PROJECT facts

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

Sequestration and Gasification Technologies

04/2008

Carbon Dioxide Hydrate Process for Gas Separation from a Shifted Synthesis Gas Stream

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Background

One approach to de-carbonizing coal is to gasify it to form fuel gas consisting predominately of carbon monoxide and hydrogen. This fuel gas is sent to a shift conversion reactor where carbon monoxide reacts with steam to produce carbon dioxide (CO_2) and hydrogen. After scrubbing the CO_2 from the fuel, a stream of almost pure hydrogen stream remains, which can be burned in a gas turbine or used to power a fuel cell with essentially zero emissions. However, for this approach to be practical, it will require an economical means of separating CO_2 from mixed gas streams. Since viable options for sequestration or reuse of CO_2 are projected to involve transport through pipelines and/or direct injection of high pressure CO_2 into various repositories, a process that can separate CO_2 at high pressures and minimize recompression costs will offer distinct advantages. This project addresses the issue of CO_2 separation from shifted synthesis gas at elevated pressures.

The project is concerned with development of the low temperature SIMTECHE process, which utilizes the formation of CO_2 hydrates to remove CO_2 from a gas stream. Many people are familiar with methane hydrates but are unaware that, under the proper conditions, CO_2 forms similar hydrates. In Phase 1, a conceptual process flow scheme was developed. The thermodynamic limits of such a process were confirmed by equilibrium hydrate formation experiments for shifted synthesis gas compositions, and rapid hydrate formation kinetics were demonstrated in a bench-scale flow apparatus. Performance projections were then made for a few selected process configurations, and encouraging preliminary economics were developed.

Primary Project Goal

The goal of this project is to construct and operate a laboratory-scale unit utilizing the hydrate process for CO_2 separation.

Objectives

This project will investigate an innovative, proprietary, CO_2 capture technology that can be applied to integrated gasification combined cycle power plants and other industrial gasification facilities. The SIMTECHE CO_2-Hydrate Separation Process holds promise of not only greatly reducing CO_2 emissions but also reducing the costs and the energy penalty associated with the capture process.

PARTNERS

Nexant

Los Alamos National Laboratory

SIMTECHE

COST

Total Project Value
$14,385,000

DOE/Non-DOE Share
$5,435,000 / $0

Los Alamos National Laboratory DOE/Non-DOE Share
$8,950,000 / $0

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Objectives include:

- Experimental confirmation of the feasibility of the proposed CO_2 hydrate concept.
- Extending previously developed process modeling to the latest proposed concept for the SIMTECHE process.
- Determining the ultimate reduction in CO_2 concentration that can be achieved and assessing the potential negative influence of H_2S and CH_4 on the process.
- Providing detailed design and operating data in preparation for field testing of a slipstream test unit at an industrial site.
- Assessing the impact of the experimental findings on the overall process economics and identifying critical properties and critical parameters.

Accomplishments

- Demonstrated the viability of low-temperature CO_2 separation from a mixed-gas stream through the formation of CO_2 hydrates.
- Potential 68 percent CO_2 removal was demonstrated during once-through operation at 1000 psi without promoters.
- Potential 90 percent CO_2 removal was demonstrated with promoters.
- Confirmed design residence time assumptions on both a kinetic and heat transfer basis.
- Engineering analysis showed that a two-stage Simteche process with a promoter and 90 percent CO_2 removal was most economic, and compared favorably with a two-stage Selexol process.

Benefits

The hydrate process will provide a high-pressure, low-temperature system for separating CO_2 from shifted synthesis gas in an economical manner. The process can be adapted to an existing gasification power plant for CO_2 separation in the production of synthesis gas. Overall, the process will result in a residual concentrated stream of hydrogen capable of fueling zero-emission power plants of the future and a concentrated CO_2 stream available for re-use or sequestration.