R & D facts

U.S. Department of Energy
Office of Fossil Energy
National Energy Technology Laboratory

Carbon Sequestration

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Ammonia-based Process for Multicomponent Removal from Flue Gas

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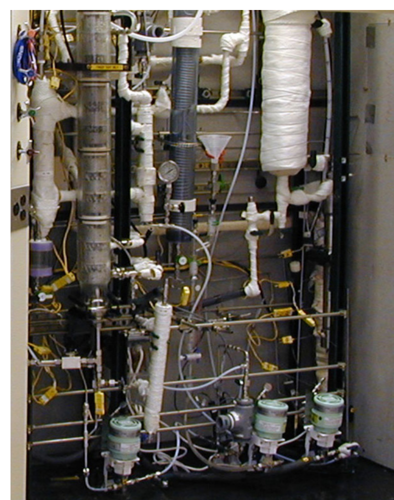
Background

Carbon sequestration is considered a viable method of reducing carbon dioxide (CO_2) emissions from large point sources. One point source, the pulverized coal-fired power generator, has been and will be in the near future the predominant power-generating technique. In response, NETL is developing an ammonia-based wet scrubbing process for capturing CO_2 in flue gas.



Continuous flow system for testing the ammonia-based process.

The project began as part of an international collaboration with China with an interest in the formation of ammonium bicarbonate fertilizer. However, as there is not a significant market for this type of fertilizer in the United States, NETL recognized the need to develop an ammonia-based scrubbing technology as a regenerable process. In an effort to control multiple acidic gases (e.g., CO_2, SO_2, NO_x, HCl) plus fine particulates from flue gas produced by coal-burning power plants, NETL proposed the use of an ammonia-based process that is regenerative in terms of CO_2 capture for carbon sequestration. While the ammonia solution is used to produce ammonium sulfate and ammonium nitrate by-products for fertilizer production, the ammonium bicarbonate solution is heated to release high-purity CO_2, which will be sequestered. The other product of the regeneration step, ammonium carbonate solution, is recycled in the process and reused to absorb more CO_2. The regenerative CO_2 capture chemistry is described by reversible chemistry between the ammonium carbonate and ammonium bicarbonate in an aqueous solution:

$$(NH_4)_2CO_3 + CO_2 + H_2O \leftrightarrow 2\ NH_4HCO_3$$

Although commercial ammonia-based processes exist for the removal of SO_2 and NO_X from flue gas, NETL developed this additional scrubbing capability for CO_2 capture.

Primary Project Goal

The primary goal is to select a regenerable CO_2 carrier with high CO_2 carrying capacity. The process must be energy efficient, and the new robust carrier must not be degraded by O_2 or SO_2, NO_X, and other acidic gases that exist in the fossil fuel combustion flue gases.

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Powerspan's demonstration plant in Shadyside, OH, already cleans coal combustion flue gas to remove mercury vapor, SO_2, and NO_x .

Objectives:

Major objectives are to:

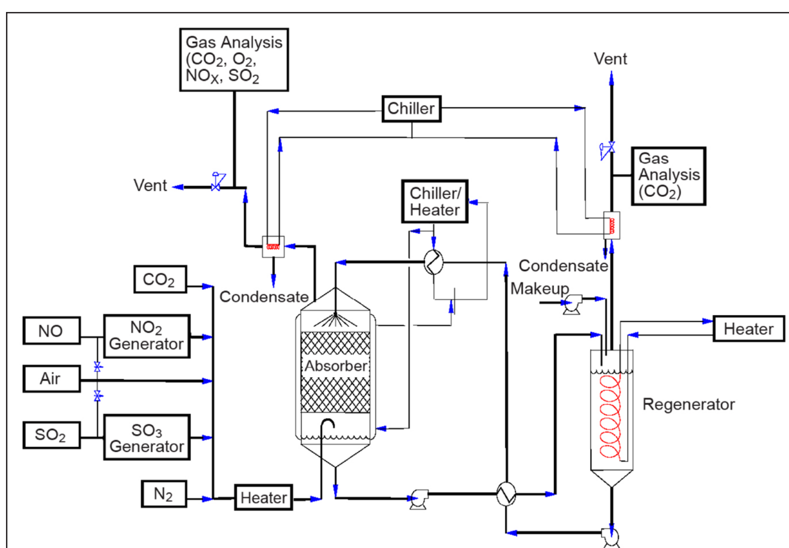
- Search for a carrier that has overall lower parasitic power loss than other carriers (commercially available monoethanolamine).
- Develop a process to clean criteria pollutants from flue gas and generate salable by-products, such as fertilizers, that could offset the costs of sequestration.
- Develop a single-solvent process for multicomponent control of flue gas emissions.
- Ensure the process is technically and economically feasible through a systems analysis.
- Collaborate via a CRADA with an industrial partner, Powerspan Corp., utilizing their experience with ammonia scrubbing to further develop the process.
- In partnership with the University of Pittsburgh, develop a process simulation model to aid in process scale-up to commercial size.

Accomplishments

A continuous flow closed-loop reactor was designed and constructed, and parametric tests were performed. The effects of process operating parameters on CO_2 removal efficiencies were analyzed and reported. These quantification/optimization tests established major impacts of these parameters on CO_2 carrying capacity, ammonia losses, and ammonium species. Major ammonium species in the reactor were identified, and it was determined that excessively high temperatures during regeneration should be avoided to reduce ammonia gas loss.

Benefits

Because of the widespread use of coal to produce power, an alternative scrubbing technique is needed to further capture CO_2 in flue gas. Ammonia-based scrubbing can produce technical and economic benefits compared to current scrubbing technologies. From the experimental information to date, lower parasitic energy consumption, the production of a salable fertilizer, and the capability of one solvent to remove many components are just some of the reasons that the ammonia-based process will be a significant technology in the carbon sequestration area.



Continuous process flow diagram.