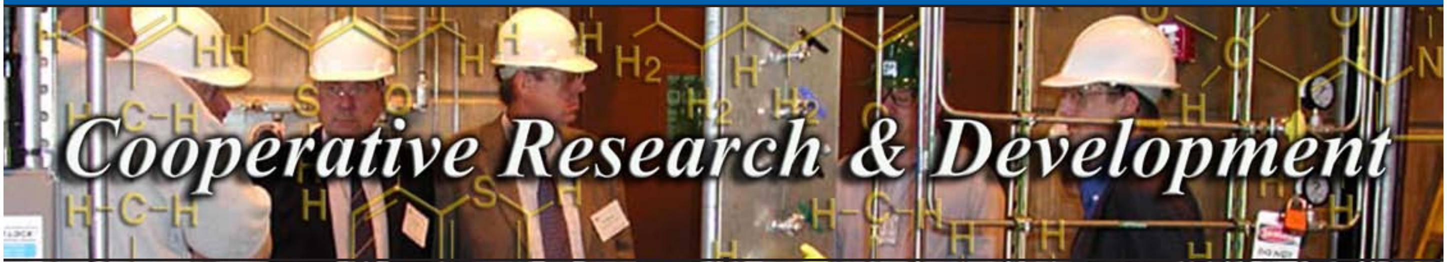

Successes

Inorganic Coal Additive for Controlling Mercury Emissions and Mitigating Slagging and Fouling

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 innovation
- ✓ Cost reduction
- ✓ Greater efficiency
- ✓ Environmental benefits

Introduction

A project sponsored by the U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL)—entitled "Development and Demonstration of an Inorganic Coal Additive for Controlling Mercury Emissions and Mitigating Slagging and Fouling"—has led to a new follow-on opportunity. To commercialize this opportunity, Energy Efficient Combustion Technology (EECT) teamed with the Energy & Environmental Research Center (EERC) to further develop EECT's noncarbon-based mercury (Hg) control technology. The EERC has physically and chemically modified EECT's inorganic additive technology and performed bench- and pilot-scale optimization efforts to achieve significant Hg removals from the combustion of a high-ash-content (16 wt%) and low-Hg-content (0.04 ppm dry basis) subbituminous coal.

Commercial Application

EERC, together with its partner EECT, has conducted coal combustion testing that has achieved a goal of at least 60 percent electrostatic precipitator (ESP) Hg removal in high-ash, high-alkaline subbituminous coal. In fact, 72–76 percent removal efficiencies have been obtained. Additional testing is planned to provide longer-term ESP Hg removal results with the modified EECT additive. The technology is commercially available through EECT.

Commercial Need

Because mercury is a neurotoxin that, in certain forms, may accumulate in biological organisms, it is being regulated in many industries. Coal-fired power plants are currently faced with this challenge, but many commercial sectors that combust coal for production of hot water, steam, or other uses may be subject to future regulations. Consequently, mercury removal processes are needed that are effective for both oxidized and elemental (Hg^0) mercury. Installation of a mercury control technology often requires lengthy lead times, making it prudent to develop strategies that can reduce mercury emissions at reasonable cost and with minimal operational impacts on the facility.

The coal-fired electric power generation sector is the biggest single anthropogenic (human-made) source of Hg emissions in North America. In turn, regulators have focused on setting Hg emission standards for the sector.

Figure 1. Mercury emitted from power plants may accumulate in the environment.

Project Duration

Start Date
01/01/08

End Date
06/30/08

Cost

Total Project Value
$326,351

DOE/Non-DOE Share
$114,255 / $212,096

Partners

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

Energy Efficient Combustion Technology (EECT)
Grand Forks, ND

Current Approaches

The challenge is to capture low concentrations of various forms of mercury within seconds. Currently, mercury is captured from flue gas in scrubbers or by using various sorbents upstream of particulate control devices. The levels of performance are mixed, depending on coal type, flue gas constituents, and plant configuration.

Injection of activated carbon has proven effective at removal of the oxidized form of mercury from flue gas streams. However, the removal of elemental mercury has been much more challenging, as has the removal of mercury in various flue gas scenarios where the activated carbon sites are poisoned before they can bind with the mercury. A disadvantage of activated carbon injection, however, is that it contaminates fly ash and renders it unmarketable for beneficial uses such as building materials. This tendency is particularly pronounced in uses related to high-ash- and low-Hg- content coals.

Technical Description

The new EECT–EERC technology addresses these shortcomings by providing a solution that is environmentally friendly, effective at removing both elemental and oxidized forms of mercury, and usable in many flue gas streams that would normally poison activated carbon sorbents. Under this project with EECT, the EERC is developing inorganic additives for capturing Hg that are specifically tailored to key parameters related to coal chemistry and that avoid potential ash-handling issues.

Combustion Test Facility

An isometric drawing of the EERC's combustion test facility (CTF) is shown in Figure 2. The furnace capacity is approximately 100 lb/hr (750,000 Btu/hr) of a moderately high Btu content fuel. The combustion chamber is 30 inches in diameter, 8 feet high, refractory-lined, and has been used for combustion testing of all ranks of fuels.

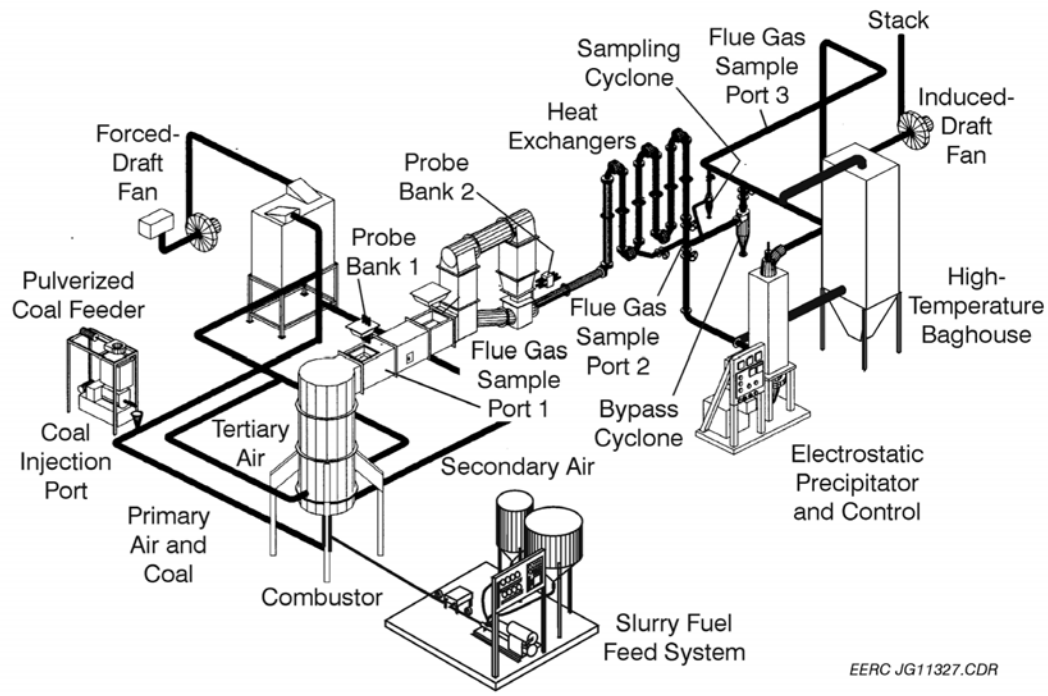

Figure 2. The CTF, with its auxiliary systems, provides a controlled environment for combustion tests.

Electrostatic Precipitator

A single-wire, tubular ESP was used for testing. A flue gas flow velocity through the ESP of 5 ft/min (1.52 m/min) and a plate spacing of 11 in. provide a specific collection area of 125 ft^2/1000 actual cubic feet per minute (acfm), or 11.6 m^2/28.32 actual cubic meters per minute (acmm) at 300 °F (149 °C). The ESP has an electrically isolated plate that is grounded through an ammeter, thus enabling continual monitoring of the actual plate current to ensure consistent ESP operation. The ESP was operated at 40–60 kV and a corona current[1] of 4.0 mA. The ESP was thoroughly cleaned between tests so that all tests began on the same basis. On average, the ESP attained 99.95 percent particulate removal efficiency.

Additive Injection

EECT's additive was sized to 80–200 mesh to maximize surface area before it was chemically treated. Chemically treated EECT additives were injected through several ports during testing to achieve various residence time and temperature profiles in an attempt to optimize Hg capture. Injection rates in millions of actual cubic feet (Macf) were calculated for the total flue gas flow at the ESP inlet temperature of about 320 °F, excluding the additional volume of flue gas resulting from the additive transport air. Flow through the ductwork to the ESP is in the turbulent regime at an average flue gas velocity of approximately 60 ft/s. Ten elbows in the duct upstream of the ESP ensured a high degree of mixing. Additive residence time in the flue gas was about 1.7 s upstream of the ESP. The residence time in the ESP was about 1.6 s.

ESP Hg removal efficiencies of 72–76 percent were obtained on the high-ash high-alkaline subbituminous coal combustion flue gas during the injections of EECT additive into the furnace, as indicated in Figure 3.

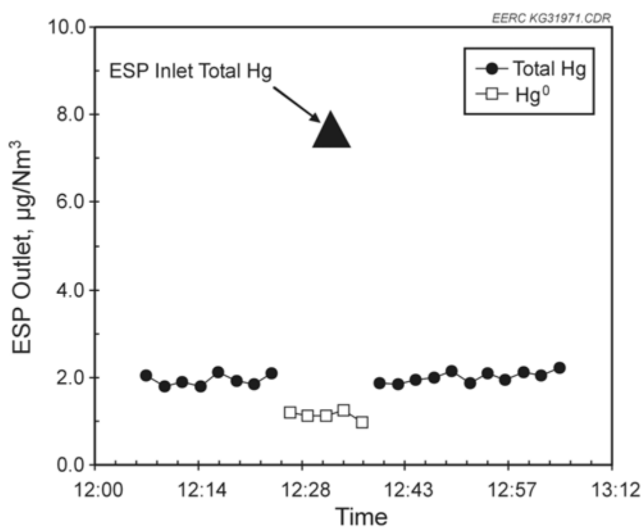

Figure 3. Continuous mercury monitoring results during the injection of EECT additive into a coal combustion flue gas.

"The EERC has physically and chemically modified EECT's inorganic additive technology and performed bench- and pilot-scale optimization efforts to achieve significant Hg removals from the combustion of a high-ash-content (16 wt%) and low-Hg-content (0.04 ppm dry basis) subbituminous coal."

States and Localities Impacted

Grand Forks, ND

Benefits

In summary, the new EECT–EERC technology offers the following advantages:

- *Effectiveness* – EECT's enhanced additives improve capture over conventional activated carbon.
- *Environmentally friendly* – using the non-carbon-based additive allows subsequent beneficial use of fly ash.
- *Flexibility* – technology allows for a wider range of fuel choices, operations, and future plant modifications.
- *Scalability* – the technology is easily scalable to accommodate small to large facilities.
- *Operability* – the additive reduces potential slagging and fouling issues.

[1] Defined as the current of electricity equivalent to the rate of charge transferred to the air from an object experiencing corona discharge.

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