

Get smart about removing slag

More often than not, sootblowing is literally a shot in the dark. Clyde Bergemann's solution to this problem: Control sootblowing operations intelligently, based on the outputs of real-time weight and heat-flux sensors and the calculations of a computer model.

By Ken Wicker

Every coal plant operator knows that burning coal produces ash, which can melt into slag that can be difficult to remove. So difficult, in fact, that dynamite may be the only solution. Slag on boiler tubes has two undesirable effects. It always reduces the tubes' heat-transfer capacity, and if it comes loose in big enough chunks and falls, it can damage or destroy tubes or structures below. In the first case, the consequences are reduced boiler efficiency and plant output and—potentially—catastrophic tube overheating. In the second, the result is typically a forced outage.

All coal-burning plants are susceptible to slagging, and different types of coal foster different kinds of slag formation. For example, the burning of low-sulfur Powder River Basin (PRB) coals produces ash whose low softening temperature can turn it to slag on hot convection-pass surfaces. At the other end of the spectrum is high-sulfur Eastern bituminous coal, whose high iron content significantly lowers the ash fusion temperature.

To clean their boilers, plants periodically sootblow their tubes and other heat-transfer surfaces with water, compressed air, or high-pressure steam. But determining the optimal cleaning frequency for each sootblower is nearly impossible in the absence of a real-time picture of how much slag exists, and where it is. For this reason, at many plants the operating frequency for each of the dozens of sootblowers is based on past positive results. But sootblowing too often is just as bad as sootblowing too infrequently. The former wastes money, labor, and steam, and the latter is just asking for trouble.

Two years ago, in the October 2003 issue of *POWER*, we reported that Atlanta-based Clyde Bergemann Inc. (CBI) had teamed up with Georgia Power Co. to fight slag at Plant Bowen. On that project, CBI installed real-time strain-gauge sensors on rods between the pendant heat exchange surfaces of the plant's boiler to detect the increased weight of slag buildup. Since then, CBI has taken its "smart" sootblowing technology to a higher level, one that

the company calls intelligent sootblowing (ISB). This article describes the results of a deployment of CBI's new system—which features smart pressure and heat-flux sensors, smart water cannons and steam lances, and smart models and controls—at the coal-burning plant of an independent power producer in a midwestern U.S. state.

Slagbusters

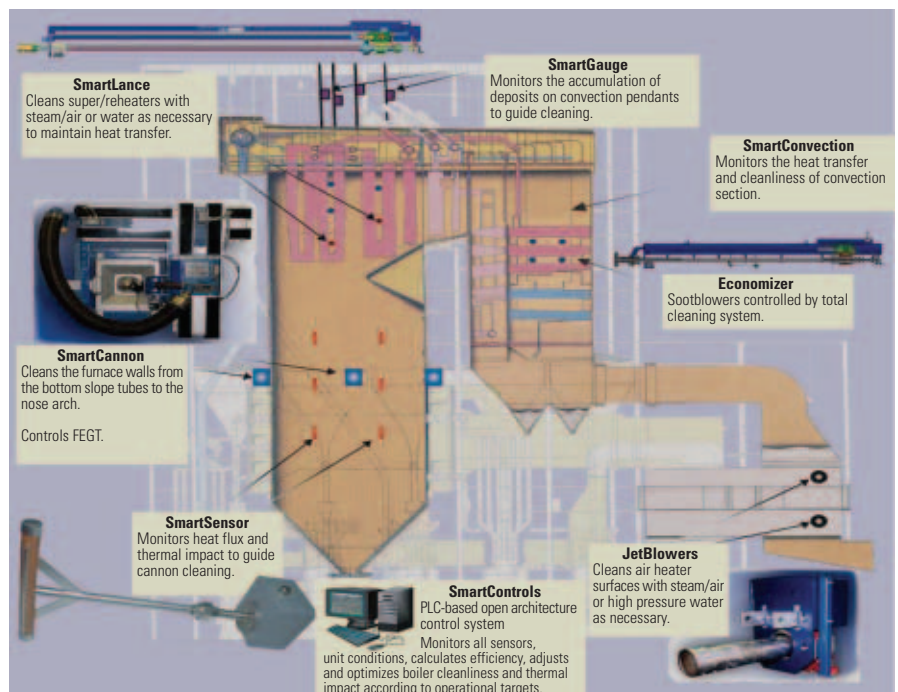
Huiying Zhuang, a boiler process engineer at CBI, explains that the effectiveness of his company's ISB line derives from several pieces of hardware and software working in concert. Figure 1 shows which pieces perform which functions, and where:

- SmartCannons (Figure 2) clean the entire furnace by spraying jets of water to the opposite or adjacent wall.
- SmartSensors (Figure 3) installed within the furnace's waterwalls detect the local

level of heat flux in real time. This information can be invaluable in determining where and when to sootblow, and which kind of sootblower to use.

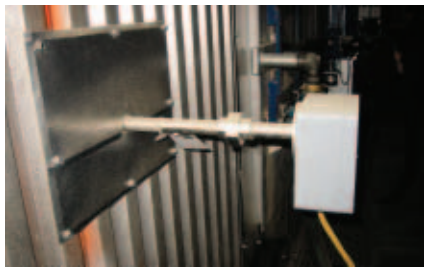
- SmartGauges—strain gauges mounted on the support structure of the boiler's pendants—quantify the extent of slag buildup.
- SmartLances—retractable sootblowers aimed at the superheater and reheater—use steam as their default cleaning agent. But they also can blend water with the steam when doing so would increase the lances' effectiveness.
- The SmartModel constitutes the system's "brain," determining when and where cleaning is really needed.
- The SmartControls serve as a traffic cop, by taking information from the SmartModel and the sensors and gauges, and directing the operation of the cannons and lances.

1. Wise choice. Clyde Bergemann Inc.'s intelligent sootblowing system relies on sensors, gauges, water cannons, and lances working together to keep boiler internals slag-free. Source: Clyde Bergemann Inc.





2. Fire away. The SmartCannon uses bursts of pressurized water to clean a furnace's waterwalls of slag. *Courtesy: Clyde Bergemann Inc.*



3. Introspective. SmartSensors like this one monitor local heat-flux levels inside a boiler. By integrating their readings with those of the SmartGauges, the system's control software can determine where slag has built up and devise a sootblowing strategy to eliminate it. *Courtesy: Clyde Bergemann Inc.*

Getting smart pays off

According to Zhuang, a plant can save big bucks by deploying an ISB system. He claims that an 800-MW unit might increase its profitability by one-third by boosting the efficiency of its boiler and reducing plant downtime. With such a dramatic gain in profits, a CBI system priced at \$1.2 million might pay for itself in just six months, Zhuang said.

Zhuang went on to detail where those gains would be realized. Prefacing the following explanation with the remark that "fuel costs can represent 80% of a plant's operating costs," he said, "An ISB system can enable a plant to burn lower-quality, cheaper coal, saving millions of dollars annually."

In addition, increased boiler efficiency produces additional financial gains. As Zhuang explained, "A cleaner furnace means greater radiant heat absorption and a reduction in furnace exit gas temperature [FEGT]. It also means a lower attemperator flow, which reduces the cost of water treatment and the consumption of sootblowing steam." Because a boiler with clean heat-transfer surfaces runs more efficiently, installing an ISB system can even enable a plant to sell, rather than buy, NO_x emissions credits. What's more, such a plant's selective catalytic reduc-

tion system wouldn't have to work as hard, which would reduce its O&M costs.

Finally, an ISB system also can improve a plant's capacity factor. As Zhuang explains, a clean boiler doesn't have to be shut down as often to remove built-up slag or to repair or replace damaged tubes.

Flagging slagging

The midwestern power plant at which the CBI system was most recently installed is rated at 700 MW and has a wall-fired, single-drum boiler from Babcock & Wilcox Co. (Barberton, Ohio). According to the plant's operations manager, the recent addition of a flue gas desulfurization system for environmental compliance enabled the plant to switch to a higher-sulfur Pennsylvania coal than the boiler was designed to burn.

Unfortunately, this higher-sulfur coal also has a lower ash fusion temperature than the boiler's design fuel. Soon after the switch, there was a noticeable increase in slagging in the boiler's furnace and convection pass. In an attempt to compensate, the plant began burning a blend of high- and low-sulfur coal. But that didn't put a stop to the increased slagging, so the plant contracted with CBI to install one of its fully configured ISB systems.

Clyde Bergemann installed four SmartCannons, one on each wall of the furnace. A pump custom-designed for CBI by Sundyne Corp. (Arvada, Colo.) supplies the cannons with water. In addition to two steam/water SmartLances, CBI installed 24 heat-flux SmartSensors in the boiler's waterwalls to provide feedback on the effectiveness of the SmartCannons and SmartLances. Finally, CBI mounted SmartGauges on the suspension rods of the superheater pendants to monitor the level of slag buildup.

The two pieces of software that control the operation of the SmartCannons and SmartLances are CBI's SmartControls and SmartModel. The former takes boiler steam temperatures, pressures, and flow rates tracked by the plant's distributed control system and combines them with the data flowing from the SmartGauges and SmartSensors. It then calculates the optimal mix of sootblowers and the optimal sootblowing frequency as directed by SmartModel. The program determines how dirty different heat-exchange surfaces are, based on their heat-transfer coefficients.

The operation of the ISB system, which was installed in early 2004, was closely monitored over the remainder of the year to gauge its effectiveness. According to the plant's operations manager, it produced the desired results. Following the deployment, heat flux in the furnace increased significantly (from 51 to 59 kBtu/hr-ft²), while FEGT decreased by 40 degrees F.

More to the point, the system also mitigated the slagging problem in the boiler's furnace and convection pass brought on by the switch to the higher-sulfur coal. The boiler's average cleanliness factor improved by 2.22% without increasing sootblowing frequency. Under the watchful eye of SmartControls, the sootblowers in the dirtier parts of the furnace were run more frequently than those in relatively cleaner areas. Yet another benefit was one Zhuang predicted: The flow of attemperation spray for controlling reheat steam temperatures fell by 35.2%. This produced a 34 Btu/kWh improvement in the unit's heat rate.

Too much of a good thing

Everything seemed to be going well at the host plant until tube failures on two different boiler sidewalls caused a forced outage in February 2005. According to the operations manager, ultrasonic readings indicated that the fireside corrosion rates of some of the waterwall tubes had increased significantly, from about 0.02 inches per year to almost 0.15 inches.

According to Zhuang, "The apparent cause [of the outage] was a 'perfect storm' of several factors combining to accelerate the breakdown of the waterwall tubes." He explained that when a boiler burns high-sulfur coal, corrosion is likely to occur on the external surfaces of its waterwall tubes. Why? "Because as this and other plants burning this type of coal have experienced," Zhuang continued, "the combustion process can produce a reducing atmosphere in which there's not enough oxygen available in a given zone to completely burn the fuel. When a boiler's burners are not adjusted correctly, or they are operated with staged air zones—the technique used by low-NO_x burners or overfire air—a reducing atmosphere can be created over larger regions, increasing corrosion rates." In this case, the high-sulfur coal, the reducing atmosphere, and the thoroughness of cleaning by the SmartCannons combined to increase the tubes' fire-side corrosion rate.

The operations manager agrees that the Smart Technologies work well in keeping the slag from building up in the boiler and decided to install an Inconel 622 overlay cladding onto the fire-side of the affected waterwall tubes to prevent corrosion. Inconel has much better corrosion resistance than carbon steel. In addition, because Inconel has greater tensile strength, and it expands much like carbon steel when heated, water can be sprayed on the overlay without causing tube cracking problems. With the protection of the Inconel overlay, the plant could resume the use of its water cannons and continue to realize the benefits of the intelligent sootblowing system. ■