the ENERGY lab

PROJECT FACTS

Gasification Systems

National Carbon Capture Center - Long-term Refractory Durability Tests (Transport Gasifier)

Background

In cooperation with Southern Company Services, Inc., the U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL) established the National Carbon Capture Center (NCCC) at the Power Systems Development Facility (PSDF) in Wilsonville, Alabama. The Center will bolster national efforts to reduce greenhouse gas emissions by developing cost-effective technologies to capture the carbon dioxide (CO_2) produced by fossil-fueled power plants.

The PSDF is a unique test facility. It is large enough to provide commercially relevant data, yet small enough to be cost-effective and adaptable to testing a variety of emerging technologies. The facility is a test-bed capable of evaluating advanced technologies at multiple scales, thus allowing results to be scaled directly to commercial application. This capability gives the PSDF the flexibility to develop and demonstrate a wide range of advanced power generation technologies that are critical to developing highly efficient power plants that capture CO_2.

Testing at the PSDF led to the development of several types of advanced technologies and their successful integration into a reliable gasification process for generating data for scale-up to commercial applications. These technologies included a high-pressure coal feed system; a transport gasifier; hot gas filtration; continuous ash depressurization systems; and various instrumentation, sampling, and controls systems. Only eight years after construction and commissioning, the Transport Integrated Gasification (TRIG™) process developed at the PSDF was selected for commercial deployment under the DOE Clean Coal Power Initiative. The technology is incorporated in Mississippi Power Company's Plant Ratcliffe, which is currently under construction.

In 2008, DOE/NETL and Southern Company Services, Inc., entered into a five-year cooperative agreement to establish and manage the NCCC at the PSDF. The PSDF adapted its processes and operations to also develop technologies related to CO_2 capture from coal-fired power plants. The gasification system will be operated primarily as a syngas generator in support of the CO_2 capture technology development plan. However, to develop a cost-effective advanced coal power plant with CO_2 capture, not only the power block but all process blocks within the power plant must be optimized.

Including CO_2 capture in an advanced coal power plant will increase the plant cost of electricity (COE), so projects that reduce overall process capital and operating costs are also included in the NCCC test plan to partially offset incremental cost increases due to the addition of CO_2 capture. In addition to providing syngas for pre-combustion CO_2 capture testing, the gasification process operates to support the development of technologies including automatic gasifier controls, innovative coal feeders, advanced sensors and instrumentation, high efficiency particulate filtration components, gasifier fuel flexibility (including biomass gasification), warm gas cleanup (such as mercury capture), fuel cells, and materials of construction.

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PROJECT DURATION

Start Date	End Date
10/01/2008	09/30/2013

COST

Total Project Value
$251,454,148

DOE/Non-DOE Share
$201,163,318 / $50,290,830

PROJECT NUMBER

NT0000749-NCCC-Transport Gasifier (Refractory)

U.S. DEPARTMENT OF ENERGY

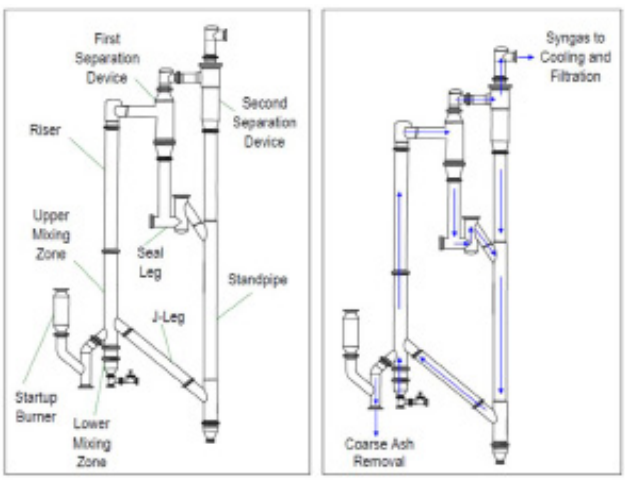
Project Description

The 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 is ideally suited to process low-rank coals, which are more than half of the world wide reserve.

The transport gasifier consists of an assembly of dual-layered refractory-lined pipe. 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.



Schematic of Transport Gasifier.

Goals/Objectives

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.

Accomplishments

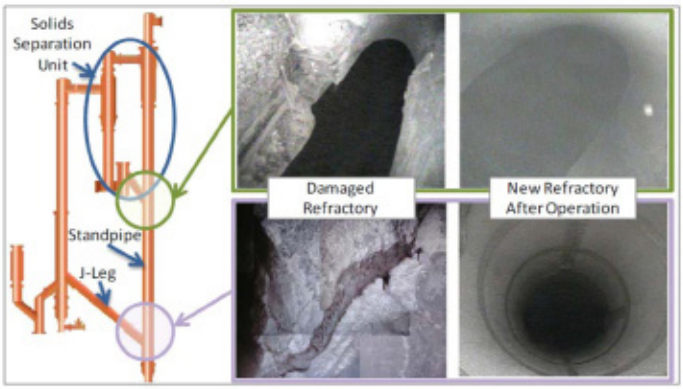
Detailed inspections were performed after test campaigns to evaluate the new and original refractory condition in the gasifier. Some of the highlights of refractory activity follow.

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.

Benefits

Materials research and development obtained from this project have helped to improve gasifier availability and reduce costs associated with plant shutdowns for repairs. Increasing the reliability of the gasifier refractory will reduce downtime, which will result in lower operation and maintenance costs. Longer lasting refractories could also lead to a reduction in the number of gasifiers required to keep the system on-line, thus reducing costs of equipment and loss of opportunity and increasing overall efficiency. Collectively, this will lead to a lower cost of electricity.

Refractory-lined standpipe in Storage.