the ENERGY lab

PROJECT FACTS

Project Description

The transport gasifier operating at the Power Systems Development Facility (PSDF) is a circulating fluidized bed reactor designed to operate at higher circulation rates and riser densities than conventional circulating bed units. The higher circulation rates result in better mixing, higher mass and heat transfer rates, and higher carbon conversion. Since the gasifier uses a dry feed system and does not slag the ash, it is well suited for high-ash fuels such as sub-bituminous and lignite coals, but can also process some higher-rank coals.

Filter element testing at the PSDF is conducted during gasification runs with Powder River Basin sub-bituminous coal, or one of several bituminous and lignite coals. After certain test runs, selected filter elements are removed for detailed inspection, flow tested to check for any change in pressure drop characteristics, and bubble tested to identify any media or weld problems. Scanning electron microscopy with energy dispersive x-ray analysis is used for detailed examination of corrosion and ash plugging in selected filter element sections.

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.

The National Carbon Capture Center (NCCC) is working to develop candle filters that can efficiently remove particulates from syngas at varying temperatures, using low-cost materials and innovative design.

Integrated gasification combined cycle (IGCC) plants produce a low-to-medium-BTU fuel gas (syngas) that must pass through filters to separate the fine fly ash particles from the hot gas so that these harmful by-products are deposited on the filter tubes, and do not reach the high-speed gas turbine during combustion or the atmosphere as particulate emissions. Testing and evaluation of long-term material performance of particulate control device (PCD) filter elements is performed at the NCCC using a commercially available Siemens PCD. Located downstream of the primary gas cooler, the PCD houses up to 91 candle-type filter elements. Successful development of durable, economical, high-temperature, hot gas filter systems will reduce cost and increase the efficiency by improving IGCC plant reliability, availability and maintainability.

Project Scope and Technology Readiness Level

This work will enhance the understanding of filter performance and transfer this knowledge into improved filter elements for future applications. Specific objectives in support of this goal are to test and evaluate commercially available and newly developed filter elements and fail-safes for their particulate collection efficiency, process performance, mechanical integrity, corrosion behavior of metal filter media, and lifetime prediction.

The Technology Readiness Level (TRL) assessment identifies the current state of readiness of the key technologies being developed under the DOE's Clean Coal Research Program. In FY 12, this project was assessed a TRL of 5.

The TRL assessment process and its results including definition and description of the levels may be found in the "2012 Technology Readiness Assessment-Analysis of Active Research Portfolio".

Accomplishments

- Extensive testing with ceramic, composite, sintered metal powder, and sintered metal fiber elements has shown that the mass concentration of gasification ash can be reduced from 10,000–30,000 parts per million by weight (ppmw) at the filter inlet to less than 0.1 ppmw at the filter outlet. Experience at the PSDF has shown that ceramic filter elements are prone to crack and fail during thermal excursions associated with coal feeder trips and other system upsets. To avoid these failures, recent testing at the PSDF has focused on metal filter elements.
- Since initiating gasification operations in 1999, multiple test campaigns, each 250 to 1,500 hours in duration, have been completed. During this time, the PCD candle filters have been consistently reliable and available for testing, demonstrating collection efficiencies greater than 99.999 percent.
- To date, iron aluminide sintered metal powder elements and Haynes HR-160 sintered metal fiber elements have the longest exposure times. Progressive corrosion and an increase in pressure drop have been noted in the iron aluminide elements, although the corrosion has not had significant impact on mechanical integrity of the filter media. Less corrosion or plugging has been found in the HR-160 elements, but they also have had much less exposure time than have the iron aluminide elements.
- Accomplishments at the PSDF in fail-safe development include the following: (1) new types of fail-safes were developed; (2) the fail-safe concept in the particulate control device (PCD) for Integrated Gasification Combined Cycle technology was promoted and vendors were motivated and supported to develop new fail-safes per PSDF test results and specifications; (3) fail-safes from PSDF's own design and from vendors were tested systematically under actual gasification operating conditions; and (4) fail-safes were eventually incorporated into the commercial PCDs as a standard and required item.

Contacts, Duration, and Cost

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Duration
Start Date: 10/01/2008
End Date: 09/30/2014

Cost
DOE Share: $201,163,318
Performer Share: $50,290,830
Total Award Value: $251,454,148

Presentations, Papers, and Publications

- Filter Element Lifetime Testing at the PSDF

Performer website: National Carbon Capture Center