the ENERGY lab

PROJECT FACTS

Gasification Systems

National Carbon Capture Center - Modification of the Developmental Pressure Decoupled Advanced Coal (PDAC) Feeder

Background

In cooperation with Southern Company Services, 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 has led to the development of several types of advanced technologies and demonstrated their successful integration into a reliable gasification process, generating data for scale-up to commercial applications. These technologies have included a high-pressure coal feed system; a Transport Gasifier; hot gas filtration; continuous ash depressurization systems; and various instrumentation, sampling, and controls systems. After only eight years from the time of construction and commissioning, the Transport Integrated Gasification (TRIG™) process developed at the PSDF was selected for commercial deployment through the DOE Clean Coal Power Initiative and is incorporated in Mississippi Power Company's Plant Ratcliffe, which is currently under construction.

In 2008, DOE/NETL and Southern Company Services entered into a five-year co-operative 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-fueled power plants. The gasification system will be operated primarily as a synthesis gas (syngas) generator in support of the CO_2 capture

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PROJECT DURATION

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

COST

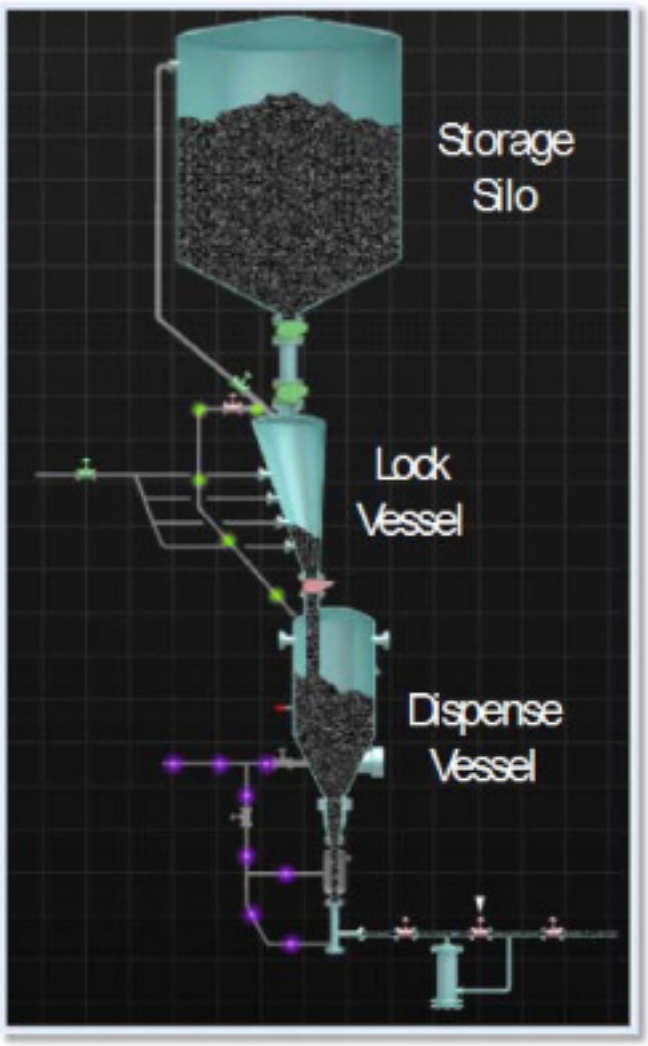
Total Project Value
$251,454,148

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

PROJECT NUMBER

NT0000749-NCCC-PDAC

technology development plan. However, to develop a cost-effective advanced coal power plant with CO_2 capture, all process blocks within the power plant must be optimized in addition to the capture block. 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_2capture testing, the gasification process operates to support the development of technologies including automatic gasifier controls, advanced sensors and instrumentation, high efficiency particulate filtration components, gasifier fuel flexibility (including biomass gasification), warm gas clean-up (such as mercury capture), fuel cells, and materials of construction. Also under this agreement, NETL has partnered with the NCCC to develop an innovative coal feed system capable of handling a wide range of fuels.



The developmental Pressure Decoupled Advanced Coal feeder.

Project Description

The developmental Pressure Decoupled Advanced Coal (PDAC) feeder, a non-mechanical, dry solids feed control device with no moving parts, combines some of the successful concepts developed for continuous ash depressurization systems with traditional designs for flow rate control. The driving force for solids flow is a pressure differential, and the solids flow is metered by the conveying gas. The feeder consists of an atmospheric storage silo for surge capacity, a lock vessel to pressurize the coal above gasifier operating pressure, and a dispense vessel to feed coal to the gasifier. The feeder can also be operated in offline mode utilizing a high pressure offline test system capable of pressures as high as 500 pounds per square inch and coal feed rates of 20,000 pounds per hour (lb/hr). The feeder is capable of accommodating a range of coal particle sizes (250 to 600 microns mass median diameter) and moisture concentrations (up to 25 weight percent).

PDAC feeder enhancements have included several mechanical and control modifications to improve reliability and reduce coal feed rate fluctuation. These modifications comprise improvements to conveying gas distribution and feeder geometry to reduce pressure drop, optimization of coal feed rate and dispensing vessel level control, improvements to the operator control interface, and testing of a gasifier temperature controller utilizing changes in coal feed rate. Additional modifications may be incorporated in the future based on subsequent observations of these enhancements. In addition to working on the existing feeder, project personnel are evaluating other feeder system components that could further improve feeder reliability and efficiency. An example of such a technology is a new, piston-type coal feed device (developed and provided by TK Energi/Electric Power Research Institute) for testing in parallel with the existing PDAC feeder lock vessel as a potential replacement option for the pressurization step.

Goals/Objectives

The key objectives of this project are to:

- Advance PDAC feeder operation through mechanical and control modifications.
- Conduct feeder testing utilizing offline feed system at higher pressures and coal feed rates.
- Evaluate coal feeder level probes.
- Evaluate new coal flow measurement devices.
- Enhance fuel flexibility of feeder with other potential gasifier feedstocks.
- Explore and test other dry solids feed systems/components as available.

Accomplishments

- The PDAC feeder has operated for approximately 6,900 hours at coal feed rates between 750 and 5,700 lb/hr during gasification operation. Coal feed rates as high as 8,500 lb/hr have been achieved while utilizing the high pressure offline test system. Gasifier feedstocks tested to date include subbituminous and lignite coals and coke breeze.
- Several non-intrusive coal flow measurement devices have been tested to provide instantaneous indication of coal feed rate changes. Most recently, performance of a dense flow coal meter was evaluated over the course of several gasification runs. The device provides measurement of coal density and velocity in the discharge line to the gasifier and uses these measurements to calculate a mass flow rate. While the measurement provided by the device has shown good response to instantaneous changes in coal feed rate when compared to existing conveying line differential pressure readings, the absolute reading has not matched up well with the loss in weight calculation provided by the PDAC feeder storage silo weigh cell device. Additional discussions are ongoing to resolve this difference. Dynatrol vibration level probes installed in the PDAC feeder dispense and lock vessels have operated for more than 6,000 hours. The probes have consistently indicated solids levels inside the vessels for both lignite and subbituminous coals. The high reliability of the probes allowed for control logic modifications to optimize the lock vessel filling cycle and provide a wider range of operational capability.
- The Drexelbrook point sensitive level probe, installed in the top of the PDAC feeder dispense vessel, has continuously provided steady solids level control, mitigating the impact of solids level variation on coal feed rate. A total of 5,000 hours of reliable operation has been achieved to date.
- Modifications were made to better distribute nitrogen gas to the bottom of the PDAC feeder, resulting in improved coal flow rate control and overall nitrogen flow control.
- Improvements have been made to the PDAC feeder control logic to provide improved control of dispense vessel pressure resulting in a more consistent coal feed rate to the gasifier. Additional control improve-ments include several feedback controllers to modulate conveying gas flow to the feeder to maintain steady coal feed to the gasifier. These include feedback control on instantaneous coal feed rate utilizing a differential pressure transmitter (can be modified in the future to use other coal flow measurement devices) and feedback control on sudden changes in gasifier pressure. Preliminary testing has also been conducted using temperature indications in the gasifier mixing zone to adjust conveying gas to the feeder.

Benefits

The PDAC feeder system testing conducted at NCCC is focused on providing a highly reliable, non-mechanical dry solids feed system for commercial gasification systems. The current version of this feeder technology has already been scaled up and is being commercially deployed at Mississippi Power Company's Plant Ratcliffe. The feeder will provide high capacity and availability due to its non-mechanical design and, because the coal is fed dry to the gasifier, will increase power plant efficiency while contributing to a decrease in total cost of electricity, in-plant energy consumption, and initial capital costs.