Scoping Studies to Evaluate the Benefits of an Advanced Dry Feed System on the Use of Low Rank Coal in Integrated Gasification Combined Cycle

Background

Gasification of coal or other solid feedstocks (biomass, petroleum coke, etc.) produces synthesis gas (syngas), which can be cleaned and used to produce electricity and a variety of commercial products that support the U.S. economy, decrease U.S. dependence on oil imports, and meet current and future environmental emission standards. The major challenge is cost, which needs to be reduced to make integrated gasification combined cycle (IGCC) technology competitive. An IGCC plant combines a combustion turbine operating on a gasified fuel stream--syngas--with a steam turbine to capture what would otherwise be waste heat. Currently, the estimated cost of power from IGCC is higher than that from conventional coal power plants. However, IGCC has the potential to capture and store greater than 90 percent of the carbon in coal, at lower costs than conventional coal-based power production. The Department of Energy’s (DOE) Gasification Program is developing technology to accomplish this at a cost of electricity (COE) that is lower than that of any other coal-fueled power generation technology that includes carbon capture. The public benefits of the Gasification Program are significant—lower cost power, cleaner environment, reduced carbon footprint, reduced water use, reduced dependence on imported oil, and high-value U.S. jobs.

In alignment with DOE’s Gasification Program goal of reducing cost, the National Energy Technology Laboratory (NETL) has partnered with GE Energy (USA), LLC (GE) to perform a scoping study to evaluate the benefits of an advanced dry feed system for feeding low-rank coal in IGCC plants.

Project Description

The U.S. has large reserves of low-cost, low-rank coal, but use in IGCC systems is, to a large extent, limited by the capabilities of available coal feed systems. Conventional dry feed systems feed coal through a system of lock hoppers. This approach has high capital, operating, and maintenance costs and poor reliability, issues that are exacerbated as operating pressure increases. Slurry feed systems suffer an efficiency penalty resulting from the need to evaporate and heat the water contained in the high inherent moisture low-rank coals and the additional water added to form a pumpable slurry, thereby reducing efficiency.

Project personnel are preparing comparative techno-economic studies of two IGCC power plant cases: one with and one without advanced dry feed technology. A common basis of design is being developed. For both cost and performance comparisons, the baseline case (without advanced dry feed technology) is being developed using operational data from the Eastman Chemical Company’s Kingsport gasification.
facility in combination with data from the DOE case study for IGCC using a low-rank coal with 90 percent carbon capture. Advanced dry feed technology, based upon the Posimetric pump currently under development by GE, will be developed to match the proposed plant conditions and configuration, and analyzed to provide comparative performance and cost information to the baseline plant case. The scope of this analysis covers the feed system from the raw coal silo through the gasifier injector.

Goals/Objectives

The primary goal of this project is to evaluate and demonstrate the benefits of novel dry feed technology that effectively, reliably, and economically feeds low-cost, low-rank coal into a commercial IGCC gasifier. This study will focus primarily on IGCC systems with 90 percent carbon capture, but the dry feed system will be applicable to all IGCC power generating plants and other industries requiring pressurized syngas. Supporting this goal are three broad objectives:

• Evaluate the cost of electricity in an IGCC plant using GE’s new dry feed technology compared to GE’s current, commercially available slurry feed system feeding low rank coal in an IGCC plant configured for 90% carbon capture.

• Generate an up-to-date commercial design for the new dry feed system.

• Prepare an assessment of the development and commercialization status of the key component of the new dry feed system, GE’s Posimetric Feeder, that combines both coal pressurization and coal metering in a single device.

Accomplishments

The slurry feed Base Case study (Base Case) was completed. The Base Case plant configuration includes a conventional GE coal grinding and slurry preparation unit that feeds an aqueous slurry of Montana Rosebud Powder River Basin Coal to a single 1800 cubic foot (ft³) GE quench gasifier. GE in-house models of the gasifier, the gasification island, and the power island were used for simulating the Base Case plant.

The following items were completed or developed:

• Overall plant process flow diagram.
• Simulation of the gasifier, gasification island, and power block.
• Equipment list, size, and capital cost for all key equipment and total plant cost.
• Reliability, availability, maintainability analysis for the entire plant.
• Operating and maintenance costs.
• Cost of electricity and levelized cost of electricity (LCOE).

An initial IGCC plant configuration for the Advanced Technology Case was developed. The Advanced Technology Case plant configuration includes a proprietary GE Posimetric Feed System that feeds partially dried particulate Montana Rosebud Powder River Basin coal to a single 1800 ft³ quench gasifier. In addition to the Posimetric Feed System and the gasifier, the gasification island includes the usual coarse and fine slag handling and syngas scrubbing systems. Saturated syngas from the syngas scrubber is passed through a sour water gas shift unit and a 95 percent mercury removal unit and then to a dual-absorber Selexol unit that removes hydrogen sulfide (H₂S) and sends it to a conventional sulfur recovery unit for the production of elemental sulfur. It also absorbs carbon dioxide (CO₂) from the syngas amounting to at least 90 percent of the carbon that was fed to the gasifier. A portion of the CO₂ is compressed for recycle to the Posimetric Feed System for use as carrier gas, while the rest is compressed to even higher pressure for use in enhanced oil recovery (EOR). The clean, hydrogen rich syngas is reheated and burned in a GE F-class turbine.

Heat and material balances, together with the down selected configuration for the Posimetric Feed System, were used to calculate auxiliary power consumption and overall plant efficiency for the Advanced Technology IGCC Case. On the basis of these results, a number of improvements were identified that will significantly increase overall plant efficiency. An optimization effort was initiated and is currently ongoing to integrate these improvements in the IGCC plant design.

Benefits

IGCC has the potential to significantly reduce U.S. dependence on foreign energy sources while dramatically reducing the environmental impact of using coal for power generation, since emissions from IGCC plants are much lower than those from conventional coal-fired power plants. The outcome of the design effort will demonstrate the benefits of novel dry feed technology to effectively, reliably, and economically feed low-cost, low-rank coal into commercial IGCC gasifiers. Successful demonstration of this advanced dry feed technology will allow utilization of vast reserves of low rank coal in the U.S. for power production, thus enhancing energy security.

1 “Posimetric” is a trademark of General Electric Company and/or its affiliates.