RESEARCH SHOWS MERCURY CAPTURE ENHANCED BY BOILER TUNING

With EPA preparing to issue regulations on control of mercury emissions from coal fired boilers and some states having already issued mercury regulations which will go into effect in the near term, power generation companies with coal-fired boilers are beginning to consider their options for mercury control. The Energy Research Center has been developing an approach for mercury control which relies, in part, on tuning the boiler to enhance mercury capture on fly ash. Results of recent full-scale tests indicate boiler tuning can significantly reduce the costs of mercury control. The project team is led by Dr. Carlos Romero and includes Drs. Harun Bilirgen and Nenad Sarunac, along with graduate students from Chemical Engineering and Mechanical Engineering and Mechanics.

At combustion temperatures, Hg is present as elemental vapor. However, due to processes which occur naturally in the boiler, by the time the flue gas reaches the back end of the boiler, some of the Hg is present in an oxidized gaseous state and some as particulate bound Hg. While elemental Hg is extremely difficult to capture, oxidized Hg is more readily adsorbed by fly ash, and thus it can be removed in scrubbers, electrostatic precipitators and fabric filters.

According to Romero, “The degree of oxidation of Hg in boiler flue gas is affected by coal type and composition, boiler design, type of environmental control equipment, fly ash characteristics and boiler operating conditions. Published data indicate that chlorine concentration is the single most important variable with respect to influencing Hg oxidation and removal in coal fired boilers. However, computer simulations performed at the ERC and recent test results obtained by the Lehigh team show that selection of the proper boiler operating settings can also play a significant role.”

“Over the past year, we have carried out tests at three pulverized coal-fired boilers to determine the extent to which Hg oxidation and capture can be influenced by modifying boiler control settings. The testing also documented the simultaneous impacts on parameters such as heat rate, NOx, and fly ash unburned carbon. Two of the boilers are of tangential design and one is wall-fired. All three have either conventional or low NOx firing systems and electrostatic precipitators for fly ash capture. None of the three is equipped with either SCR for NOx control or a flue gas SO2 scrubber. One unit fires an Eastern Bituminous coal and the other two fire an imported coal which has high mercury and low chlorine content.”

The mercury measurements were made by a team from Western Kentucky University using semi-continuous Hg analyzers and the Ontario Hydro Method. These provided both elemental and oxidized Hg concentrations in the flue gas at
various locations along the gas path, starting in the economizer exit gas duct and continuing to the stack. Some measurements, made with normal or baseline operating conditions, gave results on the measured baseline mercury emissions and the extent to which they are affected by changes in coal quality and measurement uncertainties. The majority of the tests were carried out to measure the effects of changes in combustion parameters, air preheater cold end temperature, boiler cleanliness, electrostatic precipitator operation, and load on mercury oxidation and capture.

Romero continues, “Our test results show that changes in combustion conditions that result in higher levels of fly ash unburned carbon also result in lower mercury emissions. This can be achieved, for example, by reducing furnace O$_2$ level, modifying the distribution of secondary air and coal to the burners, and increasing coal particle size leaving the pulverizers. We found that, as an additional benefit, the factors that result in increased mercury capture also tend to reduce NO$_x$ emissions.”

“Our test results also show that changing the temperature profile along the flue gas path by reducing the air preheater gas exit temperature had a beneficial effect on mercury capture. Modifications to the operation of the electrostatic precipitators were also found to be extremely helpful.”

Complete boiler optimizations were carried out at two of the three units tested by the Lehigh team, and the results showed reductions in mercury level at the stack in the range from 60 to 70 percent. Emissions reductions of this magnitude will be sufficient for satisfying the proposed Federal Hg regulations for many units, at least in the near term. In other cases, boiler tuning, in combination with activated carbon injection, is likely to be the low cost compliance option.

Romero adds, “To explore this option, testing at two of the three boilers also included the combined effects of boiler optimization and activated carbon injection on mercury emissions. The results showed that at low rates of activated carbon injection, the effects of the boiler tuning and AC injection were additive, with both causing some of the reduction of mercury emissions. At high rates of activated carbon injection, the activated carbon accounted for most of the mercury capture, with boiler optimization providing very little additional mercury capture benefits.

The advantage of the combined approach is that less activated carbon will be needed, and this can result in significant dollar savings. Typical activated carbon compliance costs are estimated to add up to 5 mils/kWh. In contrast, a strategy of mercury control for a 250 MW unit that results in a 50 percent reduction in mercury emissions through boiler optimization and the rest through activated carbon injection will reduce the cost of compliance by more than one million dollars per year.”

Romero concludes, “The studies we’ve made on these first three boilers have taught us a lot about the factors which affect mercury capture and have also given us good insight into how to obtain reliable mercury measurements and how to generate meaningful data on baseline mercury emissions. We’ve also learned a lot about the impacts of boiler optimization and activated carbon injection on mercury emissions. We hope to be able to carry out additional field trials to determine how much emissions can be reduced with boilers of other designs and with boilers which fire other kinds of coals. We found boiler tuning, in combination with sorbent injection, to be a low cost option for certain situations, and we look forward to being able to investigate the synergies between these two mercury compliance techniques in much more detail. We certainly welcome inquiries from power generation companies concerned about how to control mercury emissions at their plants.” #
RESEARCHERS’ PROFILES

- **Dr. Harun Bilirgen** has a Ph.D. in Mechanical Engineering and is a Research Scientist in the Energy Research Center. One of his research specialities is the fluid mechanics of gas-particle flow systems.

- **Dr. Carlos Romero** is an Associate Director of the Energy Research Center with a Ph.D. in Mechanical Engineering. He is a specialist in combustion kinetics and emissions control.

- **Dr. Nenad Sarunac** has a Ph.D. in Mechanical Engineering and is an Associate Director of the Energy Research Center. His research focuses on power plant heat rate improvement, emissions control and process optimization.