PROJECT facts

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

Hydrogen and Clean Fuels from Coal

10/2007

ENHANCED HYDROGEN PRODUCTION INTEGRATED WITH CO_2 SEPARATION IN A SINGLE-STAGE REACTOR

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Description

One alternative for the United States to establish independence from foreign energy sources is to utilize the nation's abundant domestic reserves of coal. Gasification provides a route to produce liquid fuels, chemical feedstocks, and hydrogen from coal. Coal continues to be viewed as the fuel source for the 21st century. Products from coal gasification, however, contain other gases, particularly carbon dioxide, as well as other contaminants that must be removed to produce the pure stream of hydrogen needed to operate fuel cells and other devices. This project seeks to demonstrate a technology to efficiently produce a pure hydrogen stream from coal gasification products with an integrated capture of carbon dioxide. This is accomplished by using a highly reactive mesoporous calcium oxide for in-situ carbon dioxide capture. The morphological properties of the patented calcium sorbent will be tailored using surface modifiers to demonstrate a high carbon dioxide capture capacity of about 70 percent by weight (~700g of CO_2/kgsorbent), remove hydrogen sulfide at high temperature (700-900 °C), and produce hydrogen at a purity greater than 95 percent without the water-gas shift (WGS) catalyst.

Primary Project Goals

Phase I

- Using thermodynamic analyses, identify the optimal operating conditions for different hydrogen production scenarios (e.g., 90-95 percent purity hydrogen without WGS catalyst or 99^+ percent purity hydrogen with a WGS catalyst).
- Identify a suitable temperature range that is selective towards carbonation by a temperature-programmed reaction of the calcium oxide sorbent in a Thermal Gravimetric Analyzer (TGA).
- Estimate the kinetic parameters of the carbonation reaction.

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Phase II

- Conduct integrated system studies with reduced catalyst volume and with/without a sorbent-catalyst mixture to demonstrate hydrogen production and simultaneous carbon dioxide and sulfur removal with reduced excess steam.

- Evaluate the regenerability of the calcium oxide sorbent by repeated in-situ carbonation and regeneration via vacuum/steam calcination for 10-100 cycles.

Phase III

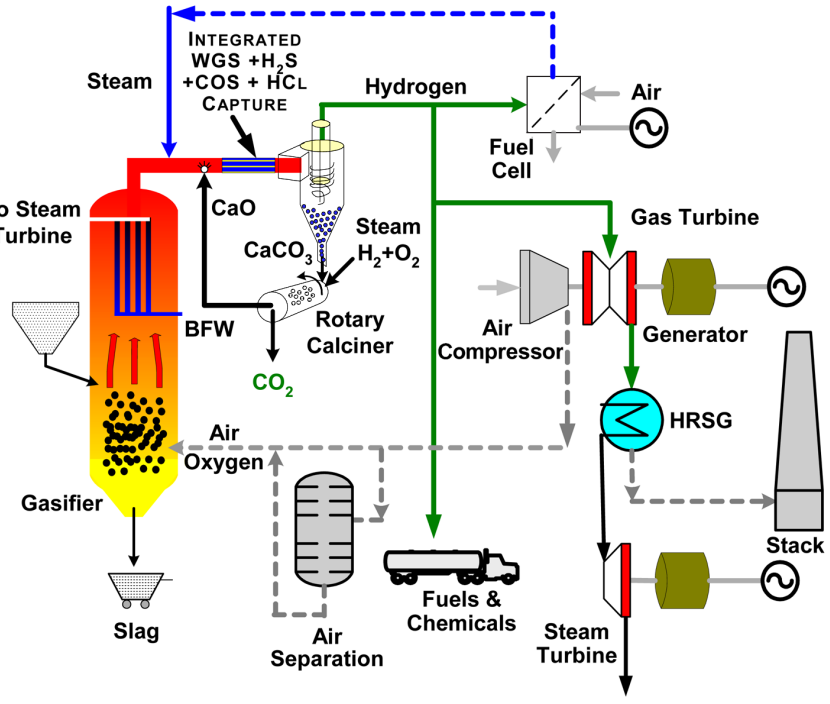
- Perform a techno economic feasibility study (using ASPEN+ software) for different integrated process scenarios (i.e., production of hydrogen for a hydrogen fired turbine with integrated carbon dioxide removal, production of high purity hydrogen for fuel cell applications) using the results of Phase I and II, the OSU hydrogen process obtained from the earlier phases.

Accomplishments

None at present – New project initiated in FY 2007

Benefits

The project, if successful, will yield a novel technology that can produce hydrogen and simultaneously capture carbon dioxide using a reactive mesoporous calcium oxide. This is an alternate approach to producing hydrogen and separating carbon dioxide via physical processes through the use of membrane separators. The project will reduce the number of process steps used in hydrogen production and consequently improve process cost economics.



Calcium Looping Process for Enhanced Hydrogen Production with In-situ CO_2 and Sulfur Capture in a Single Stage Reactor