CCS and Power Systems
Warm Gas Cleanup

Project No.: 2012.03.03 Task 5

Project Description

The Environmental Protection Agency (EPA) has established strict regulations for the trace contaminant emissions from integrated gasification combined cycle (IGCC) systems. The Department of Energy (DOE) performance goals for trace contaminant removal were selected to meet or exceed EPA's standard limits for contaminants, as well as to avoid poisoning of:

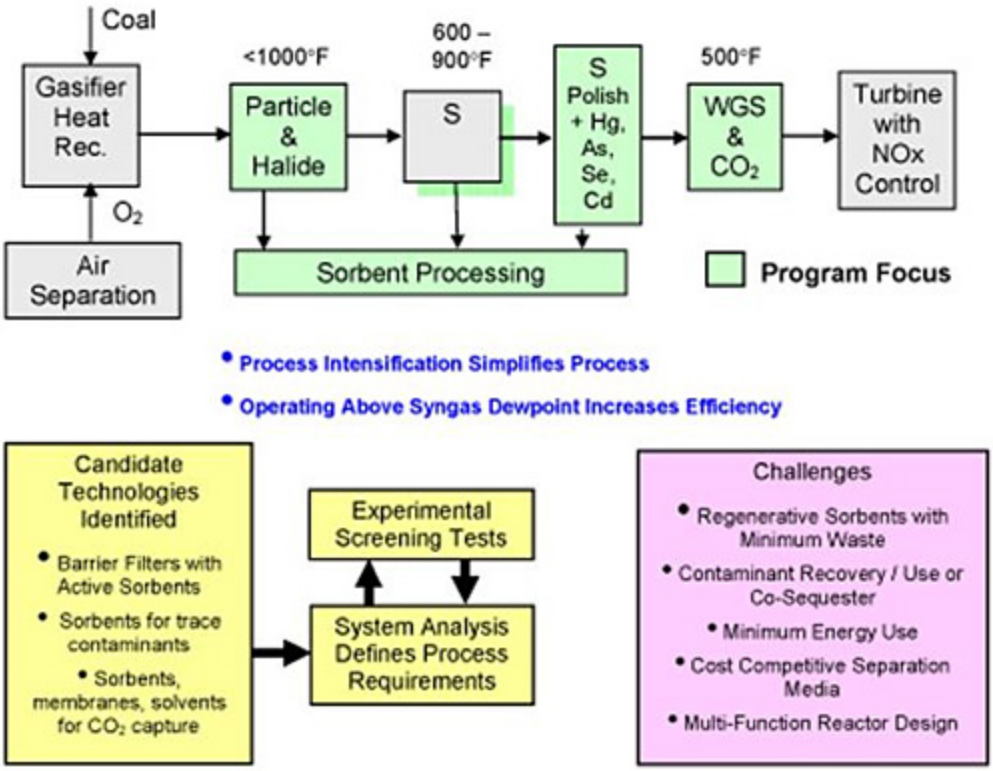
- the catalysts utilized in making liquids from fuel gas
- the electrodes in fuel cells
- selective catalytic reduction (SCR) catalysts

The objective of the NETL's ORD Warm Gas Cleanup project is to assist in achieving both DOE and EPA targets for trace contaminant capture from coal gasification, while preserving the high thermal efficiency of the IGCC system. To achieve this, both lab and pilot-scale research is underway to develop sorbents capable of removing the following contaminants from high temperature syngas (up to 550°F):

- mercury (Hg)
- arsenic (As)
- selenium (Se)
- phosphorus (P)
- antimony (Sb)
- cadmium (Cd)

The removal of the trace contaminants at elevated temperatures preserves the higher thermal efficiency of the IGCC system. Unfortunately, most sorbents display poor capacity for elemental Hg and the 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, As, Se and P have been determined in simulated gas streams.

Palladium-based sorbents are currently among the most promising candidates for high-temperature capture of trace elements from fuel gases. High temperature capture of the trace elements in one step reduces the footprint, cost, and complexity of the pollution mitigation method; and increases the certainty of the final disposition of the trace elements.



2nd Generation IGCC Plant Gas Cleaning Technology

Program Background and Project Benefits

Gasification is used to convert a solid feedstock, such as coal, petcoke, or biomass, into a gaseous form, referred to as synthesis gas or syngas, which is primarily hydrogen and carbon monoxide. With gasification-based technologies, pollutants can be captured and disposed of or converted to useful products. Gasification can generate clean power by adding steam to the syngas in a water-gas-shift reactor to convert the carbon monoxide to carbon dioxide (CO_2) and to produce additional hydrogen. The hydrogen and CO_2 are separated—the hydrogen is used to make power and the CO_2 is sent to storage, converted to useful products or used for EOR. In addition to efficiently producing electric power, a wide range of transportation fuels and chemicals can be produced from the cleaned syngas, thereby providing the flexibility needed to capitalize on the changing economic market. As a result, gasification provides a flexible technology option for using domestically available resources while meeting future environmental emission standards. Polygeneration plants that produce multiple products are uniquely possible with gasification technologies. The Gasification Systems program is developing technologies in three key areas to reduce the cost and increase the efficiency of producing syngas: (1) Feed Systems, (2) Gasifier Optimization and Plant Supporting Systems, and (3) Syngas Processing Systems.

Syngas processing research and development underway emphasizes technologies that can be efficiently integrated into the plant, optimized with the temperature and pressure requirements of other systems, and meet product delivery specifications. A major cost element in gasification plants is converting raw syngas into a pure and specific gas used to create the plant's target product suite. High-hydrogen, low-methane, ultraclean syngas is versatile and can be used for power production with CO_2 capture, fuels or chemicals production, and for many polygeneration applications. The technologies being developed are focused on high-efficiency processes that operate at moderate to high temperatures and clean syngas of all contaminants to the extremely low levels needed for chemical production—often significantly lower than the U.S. Environmental Protection Agency (EPA) required levels for power plants.

NETL's Office of Research and Development (ORD) is developing palladium sorbents at lab and pilot-scale for capture of trace metals (mercury, arsenic, selenium, phosphorus, antimony, and cadmium) from integrated gasification combined cycle (IGCC) plants to meet or exceed EPA's standard limits for contaminants, and to avoid poisoning of downstream process elements such as catalysts and fuel cell electrodes. ORD is also developing a novel warm-gas reactor to allow for capture in one step to reduce the process footprint, cost, and complexity; and increase the certainty of the final disposition of the trace elements. A benefit of removing contaminants at elevated temperatures (up to 550°F) is preserving the higher thermal efficiency of the IGCC system.

Presentations, Papers and Publications:

- Project Fact Sheet
- Gasification Modeling Activities at the National Energy Technology Laboratory (Oct 2012)
  Presented by Chris Guenther, Gasification Technologies Conference, October 28-21, 2012, Washington DC.
- Method for Removing Heavy Metals from Gases
  Hamilton; Hugh Gavin Charles (Reading, GB), Poulston; Stephen (Reading, GB), US Patent 8,366,807; February 5, 2013.
- Method for High Temperature Mercury Capture from Gas Streams [PDF-633KB]
  Evan Granite and Henry Pennline, US Patent 7,033,419; April 25, 2006.

Performer website: NETL Office of Research and Development