the ENERGY lab

PROJECT FACTS

Project No: NT0000749
Performer: Southern Company Services, Inc.

Project Description

The Power Systems Development Facility (PSDF) gasification process features the transport gasifier, which is a dry-feed, non-slagging, fluidized bed gasifier. The gasifier has operated successfully on a wide range of fuels, including sub-bituminous, bituminous, and lignite coals as well as biomass fuel. It consists of an assembly of dual-layered refractory-lined pipe and is ideally suited to process low-rank coals, which are more than half of the worldwide reserve. The outermost refractory is for insulation as it is necessary to withstand the variations in temperature (ambient up to 1,800 degrees Fahrenheit). The inner most refractory provides erosion resistance as it must also tolerate corrosive gases, rapidly flowing fuel, and ash particles. Failure of the refractory requires unit shut-down and the loss of valuable power production.

In the gasifier, solids from the separation and collection unit enter the lower portion of the mixing zone and combust to provide the heat necessary for the gasification reactions. Coal and sorbent are fed to the gasifier in the upper mixing zone, where hot circulating solids traveling upward from the lower mixing zone provide the heat necessary to devolatilize and gasify the coal in the riser, producing syngas and gasification ash.

Operational reliability depends upon the ability of the materials, especially the refractory, to tolerate these harsh environments for extended periods of time. This work examines the refractory materials and operational environment with the goal of increasing service life.

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.

Gasifier Optimization and Plant Supporting System technologies under development are targeted at increasing gasifier availability and efficiency, improving performance, and reducing the capital and operating costs of advanced gasification plants. Ongoing R&D projects are developing more durable refractory materials, creating models to better understand the kinetics and particulate behavior of fuel

inside a gasifier, and developing practical solutions to mitigate the plugging and fouling of syngas coolers. Future work will focus on the development of cutting edge gasifier technologies, which will start with multiple competing concepts and continue with support of the most aggressive and successful technologies being developed, both in the Gasification Systems program and other DOE programs, to reduce the cost of coal gasification. Future work will also aim to reduce the amount of water used in gasification plants and integrate technologies throughout the plant and beyond in a holistic approach to increase efficiency and reduce costs (e.g., the optimization of gasification plants to sell CO_2 for EOR applications).

The National Carbon Capture Center (NCCC) operates a Transport Gasifier to provide a platform for its testing and development of numerous gasification related technologies, including testing the durability of refractory. By combining the use of strategically placed, precision instrumentation and monitoring controlled solids inventory and solids circulation with the ability to operate across a wide range of flow rates and adjustable process conditions, the facility is monitoring and measuring slag/refractory interactions and testing various materials for durability. Providing new materials helps manufacturers to improve gasifier availability and reduce costs associated with plant shut-downs for repairs.

Project Scope and Technology Readiness Level

The primary goal is to increase the dependability of the refractory, thereby increasing overall system reliability, by examining and improving the refractory used in the transport gasifier component of PSDF during the NCCC's effort to develop and demonstrate advanced power generation technologies and CO_2 capture. The objectives are to reduce operating and maintenance costs and to avoid maintaining extra refractory-lined pipes in inventory.

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

- Prior to Test Run 2 (R02), gasifier inspection identified refractory damage in the standpipe, with hot-face refractory loss on both sides of the J-leg/standpipe intersection. The refractory in these places was the original refractory installed in the gasifier (Rescocast 17EC). Repairs were completed prior to R02 using Resco Quikturn 60 RSP (rotor stator pump) refractory. This area was monitored during the run using a thermal imaging camera and skin-mounted thermocouples. Post-run inspections showed that the repaired refractory was in good condition.
- During the February 2008 test run, several pieces of separated refractory (2 inches thick by 8 inches wide by 12 inches long) were found in the solids separation unit of the gasifier. The extent of refractory damage made a complete replacement necessary. The Atchem 85VC refractory was replaced with Rescocast 88VC. Based on the operating experienced at the PSDF, the Atchem 85VC refractory is not suitable in this application due to the high number of thermal cycles associated with multiple startups and shutdowns.
- During routine inspections of the gasifier in 2009, refractory damage arising from the loss of hot-face refractory was identified in the standpipe. A major 2012 accomplishment was the replacement of the gasifier standpipe. Since the repair, the new gasifier standpipe has demonstrated excellent refractory performance.

Contacts, Duration, and Cost

Contacts

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Duration
Start Date: 10/01/2008
End Date: 03/31/2014

Cost
Total Project Value: $251,454,148
DOE Share: $201,163,318
Non-DOE Share: $50,290,830

Presentations, Papers, and Publications

- Refractory Reports

Performer website: National Carbon Capture Center

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