-based systems are used commercially to remove CO_2 from industrial gases, they have 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 penalties.

Description

The University of Illinois at Urbana-Champaign has partnered with Energy Commercialization, LLC to investigate the use of a Hot Carbonate Absorption Process (Hot-CAP) with crystallization-enabled, high-pressure stripping for post-combustion CO_2 capture. The process uses a carbonate salt (potassium or sodium carbonate)

CONTACTS

Shailesh D. Vora
Technology Manager
Existing Plants, Emissions & Capture
National Energy Technology Laboratory
626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236-0940
412-386-7515
shailesh.vora@netl.doe.gov

Andrew Jones
Project Manager
National Energy Technology Laboratory
626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236-0940
412-386-5531
andrew.jones@netl.doe.gov

Yongqi Lu
Principal Investigator
University of Illinois at Urbana-Champaign
Illinois State Geological Survey
615 E. Peabody Drive
Champaign, IL 61820-7406
217-244-4985
lu@isgs.illinois.edu

PARTNERS

Energy Commercialization, LLC
Illinois Clean Coal Institute

PERIOD OF PERFORMANCE

Start Date	End Date
01/01/2011	12/31/2013

COST

Total Project Value
$1,642,156

DOE/Non-DOE Share
$1,277,118 / $365,038

AWARD NUMBER

DE-FE0004360

U.S. DEPARTMENT OF ENERGY

as a chemical solvent to remove CO_2 from flue gas. The carbonate solvent absorbs CO_2, as well as SO_2 and other acid gases, in a high-temperature (70–80°C) absorption column; the CO_2-rich solvent undergoes treatment to crystallize and separate the bicarbonates formed, and the resulting slurry is sent to a high-pressure stripping column which removes the CO_2 and recycles the solvent. Calcium sulfate is recovered separately as a byproduct of SO_2 removal. The Hot-CAP offers the potential to significantly reduce the energy penalty compared with the monoethanolamine (MEA) process; a preliminary techno-economic evaluation has shown that energy use with the Hot-CAP is about half that of its MEA counterpart due to reduced steam requirements and compression costs. Successful optimization of this technology will show promise to meet or exceed DOE's technical and cost goals.

Primary Project Goal

The project goal is to perform a proof-of-concept study that will generate process engineering and scale-up data to optimize the Hot-CAP technology and demonstrate its capability to achieve the DOE goals of at least 90 percent CO_2 removal from coal-fired power plant flue gas with less than a 35 percent increase in the cost of electricity (COE), and that will help to advance the process to pilot-scale level within three years.

Objectives

The project objectives are to perform laboratory- and bench-scale tests to measure thermodynamic and reaction engineering data that will be used to evaluate technical feasibility and cost effectiveness, performance and scale-up, and commercial competitiveness of the Hot-CAP process with MEA-based processes and other emerging post-combustion CO_2 capture technologies. A combination of experimental, modeling, process simulation, and technical and economic analysis studies will be performed.

Planned Activities

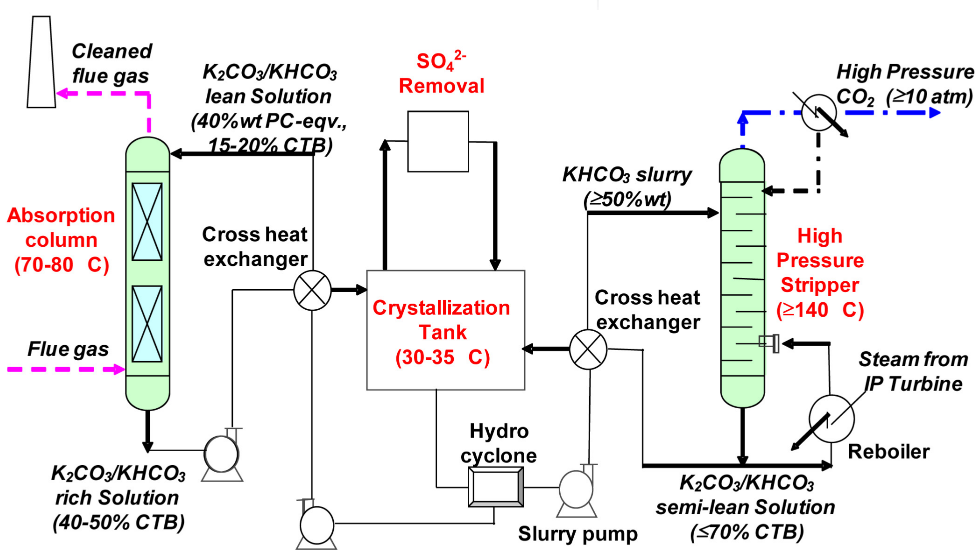
- Kinetics and phase equilibrium data associated with the major reactions and unit operations in the Hot-CAP will be measured, including CO_2 absorption, bicarbonate crystallization, sulfate recovery, and CO_2 stripping.
- Energy Commercialization, LLC will use the results from the experimental studies to help create a process flow diagram, perform equipment and process simulations, and conduct a techno-economic analysis study for a conceptual 550 MW high-sulfur coal-fired power plant retrofitted with the Hot-CAP.
- The results from experimental and process simulation studies will be used to identify optimal process conditions of the Hot-CAP to meet or exceed the DOE technical and cost goals.

Accomplishments

- Project awarded in September 2010.
- Kick-off Meeting conducted in December 2010.

Benefits

The Hot-CAP technology offers the potential to significantly reduce the energy penalty associated with CO_2 separation and capture when compared to conventional technologies. The carbonate solvent has a lower overall heat of absorption than MEA, does not degrade, and is not corrosive. The CO_2 working capacity of the Hot-CAP solvent is 1.5 to 3 times higher than that of an MEA process as bicarbonate slurry is used for CO_2 stripping, and the use of a high-pressure stripping unit reduces the CO_2 compression work. The process is targeted at achieving greater than 90 percent CO_2 removal and reducing the energy use to 50 percent lower than that of MEA-based processes.



Hot Carbonate Absorption Process Flow Diagram.