the ENERGY lab

PROJECT FACTS

Existing Plants, Emissions & Capture

Development and Evaluation of a Novel Integrated Vacuum Carbonate Absorption Process

Background

The mission of the U.S. Department of Energy's (DOE) Existing Plants, Emissions, & Capture (EPEC) 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 and reuse is focused on advancing technological options for the existing fleet of coal-fired power plants in the event of carbon constraints.

Solvent-based systems, one area of interest in post-combustion CO_2 capture, apply chemical or physical sorption of CO_2 from flue gas into a liquid carrier. Several technologies and novel concepts are being researched for CO_2 separation from post-combustion flue gases. Currently, mono-ethanol-amine (MEA)-based absorption processes are considered the best available option for post-combustion CO_2 capture. However, the cost of this type of CO_2 removal from pulverized coal (PC) power plants is expensive due to the intensive energy use required in the absorption process. DOE is funding research to develop low-cost, efficient solvent-based CO_2 capture technologies that will significantly reduce CO_2 emissions and which can be retrofitted to existing PC power plants.

Description

In this project, researchers will advance an integrated vacuum carbonate absorption process (IVCAP) for post-combustion CO_2 capture. This process employs potassium carbonate (K_2CO_3) as an absorbent and can be uniquely integrated with the power plant steam cycle by using the waste stream or low-quality steam from the power plant. This integrated process results in a significantly lower loss in electricity compared to MEA-based processes.

Primary Project Goal

The primary goal of this project is to reduce energy consumption through the development of a successful post-combustion CO_2 capture process. The IVCAP process could reduce the cost of post-combustion CO_2 capture to at least $25 per ton of CO_2 avoided (compared to $40-$60 per ton avoided using the MEA process) at 90 percent capture and greater than 99 percent of sulfur dioxide (SO_2) removal. This process is more favorable than the currently available MEA absorption process, which is extremely energy-intensive and contributes to more than half of the CO_2 avoidance cost.

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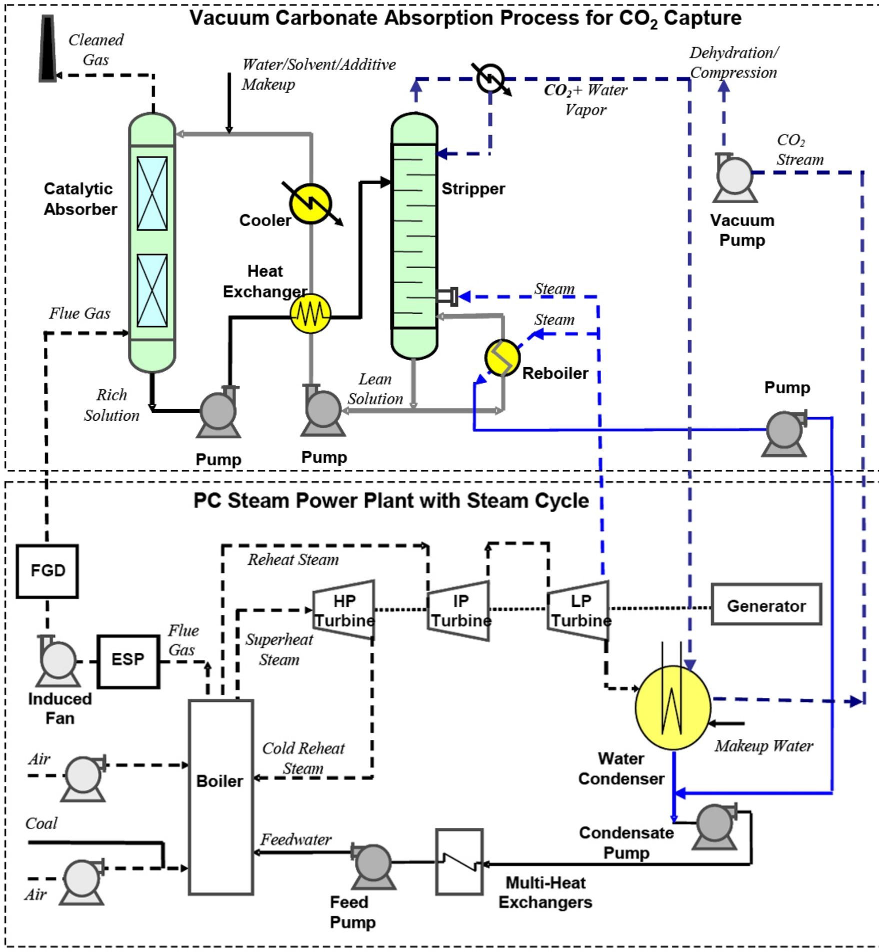
PERIOD OF PERFORMANCE

10/1/2008 to 9/30/2011

COST

Total Project Value
$1,030,450

DOE/Non-DOE Share
$691,191 / $333,259



Schematic diagram of the proposed IVCAP process

Objectives

- Perform an experimental study to test the proof of concept of the IVCAP process.
- Identify an effective catalyst for accelerating the CO_2 absorption rate and an effective additive for reducing the stripping heat.
- Evaluate a modified IVCAP process as a multi-pollutant control process for combined SO_2 and CO_2 removal.

Benefits

The IVCAP process is integrated with the power plant steam cycle and can significantly reduce the electricity loss due to steam extraction from the power plant. This absorption-based process is suitable for capturing CO_2 from a large volume of flue gas at a relatively low CO_2 partial pressure when compared to other non-absorption-based processes. Compared to the cost of MEA-based processes, this technology would significantly reduce the cost of CO_2 capture. The development of the IVCAP technology could lead to significant cost savings if CO_2 emission control in the power generation industry is mandated in the United States.

Planned Activities

- Researchers will measure an enzyme and selected inorganic compounds for catalyzing the CO_2 absorption/desorption in the K_2CO_3 solution under typical operating conditions of the IVCAP process. Because K_2CO_3 has a much slower absorption rate for CO_2 than MEA, identifying a suitable catalyst is one of the key technical issues for the success of the process.
- Researchers will measure vapor-liquid equilibrium data of the K_2CO_3 solution with selected additives to find optimum conditions to suppress the water vapor saturation pressure at the stripping temperature. Because the stripping heat contributes 70 to 80 percent of the total process heat use, suppression of water vaporization in the stripper would lead to a significant improvement of the energy requirements for the process.
- Researchers will conduct a kinetic study on the reclamation of the K_2CO_3 solvent that has reacted with SO_2 to show the feasibility of the IVCAP process for simultaneous SO_2 and CO_2 capture.
- Researchers will perform a techno-economic analysis to estimate the cost of CO_2 capture for a conceptual 500-MW PC power plant.