PROJECT facts

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

Sequestration

07/2004

Carbon Dioxide Capture by Absorption with Potassium Carbonate

Background

Alkanolamine solvents and solvent blends have been developed as commercially viable options for the absorption of CO_2 from waste gases, natural gas, and H_2 streams. Both primary and secondary amines are used in CO_2 capture processes. Monoethanolamine (MEA), considered to be the state-of-the-art technology, gives fast rates of absorption and favorable equilibrium characteristics. Secondary amines, such as diethanolamine (DEA), also exhibit favorable absorption characteristics.

Although alkanolamines have proven to be commercially successful, there is still room for process improvement. The promotion of potassium carbonate (K_2CO_3) with amines appears to be a particularly effective way to improve overall solvent performance. K_2CO_3 in solution with catalytic amounts of piperazine (PZ) has been shown to exhibit a fast absorption rate, comparable to 30 wt% MEA. Equilibrium characteristics are also favorable, and the heat of absorption (10-15 kcal/mol CO_2) is significantly lower than that for aqueous amine systems. Studies also indicate that PZ has a significant rate of reaction advantage over other amines as additives.

The Chemical Engineering Department at the University of Texas at Austin will develop a K_2CO_3/PZ solvent system that can captures more CO_2 while using 25-50% less energy than conventional MEA scrubbing. Using less energy will increase net electric power production from coal-fired plants when capturing and storing CO_2. By expanding on bench-scale modeling and pilot-scale experiments, the university will develop and validate a process model to optimize solvent rate, stripper pressure and other parameters. As gas/liquid contact and CO_2 mass transfer are enhanced, capital costs should be reduced.

Picture of the Pilot Plant

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PARTNERS

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COST

Total Project Value:
$781,677

DOE/Non-DOE Share:
$515,519 / $266,158

The first task will consist of a rigorous modeling activity that will provide the basis for interpolating and extrapolating bench and pilot scale experimental results from previous and parallel bench scale work. The model will predict performance of absorption/stripping of CO_2 with aqueous K_2CO_2 promoted by PZ. Modifications to the model inputs will be made based on results of the pilot plant work to be conducted as part of the second task.

Primary Project Goal

The primary goal of this work is to develop an improved process for CO_2 capture by alkanolamine absorption/stripping by demonstrating an alternative solvent, aqueous K_2CO_3 promoted by PZ. This will involve the development of a model to predict performance of absorption/stripping of CO_2 using the improved solvent and carrying out a pilot plant study to validate the process model.

Objectives

- To improve the process for CO_2 capture by developing aqueous K_2CO_3 promoted by PZ as an alternative solvent to MEA.
- To develop a system model based on data from bench-scale operations.
- To perform pilot-scale experiments to validate the process model and define the range of feasible process operations.
- To optimize process variables, such as operating temperature, solvent rate, stripper pressure, and other parameters.
- To quantify the effectiveness of the promoter.

Accomplishments

- The existing pilot plant facility has been upgraded with stainless steel piping and heat exchangers to provide a flexible absorption/stripping system with feed gas containing 3 to 12% carbon dioxide and a stripper that can operate over a wide range of pressure.
- Simple models have been developed to predict the absorber and stripper performance.
- A rigorous model has been developed to represent the thermodynamics of aqueous potassium carbonate promoted by piperazine. The heat of CO_2 absorption is predicted to be 25 to 50% less than in the baseline monoethanolamine solvent.

Benefits

The major benefit of this project would be decreasing the energy requirement for CO_2 capture from fuel gas or flue gas streams. Should CO_2 capture and sequestration become necessary, an improved capture process would significantly improve overall plant efficiency. The capital and operating costs for CO_2 capture could also be reduced.