TARGETED BOILER CLEANING USING SMART SOOTBLOWER

Huiying Zhuang/Clyde Bergemann  Sandip Parikh/Clyde Bergemann
Sandeep Shah/ Clyde Bergemann

ABSTRACT

A Smart Sootblower has been developed to meet the increasing demand for advanced boiler cleaning equipment. Utility plants are challenged to burn coals with severe slagging tendency. Slagging condition may be significantly different from pendant to pendant across the boiler. Conventional retractable sootblowers clean superheat and reheat pendants with even intensity, resulting in over cleaning of some pendants and “clinker” buildup in others. Modern instrumentation such as SuperHeat Fouling Monitoring (SHFM) systems and Video Cameras is able to locate the exact spot where the slag is accumulated. With the help of these detention systems, the Smart Sootblower, a multi-mode soot blower, is able to target and adjust clean intensity based on slagging condition, thus minimizing tube leakage and clinker formation. The Smart Sootblower has two motors that independently control translation and rotation motion. This allows the sootblower to change helix for different cleaning in different sections of the boiler. Operators can select zones require aggressive cleaning and zones need less or no cleaning. Integration of SuperHeat Fouling Monitoring (SHFM) system would provide operators the knowledge of fouling condition and enable automatic control of sootblowers for optimal performance. Actual installations and data are presented.

INTRODUCTION

Burning coal in the power plants produces fouling and slagging on the boiler surfaces. Deposits in boilers contribute to boiler inefficiency, capacity reductions, and tube leakages. Large clinker formations on the pendants can fall and break the bottom tubes, causing millions of dollar losses. Boiler outages, many related to ash and slag, are the major causes of lost generation in the US fleet of coal-fired power plants. The cost of these outages is in the billions of dollars per year in additional expense for replacement power and the cost of repairs. In particular, boilers switching from designed coals to low sulfur western fuels such as Power River Basin (PRB) coals often encounter severe slagging problems due to the lower ash softening temperature of PRB coals.

The boiler cleanliness demands faced by today’s boiler owners require a new solution for sootblowing. Operators are facing dynamic and higher slagging rates due to fuel variability, increased load and the like. Trying to control this slagging with old technology often results in over consumption of the sootblowing media and excessive erosion of boiler tube surfaces. In many plants, the experience results in a minimal improvement in heat transfer rate and a large increase in operating and maintenance costs.

Slagging in the boiler has become a dynamic process. Slagging condition may be significantly different from pendant to pendant across the boiler. Large chuck of “clinker” may form on pendants on one side of boiler while pendants on the other side of boiler are relatively clean. Conventional retractable sootblower technology, however, assumes that slag is evenly distributed in the boiler. It cleans all the superheat and reheat pendants with equal intensity, resulting in over cleaning of some pendants and under cleaning of others. This eventually leads to tube leakage or clinker formation.

Modern instrumentation such as SuperHeat Fouling Monitoring (SHFM) systems are able to locate the exact spot where the slag is accumulated. With the help of these detention systems, plant operators know which area needs to be cleaned more to eliminate the clinker, and which area require less cleaning to avoid tube erosion. Consequently, a Smart Sootblower, which is able to target and adjust cleaning intensity based on slagging condition, is developed to help power plants to optimize cleaning process, improve boiler reliability and efficiency, reduce operating cost, and increase fuel flexibility.
**OPERATIONAL THEORY**

Targeted cleaning is achieved by integrating two innovative technologies: Smart Sootblower and Super Heater Fouling Monitor (SHFM). With the advent of Super Heater Fouling Monitor (SHFM), real time feed back of boiler pluggage in specific areas of the boiler is available. Based on information received from the SHFM system a Smart Sootblower can be utilized to go to specific area of the boiler and focus cleaning onto the deposit. Consequently the cleaning efforts are concentrated in areas where needed most.

Contrary to conventional retractors, the Smart Sootblower are being steered to areas where plugging is most severe. Conventional sootblowers only have one motor for both transverse and rotational movement. They usually run at fixed speeds and helix. As a result, the cleaning intensity is equal in the entire cleaning path. The Smart Sootblower, however, has two motors that independently control translation and rotation motion (figure 1). This allows the sootblower to change helix and speed for different cleaning zones in different sections of the boiler.

With the Smart Sootblower, the jet impact time can be increased by slowing the traverse speed down and cleaning with a tighter helix. This allows operators to adjust the dwell time on a deposit in a particular area to take full advantage of cleaning capabilities that the blower offers. As a result, tenacious deposits can be aggressively cleaned to improve boiler cleaning and prevent large deposit build-ups. On the other hand in areas with little deposits, cleaning intensity can be reduced by operating with higher traversing speed and a less tight helix, thus saving steam and avoiding tube erosion.

SHFM is the intelligence of the targeted cleaning system. With the slag information provided by SHFM, operators understand which zones require aggressive cleaning and which zones need less or no cleaning. By integrating with SHFM module, Smart Sootblower can also be automatically controlled and optimized.

Clyde Bergemann and International Paper have pioneered the use of strain gages to measure the ash accumulation on the pendant surfaces. As described in our previous papers [1-3], SHFM utilized strain gage technology to sense slag deposits on the superheat and reheate pendants. Strain gages are installed on the hanger rods of the superheat and reheat pendants [4] (figure 2). Data from each strain gage is converted to weight using the stress strain relationship [5-6]:

\[
S = E \varepsilon
\]

Where,

- \( S = \) Stress in pounds per square inch
- \( E = \) Modulus of elasticity (30x10^6 for steel)
- \( \varepsilon = \) strain in micro inches per inch.

Using the diameter of the rod a cross sectional area can be calculated, and the stress is multiplied by the area of the rod. The weight measurement can be started at any time within the process and any subsequent readings indicate the change in weight from starting conditions. Thus it is not necessary to start from a totally unloaded rod.

**SYSTEM DESIGN**

The Targeted Boiler Cleaning system consists of two major components: Smart Sootblowers and SHFM. SHFM detects the location and quantity of slag deposit. Smart Sootblower then adjusts the cleaning intensity for different locations on the basis of the slag information provided by SHFM. The heart of the targeted sootblowing system is its zone-based cleaning (figure 3). The cleaning intensity depends on the position of the blower and the severity of slag deposits. The operator defines zones along the path of the lance and specifies the cleaning mode and parameters in each zone (figure 4). For optimal performance, the smart sootblower can automatically adapt mode and parameter utilizing real time data from SHFM. The following modes can be selected:

- **Variable Helix:** This mode is similar to standard sootblower operation, but the traversing speed and rotational speed may both be set to define a helix the will provide approximate cleaning for the conditions in that zone.
- **Intensive Cleaning:** This mode can perform aggressive cleaning. The lance can be virtually held in place while rotation continues by selecting the number of rotations, the step distance, and the interval between cleaning points.
- **Oscillation/ Partial Arc Cleaning:** In this mode the sootblower concentrate the blowing media on the area to be cleaned by restricting its arc from a given starting angel through a specified angle of rotation. Additionally, the control system can vary the rotation speed to maintain a specified jet progression velocity (JPV) (figure 5).

In addition, speed and direction control allow the operator to speed up or slow down the blower to perform "repeat" cleaning in an area without going to full retract position and starting over again. For instance, the blower can be set up via the local control panel to traverse in to the full insert position, back out for say 5 feet and go back in again to the full insert position. This method of control allows the plant to customize or "focus" cleaning in known areas of ash buildup. Operators can set up the sootblowers to clean in one direction and traverse out at a higher speed to reduce blowing media consumption and tube erosion.

The SHFM system includes dozens of strain gages and data collection and processing system. The strain gages are installed on the superheat support rods. A data amplifier receives data from the strain gages and sends the data through an Ethernet cable to a personal computer in the control room, which contains the input processing and operator interface software. Graphical representations of the pendants with color-coded status as to weight loading from the gages constitute the operator interface and provide the information of slag deposit across the boiler (figure 6).
SYSTEM OPERATON

A Targeted Cleaning system was installed on a 700MW B&W boiler that has experienced several clinker falls that caused severe tube damages. Two Smart Sootblowers, one on each side, were installed in the cavity between the Platen Secondary Superheater Pendant and the Secondary Superheater Pendant, just above the nose arc of the unit. This area did not have any existing sootblowers and it was also an area of significant slag formation. SHFM are also installed for slag monitoring and Intelligent Sootblowing (ISB) control. Eight strain gages were installed on hanger rods that support the Platen Secondary Superheat Pendants, providing the location and quantity of the ash accumulation across the boiler.

A performance test was conducted to evaluate the effectiveness of the Targeted Cleaning system. The test consists of two steps: baseline and Targeted Cleaning. In the baseline step, the Smart sootblowers were run in the same way as conventional sootblowers. They were operated with fixed speed and helix in the entire travel. In the Targeted Cleaning step, the clean intensity varies for different zones on the basis of information provide by the SHFM system. Zones with more weight were cleaned more intensely then zones with less weight. The cleaning intensity of light-weight zones was slightly reduced. Meanwhile, visual observation and flue gas temperatures across the boiler are used to confirm the slag information provided by strain gages.

Figure 7 shows the slag weight on the superheat pendants measured by strain gages. The slag is not evenly distributed across the boiler. Among the four gages on the left side, gage L-1 and L-4 have less weight than gage L-2 and L-3. Similarly, for the gages on the right side, gage R-1 and R-2 have more weight than gage R-3 and R-4. Visual observation verified that the pendants in the middle have less slag accumulation than pendants on the sides. To further confirm the slag information, temperature distribution across the boiler is also measured using a hand-held laser pyrometer through eight observation ports in the front wall. As shown in figure 8, the temperature profile is very similar with the weight profile. This indicates that the weight profile is correct because high flue gas temperature usually increases slag accumulation.

Corresponding to the strain gage layout, the boiler is also divided into eight cleaning zones. Each sootblower covers 4 zones. In the Target Cleaning test, the cleaning intensity for heavy-weight zones was increased while the intensity for light-weight zones was decreased. The cleaning intensity for different zones is shown in table 1. Figure 9 compares the weight reduction by using Targeted Cleaning method with the conventional cleaning method. It shows that by using Target Cleaning, much more slag is removed for zones that are were cleaned more intensely. The zones include zone L-2 and L-3 on the left and zone R-1 and zone R-2 on the right. In contrast, there is no significant change of weight reduction for the rest zones including R-3, R-4, L-1, and L-4 even though their intensity was slightly decreased. This result also indicates that those four heavy-weight zones are under cleaned in the conventional operation since almost twice as much of slag can be removed with an increased cleaning intensity. Those under cleaned areas could potentially cause “Clinker” formation.

CONCLUSION

By combining the SHFM and Smart Sootblower technologies, Targeted Cleaning system is able to focus on the dirty areas and skip the clean areas, thus eliminating tube leakage and clinker formation. The operational results in a 700 MW boiler have demonstrated that Targeted Cleaning cleans more effectively than conventional cleaning method by increasing cleaning intensity on dirty pendants. Installation of Targeted Cleaning system results in reduced boiler downtime, steam saving and increased boiler efficiency and fuel flexibility.

REFERENCES


Figure 1 Smartblower Dual Motor Carriage Assembly

Figure 2 Superheat Suspension Structure and Strain Gage Location
Figure 3 Mechanism of Zone-based Targeted Sootblowing

Figure 4 Cleaning Mode Selection for Different Zones
Figure 5 Oscillation/Partial Arc Cleaning with Constant JPV

Figure 6 Slag Information across the Boiler Provided by SHFM
Figure 7 Display on the SHFM screen

Figure 8 Temperature measurement across the boiler
### Table 1 Cleaning Intensity for Different Zones

<table>
<thead>
<tr>
<th>Zones</th>
<th>L-1</th>
<th>L-2</th>
<th>L-3</th>
<th>L-4</th>
<th>R-4</th>
<th>R-3</th>
<th>R-2</th>
<th>R-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional Cleaning</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Speed (fpm)</td>
<td>79.2</td>
<td>79.2</td>
<td>79.2</td>
<td>79.2</td>
<td>79.2</td>
<td>79.2</td>
<td>79.2</td>
<td>79.2</td>
</tr>
<tr>
<td>Helix (inch)</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Targeted Cleaning</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Speed (fpm)</td>
<td>95</td>
<td>62</td>
<td>62</td>
<td>95</td>
<td>95</td>
<td>95</td>
<td>62</td>
<td>62</td>
</tr>
<tr>
<td>Helix (inch)</td>
<td>6</td>
<td>3.8</td>
<td>3.8</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>3.8</td>
<td>3.8</td>
</tr>
</tbody>
</table>

Figure 9 Slag removed in conventional and targeted cleaning operation