the ENERGY lab

PROJECT FACTS

Existing Plants, Emissions & Capture

Hybrid Membrane/Absorption Process 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 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. Post-combustion CO_2 control technologies include the use of solvents, solid sorbents, and membranes, alone or in beneficial combinations.

Description

The Gas Technology Institute (GTI), in partnership with PoroGen Corporation and Aker Process Systems, will develop a cost-effective separation technology to capture CO_2 from coal-fired power plant flue gas based on the combination of a hollow fiber membrane contactor with absorption technologies. The hybrid process utilizes solvent absorption, which performs as the selective layer, within a hollow fiber configured membrane contactor made of the chemically and thermally resistant polymer polyether ether ketone (PEEK). With the novel hollow fiber configuration, the interfacial area is increased by an order of magnitude compared to conventional packed or tray column systems, increasing CO_2 mass transfer rates and reducing the overall size of the processing equipment. The reduced size requirements translate to lower solvent inventories, less metal exposure to corrosive liquids, and lower space impact for siting at congested power plants, ultimately leading to reduced capital and operating costs. The membrane contactor process combines the advantageous features of both membrane and absorption technologies and enables economical utilization of advanced absorption solvents.

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

José D. Figueroa
Project Manager
National Energy Technology Laboratory
626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236-0940
412-386-4966
jose.figueroa@netl.doe.gov

Dr. Shaojun Zhou
Principal Investigator
Gas Technology Institute
1700 South Mount Prospect Road
Des Plaines, IL 60018-1804
847-544-3403
shaojun.zhou@gastechnology.org

PARTNERS

PoroGen Corporation
Aker Process Systems
Midwest Generations EME, LLC

PERIOD OF PERFORMANCE

Start Date	End Date
10/01/2010	09/30/2013

COST

Total Project Value
$3,736,063

DOE/Non-DOE Share
$2,986,063 /$750,000

AWARD NUMBER

DE-FE0004787

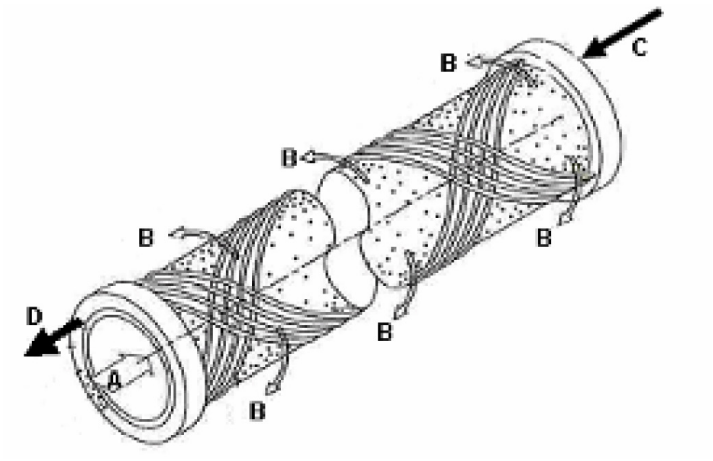
NATIONAL ENERGY TECHNOLOGY LABORATORY

Albany, OR • Fairbanks, AK • Morgantown, WV • Pittsburgh, PA • Sugar Land, TX

Website: www.netl.doe.gov

Customer Service: 1-800-553-7681

U.S. DEPARTMENT OF ENERGY



Hollow fiber membrane contactor for purification of flue gas (A: lean solvent; B: rich solvent; C: CO_2 feed flue gas; D: purified flue gas)

Primary Project Goal

The overall goal of the project is to develop a cost-effective separation technology for CO_2 capture from both new and retrofit PC power plant flue gas based on a hybrid membrane contactor/absorption process that will provide a step change reduction in cost, capturing at least 90 percent of the CO_2 with no more than 35 percent increase in the cost of electricity.

Objectives

Project objectives are to develop an efficient hybrid membrane/absorption process that enables generation of sequestration-ready CO_2 at elevated pressure, perform extensive laboratory and bench-scale tests using synthetic flue gas streams, demonstrate technology readiness by conducting bench-scale field tests utilizing a slipstream from a PC power plant, and perform an engineering and economic analysis of the proposed process.

Planned Activities

- Phase I will establish the feasibility of the gas/liquid membrane concept for absorbing CO_2 from flue gas and includes developing and down-selecting the optimal membrane configuration (porous or composite), optimizing the module design, evaluating absorbents and down-selecting the most optimal absorbent for scale-up, and performing process design and economic analysis based on test data.
- Phase II work will develop an energy efficient regeneration process that enables collection of sequestration-ready CO_2 at elevated pressures. The tasks include construction of a high temperature contactor regeneration test system; fabrication of membrane contactor modules tailored for high temperature operation; testing of the contactor regeneration process stability and sensitivity to process variables; membrane contactor stability and life cycle assessment; design of a bench scale test unit; initiation of the planning process for the proposed membrane contactor technology field test at Midwest Generation's Joliet Power Station, a twin 550 MW PC site; and refinement of the process economics based on the lab test data.
- Phase III work will consist of bench-scale field tests of the membrane contactor technology at Midwest Generation's Joliet Power Station. Tasks include the manufacture of bench-scale membrane contactor modules, construction and installation of the bench-scale system, operation of the system on a flue gas slipstream, and final economic analysis based on the field test data.
- Process design and economic evaluations will be carried out continuously throughout all project phases to guide development activities. At the completion of the project, the technical and economic benefits of the concept will be demonstrated and the technology will be positioned for scale-up and rapid commercialization.

Accomplishments

- Project was awarded in October 2010.
- Kick-off Meeting was conducted in November 2010.

Benefits

This project will result in the maturity of a novel gas separation technology based on the combination of absorption and hollow fiber membrane technologies. This technology will provide a step change reduction in the capital and energy costs of separating and capturing CO_2 from flue gases and will meet DOE program objectives for CO_2 separation and capture technology for PC power plants. The successful development of the proposed technology will provide numerous broad-based benefits in addition to enabling cost-effective separation and capture of CO_2 from flue gases. The proposed membrane absorber will provide a paradigm shift in gas separations by liquid absorption. The contactor can be utilized for removal of numerous other gas pollutants such as NO_X and SO_X, for separation of CO_2 from hydrogen in refinery streams, and for separation of CO_2 from natural gas (natural gas sweetening).