the ENERGY lab

PROJECT FACTS

Gasification Technologies

Advanced Gasification Mercury/Trace Metal Control With Monolith Traps

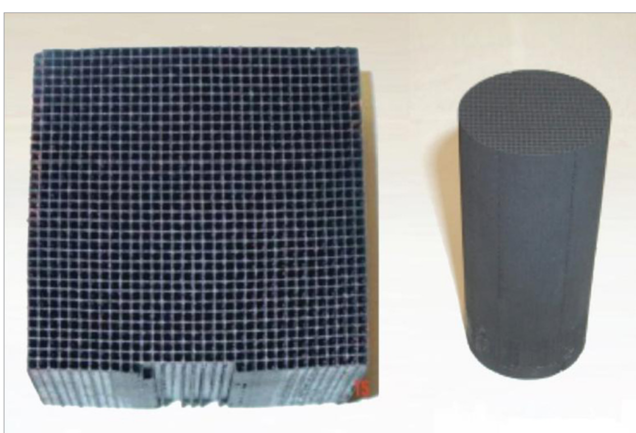
Background

One technology being developed to support ultra-clean power plants is gasification. Gasification is a clean way to produce electricity, fuels, or chemicals from coal or other solid feedstocks by first converting the solid feedstock to a gaseous form (synthesis gas, or syngas), and finally reducing the potential pollutants to near-zero levels.

Currently available cleanup technologies require that the syngas from the coal gasifier be cooled before pollutant scrubbing can occur. After this cleanup stage, syngas needs to be reheated for downstream applications, resulting in a significant energy penalty. The University of North Dakota Energy and Environmental Research Center (UNDEERC), in partnership with Corning, Incorporated (Corning), pursued the development of an integrated system to remove trace metals from coal-derived syngas in one step at a higher temperature than conventional processes to improve process efficiency.

Project Description

Corning has developed a high surface area carbon monolith, and UNDEERC has developed a mercury (Hg) sorbent, which showed promise for syngas cleanup at elevated temperature (e.g., 400 degrees Fahrenheit [°F]). The monolith is a fixed, honeycomb-like structure that forces the contaminant-laden syngas to travel through multiple small channels. This project merged these two technologies into one integrated process and developed a sorbent to remove other metals, including



Sulfur-impregnated carbon honeycomb monoliths

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PARTNERS

Corning, Inc.

PROJECT DURATION

Start Date
07/01/2005

End Date
07/31/2010

COST

Total Project Value
$7,409,604

DOE/Non-DOE Share
$5,926,319 / $1,483,285

arsenic (As), selenium (Se), and cadmium (Cd). The inside surfaces of the monolith channels are impregnated with the reactive sorbents resulting in a monolith structure with high syngas/sorbent contact, low pressure drop, and long sorbent life, all of which show potential for substantial cost savings compared to the more common particle sorbent approaches currently under development.

Goals and Objectives

The objectives of this project are to (1) demonstrate, at laboratory scale, the ability of monolith-sorbent materials to remove Hg, As, Se, and Cd (individually) at 600 pounds per square inch gauge (psig) at various commercial conditions, and determine the Hg loading capacity; (2) modify the continuous fluid-bed gasifier (CFBG) to operate at increased pressure (the revised reactor is called the fluidized-bed gasification [FBG] system); (3) test the performance of candidate monoliths in the FBG for simultaneous capture of all species utilizing actual coal-derived syngas at elevated pressure; and (6) perform an economic analysis of the multi-contaminant process for both power and chemical/liquid fuel production applications.

Accomplishments

UNDEERC and Corning have completed all laboratory-scale testing on materials. Researchers have also completed construction and test performance of the FBG system. During Phase I, the UNDEERC and Corning team developed three potential additives for controlling Hg emissions from syngas at temperatures ranging from 350 °F up to 500 °F. Project results also indicate that one of the same sorbents could also successfully be utilized for As and hydrogen selenide (H_2Se) removal. Cd removal results are unavailable due to the difficulty and expense encountered with sample preparation.

The FBG system was designed and constructed to operate at higher temperatures and pressures than the CFBG system to enable emissions reduction testing at elevated conditions. The FBC underwent shakedown testing to assure operational integrity.

During Phase II, two Corning monoliths and a non-carbon-based material were identified as potential additives for Hg capture in simulated fluegas at temperatures above 400 °F and a pressure of 600 psig. All sorbents tested with arsine (AsH_3) or H_2Se, including Corning monoliths and the metal-based materials, showed an ability to capture at 400 °F and 600 psig. Two of the monoliths removed 100 percent of the As and removed Hg below the DOE target of 5 parts per billion (ppb). All copper/zinc-based sorbents tested exhibited 100 percent H_2Se reduction from an inlet concentration of approximately 400 ppb.

Carbon monolith test stand

An updated economic analysis for the control of Hg emissions using the Corning monolith system in an integrated gasification combined cycle (IGCC) was performed following the completion of Phase II testing. This modeling suggested that similar gasifier outlet flows and an Hg removal process operating at a higher temperature (warm-gas cleanup) would result in a net power increase of 15 megawatts (MW) that, if priced at an average power selling price of $45/MWh, would result in an annual revenue increase of $4.7 million per year.

Benefits

This project contributed to the knowledge base of trace metals removal from coal-fired power plant flue gas. This knowledge will be useful in the advancement of ultra-clean, coal-based gasification facilities and will facilitate the continued utilization of the vast domestic reserves of U.S. coal resources.

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