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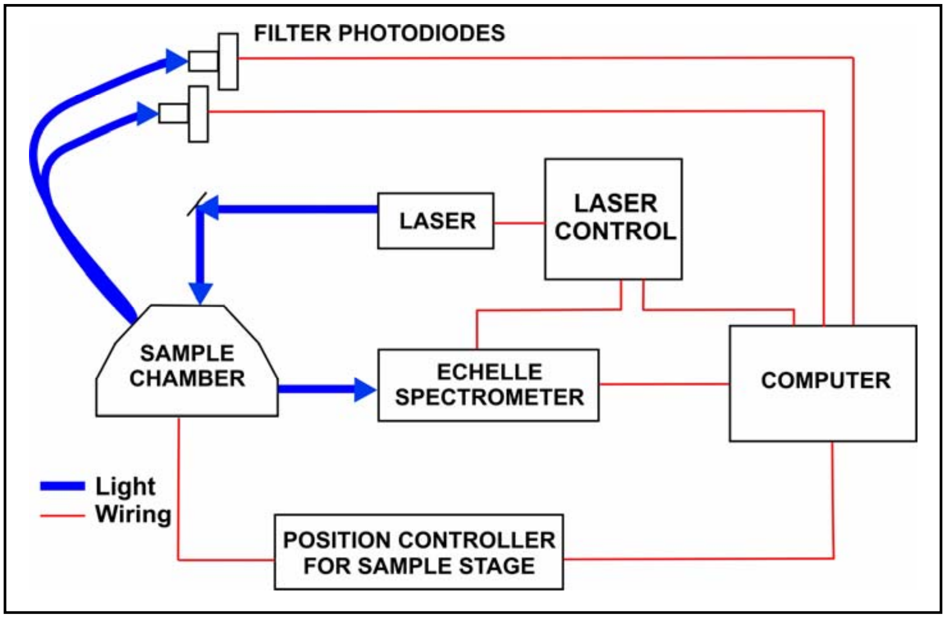
LASER MEASUREMENT OF COAL ASH COMPOSITION DEMONSTRATED AT POWER PLANT

The Brayton Point power plant in southeastern Massachusetts fires a range of coals, including bituminous coals from the eastern U.S. and South American coals from Colombia and Venezuela. Some of these coals have mineral compositions which are susceptible to high temperature slagging, and the resulting variability in coal feedstock causes difficulties for the station, sometimes forcing it to take remedial actions on a retroactive basis to mitigate the impacts of coal ash slagging. Carlos Romero of Lehigh's Energy Research Center is collaborating on a project to develop a laser-based measurement system, which promises to become a valuable tool for predicting the onset of slagging conditions in coal-fired boilers. The research project team includes Romero, Ricardo Moreno and Zheng Yao from the Energy Research Center and investigators from the Energy Research Company of Staten Island, New York, led by Robert DeSaro.

Romero explains, "We are using a measurement technology referred to as Laser Induced Breakdown Spectroscopy (LIBS) along with neural network techniques to determine the composition of the coal ash and relate the composition measurements to ash slagging potential. The LIBS System consists of a pulsating laser, sample chamber, optical spectrometer and photodiodes, amplifier unit and a processing computer. The laser vaporizes a small portion of the coal sample, and the resulting measured emission spectrum provides an indication of the wavelengths of the elements which were present in the coal sample. The measured wavelengths are then used to identify the elements and their relative concentrations. The following elements can be measured with the type of spectrometer used in the system: Al, Ca, Mg, Na, Fe, Si, and Ti.



Schematic of LIBS System Used for Coal Mineral Composition Analysis

The LIBS measurement system is extremely fast, with data from a coal sample collected in a matter of seconds. The project team performed laboratory tests on a set of 16 coals assembled from coal-fired power plants and having a range of slagging issues. These samples were also analyzed independently for ash minerals and ash fusion temperatures using standard ASTM methods. Calibration curves were developed to relate LIBS signal output to the amount of each element present as determined by the ASTM tests.

We then used neural network models to relate the mineral composition measured by LIBS to the initial ash deformation temperatures obtained from the ASTM tests. Initial ash deformation temperature is often used as an indicator of the onset of slagging, and we expect the LIBS system to provide us with a signal which, when compared to the gas temperatures at the furnace exit, will indicate whether the coal being burned will cause slagging problems on the waterwalls or on heat exchangers at the high temperature end of the boiler."

Tests were performed at Brayton Point Station in which coal samples were collected manually from the pulverizers and coal pipes and analyzed in the LIBS system. These tests were performed using three different coals from the U.S. and South America. The resulting neural network predictions of ash deformation temperatures were within close agreement with deformation temperatures measured by the ASTM tests. The graph shows a comparison of the LIBS acquired temperatures with those obtained from the ASTM analyses and with fusion temperatures provided by the coal delivery certificates. These results demonstrated that LIBS coal analyses performed on an hourly basis would be capable of providing feedback on ash deformation temperatures with sufficient resolution to alert the station personnel to changes in as-fired coal quality. By having a timely warning that the slagging potential of the coal ash has

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changed, the boiler operators would be in a position to take actions to adjust the furnace exit gas temperature or initiate a more aggressive waterwall or leading edge superheater sootblowing. Depending on the boiler, these adjustments might involve parameters such as fuel air ratio, burner tilt angle, air register setting, and mill loading patterns.

Romero continues, “We are now working on automating the LIBS measurement system by combining the instrument with an automatic coal sampling system. We also plan to develop intelligent computer software which would provide advice to the Station personnel on the actions they might take to adjust the boiler control settings to compensate for a measured change in coal ash fusion temperature. We are also interested in performing additional power plant field trials of LIBS with manual coal sampling to verify that it can measure initial ash deformation temperature for a much wider range of coal properties.”

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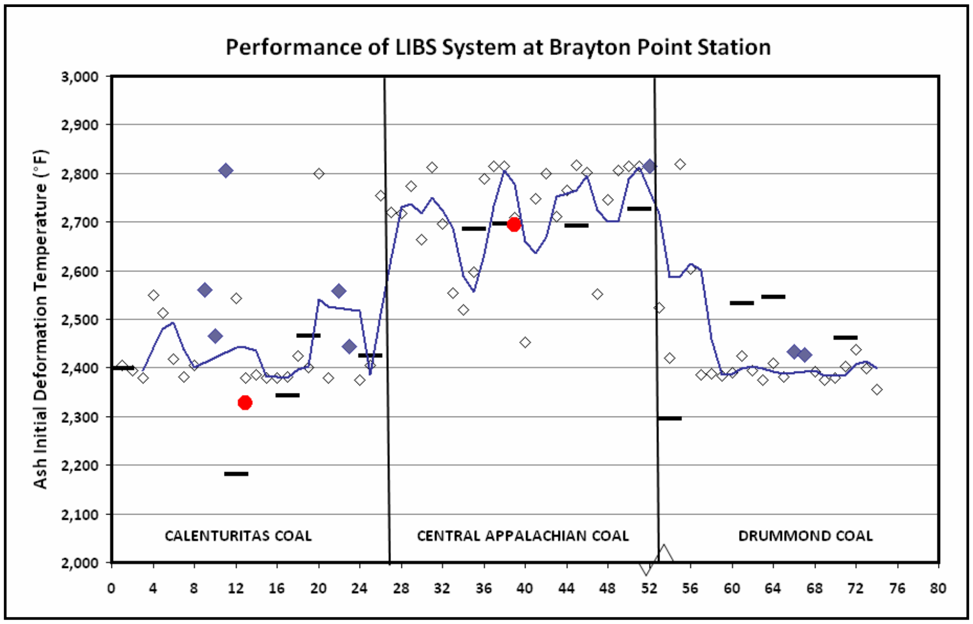

Predicted and Measured Initial Deformation Temperatures – Brayton Point Tests [◊ LIBS (Conveyor Belt Samples); ♦ LIBS (Coal Pipe Samples); ▬ ASTM Analysis; ● Coal Certificate (ASTM); —— Moving Average]

RESEARCHERS’ PROFILES

- ***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.
- ***Zheng Yao*** is a Research Scientist at the Energy Research Center and he has a MS degree from Lehigh University in Mechanical Engineering.
- ***Ricardo Moreno*** is studying for an MS degree in Mechanical Engineering at Lehigh University.
- ***D. Gary Harlow*** is Professor of Mechanical Engineering and Mechanics (MEM) and Chair of the MEM Department. His research interests encompass stochastic modeling and fracture mechanics, addressing topics such as the modeling of failure processes in aluminum alloys, steels, and composites, and mechanical and system reliability.
- ***Terry Delph*** is Professor of Mechanical Engineering and Mechanics. He is a specialist in high temperature creep phenomena in structural steels.
- ***Murat Ozturk*** is a Research Engineer in Mechanical Engineering and Mechanics with a Ph.D. in Mechanical Engineering. His research interests are in computational mechanics involving elastic and plastic deformations and stresses.