the ENERGY lab

PROJECT FACTS

Carbon Sequestration

Pressure Swing Absorption Device and Process for Separating CO_2 from Shifted Syngas and its Capture for Subsequent Storage

Background

Pulverized coal-fired power plants provide more than 50 percent of electricity needs while accounting for a third of the total carbon dioxide (CO_2) emissions in the United States. However, capturing CO_2 from the flue gas stream in coal-fired power plants using current commercial CO_2 capture technology could consume up to 30 percent of the total electricity generated in the plant, resulting in an increase of more than 85 percent in electricity production cost. Integrated gasification combined cycle (IGCC) power production is a technology alternative that has the potential to generate power from coal more efficiently, produce fewer emissions, and capture carbon with only 30 percent increase in electricity production cost. With this in mind, advances in new syngas separation processes that can efficiently produce the hydrogen for the combustion turbine of the IGCC while cost-effectively producing a high-purity by-product CO_2 stream are required. Thus, the Department of Energy (DOE), National Energy Technology Laboratory (NETL), is sponsoring research on various advanced separation approaches that when utilized in IGCC systems have the potential to provide significant reductions in greenhouse gas (GHG) emissions with low electricity costs. NETL has partnered with the New Jersey Institute of Technology (NJIT) to develop a pressure swing absorption device and process for separating CO_2 and hydrogen in IGCC process gas streams.

Project Description

The research team, led by NJIT, is developing an advanced pressure swing absorption-based (PSAB) device via laboratory-based experiments. The device will be used to accomplish a cyclic process to process low temperature post-shift-reactor synthesis gas resulting from the gasification process into purified hydrogen at high pressure for use by the combustion turbine of an IGCC plant. Simultaneously, this separation process will produce a highly purified CO_2 stream (containing at least 90 percent CO_2) in the post-shift-reactor gas stream, which is suitable for subsequent uses or sequestration. These laboratory-based experiments provide data and an analysis of the PSAB device and cyclic process to facilitate scale-up during subsequent design, allowing economic evaluation for potential larger-scale use. The PSAB device and cyclic process will be located in the gas cleanup systems of an IGCC plant. This cyclic process is achieved without a membrane or the extensive plumbing required in processes that depend on continuous flow.

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SUBCONTRACTORS

Media and Process Technology, Inc.
Applied Membrane Technologies, Inc.
Techverse, Inc.

PROJECT DURATION

Start Date
10/01/2009

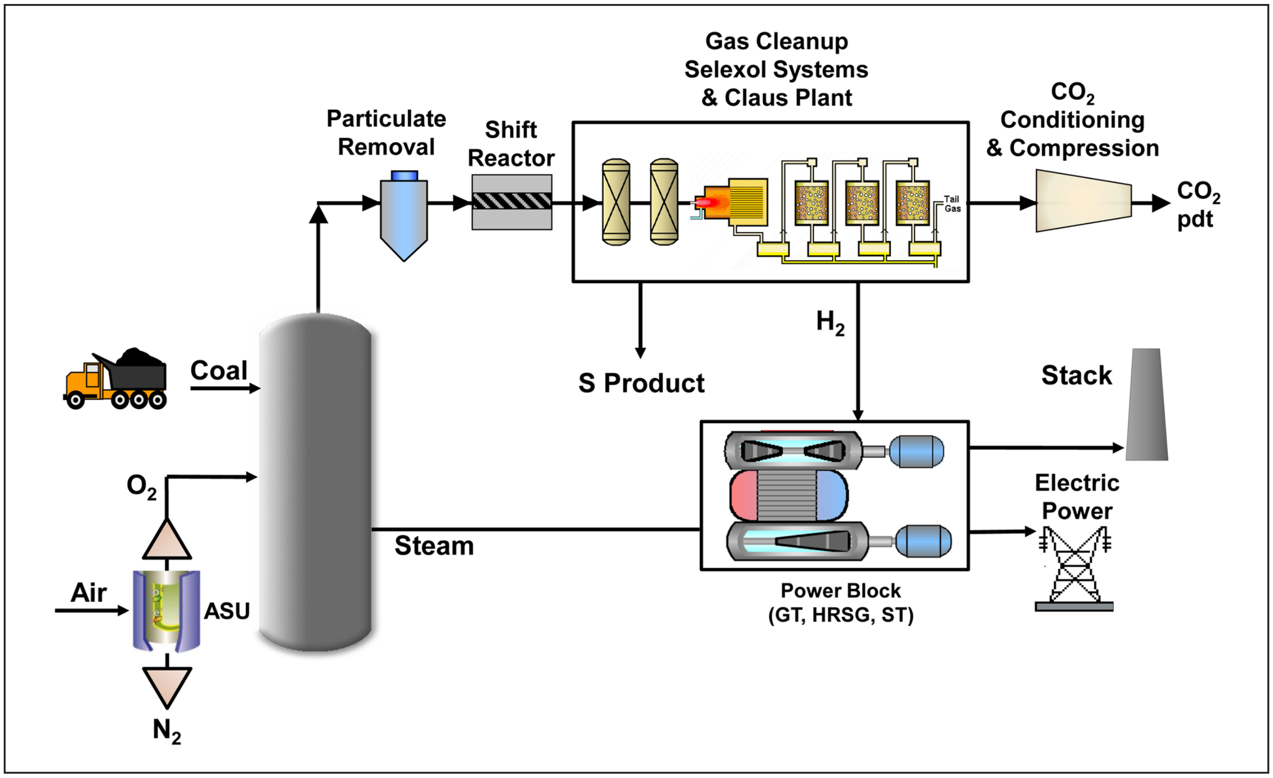
End Date
09/30/2012

COST

Total Project Value
$1,025,038

DOE/Non-DOE Share
$815,819 / $209,219

U.S. DEPARTMENT OF ENERGY



Schematic diagram of a typical IGCC plant with a Shift/Selexol-based hydrogen production and CO_2 capture system where the PSAB device and process will be located

Goals and Objectives

The overall goal of the proposed work is to develop an advanced pressure swing absorption-based device and cyclic process for use in a coal-fired IGCC plant to produce purified hydrogen at high pressure and a highly purified CO_2 stream suitable for use or sequestration. The hydrogen would be used for the plant's combustion turbine. Specific objectives of the project include providing data and a sufficiently detailed analysis of the PSAB device and process to facilitate scale-up during subsequent design and allow economic evaluation for larger-scale use. Specific objectives for the project's three phases include 1) developing PSAB devices based on ceramic tubules and polytetrafluoroethylene (PTFE) hollow fibers for liquid absorbents during the first phase; 2) exploring the purification and separation performance of the absorption device and process, measuring solubility and diffusion coefficients, and developing a model of the purification process during the second phase; and generating solubility and diffusion coefficient data, exploring scale-up, and determining the extent of loss/deterioration of the absorbent liquid during the third phase.

Accomplishments

The project team successfully fabricated the novel absorption module and completed the PSAB experimental setup. The team upgraded the PSAB device with a five-cycle valve configuration to ensure a high-quality CO_2 product for experimentation. The CO_2 solubility apparatus was constructed and is being used to test CO_2 solubility in ionic liquids. The team is developing mathematical models for the PSAB system for non-reactive systems, beginning with helium/CO_2. Preliminary results showed the best results for hollow, hydrophobized poly (ether ether ketone) (also known as PEEK) fiber systems with high surface area per gas volume ratios. The research team continues to evaluate and test these and other candidate systems for hydrogen/CO_2 separation.

Benefits

The success of this pre-combustion carbon capture technology will contribute to the cost-effective and efficient reduction of CO_2 emissions from future coal-based IGCC power plants. Using appropriate CO_2 absorbents, this separation technology will recover a CO_2 stream with greater than 90 percent CO_2 at a pressure of one to five atmospheres. This highly-enriched stream requires limited compression prior to sequestration, reducing the cost of CO_2 sequestration. In addition, hydrogen will be available at a partial pressure approximately equal to its feed partial pressure in the low temperature water-gas-shift reactor product stream, which will allow it to be used for the production of energy, fuels, and/or chemicals.

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