Engineers develop a laser solution to power plants slowed by slagging

September 9 2008

Quietly, and with little of the fanfare accompanying the relentless surge in gasoline costs, the price of coal has doubled in less than a year.

The reasons are varied. Worldwide demand for coal is growing sharply. Bad weather has hampered production in Australia and China. Shipping problems have slowed exports from Australia and South Africa.

Because coal-fired power plants produce half the electricity in the U.S., the spike in prices has increased utility bills in some states, just as consumers are already coping with rising food and gas prices.

The climbing coal costs are also giving power plants owners an incentive to innovate, says Carlos Romero.

Romero is associate director of Lehigh's Energy Research Center, which in 30 years has gained renown for, among other accomplishments, solutions that enable power plants to run more efficiently and cleanly.

In the past two years, Romero has worked with the Energy Research Co. (ERCo) of Staten Island, N.Y., to develop an optical technology that would allow power plant operators to make rapid adjustments to prevent boiler slagging and fouling problems.

Slagging occurs when coal ash accumulates, at high temperatures, outside the tubes that carry steam inside a power plant boiler. Slagging reduces heat transfer from the flue gas to the steam tubes and decreases a plant's efficiency. In extreme cases slagging can require a boiler to be shut down while heat transfer surfaces are cleaned or repaired. According to a report by the Electric Power Research Institute, slagging and associated problems cost coal-fired power plants $2.4 billion each year.

An instant and critical analysis

The ERC and ERCo have applied a technique called laser-induced breakdown spectroscopy, or LIBS, to provide instant analysis of the elemental composition of the coal being burned and correlation of the fusion temperature of the coal ash, which is affected by the ratio of the elemental ingredients.

The project was funded by the U.S. Department of Energy (DOE) through the New York State Energy Research and Development Authority.

The LIBS system uses a pulsating laser with two frequencies, one infrared (IR) and one visible light. The laser vaporizes a sample and gives a distinct elemental signature represented by intensity and wavelength. From these data, a software package containing artificial neural network models estimates ash fusion temperature and predicts coal slagging potential.

Traditional techniques for measuring coal composition and ash fusion temperature require operators to remove a sample from a boiler and test it in a lab, which can take up to three days. LIBS provides instantaneous data without interrupting the process.

Operators also have the option of taking the measurements with a nuclear analyzer that uses gamma rays. But the analyzer has a large footprint, says Romero, and is potentially hazardous. LIBS is the size of a table top and is relatively safe to use.

The LIBS system was verified in lab experiments and then tested at Brayton Point Station, a 1,150-MW coal-fired power plant in Somerset, Mass.

"Our results have been very positive," says Romero. "LIBS analyzes coal composition accurately and with good repeatability. It also predicts ash-fusion temperature accurately, with results that compare very favorably with the results obtained using the American Society for Testing Materials' (ASTM) standards."

More options for plant operators

The problems addressed by LIBS, says Romero, have been aggravated by changes in coal-buying patterns triggered by coal's growing cost.

Coal contains up to 10 component elements, including iron, aluminum, sodium and calcium. The ratios of these elements vary from one coal mine to the next and even among different seams from the same mine. These ratios affect ash fusion temperature, as some mineral compositions are more susceptible than others to high-temperature slagging.

"A ship or cargo can deliver 100,000 tons of coal at a time to a plant," says Romero. "Even if all of the coal comes from the same mine, it can come from different seams within the same mine, with each seam producing coal with a different composition.

"These difficulties are compounded when coal comes from different countries, which is becoming the case more and more as rising costs force plant operators to buy coal on the spot market to get the cheapest price."

The Brayton Point Station is a case in point, burning Eastern U.S. bituminous coal along with a variety of coals from Colombia and Venezuela.

"The variability in coal feedstock at Brayton Point poses a significant challenge to the station," Romero wrote in a report coauthored with Ricardo Moreno and Zheng Yao. Moreno recently earned his M.S. in mechanical engineering from Lehigh. Yao is a researcher with Lehigh's Energy Research Center.

Because some of the coals burned at Brayton Point are susceptible to slagging, the station must sometimes take corrective action "on a retroactive basis," the report said.

The results from the tests at Brayton Point showed that LIBS analyses performed once an hour could provide sufficiently accurate feedback on ash fusion temperatures to enable boiler operators to take remedial steps in real time, the report said.

Those steps can include minor adjustments to boiler operations, such as increasing combustion air supply. Operators can also decide more quickly and more intelligently when to blend good and bad ash, when to mix different types of coal, and when to route low-quality coal to a higher-performing boiler.

"LIBS would enable us to do a test online with the same accuracy as a three-day lab test while meeting ASTM standards," says Romero. "Any problem we detect can be corrected in real time.

"This will be a tremendous help to the utility industry. We get a lot of phone calls from utilities that are struggling because a supplier switched fuels and they have to blend fuels because of slagging."

Source: Lehigh University

Citation: Engineers develop a laser solution to power plants slowed by slagging (2008, September 9) retrieved 11 May 2024 from https://phys.org/news/2008-09-laser-solution-power-slagging.html