POWER Engineering PEi Power Engineering

Click here to enlarge image

NRG Texas's Limestone Power Plant in Jewett, Texas

Mercury Specie and Multi-Emission Control Project

By the National Energy Technology Laboratory

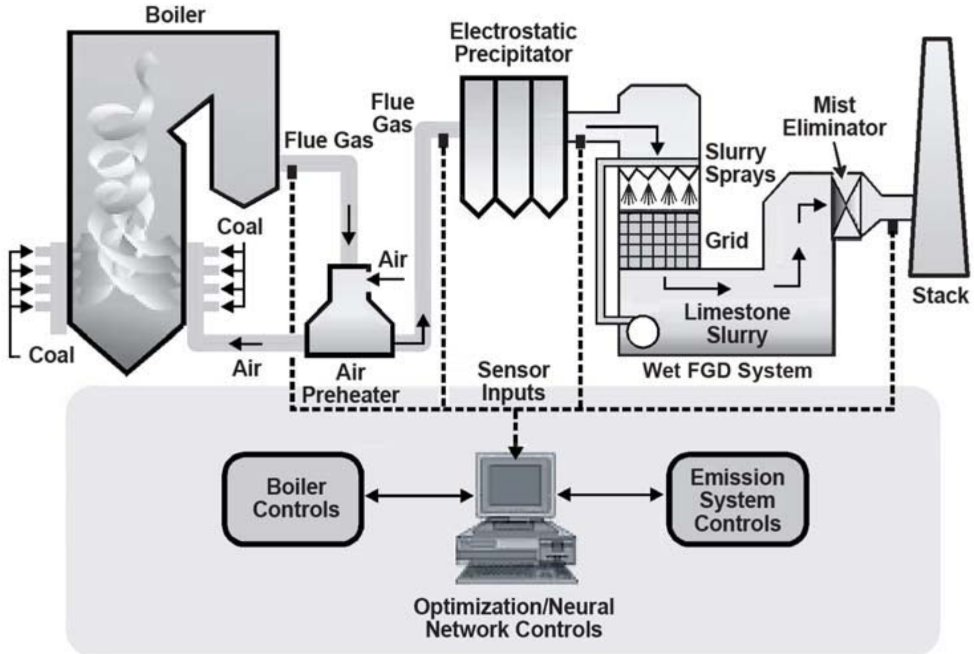
The Clean Coal Power Initiative (CCPI) project at the NRG Texas Limestone Electric Generating Station in Jewett, Texas, will demonstrate the capability to optimize mercury speciation and control emissions at an existing power plant. NeuCo, Inc. and NRG Texas are combining artificial intelligence (AI) and simulation technologies to prove that mercury speciation and multi-pollutant reduction benefits can be measured, optimized, and controlled while simultaneously improving plant efficiency. NeuCo, Inc. is demonstrating this technology on Limestone's tangential-fired 913 MW utility boiler, fueled by Texas Lignite and Powder River Basin (PRB) Coal.

Solutions gleaned from the project will allow plant operators to assess detailed plant operating parameters that affect mercury capture, overall heat rate, particulate removal, and flue gas desulfurization (FGD) efficiencies. Data will also be provided to a neural network optimization system that controls plant subsystems to provide the lowest possible pollutant emissions, highest heat rate, and least risk of environmental non-compliance, all with minimal capital expenditure.

This technology is anticipated to have broad application to existing coal-fueled boilers and positively impact the quality of saleable by-products such as fly ash. The project began in April 2006, with performance testing targeted for December 2008. This $15.6 million project will be 38 months in duration, with DOE sharing 39 percent of the cost.

Project Objectives

NeuCo, Inc. and NRG Limestone will demonstrate the ability to affect and optimize mercury speciation and multi-pollutant control using non-intrusive advanced sensor and optimization technologies. Advanced solutions utilizing state-of-the-art sensors and neural-network-based optimization and control technologies are being used to maximize the portion of the mercury vapor in the boiler flue gas that is oxidized or captured in particle and chemical bonds, resulting in lower releases of mercury.



Control System Schematic for NRG Texas Limestone Power Plant

Plant-wide advanced control and optimization systems are being integrated into a coal-fueled, steam electric power plant in order to minimize emissions while maximizing the efficiency and by-products of the plant. The technologies are expected to have widespread application since they can be directly retrofitted to the existing coal fleet or integrated into future new plant designs.

The neural-network-based control and optimization system gathers data from coal composition, combustion gas composition, mercury species, feed rates, etc., and uses this information to optimize power plant operations. The greatest advantage of neural networks in power plants is their ability to generalize from previous information and develop similar patterns for future use. The project is expected to demonstrate increased control of mercury, SO_2, NO_X, and particulate matter, along with reduced water use. The goal of the intelligent control project is to improve mercury capture by over 40 percent, reduce NO_X emissions by 10 percent, reduce fuel consumption by 0.5 to 2.0 percent, reduce CO_2 intensity and improve operating flexibility.

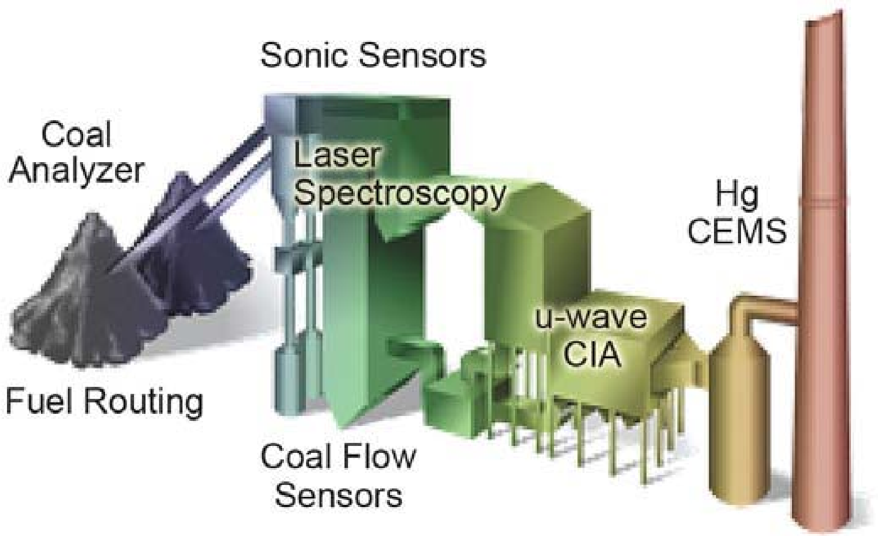
Project Overview

The estimated 48 tons of mercury emitted annually by domestic coal-fueled power plants is about one-third of the total amount of mercury released annually from all human activities in the United States. Mercury emissions take a number of chemical forms–or species–including the pure element, as part of a gaseous compound or bound to particulates in flue gas. Certain mercury species, such as mercury that is adsorbed onto fly-ash particles or bound in the FGD, are relatively easy to remove from flue gas. Adjusting certain parameters during combustion can optimize the speciation process and maximize the mercury captured in particle bonds. This results in greater capture of mercury and lower emissions.

The NRG Texas demonstration power plant is equipped with a tangentially-fired boiler that uses a blend of Texas lignite and Powder River Basin subbituminous coal, which are known to emit relatively high levels of elemental mercury under routine combustion conditions. NeuCo is applying sensors at key locations to evaluate the mercury species (elemental and oxidized mercury), developing optimization software that will result in the best plant conditions to promote mercury oxidation and minimize emissions in general, and using neural networks to determine the optimization conditions.

The unit is equipped with a cold-side ESP rated at approximately 99.8 percent particulate removal efficiency and a wet limestone FGD system rated at approximately 90 percent SO_2 removal efficiency. Both devices are capable of high mercury-capture efficiency, especially when the mercury is in an oxidized state rather than an elemental vapor state.

Using a neural network to affect and optimize mercury speciation and multi-pollutant control, the non-intrusive advanced sensor and optimization technologies will mimic the action of a highly trained operator, making decisions on inputs to the process by measuring and learning the outputs.



Key locations where sensors will be applied to evaluate mercury species

By using AI optimization technologies, NeuCo will minimize the use of raw material resources and pollutant emissions while simultaneously optimizing the operating capabilities of the plant.

This project involves the installation and demonstration of sensors and optimization software in six separate technology packages. While the modular design is transparent to this project, it is important to the future marketing of this system because of the flexibility needed with utilities to include or exclude a particular module based on either the existing equipment or budget for a specific plant. Many of the sensors and optimizer technologies that are being installed are utilized across the modules; therefore, they have been included under the module in which they are most used. The technology packages for this project include the following:

- Intelligent fuel management system (FMS): The FMS is composed of the Ready Engineering CoalFusion system and a Sabia elemental analyzer.
- Mercury specie control system: This system includes boiler area optimization, virtual online analyzers, and various sensors. Mercury emissions will be measured through PS Analytical's continuous emission monitors (CEMs).
- Advanced ESP optimization system: The ESP optimization system is composed of a carbon-in-ash virtual online analyzer, a carbon-in-ash sensor, and NeuCo's ESP optimization software.
- Advanced Intelligent Sootblowing System (ISB) system: The ISB system is made up of NeuCo sootblowing optimization software. This module has been previously demonstrated.
- Advanced FGD optimization system: The FGD System is composed of NeuCo's FGD optimization software.
- Intelligent plant system (unit optimization): This system will arbitrate among the solutions for the above systems. It will interface with users through a commercially available computer.

Each technology package includes non-intrusive sensors and the appropriate software needed for data acquisition, optimization, and integration with the overall neural network. In using this approach, all facets of coal-fueled power plant operation will be optimized by balancing the inputs and outputs of the plant within a realm of multiple constraints. The intended result is to improve the efficiency of plant operations while operating within regulatory and commercial constraints.

Project Status

The first of three performance phases has been completed. Phase I consisted of sensor installation, software system design, and baseline operating metric testing. Instruments or instrument technology packages that were installed included Sabia's coal elemental analyzer (part of the fuel management system), mercury sensors from PSA, Triple 5 Industries coal flow sensors, Zolo Technologies' laser-based furnace gas speciation sensors, ABB's online carbon-in-ash sensor, Ready Technologies' fuel blending sensors, communications links for data acquisition and control, and related computers, controllers, and NeuCo optimization products.

Baseline testing was performed to establish comparative data for the operational testing that will follow in Phase 3. After initial baseline testing, parametric testing was performed to exercise various combinations of control variables to determine their effect on mercury speciation and by-product generation and to determine overall plant performance. These data will be used in Phase 2 to adjust the neural network for optimization control.

The project is currently in Phase 2, which consists of software installation, data communications modification, and distributed control system modification. The test plan data and historical data will be evaluated to confirm that no irregularities exist prior to model development. After extraneous data (e.g., calibrations) are eliminated from the data set, operating issues and constraints will be reviewed as part of further model development. Control models will be developed to characterize the effect of control variables on the operational characteristics of the boiler, mercury speciation, and by-product generation. Models will be created that accurately and robustly represent the effects that changes in the unit have on the outputs to be optimized. Before the control models are implemented in an online system, offline simulation will be performed. The models will then be evaluated and demonstrated to Limestone Power Plant operators and engineers so their input can be used to finalize the behavior of the models.

Thus far, distributed control system modifications have been completed and tested to facilitate closed-loop optimization. NeuCo has also configured the optimizers. All optimizers are expected to be installed and, where appropriate, in closed-loop by August, 2008.

Pre-designed and custom methods for constraining the models under various design and operational limitations are being used. These are dynamic constraints that fluctuate with load, number of burners in service, rate of change, etc. After the initial modeling is completed, a shorter series of tests will be conducted. These will involve setting up operational parameters to verify the predictive capabilities of the neural network model and to assure that the model has been properly trained. During this period, the models will be coarse-tuned. Control loops will first be tested one at a time and then as groups to deal with the individual loop characteristics before dealing with the interactive characteristics.

Phase 2 is slated to conclude in December 2008. At that time, a decision will be made whether to initiate work under Phase 3 or to conclude the project after the successful demonstration of closed-loop operability for neural networks and controllers.

Phase 3 plans include demonstration and validation of all systems as well as a comparison of the test results with the project objectives. Extended mercury and multi-pollutant testing will be conducted. The technology packages—the fuel management system, combustion and mercury control system, ESP system, ISB system, FGD system, and intelligent plant system—will all be demonstrated during closed-loop operation. Operator and engineering training will also be conducted during Phase 3.

Next week, our NETL clean coal technology series will focus on optimization software at the Baldwin Energy Complex.

Find this article at:
http://pepei.pennnet.com/Articles/Article_Display.cfm?ARTICLE_ID=329127&p=6

☐ Check the box to include the list of links referenced in the article.