the ENERGY lab

PROJECT FACTS

Gasification Systems

Warm Gas Clean-up

Background

Gasification of coal and coal-biomass blends produces a hot gas mixture of mostly hydrogen and carbon monoxide known as synthesis gas (syngas). The syngas is used for production or co-production of power, fuels, and chemicals. A low-cost, moderate to high temperature syngas cleaning process for downstream applications will prevent equipment fouling and catalyst poisoning and improve the cost and efficiency benefits of gasification processes.

The U.S. Environmental Protection Agency (EPA) has established stringent regulations governing trace contaminant emissions from integrated gasification combined cycle (IGCC) systems. The U.S. Department of Energy (DOE) performance goals for trace contaminant removal were selected to meet or exceed EPA's standard limits for contaminants and are also stringent in order to avoid poisoning catalysts utilized in making liquids from fuel gas, electrodes in fuel cells, and selective catalytic reduction catalysts employed in coal or gas burning power plants.

Removal of trace contaminants at elevated temperatures preserves the higher thermal efficiency of IGCC systems. Unfortunately, most sorbents display poor capacity for elemental mercury (Hg) and other trace contaminants at elevated temperatures. Previous experience with sorbents in coal combustion flue gas has allowed for judicious selection of high-temperature candidate sorbents. The capacities of many different sorbents for Hg, arsenic (As), selenium (Se), and phosphorus (P) have been determined through testing in simulated gas streams. Palladium (Pd)-based sorbents are currently among the most promising candidates for high-temperature capture of trace elements from flue gases. High-temperature capture of trace elements in one step can reduce the footprint, cost, and operational complexity of the pollution mitigation methods and increase the level of confidence in the final disposition of the trace elements.

The Gasification Team at the U.S. Department of Energy National Energy Technology Laboratory (NETL) is addressing these issues using an integrated approach that leverages the expertise of the NETL-Regional University Alliance. The approach combines theory, computational modeling, experiments, and industrial input to develop methods, models, and tools to support the development and deployment of advanced gasification-based devices and systems.

Project Description

Work on warm gas clean-up is focused on testing and developing palladium sorbents to capture the trace metals selenium, phosphorus, arsenic, mercury, antimony, and cadmium from coal-derived syngas. A lab-scale packed-bed reactor is used to test the capacity of the Pd sorbent for Hg, As, Se, P, and cadmium from simulated flue gases at temperatures between 400 and 700 degrees Fahrenheit (°F). The performance of the Pd sorbents will be examined at larger scales via testing in small bench-scale packed-bed reactors. Additional larger-scale tests using slipstreams of actual coal gas will continue at the National Carbon Capture Center (NCCC), and pilot-scale testing at NCCC will focus on the use of smaller loadings of Pd as well as longer exposures to slipstreams of dirty syngas.

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PARTNERS

NETL-Regional University Alliance

PROJECT DURATION

Start Date	End Date
10/01/2011	09/30/2013

COST

Fiscal Year 2013 Project Value
$171,634

PROJECT NUMBER

FWP-2012.03.03 Task 5

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U.S. DEPARTMENT OF ENERGY

Warm gas clean-up enjoys a theoretical thermal efficiency advantage over cold gas clean-up of approximately three percent. A more detailed cost analysis for the use of Pd-based sorbents in trace contaminant capture has been developed and will be used for guiding the future application and development of the sorbents. Low-cost sorbents for trace contaminant capture will also be demonstrated at lab through pilot scales.

Goals and Objectives

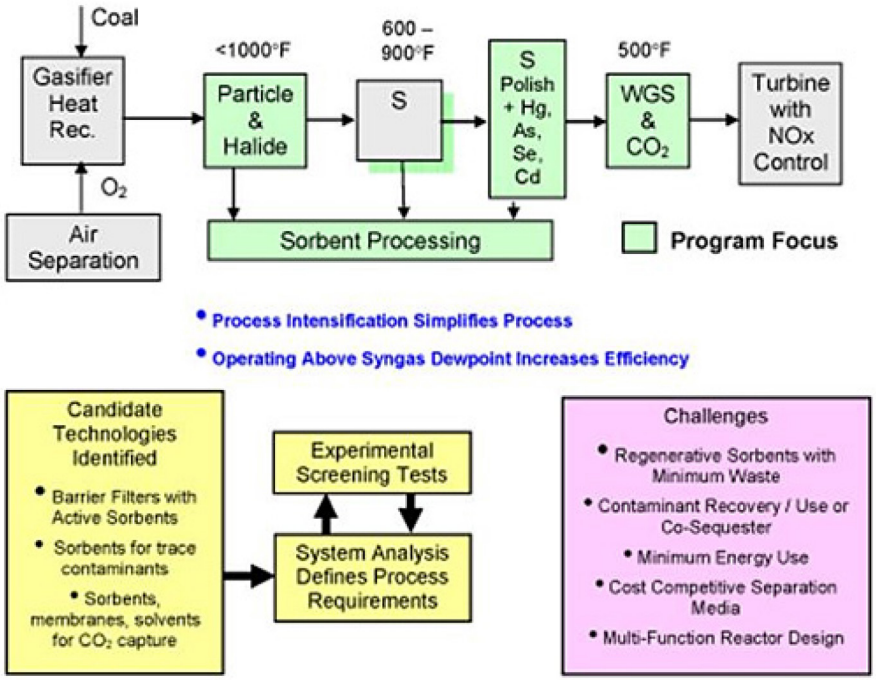
The goals of this project are to develop industry-ready technology for moderate-to-high temperature synthesis gas cleanup and to address proposed EPA mercury rules. The objectives are to (1) achieve both DOE and EPA targets for trace contaminant capture from coal gasification while preserving the high thermal efficiency of the IGCC system, and (2) develop sorbents capable of removing mercury, arsenic, selenium, phosphorus, antimony (Sb), and cadmium contaminants from high-temperature (up to 550 °F) syngas.

Accomplishments

- Work to characterize and estimate the cost of a trace Hg removal system using Pd sorbents in syngas cleanup configurations for IGCC plants has been completed. The system utilizes the Research Triangle Institute (RTI) International warm gas cleanup technology for sulfur removal from raw syngas and bulk trace contaminant removal. The RTI technology removes sulfur and heavy metals from gasification syngas at high temperatures, eliminating the need for cooling and expensive heat recovery systems and increasing thermal efficiency and reducing capital and operating costs compared to conventional contaminant removal technology. The preliminary results are very promising for use of the sorbent as a polishing step to ensure close to 100 percent removal of the trace contaminants.
- Collaborating with Carnegie Mellon University (CMU) on the development of a cheaper alloy sorbent for trace contaminant removal, and several inexpensive base metal oxide and sulfide sorbent candidates have been identified. NETL-CMU efforts will provide insight into the mechanism of sorbent removal of trace contaminants leading to improved sorbent formulations.
- A 10-pound (lb) bed of sorbent has been delivered to the NCCC test facility, where it will be exposed to a slipstream of high-temperature syngas for several hundred hours during the next scheduled test run. This test is designed to using a lower loading of Pd (2.5 percent) and a higher flow of syngas (50 lb./hr.) to the packed bed reactor.
- The team has conducted lab-scale tests to demonstrate online detection of fuel gas contaminants Hg, P, As, and Se.

Benefits

Warm gas clean-up research promotes the utilization of abundant domestic coal in a very clean and environmentally sustainable manner. The technology allows for gasification to meet the stringent EPA regulations for emissions of trace metals such as mercury and arsenic. Warm gas clean-up technologies can improve the overall efficiency of an IGCC power plant and reduce the cost of electricity.



Second Generation IGCC Plant Gas Cleaning Technology.