NETL

the ENERGY lab

PROJECT FACTS

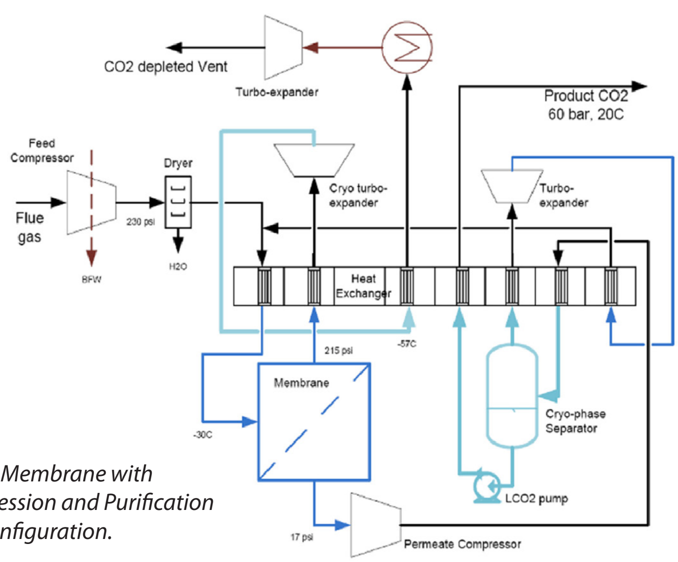
Existing Plants, Emissions & Capture

CO_2 Capture by Sub-Ambient Membrane Operation

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. A promising technology for post-combustion CO_2 control is membrane-based capture which utilizes permeable or semi-permeable materials that allow for the selective separation of CO_2 from flue gas.



Hybrid Membrane with Compression and Purification Unit configuration.

NATIONAL ENERGY TECHNOLOGY LABORATORY

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PERIOD OF PERFORMANCE

Start Date	**End Date**
10/1/2010	09/30/2012

COST

Total Project Value
$1,582,837

DOE/Non-DOE Share
$1,266,248 / $316,589

AWARD NUMBER

DE-FE0004278

U.S. DEPARTMENT OF ENERGY

Description

American Air Liquide Inc. (AL) will develop at bench-scale a novel, sub-ambient temperature, membrane-based CO_2 capture process with the potential to significantly reduce the overall cost of capturing CO_2 from power plant flue gas. AL will utilize a high-performance polyimide (PI) hollow fiber membrane operated at sub-ambient temperatures to achieve DOE cost and performance goals. PI hollow fiber membranes have been demonstrated in the laboratory to show 2-4 times higher selectivity for CO_2 when operated at temperatures below -20˚C as compared to ambient temperature values. A bench-scale test unit will be constructed and used to validate enhanced membrane performance at sub-ambient temperatures with a commercial-scale PI membrane bundle. Cryogenic operating temperatures will be achieved through the controlled expansion of the gas across the test system valves. Data obtained from the bench-scale project will be used to refine the integrated process simulation and to design a slipstream facility for possible subsequent testing at a coal-fired power plant.

Primary Project Goal

The overall goal of the bench-scale project is to develop and demonstrate a cost effective, sub-ambient temperature membrane system applicable for CO_2 capture from existing coal-fired power plant flue gas that can achieve at least 90 percent CO_2 removal with less than a 35 percent increase in the cost of electricity (COE).

Objectives

The project objectives are to (1) demonstrate high selectivity/ high permeance performance with a commercial-scale membrane module in a bench-scale test skid; (2) verify the mechanical integrity of the membrane module structural components at sub-ambient temperatures; (3) demonstrate long-term operability of the sub-ambient temperature membrane; (4) evaluate the effect of expected contaminant levels on membrane performance; (5) refine process simulation for the integrated process including flue gas conditioning and CO_2 liquefaction; and if these tasks are successful (6) design a slipstream-scale unit.

Planned Activities

- A closed loop bench-scale test system with cryogenic capability will be designed and constructed.
- Tests will be performed on the bench-scale system to demonstrate mechanical integrity of the housed membrane assembly operated at sub-ambient temperatures.
- Subsequent testing on the membrane modules at sub-ambient temperatures and with N_2/CO_2 mixtures will be performed to quantify enhanced membrane performance for CO_2 removal at low temperature.
- Laboratory testing will be performed on mini-permeators with pre-mixed gases at sub-ambient operating conditions to determine the effect of expected contaminant levels (SO_x, NO_x, water) on membrane performance.
- Laboratory results will be used to prepare design and economic estimates for a CO_2 removal slipstream-scale pilot unit which will include pre-treatment, compression, heat exchanger, and the membrane system.
- Results will be used to refine a full-scale CO_2 removal system simulation model. An evaluation of the model will provide the capital and operation & maintenance costs for full-scale technology implementation as well as provide the COE resulting from 90 percent CO_2 capture.

Accomplishments

- Project awarded on 09/27/2010.
- Kick-off meeting conducted 12/17/2010.

Benefits

Development of this novel, membrane-based CO_2 capture process has the potential to provide a significantly lower cost CO_2 capture system applicable to existing coal-fired power plants. The hybrid system is based on unprecedented membrane performance achieved by sub-ambient temperature operation of a commercially available AL hollow fiber polyimide membrane. Coupling the high performance membrane with well understood cryogenic processing technology provides a means to capture at least 90 percent of the CO_2 in the flue gas from an air/coal-fired PC power plant with an increase in the cost of electricity of less than 35 percent. Successful completion of this bench-scale project will lead to the next step—testing at a slipstream level—and toward achievement of DOE's program goals.