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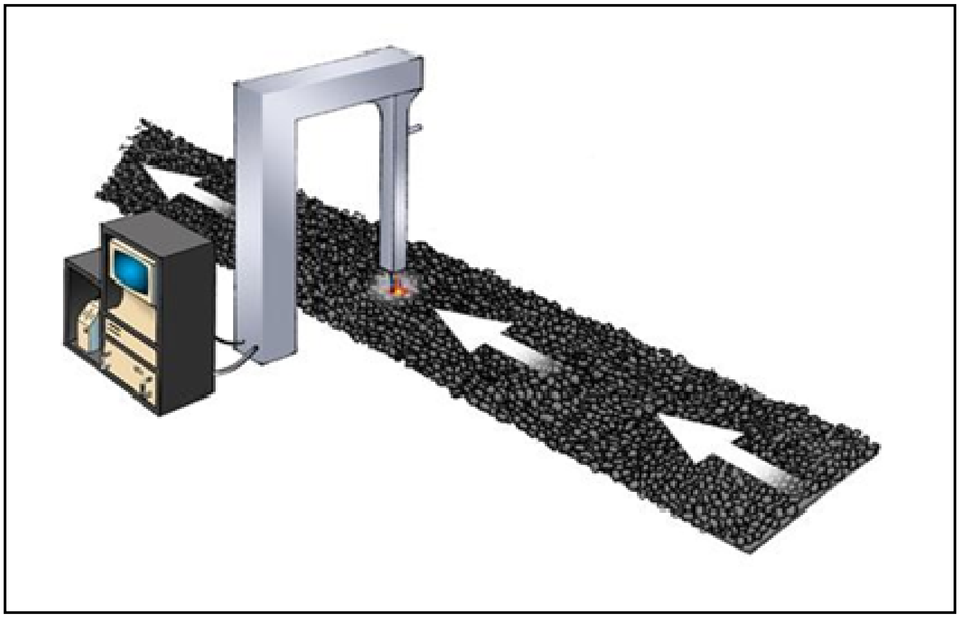
# ON-LINE LASER MEASUREMENT OF COAL PROPERTIES DEMONSTRATED AT POWER PLANT

Coal-fired power plants, which experience frequent changes in coal quality due to inherent variations in coal composition, switching of coal suppliers and/or coal blending, are subject to unexpected changes in coal higher heating value, moisture, ash content and amounts of specific elements in the coal such as sulfur. This can lead to operational difficulties due to factors such as changes in furnace and convective pass slagging/fouling patterns and changes in emissions. Carlos Romero of Lehigh's Energy Research Center and Robert De Saro from the Energy Research Company of Staten Island, New York, have been leading a research effort to develop a laser spectroscopy approach for on-line coal analysis. Their joint University-Industry team has just completed the successful deployment and testing of a commercial on-line coal property measurement system at PPL's Montour Power Station.

Romero explains, "We are using a measurement technology referred to as Laser Induced Breakdown Spectroscopy (LIBS) along with artificial intelligence techniques to determine the composition of the coal ash and relate the composition measurements to parameters such as ash slagging potential and higher heating value. The LIBS System consists of a pulsating laser, optical spectrometer, supporting optics and a signal processing computer. The laser vaporizes a small portion of the coal sample, and the resulting measured emission spectrum provides an indication of the relative intensities and wavelengths of the elements which were present in the coal sample. The measured wavelengths and their intensities 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, C, Ca, K, Mg, Na, Fe, S, Si, and Ti."



*Schematic of LIBS Measurement System Mounted Above Conveyor Belt.*

The LIBS measurements, which are made on the coal belt, are extremely fast, with data from a coal sample collected in a matter of seconds. However, a much larger number of data points are typically collected to improve the accuracy of each measurement. The measurement system is supported by computer software which allows real-time display of coal properties and provides expert advice to boiler operators for coordination of coal yard operation and modification of boiler operating conditions for efficient fuel combustion and mitigation of slagging and fouling.

Although the project team had demonstrated the ability to use the LIBS technique to measure coal properties at a power plant in 2008 (see Lehigh Energy Update, Vol. 26, No. 2, July 2008), the coal was sampled manually and the LIBS measurements and the artificial intelligence analyses of the LIBS data were made off-line. The recent demonstration at Montour Station involved a fully automated deployment of a full-scale, calibrated LIBS instrument and supporting software, where the coal measurements were made on one of the coal transfer conveyor belts between the coal crusher and the coal bunkers.

PPL's Montour Station is located in Washingtonville, Pennsylvania. The plant, which has two 775 MW coal-fired units, fires bituminous coals which arrive via rail trains from a range of suppliers. An important problem with the plant feedstock is fuel variability and delay in obtaining fuel analysis from the on-site laboratory, especially when up to 50 percent of the unloaded coal goes directly to the boilers. Montour faces the increasingly difficult job of maximizing unit generation, while accessing a large number of suppliers to offset the increasing cost of fuel, and maintaining good unit availability by mitigating the undesirable impacts of fuel quality on unit operation.

Evaluation of the LIBS System at Montour Station took place from January to March 2011. Seventy-three hours of run time were conducted with the LIBS System in service to evaluate measurement accuracy and repeatability of the analyzer and associated software in determining iron and sulfur content, coal heating value, and initial deformation ash fusion temperature. Iron is of interest since elevated concentrations of this element promote reductions in minimal ash fusibility temperatures. Sulfur is of interest since the power plant FGD scrubbers require sulfur content for optimal cost-effective operation.

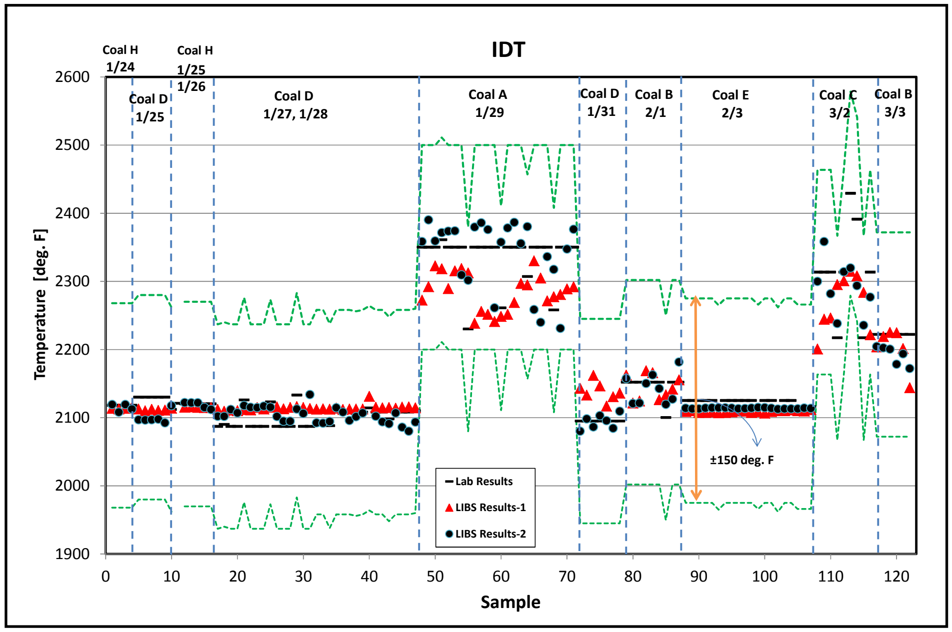
Validation tests were performed with the six bituminous coals most commonly fired at Montour to evaluate the accuracy of the on-line coal analyzer, as well as to identify limitations of the system under dynamic conditions. The validation tests consisted of grabbing reference coal samples using a conventional method, followed by ASTM laboratory analysis and then comparing the laboratory results with data collected and analyzed by the LIBS system. A statistical analysis performed on the data and the results, expressed in terms of the root mean squared difference (RMSD) between the reference and analyzer values, shows close agreement. (see Table).

De Saro adds, “With funding from DOE, the Energy Research Company and the Energy Research Center will be conducting a full-scale on-line demonstra-tion of LIBS technology in 2012 at Dayton Power & Light’s Stuart Station.

**LIBS Measurement Accuracy**

| | RMSD Accuracy |
|---|---|
| Iron (%) | 1.07 |
| Sulfur (%) | 0.14 |
| Fusion Temp. (°F) | 33.16 |
| Heating Value (Btu/lb) | 75.86 |

This application will evaluate the capabilities of LIBS to confirm the specifications of the incoming coal and to help achieve cost efficient blending of low quality Illinois and Central Appalachia coals. Other LIBS applications currently underway include the use of LIBS for biomass characterization (funded by the New York State Energy Research and Development Authority) and demonstra-tion of the capabilities of LIBS to measure slagging temperature from coal elemental composition measurements for gasification applications (funded by the Electric Power Research Institute). ■




*On-Line LIBS Data and Laboratory Results for Ash Fusion Temperature. Spread in Laboratory Results Reflects Uncertainty in ASTM Values of Fusion Temperature.*

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- ***John DuPont*** is Professor in the Materials Science & Engineering Department and Associate Director of the Energy Research Center. His research interests are in welding, corrosion, and alloy development.
- ***Carlos Romero*** is a Principal Research Scientist and Associate Director of the Energy Research Center. He is a specialist in combustion kinetics and emissions control.
- ***Robert De Saro*** is President of the Energy Research Company. He specializes in laser measurements of coal and other industrial applications.