RESEARCH DEMONSTRATES BENEFITS OF DRYING WESTERN COAL

Over the last several decades, the US electric utility industry has come to rely, increasingly, on Powder River Basin coals (PRB) and lignite for electric power generation. This increase in the use of these fuels stems, in part, from their being relatively inexpensive and low in sulfur. However, both types of fuel are high in moisture—25 to 40% for lignite and 15 to 30% for PRB—and this results in significantly lower boiler efficiencies and higher unit heat rates than occur with higher rank coals. The high moisture content can also lead to problems in areas such as fuel handling, grinding, and fan capacity. Research being conducted on lignite drying by the Energy Research Center for Great River Energy Corporation (GRE) shows that the value of lignite can be significantly enhanced and the quantities of stack emissions substantially reduced by reducing the amount of moisture in the lignite feedstock. Similar benefits are expected for PRB coal, if it is partially dried before it is burned.

The Lehigh effort is headed up by Drs. Nenad Sarunac and Edward Levy; while Charles Bullinger and Mark Ness, who are with GRE’s Coal Creek Station, are in charge of the project for Great River. Coal Creek has two units with total gross generation exceeding 1,100 MW. The units fire lignite containing approximately 40 percent moisture and 12 percent ash. Both units at Coal Creek are equipped with low NOx firing systems and have wet scrubbers and evaporative cooling towers.

According to Levy, “It is widely recognized that there are performance and operational penalties associated with using high moisture fuel. Despite this, the practice of thermal drying of coal is...
not in widespread use because of the perception that the cost of the drying process outweighs the benefits. One of the approaches being considered by Great River Energy, which we believe solves that problem, involves use of thermal energy from the hot circulating water leaving the condenser to provide the heat for drying. As shown in the sketch, ambient air, heated to 110°F by the hot circulating water, is used to fluidize the coal in the coal dryer. Simultaneously, 120°F water from the condenser is circulated through tubes in the dryer to provide the bulk of thermal energy needed for drying. Besides improving unit performance and reducing stack emissions, this also reduces the flow rate of makeup water needed for the cooling tower which would be an important benefit for some stations.”

Sarunac adds, “With assistance from Dr. Hugo Caram, professor of Chemical Engineering, Dr. Levy and I performed theoretical analyses to estimate the impact on cooling water makeup flow of using hot circulating water to the cooling tower to heat the drying air and to estimate the magnitude of heat rate improvement and emissions reductions that would be achieved at Coal Creek Station by removing a portion of the fuel moisture. The results show that drying the coal from 40 to 25 percent moisture will result in reductions in makeup water flow rate from 5 to 7 percent, depending on the season. The analysis shows the heat rate will be reduced by about 5 percent due to a lower stack loss and reduced fan and mill power requirements. The CO$_2$ and SO$_2$ mass emissions will also be reduced by about 5 percent due to the lower unit heat rate.”

A coal test burn was conducted at Coal Creek Unit 2 in October 2001 to determine the effect on unit operations. Approximately 12,000 tons of lignite were dried for this test by an outdoor stockpile coal drying system. On average, the coal moisture was reduced by 6.1 percent, from 37.5 to 31.4 percent. Analysis of boiler efficiency and net unit heat rate showed that with coal drying, the improvement in boiler efficiency was approximately 2.6 percent, and the improvement in net unit heat rate was 2.7 to 2.8 percent. These results are in close agreement with theoretical predictions. The test data also showed the fuel flow rate was reduced by 10.8 percent and the flue gas flow rate was reduced by 4 percent. The combination of lower coal flow rate and better grindability combined to reduce mill power consumption by approximately 17 percent. Fan power was reduced by 3.8 percent due to lower air and flue gas flow rates. The average reduction in total auxiliary power was approximately 3.8 percent.

Great River Energy is now in the process of designing a fluidized bed lignite drying system for Coal Creek Station. To provide the data needed to design the system, Levy is heading up an experimental investigation into the effects of fluidizing velocity and bed design parameters on rate of in-bed heat transfer and rate of drying of lignite. These experiments, performed in the Center’s Fluidized Bed Laboratory, are being carried out by DeShau Huang, a Ph.D. student, and Eric Hahn and Chris Lightcap, Mechanical Engineering undergraduate students.

According to Levy, “There are several parameters which are critical to the design of the lignite dryers for Coal Creek. For example, the velocity of the fluidizing air affects things such as heat transfer, intensity of solids mixing, rate of drying, and the percentage of the lignite particles which are entrained from the bed and transported to cyclones for capture. Because of this, air velocity affects the overall bed dimensions, size of the in-bed heat exchanger and design of the downstream particle collection system. My team of students is performing experiments in a 6” diameter bed using crushed lignite obtained from Coal Creek Station. The data we are obtaining is being used to set the parameters for the full-scale prototype dryer being developed by Mark Ness and his design team from GRE.”

Sarunac adds, “We believe this drying concept has tremendous potential for the electric utility.
industry. Based on our theoretical studies of the impacts of drying on performance and emissions, and the results of the 2001 field test at Coal Creek, we have become convinced that this is a technology with huge potential benefits. The heat rate improvements we are seeing are quite substantial, and these result in significant reductions in emissions. Furthermore, results from our laboratory experiments on fluidized bed drying, and the results of GRE's analysis of the economics of drying, show that it is definitely an economically attractive approach. Quite obviously, we will be very interested in the full scale drying data which will be generated by Coal Creek after the prototype fluidized bed dryer has been built and is placed into operation.”