LEHIGH’S INTELLIGENT SOOTBLOWING SOFTWARE INSTALLED AT TWO UTILITY BOILERS

Furnace and convection pass slagging and fouling create serious operating problems in some coal-fired boilers. The frequency with which slag and ash deposits are removed from boiler tubes can have a major effect on steam temperatures, heat rate and NO\textsubscript{x} emissions. Sootblowing practice can also affect unit availability and have an impact on maintenance costs.

The Energy Research Center (ERC) has developed two sootblowing optimization approaches to help boiler operators decide which sootblowers to activate and on what schedule. One results in written instructions to the operators and is based on fixed or time-based sootblowing schedules. The other, which makes it possible to adapt to changes in coal quality, slagging and fouling patterns and sootblower availability, utilizes an intelligent software package developed by the ERC. These advances in sootblowing capability were developed by Drs. Nenad Sarunac and Carlos Romero, with help from Xiaodong Bian and Jiefeng Shan, Ph.D. students from Mechanical Engineering.

According to Sarunac, “Sootblower cleaning effectiveness depends on sootblower location, relative to the surface that needs to be cleaned, pressure of the cleaning media, the nature of the deposit and slagging/fouling rate. While some sootblowers are very effective in removing slag and fouling deposits, and their activation results in a large and long-lasting effect, others have no detectable effect on performance, emissions, or surface cleanliness. In addition to its role in preventing unmanageable ash buildup and in controlling steam temperatures, sootblowing can also be used to control NO\textsubscript{x} emissions, which vary with furnace cleanliness. Some utility boilers are characterized by a high volumetric heat release and high temperature flame zones. Field data show that NO\textsubscript{x} correlates well with furnace exit gas temperature (see Figure), except for furnaces which operate below a critical NO\textsubscript{x} formation temperature. For this reason, lower NO\textsubscript{x} emissions can typically be achieved by maintaining cleaner furnace waterwalls.

The challenge in developing an optimal sootblowing strategy is to determine which portions of the boiler to clean and on what schedule, considering the trade-offs between NO\textsubscript{x}, opacity, steam temperatures, heat rate and other factors such as tube life, sootblower steam or air consumption and maintenance cost.

Typically, plant operators are provided with little or no information on slag and ash deposition levels or guidance regarding appropriate sootblowing operations. Some plants still use the original boiler
manufacturer recommendations, many of which go back decades. Operators use a wide variety of strategies for sootblowing, according to their personal level of understanding of the causal relationships between sootblowing and boiler performance, individual preferences, and experience level. The most common strategy is sootblowing at fixed schedules with little regard for plant performance or emissions.”

Romero adds, “Our sootblowing optimization methods begin with field tests to characterize the effectiveness of each sootblower or sootblower group in removing ash deposits, reducing NOx and controlling steam temperatures. The data generated during these tests are used to develop a sootblowing strategy. If the utility is interested in a fixed time-driven schedule, an optimal sootblowing schedule is established and provided in written form to the operators. If, however, being able to adapt to unexpected changes in slagging and fouling patterns or to changes in sootblower availability is important to the utility, the sootblower characterization data can be used to configure our intelligent sootblowing software for use at that unit.”

The ERC’s intelligent sootblowing approach is implemented in IntelliCLEAN, a computer code, which employs a knowledge based-expert system to make decisions on optimal sootblower activation. The software creates an optimal sootblowing sequence that is event-driven and goal-oriented and selects sootblower groups to be activated when and where needed to satisfy optimization goals and operating constraints.

The code is an on-line, real-time application which runs on a personal or plant computer supporting Microsoft Windows XP, 2000, 98, 95, NT and NT 2000 systems. The code is designed as a system of modules. Each module performs specific functions, such as: range check on input parameters, buffering and time-averaging of live process data, maintaining sootblower characterization database, determining and displaying cleanliness status of boiler heat transfer sections (furnace, convection pass sections), and determining an optimal sootblowing strategy. The software can also interact with existing software capabilities that perform on-line cleanliness calculations.

Cleanliness status results are presented in a graphical fashion, using dynamic bars. The length and color of the bar change as cleanliness status changes. The sootblowing advice is presented in the Advice window and includes recommendations on which sootblowing groups to activate. Separate advice is given for the controlled and scheduled sootblowing groups. Controlled groups are activated to achieve and maintain the optimization objective, while scheduled groups are activated on a time-schedule, i.e., when a maximum elapsed time for their activation is exceeded.

Sarunac continues, “We are close to fully implementing IntelliCLEAN at two utility boilers. One is a subcritical, tangentially-fired unit, rated at 520 MW. The objectives and goals of the sootblowing optimization program at this unit are to reduce the sootblowing frequency and erosion damage to boiler tubes, prioritize sootblower maintenance, and maintain steam temperatures close to their setpoint values. Prior to this project, the operators had very little information on cleanliness status of boiler heat transfer sections and the sootblowers were deployed on a time schedule and at the operator’s discretion. This frequently resulted in steam temperatures that were too low or furnace temperatures that were too high.

Implementing IntelliCLEAN was accomplished using an OPG (OLE for Process Control) Server/Client interface directly with the unit’s digital control system. Computer screens were developed for the operators to display results and
advice from IntelliCLEAN. The overview screen summarizes cleanliness status for all boiler heat transfer sections and displays the ISA advice. The operator can click on particular boiler heat transfer surfaces to obtain more information. Detail screens are available for each boiler heat transfer surface.

The IntelliCLEAN software was implemented at this unit just before a scheduled unit outage in Fall 2002. Field evaluation is expected to continue later in 2003."

Romero adds, “The second unit is a 700 MW supercritical opposed wall-fired unit. The unit suffers from heavy slagging in the upper wall, pendant surfaces and the nose region.

As a result of our testing, the boiler control settings were modified to reduce furnace temperature and the sootblowers were regrouped to provide more effective cleaning of critical areas. A manual sootblower activation schedule was developed, implemented and field-tested. The results show that implementation of both measures has reduced FEGT and eliminated slagging around the nose region of the furnace. The field results also show that recommended boiler control settings, especially excess O$_2$, need to be controlled tightly to keep the nose region of the furnace clean.

The IntelliCLEAN software has also been implemented on this boiler using an OPC server/client interface with the PI system. Evaluation of the effectiveness of the software is in progress.”

---

**RESEARCHERS’ PROFILES**

- Dr. Harun Bilirgen has a Ph.D. in Mechanical Engineering and is a Research Scientist in the Energy Research Center. His Ph.D. dissertation focused on the fluid mechanics of gas-particle flow systems.
- Dr. Edward Levy has a Ph.D. in Mechanical Engineering and is Professor of Mechanical Engineering and Mechanics and Director of the Energy Research Center.
- 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.

---

For more information either on sootblowing or burner balancing, please contact John Sale at (610) 758-4545 or by E-mail at jws3@lehigh.edu.