PROJECT facts

U.S. DEPARTMENT OF ENERGY
OFFICE OF FOSSIL ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY

Sequestration

03/2006

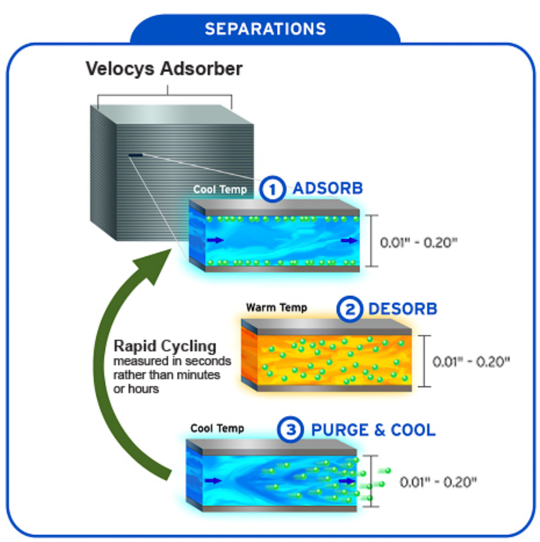
UPGRADING METHANE STREAMS WITH ULTRA-FAST TSA

Background

Most natural gas streams are contaminated with other materials, such as hydrogen sulfide (H_2S), carbon dioxide (CO_2), and nitrogen. Effective processes for removal of H_2S and CO_2 exist, but because of its relative inertness, nitrogen removal is more difficult and expensive. This project will focus on the separation of nitrogen from methane, which is one of the most significant challenges in recovering low-purity methane streams. The approach is based on applying Velocys' modular microchannel process technology (MPT) to achieve ultra-fast thermal swing adsorption (TSA). MPT employs small process channels to greatly enhance heat and mass transfer. Enhanced heat transfer allows TSA cycle times of seconds compared to hours for conventional TSA systems and enables compact, economic systems for upgrading methane streams to pipeline quality.

Primary Project Goal

The primary goal of this project is to develop a highly efficient gas separation process that enables previously uneconomical separations to be viable commercial processes. Potential applications include removing nitrogen from sub-quality natural gas streams originating from coal mines, landfills and other sources. Using thermal swing adsorption (TSA), as opposed to the more common pressure swing adsorption (PSA), the Velocys separation process incurs significantly less pressure losses, and therefore requires far less costly gas compression.



Conceptual scheme of the Ultra-Fast TSA process.

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COST

Total Project Value
$1,136,928

DOE/Non-DOE Share
$798,928 / $338,000

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Objectives

This project is in the last phase of a three-phased effort. The objective of Phase I was to assess the technical and market feasibility of a microchannel process technology – based thermal swing adsorption (MPT-based TSA) approach for upgrading low-BTU methane streams. The objective of Phase II was to conduct bench-scale demonstration of Ultra-Fast TSA. The objective of Phase III is to further evaluate the MPT under real world processing conditions. Five main tasks are proposed:

- Identify one or more commercial adsorbents that can meet the purity and recovery requirements for pipeline specifications
- Demonstrate that the adsorbents can operate with real feed mixtures of coal mine methane streams
- Demonstrate that the bench-scale adsorber meets the purity, recovery, and durability requirements
- Confirm manufacturability of adsorber units and identify critical development needs
- Show that the technology meets industry's economic targets for capital and operating costs.

Accomplishments

During Phase I and II of the project, a number of key technical accomplishments were completed including:

- The thermal swing adsorption project demonstrated sufficient initial adsorbent differential capacity for methane and nitrogen on microporous carbon. The best differential capacity was at 100 psig between 40°C and 60°C, where roughly 10 mg/gm methane and less than 1 mg/gm nitrogen was observed.
- A preliminary system and component design were performed to understand the requirements for process economics.
- An initial bench-scale demonstration was completed with a single cylindrical channel device, where a thermal swing time of 10 seconds for a bed differential temperature of 20°C was measured.
- A feed stream of 70% methane and 30% nitrogen was separated and purified to a mixture of 92% methane and 8% nitrogen with the use of an interstage purge to flush out the large dead volume on the test system.
- Identifying new structured carbon adsorbents for microchannel separators that reduce the energy and time required to conduct thermal swing operations

Benefits

Successful completion of this project would enable recovery of methane from low-grade, previously uneconomic sources, such as coal mine ventilation gas and land fill gas. Because methane is a more powerful greenhouse gas than carbon dioxide, preventing methane emissions to the atmosphere is very important. Commercial deployment of this technology has the potential to reduce annual U.S. greenhouse gas emissions by 23.5 million tonnes of carbon dioxide equivalent while simultaneously recovering 3.5 trillion standard cubic feet of natural gas.