R & D
facts

Carbon Sequestration

08/2008

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

Chemical Looping for Combustion and Hydrogen Production

Objective

The objective of this project is to determine the benefits of chemical looping technology used with coal to reduce CO_2 emissions.

Background

Chemical looping is a new method to convert coal or gasified coal to energy. In chemical looping, there is no direct contact between air and fuel. The chemical looping process utilizes oxygen from metal oxide oxygen carrier for fuel combustion, or for making hydrogen by "reducing" water. In combustion applications, the products of chemical looping are CO_2 and H_2O. Thus, once the steam is condensed, a relatively pure stream of CO_2 is produced ready for sequestration. The production of a sequestration ready CO_2 stream does not require any additional separation units and there is no energy penalty or reduction in power plant efficiency.

The majority of the work performed to date on chemical looping has been performed using methane as the fuel. There are only limited studies with oxygen carriers used to react with coal or gasified coal.

Project Description:

The project combines laboratory studies of "oxygen carriers" with models of chemical looping processes to determine how chemical looping can be used with coal. In prior work, a comprehensive literature search was performed to identify those chemical looping processes that involve coal gasification. Various oxygen carriers, including NiO on bentonite and CuO on bentonite have been prepared and evaluated as oxygen carriers at 700, 800 and 900 °C using thermal gravimetric analysis (TGA). Stable reactivity was observed over 10 cycles of oxidation with air and reduction with synthesis gas. Rate information was computed for reactions over both oxygen carriers. It was shown that particle size, temperature, and pressure affected the rate. Performance of these oxygen carriers were evaluated in a high pressure flow reactor at 150 psi with synthesis gas at 700, 800 and 900 °C. Stable reactivity was observed over 3 high pressure cycles, and complete combustion of hydrogen and complete utilization of the metal oxide were observed. Novel nano-composite oxygen carriers were also developed in collaboration with the University of Pittsburgh to improve the rates. The rate information is now being used to develop system level models of the chemical looping process, as well as

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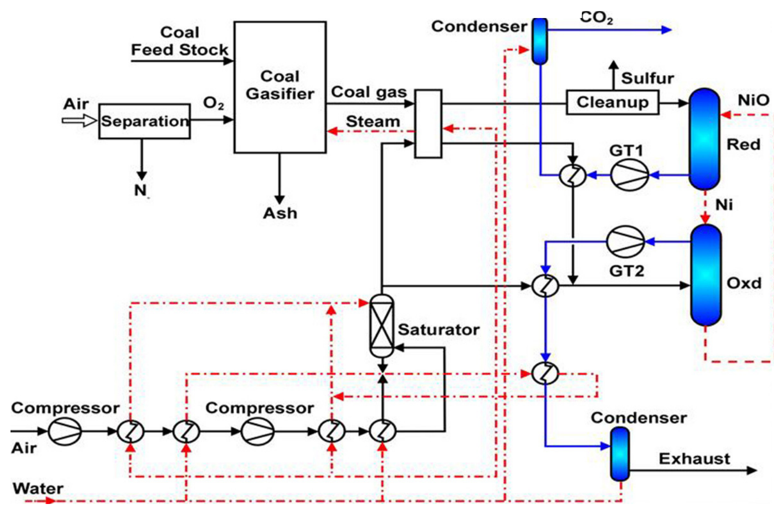
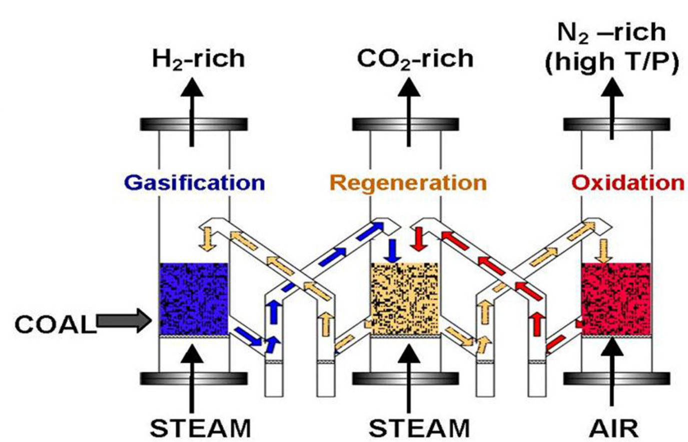
detailed Computational Fluid Dynamics (CFD) simulations of the chemical looping process itself.

Benefits:

Chemical looping can use coal to produce both hydrogen from coal, or a stream of combustion products that primarily consist of CO_2 and steam. A relatively pure stream of CO_2 that is sequestration ready can be produced by simply condensing the steam. This avoids the energy penalty traditional fossil fuel fired systems must pay to produce a pure stream of CO_2. Additionally, Chemical Looping for Combustion (CLC) minimizes production of NO_x that is produced in almost all other combustion processes.



Integrated gasification combined cycle with chemical looping combustion.



Fuel flexible gasification-combustion technology for production of H_2 and sequestration-ready CO_2 by GE Global Research.

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