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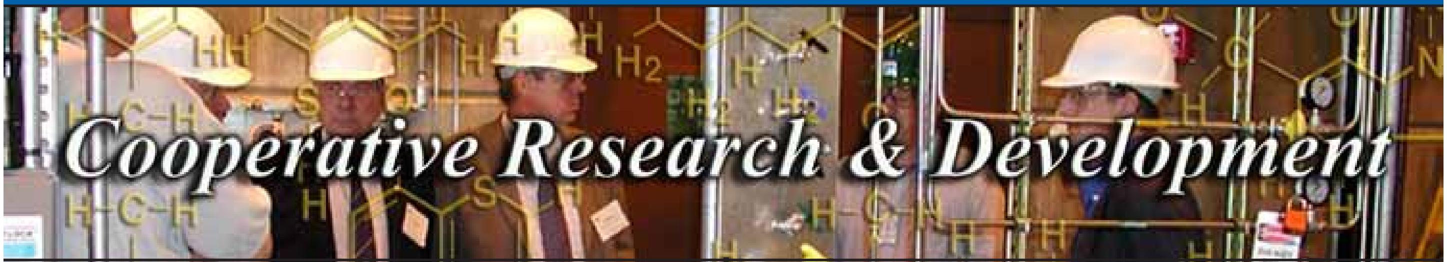
National Energy Technology Laboratory



Successes

Impacts of Lignite Properties on Powerspan's NO_x Oxidation System

Advanced Research

To support coal and power systems development, NETL's Advanced Research Program conducts a range of pre-competitive research focused on breakthroughs in materials and processes, coal utilization science, sensors and controls, computational energy science, and bioprocessing—opening new avenues to gains in power plant efficiency, reliability, and environmental quality. NETL also sponsors cooperative educational initiatives in University Coal Research, Historically Black Colleges and Universities, and Other Minority Institutions.

Accomplishments

- ✓ **Process improvement**
- ✓ **Greater efficiency**
- ✓ **Innovative materials**
- ✓ **Environmental benefits**

Introduction

This cooperative research and development (R&D) project was led by the Energy & Environmental Research Center (EERC), in collaboration with the U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL), and involved several industry partners—including Minnkota Power Cooperative, Minnesota Power Company, Basin Electric Power Cooperative, Montana-Dakota Utilities Co., and Powerspan Corporation. The project evaluated air pollution control options as part of the planning process for a new power generating unit, Milton R. Young Unit 3 (MRY3), at Minnkota's Milton R. Young Station near Center, North Dakota. One technology evaluated was Powerspan's multipollutant control process, called Electro-Catalytic Oxidation (ECO®). The ECO technology is designed to simultaneously remove nitrogen oxide compounds (NO_x), sulfur dioxide (SO_2), fine particulate matter ($PM_{2.5}$), acid gases—such as hydrogen fluoride (HF), hydrochloric acid (HCl), and sulfur trioxide (SO_3)—mercury (Hg), and other metals from the flue gases of coal-fired power plants.

Current Approaches

Urea injection and selective catalytic reduction (SCR) technologies are generally considered the best available control technologies for coal-fired power plants. Urea injection will meet most of the U.S. Environmental Protection Agency (EPA) NO_x reduction targets in the near term. However, limits to its removal rate are expected to restrict urea's use as the EPA's future NO_x reduction targets accrue. Previous testing of SCR technologies by the EERC demonstrated a high degree of blinding (plugging) of the SCR catalytic media when used in conjunction with high-sodium lignite.

Commercial Need

Because of the severe blinding and fouling of SCR catalysts in tests when high-sodium lignite is fired, alternative technologies are needed that are specifically aimed at reducing NO_x emissions for high-sodium lignite-fired boilers. The Powerspan ECO technology provides an attractive multipollutant emission control option for lignite-fired systems. This project was designed to examine the application of Powerspan's ECO reactor system to convert NO_x species to nitric acid (HNO_3) in a flue gas derived from high-sodium lignite-fired combustion.

EERC ST32604

Milton R. Young Power Station, Units 1 & 2, Minnkota Power Cooperative, Center, North Dakota

Project Duration

Start Date
05/09/07

End Date
02/29/08

Cost

Total Project Value
$379,364

DOE/Non-DOE Share
$132,800 / $246,564

Industrial Partners

Energy & Environmental Research Center (EERC)
Grand Forks, ND

Minnkota Power Cooperative
Grand Forks, ND

Montana–Dakota Utilities Co.
Bismarck, ND

Basin Electric Power Cooperative
Bismarck, ND

Minnesota Power Company
Duluth, MN

Powerspan Corporation
Portsmouth, NH

North Dakota Industrial Commission–Lignite Research Council
Bismarck, ND

Technical Description

EERC ST31931.CDR

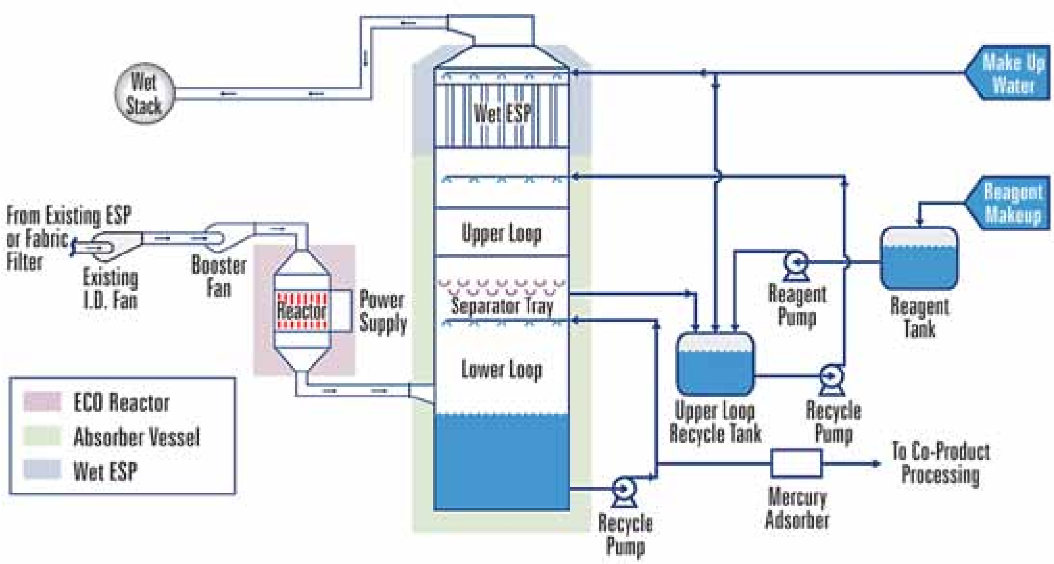
Inside the Powerspan ECO slipstream reactor

The core of the ECO technology is a dielectric barrier discharge (DBD) reactor composed of cylindrical quartz electrodes residing in metal tubes. Electrical discharge through the flue gas, passing between the electrode and the tube, produces reactive O and OH radicals. The O and OH radicals react with flue gas components to oxidize NO to NO_2 and HNO_3, and a small portion of the SO_2 to SO_3 and sulfuric acid (H_2SO_4). The oxidized compounds are subsequently removed in a downstream scrubber and wet electrostatic precipitator.

The purpose of this project was to determine the impact of lignite-derived flue gas containing sodium aerosols on Powerspan's DBD reactor, with specific focus on the interaction with the quartz electrodes. A challenging characteristic of selected North Dakota lignites is their high sodium content. During high-sodium lignite combustion and gas cooling, the sodium vaporizes and condenses to produce sodium- and sulfur-rich aerosols. Based on past work, researchers hypothesized that the sodium aerosols would deposit on and react with the silica electrodes, resulting in the formation of sodium silicate. The deposit and reacted surface layer would then electrically alter the electrode, thus impacting its dielectric properties and NO_x conversion capability.

The EERC and its commercial partners designed and fabricated a Powerspan ECO slipstream reactor system to test the in situ impacts of flue gas derived from high-sodium lignite coal on the electrodes. The reactor was in operation for four months downstream of the electrostatic precipitator on MRY1.

Following the test period, examination of the electrodes using scanning electron microscopy (SEM) x-ray microanalysis showed significant accumulations of ash coatings rich in sodium, sulfur, calcium, potassium, and silica on the surface of the electrodes. There was no evidence of the reaction of the sodium with the silica electrodes to produce sodium silicate layers. All SEM images showed a clearly marked boundary between the ash and the silica. Sodium and sulfur were found to be the main problems in the fouling of the electrodes.



ECO process flow diagram featuring DBD slipstream reactor for oxidation of multipollutants

Conclusions

Conclusions gained as a result of this work are:

1) Sodium-rich aerosols and small ash particles accumulated and bonded on the surface of the silica electrodes.
2) Ash accumulations adversely affected the NO_x conversion.
3) The adverse impact occurred within a two-week period.
4) The ash accumulations were readily removed with a water wash, and the electrodes did not appear to be permanently affected by the ash.
5) The Powerspan ECO technology may prove to be viable if the ash accumulation can be kept to a minimum.

Commercial Opportunity

Based on the results obtained in this work, it appears that the ECO technology has potential for new power plant designs that burn high-sodium lignites but are significantly impacted by the sodium-rich ash. Sodium reduction upstream of the reactor and aggressive ECO reactor-cleaning are possible methods that will enable the ECO technology to be feasible. Future testing of the technology must be aimed at measures to reduce the sodium aerosol content of the flue gas in order to prevent the formation of sodium-rich deposits.

In addition to the ECO technology, Powerspan is developing a cost-effective, ammonia-based carbon dioxide (CO_2) capture process for coal-fired power plants called ECO_2™. ECO_2 works in conjunction with Powerspan's ECO process to capture and recover CO_2 in flue gas, with potential for enhanced oil recovery or other forms of geological sequestration. The ECO process also produces an ammonium sulfate fertilizer coproduct, eliminating landfill disposal of waste and providing a possible revenue stream to offset a large portion of the operational costs. Powerspan projects a target cost of $20/ton for CO_2 capture using the ECO_2 process, with approximately $10/ton in capital expenses and $10/ton in operating expenses.

EERC ST31932.CDR

Powerspan ECO slipstream reactor installed at MRY1 during testing by the EERC

Powerspan has been developing the ECO_2 technology since 2004 in conjunction with NETL under a cooperative research and development agreement (CRADA). In December 2007, Powerspan exclusively licensed a patent from DOE. The patent granted by DOE represents the only patent issued in the United States to date covering a regenerative process for CO_2 capture with an ammonia-based solution.

"...it appears that the ECO technology has potential for new power plant designs that burn high-sodium lignites but are significantly impacted by the sodium-rich ash."

States and Localities Impacted

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