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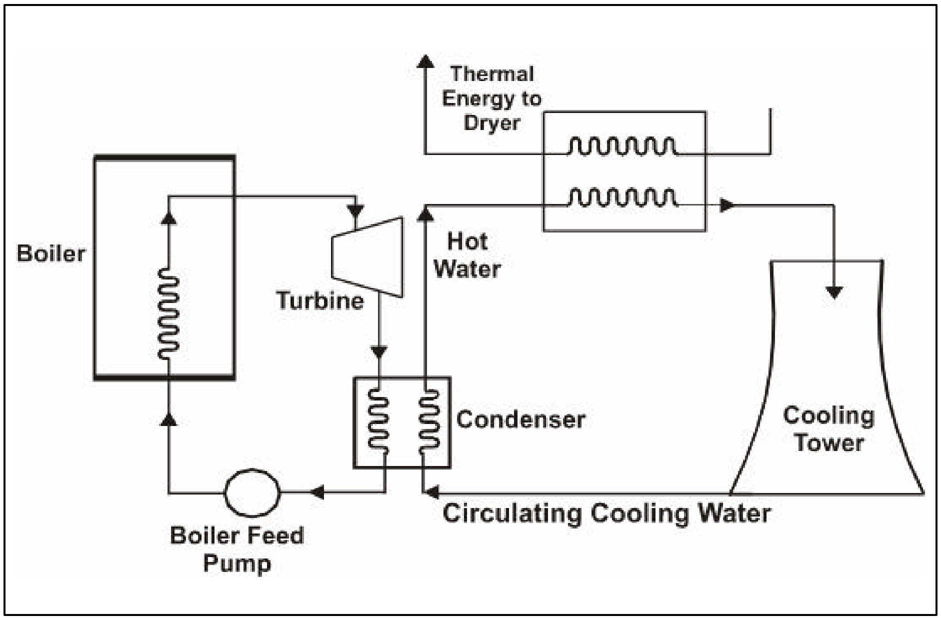
USE OF POWER PLANT WASTE HEAT TO REDUCE COAL MOISTURE PROVIDES PLANT PERFORMANCE AND ENVIRONMENTAL BENEFITS

In recent years, subbituminous coal from the Powder River Basin and lignites from Texas and North Dakota have captured an increasing share of the power generation market involving pulverized coal-fired power plants. However, these coals contain relatively large amounts of moisture, which affect unit performance, stack emissions and plant maintenance costs. The moisture also results in fuel handling problems. The Energy Research Center has just completed a research project for DOE's National Energy Technology Laboratory (NETL) which shows that use of power plant waste heat to reduce coal moisture before pulverizing the coal can result in improved operations, reduced emissions, and reduced makeup water requirements for evaporative cooling.



This Drying System Uses a Combination of Thermal Energy from Boiler and Condenser Cooling Water as the Heat Source for Coal Drying

The coal drying project, which was cofunded by Great River Energy, was led by Edward Levy and Nenad Sarunac. Other Lehigh participants included Hugo Caram, Harun Bilirgen, James Yao, David Wei, Gu Feng, Ursla Levy and John Sale.

The project involved laboratory coal drying studies to gather data and develop models on the factors which control the rates of drying. In addition, analyses were carried out to determine the relative costs and performance impacts of coal drying and develop optimized drying system designs.

Levy explains, "The first group of tasks involved coal drying experiments in our laboratory using a laboratory-scale fluidized bed dryer. North Dakota lignite and PRB coals were first crushed and then dried in the fluidized bed using various combinations of particle size, flow rate, relative humidity and temperature of the fluidization air, heat flux from an in-bed heater and bed depth. The results showed that coal moisture can be reduced to less than one-half of that in the as-received coal with relatively short coal residence times in the fluidized bed dryer. Rates of drying of lignite and PRB coals were found to be roughly the same order of magnitude, but with slightly higher drying rates for lignite."

Sarunac continues, "We then performed analyses for a 550 MW pulverized coal power plant equipped with a coal drying system. The drying system configurations we considered utilize various combinations of thermal energy from the boiler and heat rejected by the steam condenser for coal drying. These analyses provided us with data on the effects of coal drying system design and degree of drying on unit heat rate, station service power, stack emissions and makeup water requirements for the evaporative cooling towers.

Results for both lignite and PRB coals showed that as the coal product moisture is reduced, boiler efficiency increases, net unit heat rate decreases and the feed rate of cooling tower makeup water decreases. In the case of a lignite drying system which results in a 20% decrease in coal moisture using a combination of waste heat from the condenser and heat from the boiler we obtained a 3% improvement in boiler efficiency, a 3.3% improvement in net unit heat rate, and a 3.3 % reduction in emissions such as CO_2 and SO_2. The analysis also

("Coal Moisture" Continued from P. 1)

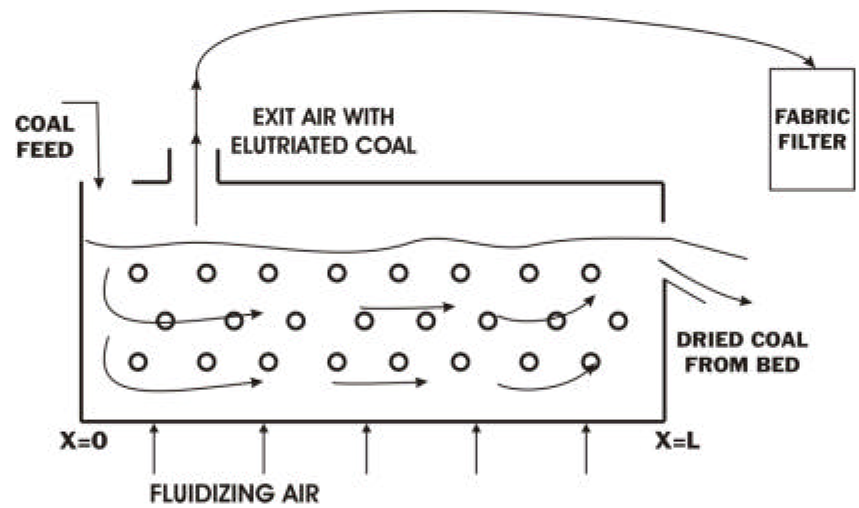
predicted a $2x10^5$ gallon per day reduction in cooling tower makeup water.

Coal drying was found to have both positive and negative effects on station service power. Pulverizer power and the power needed for the forced draft and induced draft fans both decreased, while additional power was needed to drive the fans for the fluidization air."

Levy continues, "We then performed cost-benefit analyses to determine the effects of drying system design and degree of drying on the return on investment. On the cost-side, the analyses considered the annual costs of installed equipment, operation and maintenance costs, and the cost of any increases or reductions in station service power. The savings included reductions in fuel costs and ash disposal costs resulting from the improvement in heat rate. Credit was taken for the reductions in stack emissions occurring due to improved heat rates and reductions in cost of makeup cooling water. Finally, savings due to reduced maintenance costs and reduced lost MW generation due to mill maintenance problems were estimated.

The results show that the cost effectiveness of the technology increases as the coal product moisture decreases. For the specific coal drying system configuration we analyzed and for an annual interest rate of 7.5%, the break even point was estimated to occur at 16% coal moisture reduction. The Return on Investment was then found to increase linearly to 21% at 19% coal moisture reduction.

Quite obviously, the costs of coal drying will depend heavily on site-specific factors, and detailed analyses would be needed to determine the most cost effective design for a particular application. All the analyses performed in our study are for retrofit applications. However, a comparable study should be performed for new plant designs. Potential savings from matching boiler design and mill, fan, ESP and scrubber capabilities to a lower as-fired moisture may very well lead to substantial additional reductions in installed equipment costs."



Sketch of Continuous Flow Fluidized Bed Coal Dryer

Sarunac adds, "We've also been working with Great River Energy (GRE) on GRE's lignite drying demonstration project at the Coal Creek Station in North Dakota. With partial funding from DOE's Clean Coal Power Initiative (CCPI) Program, a GRE-led team (which included participation by ERC researchers) designed and built a 100 ton/hour fluidized bed dryer. GRE has been operating that dryer since early in 2006. The design and operating conditions of the GRE dryer are based, in part, on the laboratory drying results we'd obtained and the system analyses we'd performed in our just-completed DOE Project. Most recently, we've also been analyzing GRE field data on dryer performance and on the effects of dryer operations on plant performance. The dryer performance results are extremely positive. Based on these results, GRE plans to install sufficient additional dryer capacity to dry all the coal fired in Unit 2 at Coal Creek Station. Once all the coal dryers are up and running, it will be possible to carry out a complete field assessment of the impacts of coal drying on performance, emissions, and plant operations."

Effects of Lignite Drying on Changes in Key Plant Performance Parameters with a 20 Percent Reduction in Coal Moisture

Boiler Efficiency	+3%
Net Unit Heat Rate	-3.3%
SO_2 and CO_2	-3.3%
Station Service Power	Negligible
Cooling Tower Makeup Water	$-2x10^5$ gallons/day

RESEARCHERS' PROFILES

- ***Dr. Harun Bilirgen*** has a Ph.D. in Mechanical Engineering and is a Senior Research Scientist in the Energy Research Center.
- ***Dr. Hugo Caram*** is a Professor of Chemical Engineering at Lehigh. His research is in the areas of mass transfer, chemical reactor design and chemical thermodynamics.
- ***Dr. Edward K. Levy*** is Professor of Mechanical Engineering and Mechanics and Director of the Energy Research Center. His research deals with emissions control and performance improvement in coal-fired power plants.
- ***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.
- ***David Wei*** is pursuing a Ph.D. degree in Mechanical Engineering. His Ph.D. research focuses on computer applications and modeling of fluidized bed drying of coal.
- ***James Yao*** is a Research Scientist at the Energy Research Center. His MS Thesis involved laboratory drying studies of Western fuels.