Reducing Mercury via Combustion Optimization and Sorbent Injection

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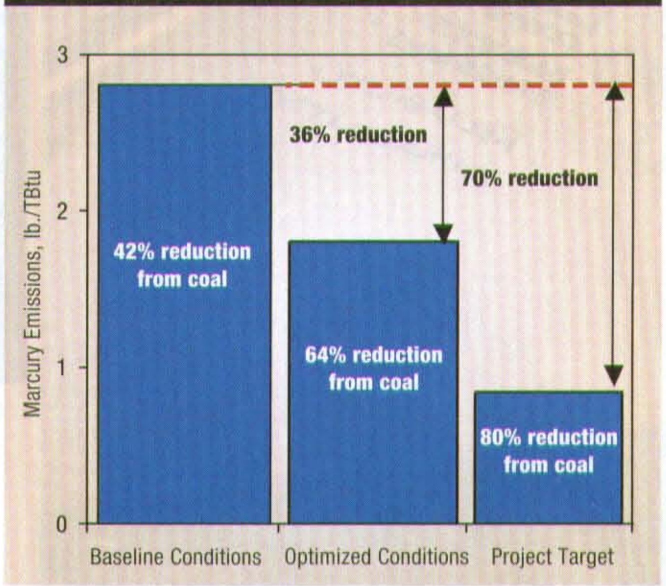
Most utilities using coal-fired power generation are actively seeking efficient, cost-effective technologies for controlling multiple pollutants, including mercury. Activated carbon injection (ACI) is currently one of the most mature mercury control technologies. The cost of mercury control using ACI in electrostatic precipitators (ESP) is dominated by the sorbent cost, which can exceed several million dollars a year for a 500 MW unit. Reducing sorbent requirements by improving "natural" mercury capture by fly ash can potentially reduce costs significantly.

GE Energy developed an integrated multi-pollutant control technology for coal-fired power plants that includes combustion system optimization to improve fly ash reactivity toward mercury. In 2005, the U.S. Department of Energy (DOE), through its National Energy Technology Laboratory (NETL), GE Energy and Progress Energy jointly funded a program to demonstrate GE's multi-pollutant control technology. The technology is designed to increase mercury oxidation and absorption by fly ash (natural mercury reduction) and ACI to further increase mercury removal efficiency. Emissions of nitrogen oxides (NO_x) are also reduced as a result of combustion optimization. This integrated approach has lower requirements for ACI than the traditional approach because combustion optimization improves the fly ash's ability to "naturally" remove mercury. The technology can be tailored to specific unit configurations and coal types, optimizing performance.

The technology evaluation took place in Lee Station Unit 3 located in Goldsboro, N.C. Unit 3, operated by Progress Energy, is a 250-MW opposed-wall fired unit equipped with an ESP that burns a low-sulfur Eastern bituminous coal. The project's technical goal was to evaluate the technology's ability to achieve 70 percent mercury reduction below the baseline emission value of 2.9 pounds per trillion Btu (lb/TBtu). This is equivalent to 80 percent mercury removal from coal. The program consisted of combustion optimization activities to improve natural mercury capture by fly ash, CFD modeling of sorbent injection to define design for sorbent injection lances, short-term sorbent study to define sorbent, sorbent injection rate for long-term testing and a 30-day sorbent injection test.

Figure 1 MERCURY EMISSIONS

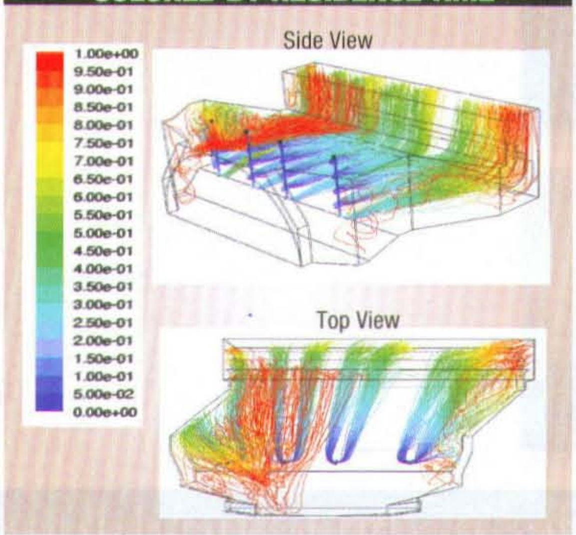


Combustion Optimization

Combustion optimization was the first step in achieving the program objective of 80 percent mercury removal from coal. Combustion optimization goals included improved natural mercury capture by fly ash and reduced NO_x emissions. Combustion optimization included balancing coal flow through individual burners to eliminate zones of carbon-rich combustion, airflow balancing and burner adjustments. As part of this project, the team replaced the original riffle boxes with adjustable riffle boxes to allow for biasing the coal flow to individual burners. A 10-point carbon monoxide/oxygen/nitrogen oxide ($CO/O_2/NO$) sensor grid was installed in the primary superheater region of the back pass to assist in these activities. The grid provided information on special distributions of these species in the back pass. With the original riffle boxes, coal balancing maximum deviation in coal flow varied 22 percent from the average flow.

After personnel installed the new riffle boxes, coal flow balancing maximum deviation was reduced to ±10 percent of

Figure 2 SORBENT TRAJECTORIES COLORED BY RESIDENCE TIME



the average and NO_x emissions were reduced by 10 percent. Through a series of adjustments to the burner air register disks, the variation in the point-to-point grid O_2 measurements was also lowered to 15 percent. As a result of air flow balancing, NO_x emissions were reduced an additional 7 percent, bringing overall NO_x reduction due to combustion optimization to 16 percent.

Mercury emissions testing before and after combustion optimization demonstrated that mercury emissions were reduced from 2.9 lb/TBtu to 1.8 lb/TBtu due to boiler operation improvements provided by combustion optimization, a 36 percent improvement in natural mercury capture by fly ash. Personnel conducted three "Ontario Hydro" tests (the U.S. Environmental Protection Agency's reference method for mercury measurements) at each set of conditions (baseline and optimized). The average natural mercury reduction from coal was about 42 percent at baseline conditions and 64 percent at optimized combustion conditions. Figure 1 demonstrates that these improvements reduced ACI requirements because the 70 percent mercury reduction from the baseline level can be achieved at a lower sorbent injection rate. Figure 1 also illustrates that without combustion optimization ACI must achieve 70 percent mercury reduction. In the absence of SO_3 injection for ESP conditioning (discussed in the sorbent optimization section, below) 70 percent mercury reduction can be achieved at an ACI rate of approximately 10 pounds per million actual cubic feet (lb/MMACF).

Under optimized combustion conditions, mercury emissions are reduced by 36 percent from the baseline level, meaning ACI has to provide only a 53 percent reduction from the 1.8 lb/MMACF emission rate at optimized conditions. This 53 percent reduction in mercury emissions can be achieved at an ACI rate of about 7 lb/MMACF, which represents a 30 percent reduction in the sorbent injection rate when compared with non-optimized combustion conditions.

CFD Modeling of Sorbent Injection

Before the sorbent injection activities began, personnel developed a 3-D computational fluid dynamic (CFD) model to study the flow distribution and sorbent injection in Lee Station Unit 3's post air heater duct. The flow pattern modeling in the air heater demonstrated that the flow after the air heater is severely biased from the south side to the north side due to a bend in the duct. The flue gas temperatures at the air heater exit varied from 250 F to 300 F and the biased temperature distribution was carried out through the duct with the degree of biasing being reduced by thermal diffusion and convection. Personnel designed lances for sorbent injection to improve distribution in the duct by addressing flow biasing. Figure 2 shows the sorbent trajectories in the duct.

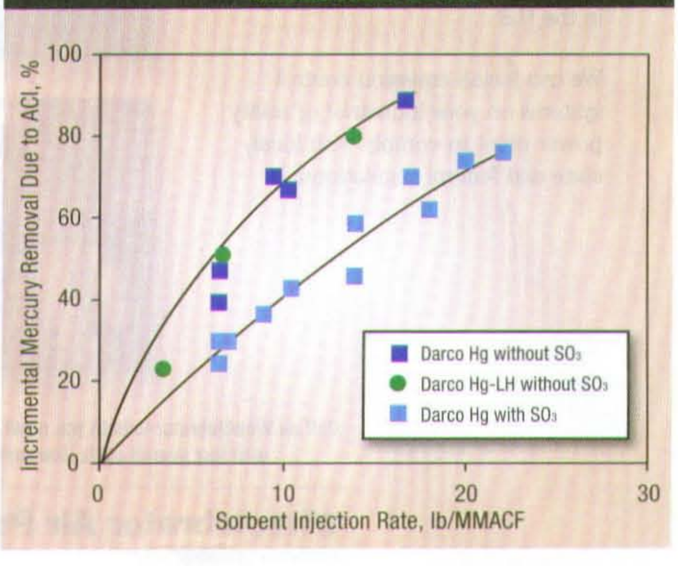
Sorbent Optimization

Personnel conducted one week of sorbent optimization tests to evaluate and select sorbent and to define the sorbent injection rate for the 30-day test. They evaluated two carbon-based sorbents supplied by Norit Americas Inc.: Darco® Hg and Darco Hg-LH. Sorbent optimization tests showed that Darco Hg and Darco Hg-LH performances were about the same in the absence of SO_3 (Figure 3). Tests also demonstrated that SO_3 injection to improve ESP performance decreased sorbent reactivity by 50 percent to 70 percent. The mechanism of sorbent "poisoning" by SO_3 is not clear and needs further investigation. Based on the sorbent optimization tests results, Darco Hg was selected for the 30-day trial. The recommended sorbent injection rate without SO_3 conditioning was 10 lb/MMACF and with SO_3 conditioning was 20 lb/MMACF.

30-day Sorbent Injection Test

The 30-day continuous sorbent injection began on August 21, 2006. Figure 4 shows data on mercury reduction from coal obtained during sorbent injection tests as well as the project target for mercury reduction. At the beginning of the sorbent injection tests, Unit 3 operated with SO_3 conditioning almost 24 hours a day. Figure 4 demonstrates that during that time mercury removal efficiency was below the 80 percent project target. In late August and early September, Unit 3 began operating at a reduced load at night and at mid-load during the day, which reduced the need for SO_3 conditioning. Figure 4 demonstrates that mercury removal efficiency improved to the target 80 percent as the SO_3 conditioning system was operated only part of the time.

Figure 3 COMPARISON OF SORBENT INJECTION DATA

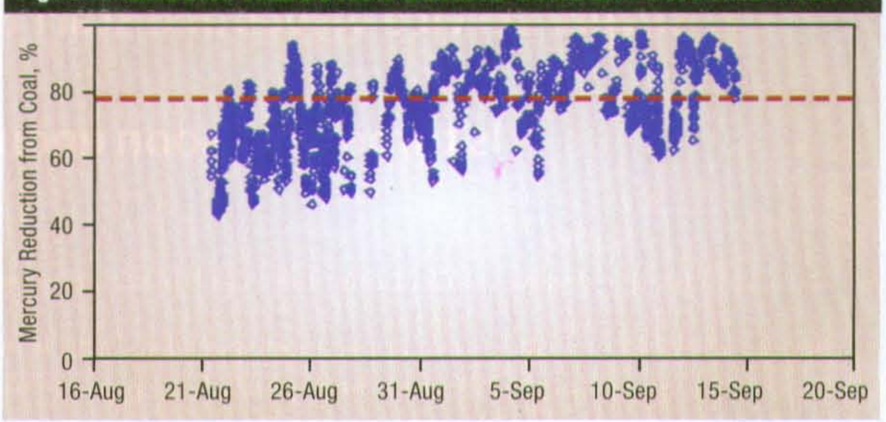


Analysis of Unit 3 opacity data suggested that stack opacity was not affected by sorbent injection.

This project's results demonstrate that combustion optimization can reduce NO_x emissions and decrease requirements for sorbent injection by improving natural mercury capture by fly ash. The degree to which these improvements can be made depends on specific unit configuration, coal type and the degree to which coal and air flows to individual burners can be controlled. The project also demonstrated that sorbent reactivity toward mercury was significantly reduced in the presence of SO_3.

GE Energy performed similar tests with TransAlta, ATCO and EPCOR using combustion optimization at coal-fired utility plants in Alberta, Canada that use sub-bituminous coal. GE Energy planned to release the results in early to mid-March 2007. **pe**

Figure 4 MERCURY REDUCTION DURING SORBENT INJECTION TEST



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