Development of an Advanced Combined Heat and Power (CHP) System Utilizing Off-Gas from Coke Calcination

Utilization of Process Off-Gas as a Fuel for Improved Energy Efficiency

Introduction

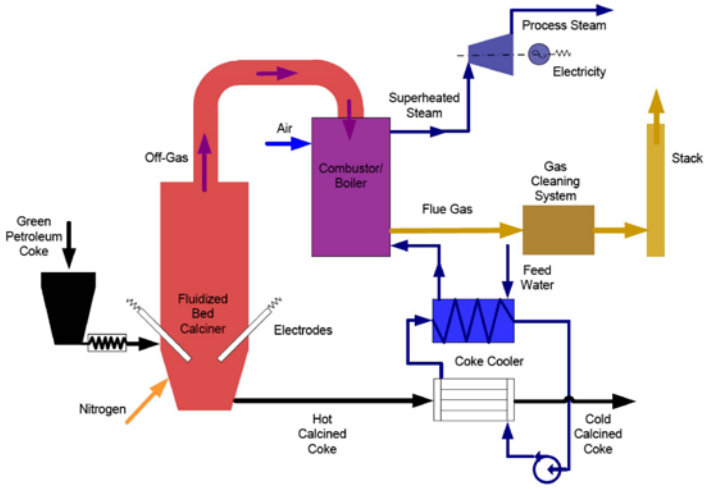
Coke calcination is a process that involves the heating of green petroleum coke in order to remove volatile material and purify the coke for further processing. Calcined coke is vital to the aluminum industry, where it is used to produce carbon anodes for aluminum production. Calcined coke is also widely used as recarburizer in the iron and steel industry. The increased use of crude oil (especially light sweet crude oil) over recent years has provoked escalated use of heavy, rather than light, crude oil for refinery process.

The resulting green coke produced from heavy crude oil processing has a higher sulfur content, which requires a significant increase in the calcination temperature and residence time. However, it is challenging to realize such a high-temperature calcination process

Benefits for Our Industry and Our Nation

The development of this process, as compared to the conventional process using rotary kilns, is expected to yield significant energy, environmental, and economic benefits, including the following:

- Reduced fuel consumption of 25%–50%
- Enhanced specific production rates of 50%–100%
- Energy savings of 0.94 trillion Btu per year for a production unit of 100,000 metric tons per year
- Lowered environmental impact resulting from improved combustion
- An approximately 60% reduction in capital and operating costs



Flow chart of the petroleum coke calcining process in an electrothermal fluidized bed, integrated with waste heat utilization. The calcining process is composed of the petroleum coke charger (black), fluidized bed calciner with electrodes and nitrogen supply (red), and gas cleaning system (yellow-gold). The waste heat utilization system (or advanced CHP) is composed of the combustor/boiler (purple), coke cooler (blue), and generator (blue-violet).

Illustration courtesy of Gas Technology Institute (GTI).

Applications in Our Nation's Industry

The project technology will have immediate applications in the calcined coke production industry. The global calcined coke market is estimated at approximately 10 million tons and is growing by 800,000–1,000,000 tons of end product each year. The concept approach to be developed and validated during this project is also expected to be successfully applied to cross-cutting markets such as steel production and power generation.

Project Description

The goal of this project is to reduce the energy and carbon intensity of the calcined coke production process. This goal will be realized through the increased utilization of solid product waste heat and opportunity fuels such as process waste off-gas. To this end, the project will design and develop an advanced CHP system to best utilize the waste off-gases as opportunity fuels.

Barriers

- High level of combustion intensity to be handled by off-the-shelf gas-fired equipment
- Very high combustion process temperature (~ 2000°C)
- Presence of solid fines in off-gas can potentially induce deposition at the heat exchange surfaces during high-temperature combustion
- Low inlet pressure of the off-gas

Pathways

The project team has an extensive research and engineering background and long-standing practical experience in the area of industrial-fired equipment and processes. This background will be necessary to efficiently overcome the potential project barriers by:

- Ensuring uniform mixing of the hot off-gas and combustion air with efficient combustion product recirculation
- Implementing a high circulating factor of two-phase (water-steam) flow in an integrated combustor-boiler arrangement
- Employing refractory-lined water-cooled combustion chamber walls for fouling mitigation and service life extension
- Applying a combustion air staging approach for nitrogen oxide (NO_x) reduction

Milestones

This project started in 2009 and is expected to be completed by September 2012.

- Appropriate scheme selected, based on configuration and concept design arrangement analysis
- Technical design completed, including set of fabrication drawings, supporting calculations, and field test agreement
- System assembled, and operating and safety precaution manuals are in place
- Pilot test completed, data processed, and test results analyzed
- Commercial design recommendations and draft marketing plan developed

Commercialization

After successful development and demonstration of the proposed technology, project partners Gas Technology Institute (GTI) and Superior Graphite Co. (SGC), along with selected equipment manufacturers, will deploy the technology within SGC's facility in Hopkinsville, Kentucky. Furthermore, the project partners will market the technology to producers of calcined coke and related industries. GTI has a track record of more than 65 years in the successful commercialization of efficient combustion technologies for energy-intensive industrial applications. SGC is one of the leading companies in the area of high-temperature (up to 2600°C) EFB process technology, with over 30 years of practical experience in the development, design, and commercial operation of high-temperature EFB processes for deep desulfurization and purification of various types of raw and partially heat-treated carbonaceous materials such as natural/synthetic graphite, petroleum, and coke.

Project Partners

Gas Technology Institute (GTI)
Des Plaines, IL
Principal Investigator: Yaroslav Chudnovsky
E-mail: yaroslav.chudnovsky@gastechnology.org

Superior Graphite Co. (SGC)
Chicago, IL
Co-Principal Investigator: Mark Zak
E-mail: mzak@superiorgraphite.com

For additional information, please contact

Bob Gemmer
Technology Manager
U.S. Department of Energy
Industrial Technologies Program
Phone: (202) 586-5885
E-mail: Bob.Gemmer@ee.doe.gov

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