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Technical Paper

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Abstract

Electric generation from the installed base of pulverized coal-fired boilers is critical for the electric utilities to meet growing demands for electricity while holding down the cost of generation. Volatile supplies and market prices of natural gas have made readily available coal the fuel of choice for a large percentage of the base load generation. In fact, operating companies are striving to increase availability of this important generation by extending the run time between outages.

From the western United States to the Mississippi River and increasingly east of the Mississippi, the coal of choice is becoming western subbituminous coal such as Powder River Basin coal. The lower cost and lower sulfur fuel has both economic and environmental advantages but can also have a negative impact on the operations of boilers. Increased slagging and fouling of heating surfaces can occur and must be managed.

Control of heating surface cleanliness impacts boiler performance, reliability, and availability so that optimizing the operation of cleaning equipment has become increasingly important to today's operating companies. The Babcock & Wilcox Company (B&W) introduced its Powerclean™ system in 2002 on B&W wall-fired boilers to enable intelligent control of boiler heating surface cleanliness.

The B&W approach is based on use of technology developed by B&W for the design of coal fired boilers so that it has the benefits of utilizing a proven first-principles based thermodynamic performance model at its core. The modeling process also must consider fuel types and the combustion requirements. A reliable boiler model makes it possible to accurately determine when and where heating surfaces are experiencing diminished performance due to ash buildup and fouling.

Powerclean has been successfully implemented on numerous boilers since its introduction; in each case, savings in steam usage for sootblowing, improved efficiency and improved operations have resulted in payback in less than one year. B&W's modeling experience is not limited to boilers originally built by B&W. Major retrofits and upgrades have been done by B&W on non-B&W units both wall fired and tangentially fired. This paper addresses the implementation of the B&W Powerclean technology on tangentially fired boilers.

Two applications of Powerclean on a tangentially (corner) fired boiler will be presented. The first application involves the installation of the Powerclean intelligent sootblowing system on a supercritical, tangentially fired (T-Fired) unit in the southern United States. The second application involves a subcritical unit at Omaha Public Power District's (OPPD) North Omaha Station - Unit 3.

Power generation from coal

More than 50% of the power generated in the United States (U.S.) is from coal-fired power plants. Coal will continue to be a dominant fuel source for fossil-fuel steam generation into the foreseeable future. Pressure to reduce the emissions of sulfur dioxide (SO_2), nitrogen oxides (NO_x), mercury (Hg) and carbon dioxide (CO_2) make it imperative for owners to seek cost effective strategies to meet the regulations. One option being used by more and more utilities is the use of low sulfur western fuels such as Powder River Basin (PRB) coals, which produce less SO_2 emissions and can avoid the need to install high cost wet or dry scrubbers. However, this western fuel also contains greater amounts of moisture with less heating value on a per pound as-received basis. Western fuels can also have lower ash softening temperatures. The result of the fuel switching is greater ash loading, with greater fouling and slagging of the boiler surfaces. This places a premium on effective use of sootblowers to control the buildup of ash deposits. The addition of sootblowers or improved blower designs may be part of the strategy when switching to a western fuel; however, improved use of the blowers by better determination of where and when to clean heating surfaces is also important. Historically, a program of monitoring the unit is implemented to develop a set of "best practices" for use of the blowers based on load, fuel source, etc. Now, improved control systems are available to allow "intelligent" cleaning of heating surfaces.

B&W boiler modeling technology and intelligent sootblowing

The Babcock & Wilcox Company (B&W) has been modeling boilers and the combustion process for many decades. A common misconception about B&W's technology is that it only applies to B&W designed boilers. In fact, B&W has modeled and improved on the designs of many other boiler manufacturers, including those of tangentially fired boilers manufacturers.

B&W's technology is based on the principles of heat transfer, fluid flow and combustion. Much of what makes B&W's modeling technology effective has been the application of this technology to operating units in which actual measured field data was used to empirically update the modeling for accurate prediction of performance. Commercial PC-based versions of the B&W performance modeling programs have been deployed on operating units since the early 1980s. The first systems were offered to allow plant engineers and operators to track the real time performance of the unit.

Even in those early days, plant engineers used the performance and cleanliness data provided by the systems to optimize the sootblowing process. These users found that an accurate first-principles model of the boiler provided repeatable cleanliness factors that they could use to make changes to better optimize sootblowing. One of the drawbacks of these early systems was that they were advisory, such that a plant engineer needed to use the data to track and manually alter the sootblowing schedules. Today, B&W's commercial version of the boiler modeling system is the Heat Transfer Manager™ (HTM) performance program.

Heat Transfer Manager™ performance modeling

The Heat Transfer Manager (HTM) program is the core of the Powerclean™ sootblower optimization system. The HTM program is applicable to boilers manufactured by B&W as well as other manufacturers. The HTM program is based on the heat transfer analysis methods that B&W has developed over many years of designing and upgrading boilers. The heat transfer analysis begins with combustion and efficiency calculations that HTM calculates in accordance with ASME PTC 4 procedures. Input data is obtained from the plant historian, DCS or data acquisition system.

In a typical installation for a reheat utility boiler, the HTM model consists of the following components: furnace, economizer, primary superheater, furnace platens, secondary superheater, and reheater. Fuel input is calculated from measured boiler output and efficiency. Flue gas weight is calculated stoichiometrically from fuel input and excess air which is determined from measured oxygen in the flue gas.

HTM includes a detailed computer model in which the furnace as well as the convection surfaces are configured. The furnace portion of the model divides the furnace into volumes whereby the location and input of burners and changes in furnace shape, such as the furnace arch, are described. The furnace model calculates the expected furnace exit gas temperature (FEGT) for comparison to the FEGT value determined analytically.

The convection portion of the boiler model consists of tube banks, gas cavities between the tube banks, and the steam/water cooled enclosure surface surrounding the banks and cavities. Tube banks are modeled in detail and include parameters such as tube diameter, tube side and back spacing, heating surface, gas free flow area, steam/water flow per tube, etc. Starting at the air heater gas inlet (economizer gas outlet), the gas temperature entering each component is calculated by heat balance based on calculated gas weight and measured absorption of each boiler component. For units with parallel gas paths for reheat steam temperature control, it is also possible to calculate gas splits between the reheater and superheater gas paths, provided the gas temperature leaving each path is measured.

Utilizing the measured steam/water temperature entering and leaving each component and the calculated gas temperatures, the actual as well as expected overall heat transfer coefficient is determined for each boiler component. The relative measure of the actual versus expected heat transfer coefficient provides the cleanliness index that is critical to intelligent sootblowing decisions. Since the HTM program is based on the technology used by B&W for boiler design and performance evaluation, there is extensive empirical data and validation of the accuracy of the program for predicting heat absorption within tube banks. This is true for boilers originally supplied by B&W as well as units designed by other manufacturers.

In configuring the boiler model, B&W reviews the complete Input/Output (I/O) list of plant data available from the data acquisition system (DAS), DCS or historian to select the points needed for HTM analysis and for use in setting sootblowing strategy. In general, all the critical data used by the HTM model is part of the normal measured operating data for the boiler controls. Once the boiler model is established, the system is installed at the site and interfaced with both the sootblower controls and the plant DAS, DCS or historian. The HTM model provides the critical boiler performance and heating surface data that is used by the Powerclean module when setting up strategies that guide sootblowing. HTM model results are displayed on the Powerclean graphical interface in a boiler sideview for a comprehensive view of cleanliness by boiler region (Figure 1).

Fuel analysis

HTM requires an analysis for the typical fuel being used. It is commonly thought that a different fuel analysis is required for all variations of fuel used in a boiler. However, when using a reliable first-principles model such as HTM, different fuel analyses are only required when major changes are made to the fuel source. As an example, one representative fuel analysis is needed for firing many different coals of the same rank such as bituminous coal from more than one source. However, significant changes in coal from one rank to another, such as the use of a subbituminous coal instead of bituminous, will require that a different fuel analyses be used to ensure accurate performance modeling results. Since B&W uses the modeling behind Heat Transfer Manager for boiler design, the company has extensive data on coal types and their impact on boiler performance. When determining the coal analyses for use in HTM, all coals used by the plant are considered. The program can be configured so that a different fuel analysis is substituted when a significant fuel switch (e.g. change of coal rank) is made.

Furnace gas temperatures

As noted above, the HTM program calculates upper furnace exit gas temperatures (FEGT) for use by the Powerclean system in optimizing sootblowing. This is an important feature of the B&W system since it eliminates the need for installing field instrumentation for this purpose. Upper furnace temperature measuring devices such as optical pyrometers or acoustic pyrometers can be costly to install and difficult to maintain in reliable operation. Field installed devices are also dependant on the installation location and field of view such that determining an expected temperature for making cleaning decisions is best done by a period of operation and learning in the specific unit. By contrast, HTM calculates a thermodynamic average FEGT in a specific plane of the boiler which is consistent with FEGT values used by B&W for design. This allows use of an FEGT value that can be compared to an expected value based on historical empirical data. Not only does this calculated FEGT provide important information to aid in optimizing performance but it also allows calculation of a furnace cleanliness factor that is used to help determine when best to clean the furnace walls.

The Powerclean intelligent sootblowing system has been installed on boilers with instrumentation for measuring furnace gas temperatures. Figure 2 shows a comparison of the platen inlet gas temperature (PIGT) and FEGT as determined by HTM versus the upper furnace temperature as measured by two optical furnace pyrometers. The furnace pyrometers were installed on the east and west sides of the boiler in the upper furnace. Note that the temperatures behave similarly in response to actual furnace conditions. The values are not in exact agreement since the HTM values are thermodynamic average temperatures in a specific plane of the boiler while the pyrometers detect the average peak temperature based on their physical location with a heavier weighting toward the near field in its field of view.

The Powerclean™ sootblowing optimization program

Because boiler heating surface performance may not be the only reason to clean or not clean an area of the boiler, B&W combines the performance diagnostic capabilities of HTM with an expert system to capture and implement strategies for cleaning the unit. The Powerclean™ Expert System and the HTM program are the core elements of the Powerclean sootblowing optimization system.

When developing the Powerclean system, B&W realized that other parameters, in addition to how dirty tube surfaces have become, must be considered when deciding to clean a given region of the boiler. As an example, a plant may want to set a lower limit on cleanliness (i.e. let the surface get dirtier) for the secondary superheater (SSH) outlet sections if the unit is operating below a threshold for reheat outlet temperature. This may be necessary as increased absorption in the SSH would further reduce attainable reheat temperature.

In general, the goal in creating Powerclean was to give the system enough flexibility such that the observations of the plant engineer, operator or a B&W service engineer could be incorporated into cleaning strategies as needed. With the rule-based expert system designed to capture and implement unit-specific knowledge about sootblowing, the Powerclean approach provides the engineer or operator with significant flexibility to set different strategies for cleaning the unit under different conditions. For instance, separate strategies can be developed for multiple operating load ranges. The Powerclean system also serves as a useful tool to evolve cleaning strategies and practices over time. The user can update and modify the expert system as needed when changes occur. One example is a significant change in fuel source.

Powerclean™ system experience on tangentially fired boilers

Case 1: 660 MW T-Fired supercritical unit

In this paper, two applications of Powerclean on a tangentially (corner) fired boiler will be presented. The first application involves the installation of the Powerclean intelligent sootblowing system on a supercritical, tangentially fired (T-Fired) unit in the southern United States. This unit is a Combustion Engineering tangentially fired boiler commissioned in 1974 and was originally designed with a maximum continuous rating (MCR) steam capacity of 4,333,000 lbs/hr at 3,690 psi, 1000F at the superheater (SH) outlet. Reheat (RH) capacity is 3,944,000 lbs/hr steam flow at 631 psi reheater outlet pressure and 1000F. The unit was designed to produce MCR steam flow and generate approximately 660 MW and currently burns a blend of 50% lignite and 50% subbituminous coal.

Exiting the furnace, the convection pass heating surfaces are arranged with two vertical division panel superheater banks, followed by a platen superheater bank, a platen reheater bank, a pendant superheater bank, and a vertical reheat bank (Figure 3). A horizontal reheat bank is followed by the economizer in the vertical down pass of the unit. Steam temperature from the superheater and reheater is controlled by spray attemperation. To control slagging and fouling of the furnace and convection pass tube surfaces, the unit was originally equipped with Copes-Vulcan sootblowers. Six additional Clyde Bergemann blowers were added in 2005 to cover a new bank of reheat tubes. The blowing medium is air which is supplied by dedicated compressors. The furnace waterwalls have 86 active wall blowers. The convection pass surfaces are cleaned by 29 retractable air sootblowers covering the superheater, platens, pendant SH and vertical RH. Ten blowers are in the vertical down pass to clean the reheat and economizer horizontal tube banks.

Operating history

For most of its life the unit has burned 100% western lignite fuel. In recent years a blend of 50% lignite and 50% subbituminous coal has been fired. The preference is to burn as much subbituminous coal as possible without hurting the operation of the unit. Heavy slagging and fouling can occur with resulting pluggage if cleaning is not closely monitored and controlled.

In general, the unit has had an excellent operating history with good availability. Normal preventive maintenance has been performed over the years to address component wear and deterioration as required including the burners, pulverizers and sootblowers. A new reheat bank was added recently to the convection pass to accommodate the burning of subbituminous coal. Burner tilts are currently stationary near 50%, rather than being modulated to control reheat temperature.

With the current setup, the sootblowing system has a finite capacity which limits sootblowers to run one at a time. Opacity must be maintained below a regulated limit, and is a defined parameter in Powerclean regulating initiation of blowing sequences.

Powerclean was installed on this unit to manage the sootblowing process with the goal of improving unit operation while firing a blend of lignite and subbituminous coal.

Powerclean system installation and operation

Powerclean was installed with a communications link to the Honeywell PHD historian that interfaces with the DCS. Closed loop control for furnace and convection pass cleaning was implemented through a communications link from the Powerclean PC to the plant developed Allen-Bradley PLC based sootblowing control system.

Once communications were established and the I/O points were set up in Powerclean, the system was configured for the components, regions and blower sequences specific to this unit. As is typical of Powerclean installations, the initial configuration of Powerclean utilized B&W's experience on similar unit types and fuels. During the configuration of regions, the initial blowing strategies were also developed.

The Powerclean system design includes remote access such that B&W engineers can monitor, collect data, and modify the system from its offices in Ohio during initial startup and commissioning. All parametric testing, data collection and analysis to determine where surfaces were dirtiest, the rate of heat transfer degradation, and the effectiveness of specific blower and blower sequences were done remotely from the Ohio office. This was an advantage to plant operations as the startup schedule could be easily manipulated to accommodate plant schedules and demands.

This unit has nine levels of furnace blowers, with the lower five levels not in service. As required by the plant, the lower five levels remain inactive because of potential tube erosion, limited access for repair and limited effectiveness in cleaning areas of the furnace most prone to slag buildup. The original furnace sequence was a collection of six groups of blowers, all being blown once each shift.

Based on initial testing and setup, furnace sootblowing was divided into three different regions. The hot corners on the top four levels of this furnace were included in the first region. As a result of the significant effectiveness of these blowers during testing, and feedback from plant personnel, this group of blowers was designated as the primary furnace blowing sequence. The remaining blowers were split into two additional regions that would be blown when furnace cleanliness required additional support beyond the more strategic hot corner group. The most critical blowers in the first group were added to these two groups to allow increased cleaning of the most critical areas. This illustrates the use of experience and operating knowledge in implementing a cleaning strategy that targets specific areas where greater cleaning is needed while reducing blower cycles in areas that do not slag as badly.

Prior to Powerclean implementation, there were four blower sequences in the horizontal convection pass, blown once a day during the day shift. There were two sequences in the vertical pass, blown once a day during the evening shift. A select group of ten vertical upper RH and SH platen, and horizontal RH blowers were only activated every five days to avoid excessive reheat and superheat temperatures.

Since most of the slagging on these banks occurs on the lower portion of the inlet and outlet pendants, the sequences for Powerclean implementation were modified to allow more blowing on the lower sections to achieve optimal cleaning in that region and reduce sootblower erosion on the upper areas of the SSH pendants. To avoid manual blowing of an inherently problematic area of this corner fired boiler, an additional sequence was added. This sequence prevents slagging and bridging characteristic of the south arch of the convection pass due to the heat concentration from the gas path over that area of this particular corner fired boiler.

To avoid manual blowing of a particularly problematic area of this corner fired boiler, an additional sequence was added. This sequence prevents slagging and bridging of the south arch of the convection pass due to the heat concentration from the gas path over that area of the boiler. Similar to the furnace blowing strategy, this illustrates the use of cleaning strategies based on performance, operating knowledge, plant experience, and the flexibility of Powerclean to automate.

Results

The Powerclean system has had a very positive impact on the operation and maintenance of the unit. Powerclean continues to monitor unit operation, operate in closed loop and initiate sootblowing sequences in the furnace and convection pass.

Operational improvements

Operations personnel have found the system to be very helpful since it manages the task of scheduling sootblowing so that the operators do not have to focus on this activity. In the past, operations personnel had to manually initiate sequences from the sootblowing control system. Although results and the impact of the system will vary from unit to unit, the data from this plant has shown improvement in unit efficiency.

Data was available from the Powerclean historian which had been collecting raw plant data since the communications link was established. Results shown here are derived from a baseline sample period in September 2005 prior to closed loop control and a sample period in February 2006 with Powerclean in closed loop operation. Full load unit operational data was used.

The unit experienced an improvement in net unit efficiency with Powerclean in closed loop operation. Based on data from Heat Transfer Manager and the plant's net unit heat rate calculation, progressive gains have been made. Increased cleanliness in the furnace and the convection pass (Figure 4) improved heat absorption and allowed for more generating capacity with the same amount of heat input.

From September to February, there was approximately a 42 Btu/kWh reduction in heat rate as indicated in the plant heat rate calculation. This translates into almost a 0.5% unit efficiency improvement to the unit and a reduction of approximately 17,000 tons of fuel per year. (Figure 5)

Economizer exit gas temperature

Economizer exit gas temperature decreased from 869F in September to 857F in February. Because load was so much greater in February, a better representation of the improvement is seen by removing the data above the September peak load of 611 MW. This results in an average temperature of 835F for February. Thus, for a like load range, a much more significant reduction of 34F was realized. This reduction was a result of increased furnace and convection pass cleanliness. Powerclean's Heat Transfer Manager provides cleanliness values for the furnace, primary superheater, reheater, economizer, and the secondary superheat inlet and outlet pendants. An evaluation of these values showed that unit cleanliness improved steadily from September to February (Figure 6).

Furnace exit gas temperature

As shown in Figure 7, furnace exit gas temperature decreased from an average of 2332F in September to 2314F in February. The decrease in FEGT for like load ranges was much more significant with an average temperature of 2255F for February. This results in an average reduction of 77F.

Overall unit improvements

The most significant results from Powerclean sootblowing optimization were improvements made to the cleanliness of furnace waterwalls, the reheater, and the secondary superheater outlet pendants. Cleanliness values for these three regions improved with positive impact on RH spray flow and temperatures. The reheat outlet temperature improved due to a cleaner RH surface as well as decreased RH outlet temperature set point. Furnace absorption also improved resulting in a lower furnace exit gas temperature and lower RH spray flow (Figures 8 and 9). From September to February, the combination of lowered RH spray and reduced economizer outlet gas temperature had a positive impact on unit efficiency and heat rate.

Sootblowing frequencies

Comparing sootblowing during baseline operation to operation after Powerclean was placed in closed loop mode, the sootblowing frequency in the furnace increased. During baseline operation approximately 4.5 sequence blows were performed. With Powerclean in operation, that frequency increased to just over 5 times per day. This resulted in improved furnace cleanliness. A major factor contributing to increase in sootblowing was that average load was higher by 60 MW in February (635 MW) than during baseline operation in September (575 MW).

The sootblowing frequency has also increased somewhat for about half of the convection pass sequences as a result of the load shift from baseline to February (Figure 10).

Overall, the unit is cleaner and heating surface absorption has improved.

Conclusion

The Powerclean intelligent sootblowing system on this supercritical, tangentially fired boiler was very successful. It has provided better control of heating surface cleanliness and improved overall unit performance. Furnace cleanliness is improved, FEGT is lower, RH spray flows are lower and boiler efficiency is improved. The system has also proven to be a valuable tool for plant personnel by simplifying boiler cleaning of this unit.

Case 2: Omaha Public Power District - North Omaha Unit 3

Omaha Public Power District (OPPD) - North Omaha Unit 3 is a Combustion Engineering tangentially fired boiler commissioned in 1958 and was originally designed with a maximum continuous rating (MCR) steam capacity of 750,000 lbs/hr at 2,160 psi, 1005F at the superheater (SH) outlet. Reheat (RH) capacity is 750,000 lbs/hr steam flow at 600 psi reheater outlet pressure and 1005F. The unit was designed to produce MCR steam flow and generate 102 MW and currently generates approximately 120 MW and burns a 100% subbituminous coal.

The convection pass heating surfaces are arranged with finishing superheater banks (SSH), followed by a finishing reheat bank (Figure 11). A low temperature primary superheat bank (PSH) is followed by the economizer in the vertical down pass of the unit. Steam temperature from the superheater is controlled by spray attemperation. Reheat steam temperature is first controlled by burner tilt position and then moderated with spray attemperation. To control slagging and fouling of the furnace and convection pass tube surfaces, the unit's original sootblowers are Diamond Power International. The blowing medium is steam. The furnace waterwalls have 20 active wall blowers arranged in two elevations of ten blowers. The convection pass surfaces are cleaned by ten retractable steam sootblowers covering the superheater and vertical RH. Twelve blowers are in the vertical down pass to clean the low temperature superheat and economizer horizontal tube banks.

Operating history

Historically, this unit burned a variety of fuels including western lignite fuel. In recent years, 100% subbituminous coal has been fired. Again, as is common in the coal burning utility industry, the preference is to burn as much subbituminous coal as possible without hurting the operation of the unit. Close monitoring and control of cleaning is required to avoid heavy slagging, fouling, and resultant pluggage.

As a result of its age, several upgrades have been made allowing this unit to provide dependable operation and availability. Upgrades included the addition of a Bailey DCS control system and tube bank replacements. Normal preventive maintenance has been performed over the years to address component wear and deterioration. Burner tilts are controlled by the reheat temperature, with optimal position settings of about 50%.

With the current setup, the sootblowing system has a finite capacity which limits sootblowers to running one at a time. The flue gas outlets of Units 1 to 3 share a common stack and opacity must be maintained below a regulated limit. Maximum opacity is a defined parameter in Powerclean regulating initiation of blowing sequences.

Powerclean was installed on this unit to manage the sootblowing process with the goal of improving unit operation while firing 100% subbituminous coal.

Powerclean system installation and operation

Powerclean was installed with an OPC communications link to the Bailey Infi-90 DCS. Closed loop control for furnace and convection pass cleaning was also implemented through an OPC communications link from the Powerclean PC to an Allen-Bradley PLC based sootblowing control system.

Once communications were established and the I/O points established in Powerclean, the system was configured for the components, regions and blower sequences specific to this unit. As described earlier, the initial configuration of Powerclean utilized B&W's experience on similar unit types and fuels. After testing the sootblowers and analyzing the results, the initial blowing strategies were also developed.

This unit has two levels of furnace blowers. The original furnace cleaning philosophy prior to the implementation of Powerclean was to clean the entire furnace once a shift. When Powerclean was installed, only the top level of furnace wall blowers was in service. The lower ring of wall blowers had been removed from service several years earlier.

Based on initial testing and setup, furnace sootblowing was divided into two cleaning regions. Top elevation blowers were found to have a significant impact on FEGT and reheat temperature. Because of the smaller size of the unit, it only required a few of the blowers at this elevation be blown to have a large impact on unit operation. Thus, this level was divided into odd and even numbered blower regions. These two furnace regions were assigned the highest blowing priority.

Powerclean was in service for several months and visual observation revealed a slight slag accumulation in the lower furnace. This region would normally be cleaned by the lower level wall blowers. The lower elevation wall blowers were reinstalled and optimized by Powerclean. These blowers were set as the third furnace region with a significantly lower blowing frequency. Additionally, since burner tilts are controlled by reheat temperature, their position and interaction with furnace cleanliness and furnace exit gas temperature are critical components in determining frequency of furnace sequence blowing.

Historically, the horizontal convection pass blowers were used once a shift. The vertical pass blowers were used once or twice a shift. However, since most of the slagging on these banks occurs on the lower portion of the inlet and outlet pendants, the sequences were modified to allow more blowing on the lower sections to achieve optimal cleaning in that region and reduce sootblower erosion on the upper areas of the SSH pendants.

The difference between a smaller scale unit such as OPPD North Omaha Unit 3, a larger scale unit such as the 660MW unit discussed previously, and varying operating practices illustrates the need for similar yet specialized cleaning strategies for each tangentially fired boiler.

Results

The Powerclean system has had a very positive impact on the operation and maintenance of the North Omaha Unit 3. Powerclean continues to monitor unit operation, operate in closed loop and initiate sootblowing sequences in the furnace and convection pass.

Operational improvements

Operations personnel have found the system to be very helpful since it manages the task of scheduling sootblowing so that the operators do not have to focus on this activity. In the past, operations personnel had to manually initiate sequences from the sootblowing control system. Blowing areas of the boiler at the appropriate times, particularly the reheat banks, has improved burner tilt control. Additionally, boiler exit gas temperatures are under better control which has taken a burden off of the operators. In efforts to reduce high exit gas temperatures in the past, many areas of the boiler were often overblown.

Data was available from the Powerclean historian which has been collecting plant data since the communications link was established. Results shown here are derived from a baseline sample period in February 2005, just prior to closed loop control, and a sample period in June 2005 with Powerclean in closed loop control of sootblowing. Full load unit data was used for all analysis.

The unit experienced an improvement in net unit efficiency with Powerclean in closed loop operation. Based on data from Heat Transfer Manager and the plant's net unit heat rate calculation, progressive gains have been made. Increased cleanliness in the furnace and the convection pass (Figure 12) improved heat absorption and allowed for more generating capacity with the same amount of heat input.

From February to June, there was approximately a 93 Btu/kWh reduction in heat rate as indicated in the plant heat rate calculation. This translates into almost a 0.7% unit efficiency improvement, and a reduction of approximately 3,600 tons of fuel per year (Figure 13).

Economizer exit gas temperature

Economizer exit gas temperature decreased about 20 to 30F with Powerclean in operation and the resultant reduction in blowing frequency. The primary objective was to eliminate exit temperatures over 900F (Figure 14).

Overall unit improvements

The most significant results from Powerclean sootblowing optimization at North Omaha Unit 3 were improvements made to the reheater and secondary superheater. Cleanliness values for the reheat region improved with positive impact on RH temperature. Cleanliness values for the superheat region improved with positive impact on SH spray flow and temperatures. Furnace exit gas temperature was maintained. Comparing baseline performance to Powerclean operation, the combination of lowered SH spray and reduced economizer outlet gas temperature had a positive impact on unit efficiency and heat rate.

Superheat temperature and spray flow

With Powerclean in control, superheat temperature performance improved. One goal of the project that was accomplished was eliminating high and low SH temperature excursions. Superheat spray flow was also reduced with an objective of minimizing peaks over 25klb/hr. Average spray flow was reduced from 14.6 klb/hr during baseline to 11.9 klb/hr utilizing Powerclean (Figure 15).

Reheat temperature and spray flow

During initial Powerclean setup, burner tilts in the upward position were found to have a positive and significant impact on FEGT and RH temperatures. Improved RH cleanliness and a good furnace cleaning strategy helped to minimize any large RH temperature drops (less then 980F) during furnace cleaning events. Because of the improved RH cleanliness, RH spray flow is running slightly higher, increasing from 6 klb/hr during baseline to 8 klb/hr with Powerclean in operation (Figure 16 and 17).

Furnace exit gas temperature

Furnace exit gas temperature remained relatively constant at 2180F from baseline to Powerclean in service. With greater movement in burner tilt position based on the RH temperature set point, Powerclean was able to maintain control of FEGT at different loads and under various firing conditions (Figure 18).

Burner tilt position

Historically at higher loads, the burner tilts would remain in the 0% position. This resulted in the burners consistently tilted towards the lower furnace. This was causing large slag accumulations in the lower furnace. The addition of the lower ring of wall blowers and having Powerclean in control increased furnace absorption and allowed the burner tilts to rise off of their minimum setting. Overall, this had a very positive impact on burner tilt position at higher loads.

Sootblowing frequencies

Figure 19 shows the sootblower frequencies in the regions of the boiler as defined in Powerclean. All areas of the unit experienced a decrease in sootblowing except for the furnace. Overall, the unit is cleaner with less blowing.

Conclusion

The Powerclean intelligent sootblowing system on OPPD's North Omaha Unit 3 boiler was a successful implementation on a tangentially fired unit. The unit is running more efficiently and the improved furnace operation has returned the burner tilt control to the operators. The unit is benefiting from better control of heating surface cleanliness and improved overall unit performance.

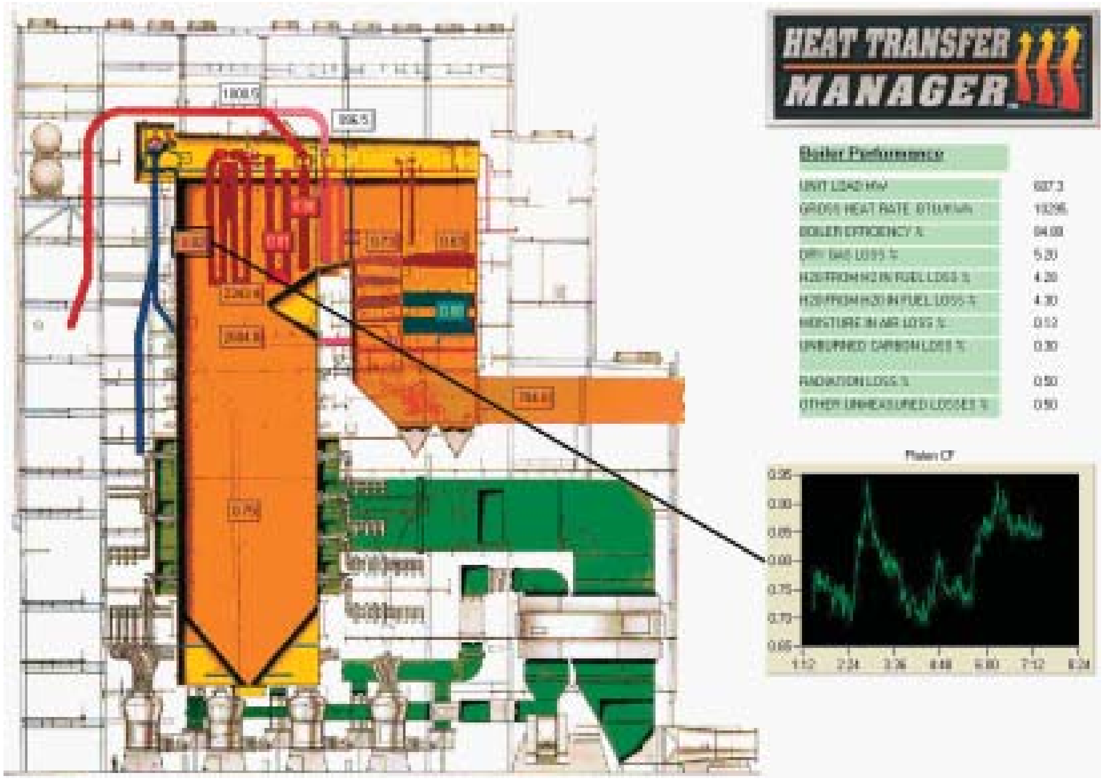

Figure 1 HTM boiler sideview.

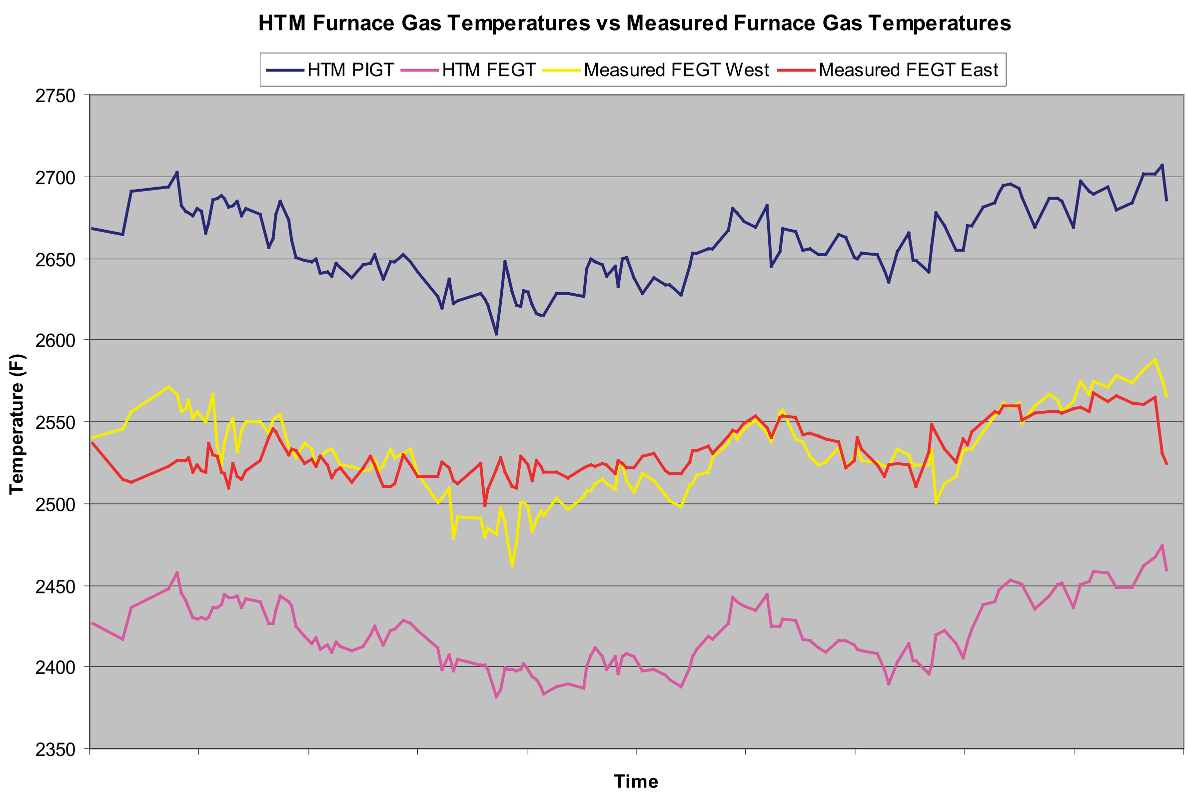

Figure 2 HTM furnace gas temperatures versus measured temperatures.

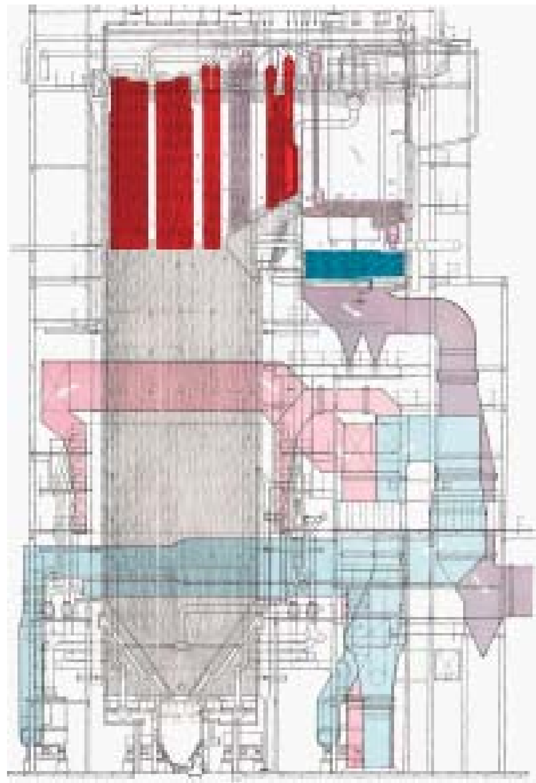

Figure 3 Tangentially fired boiler.

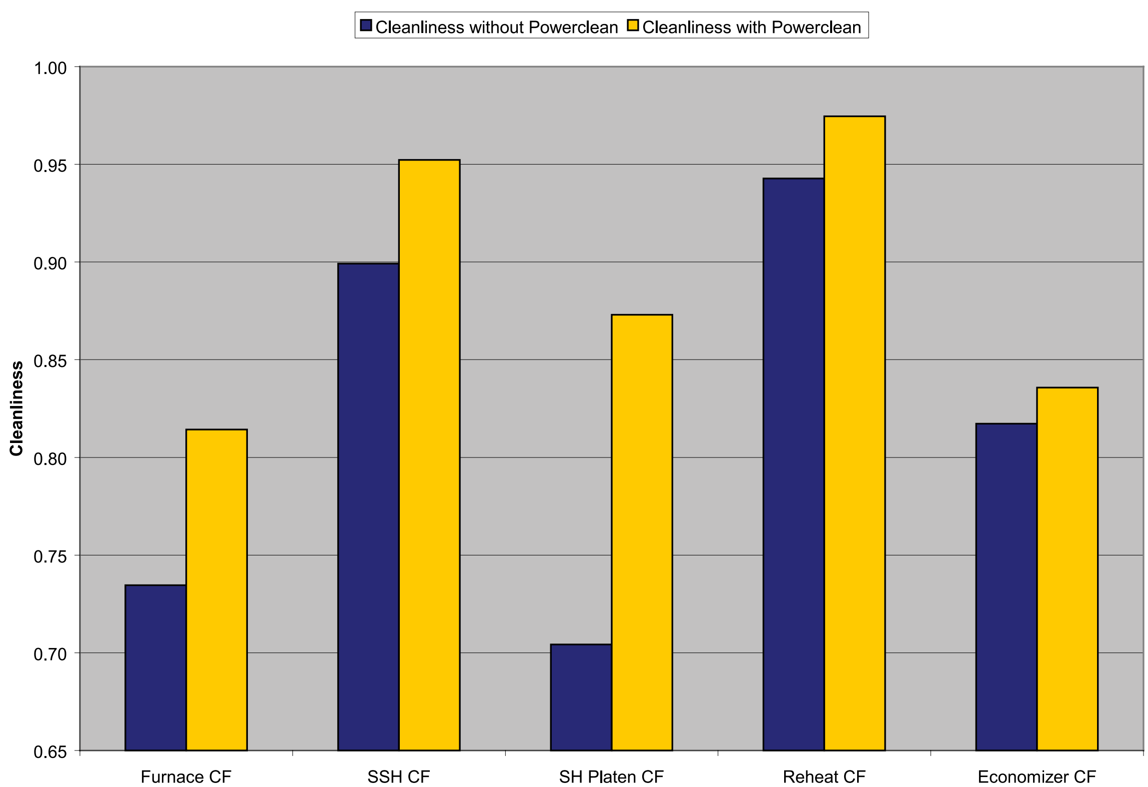

Figure 4 HTM unit cleanliness values - September 2005 and February 2006.

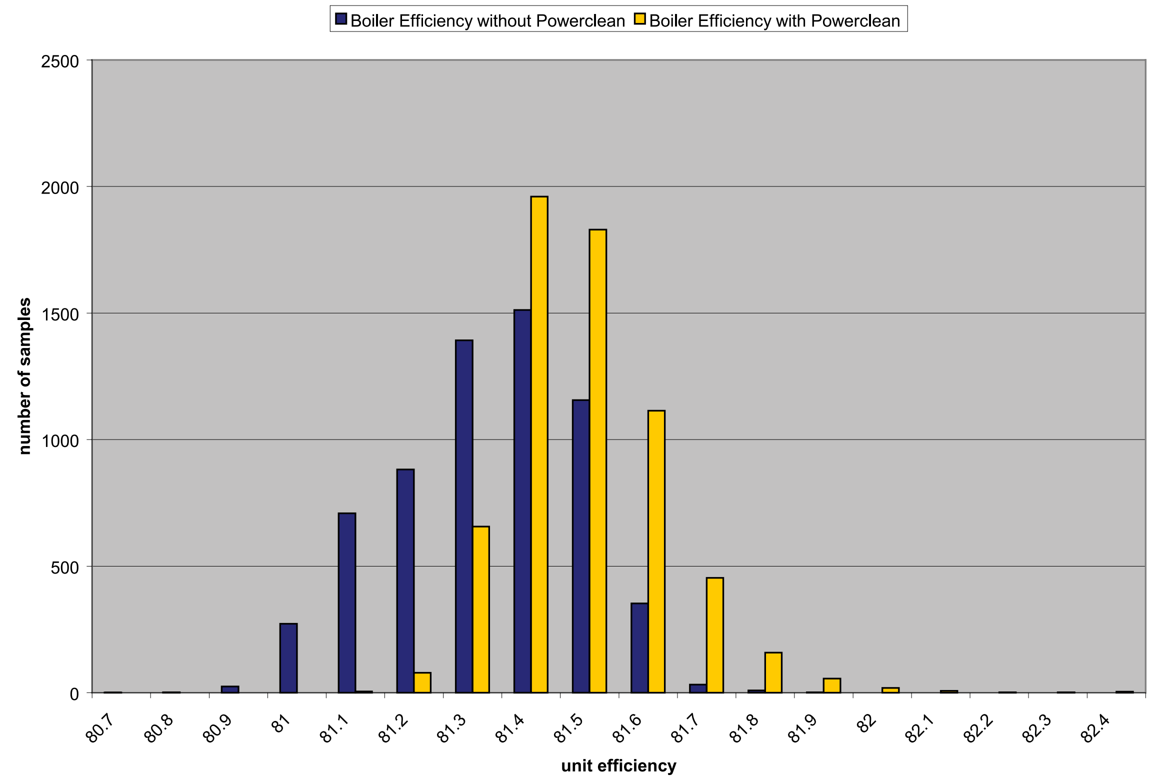

Figure 5 Corrected unit efficiency - September 2005 and February 2006.

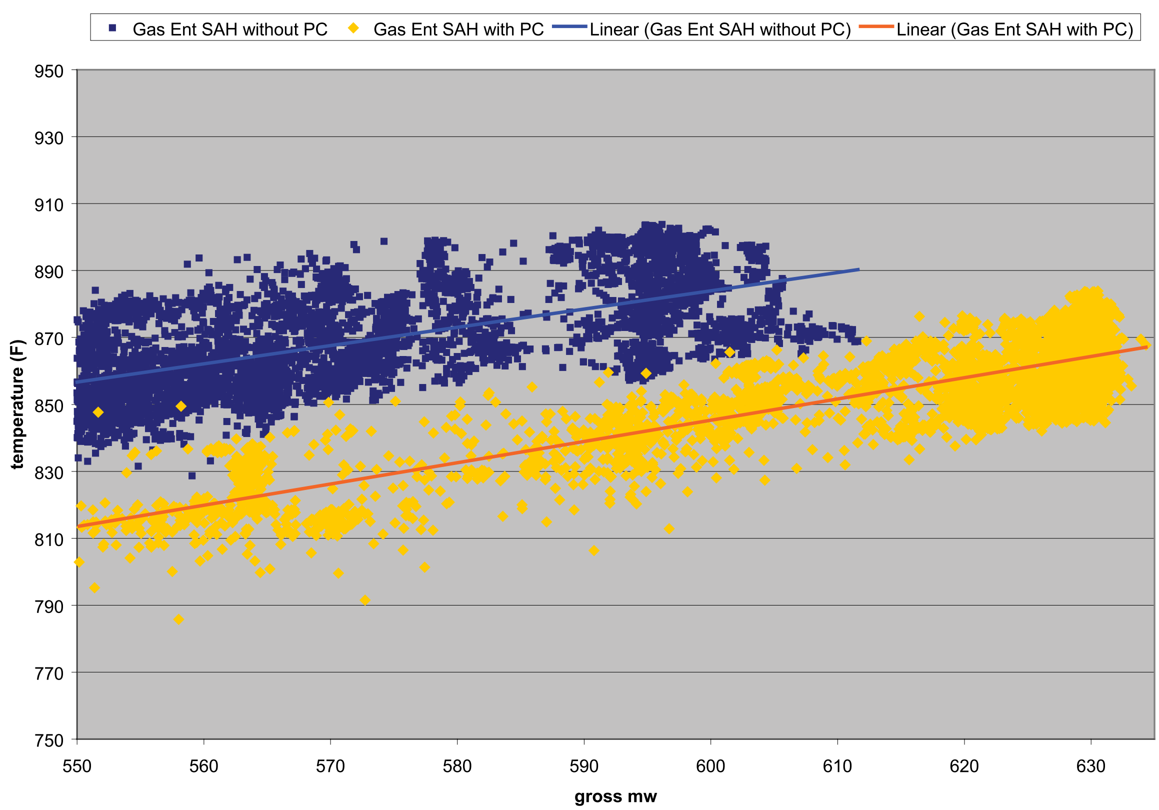

Figure 6 Economizer exit gas temperature - September 2005 and February 2006.

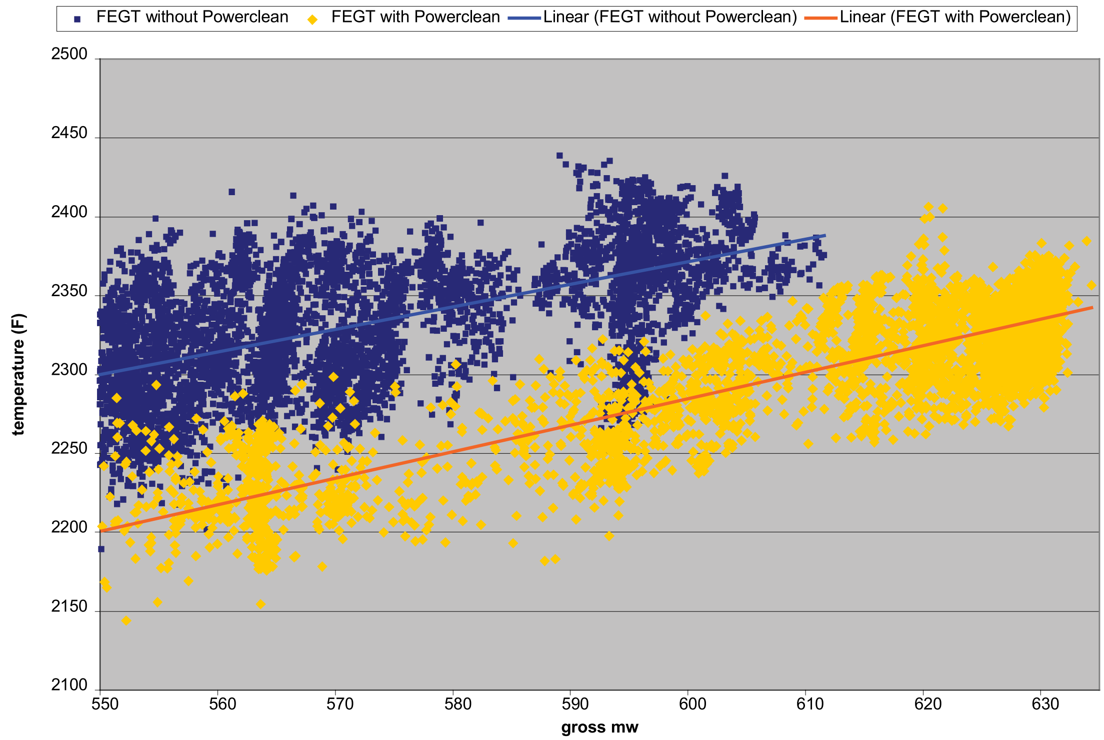

Figure 7 Furnace exit gas yemperature - September 2005 and February 2006.

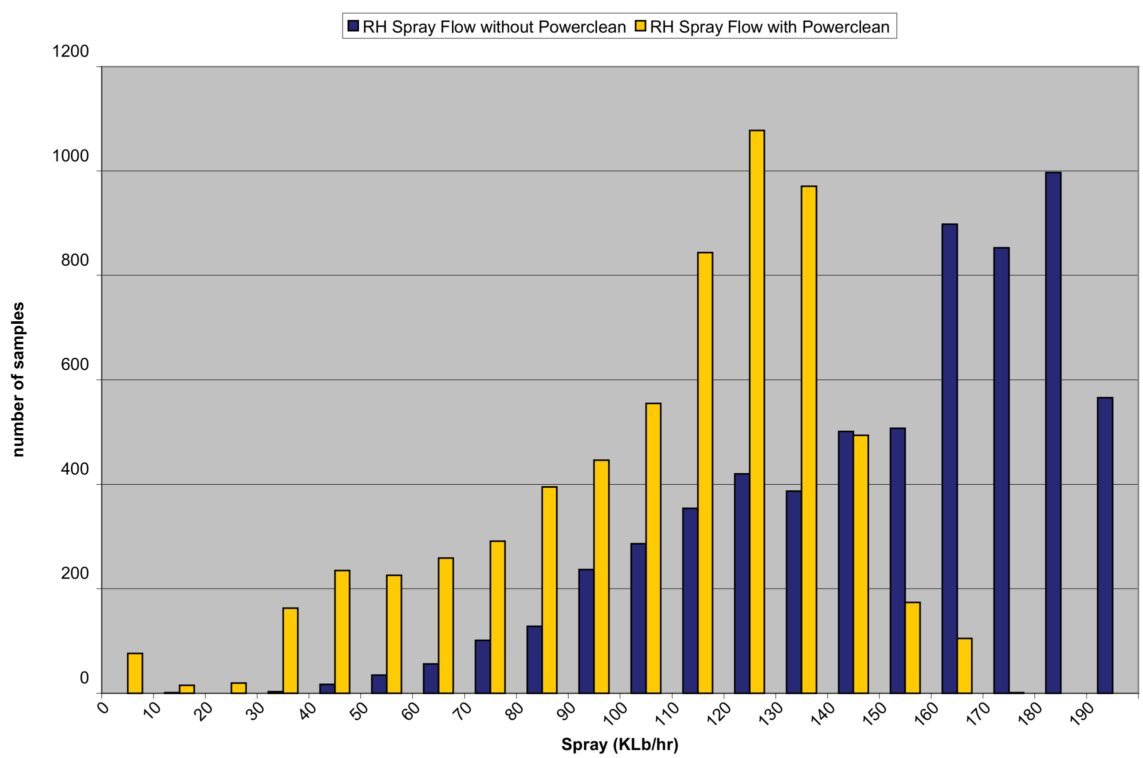

Figure 8 Reheat spray flow - September 2005 and February 2006.

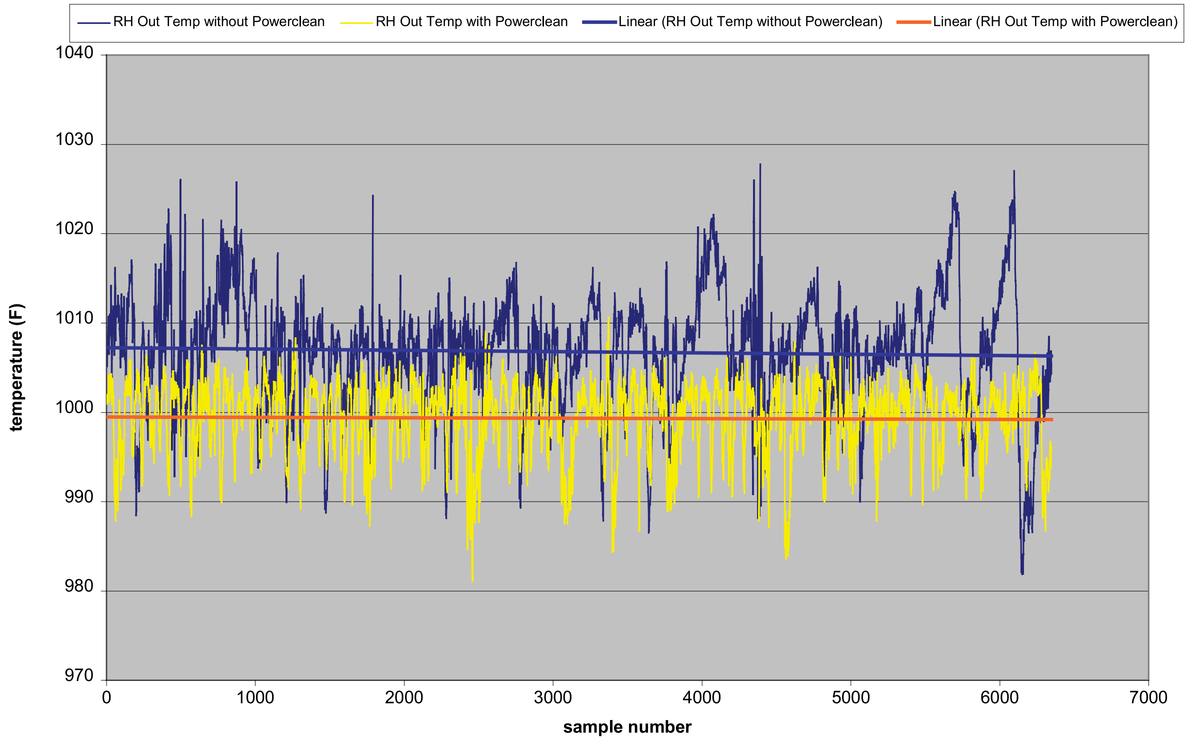

Figure 9 Reheat outlet temperature - September 2005 and February 2006.

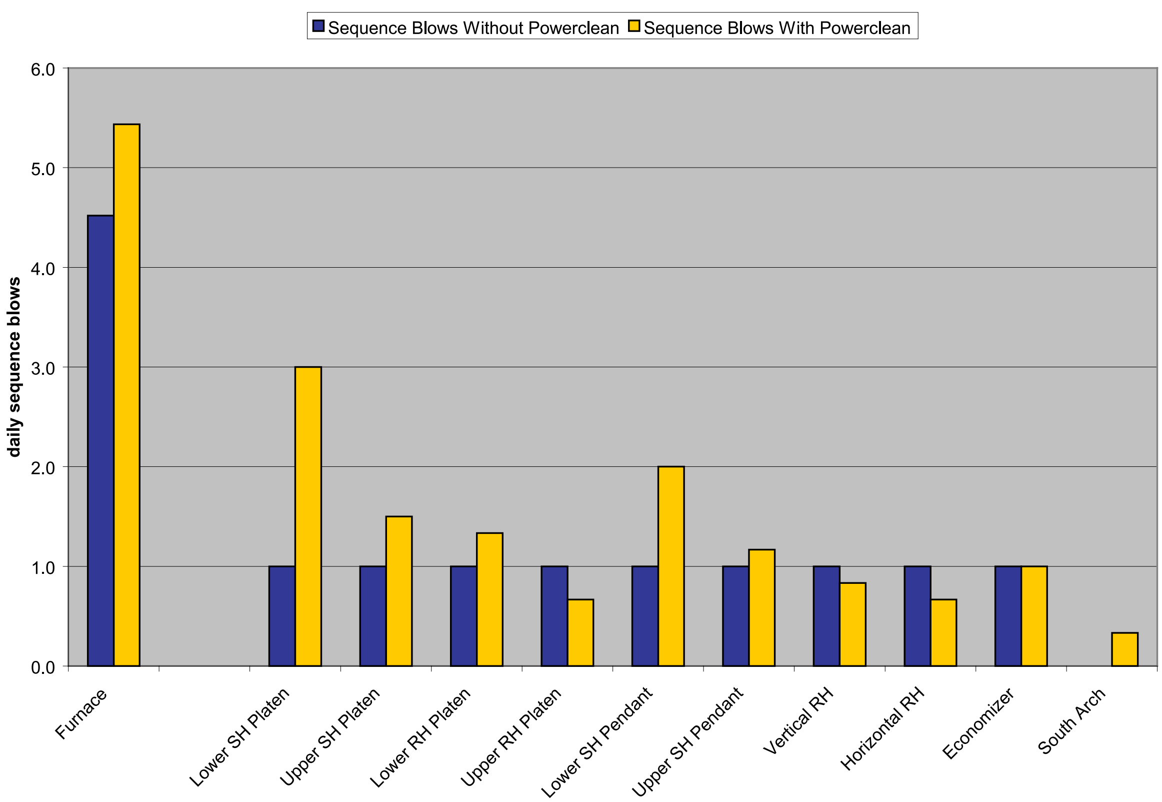

Figure 10 Daily sequence sootblowing frequency - September 2005 and February 2006.

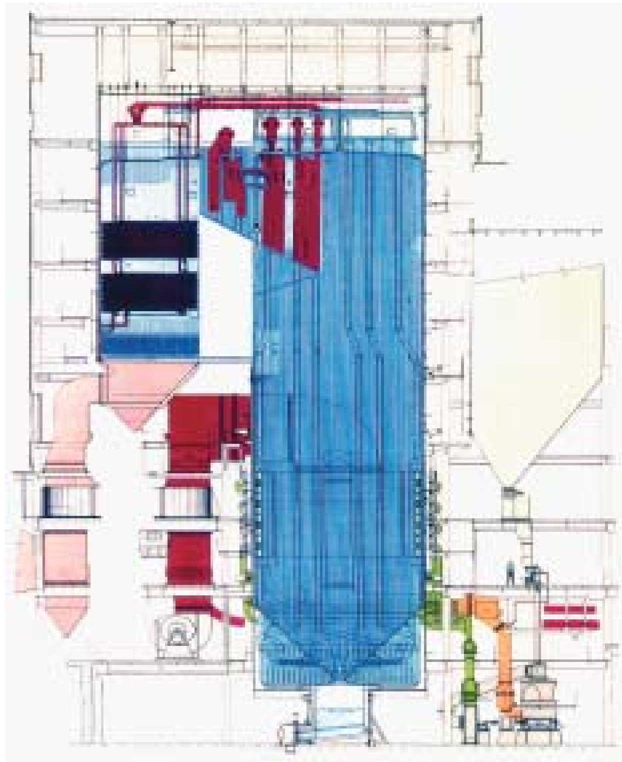

Figure 11 OPPD North Omaha Unit 3.

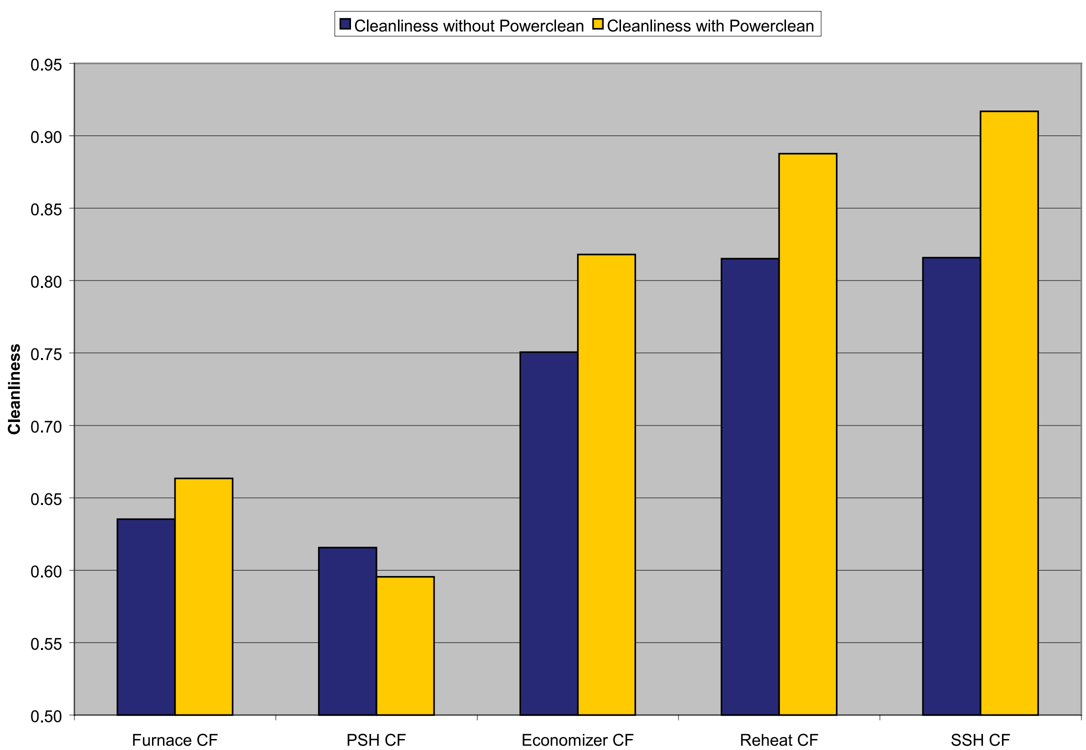

Figure 12 HTM unit cleanliness values - February 2005 and June 2005.

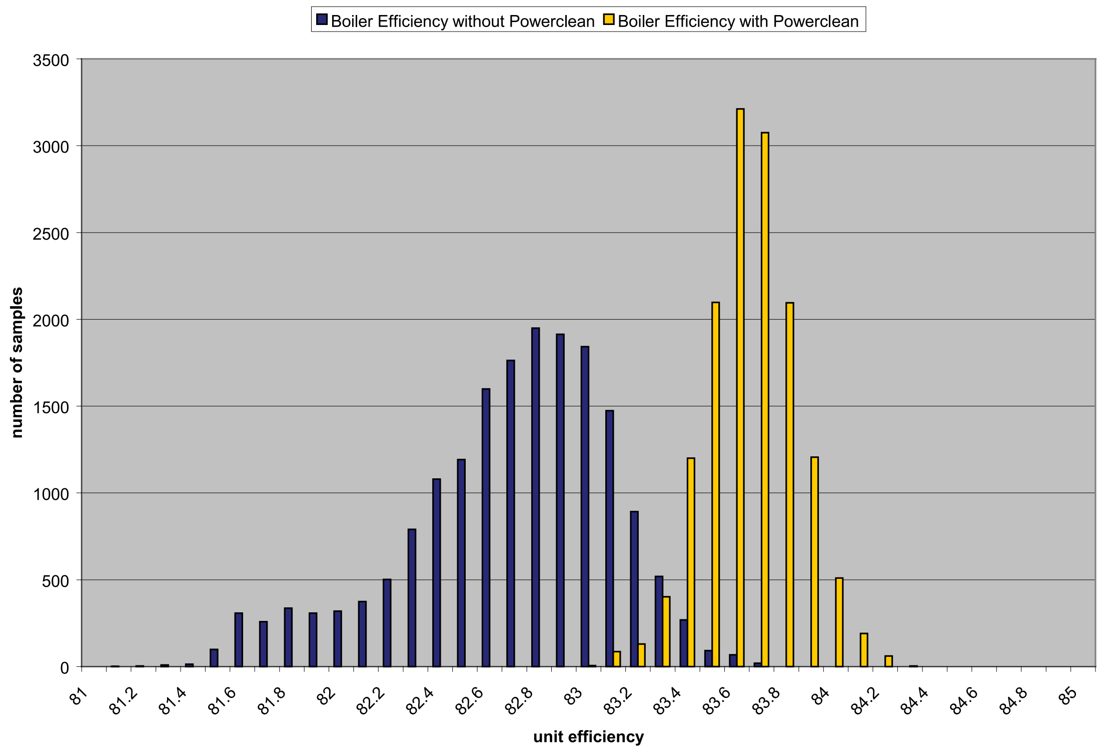

Figure 13 Corrected unit efficiency - February 2005 and June 2005.

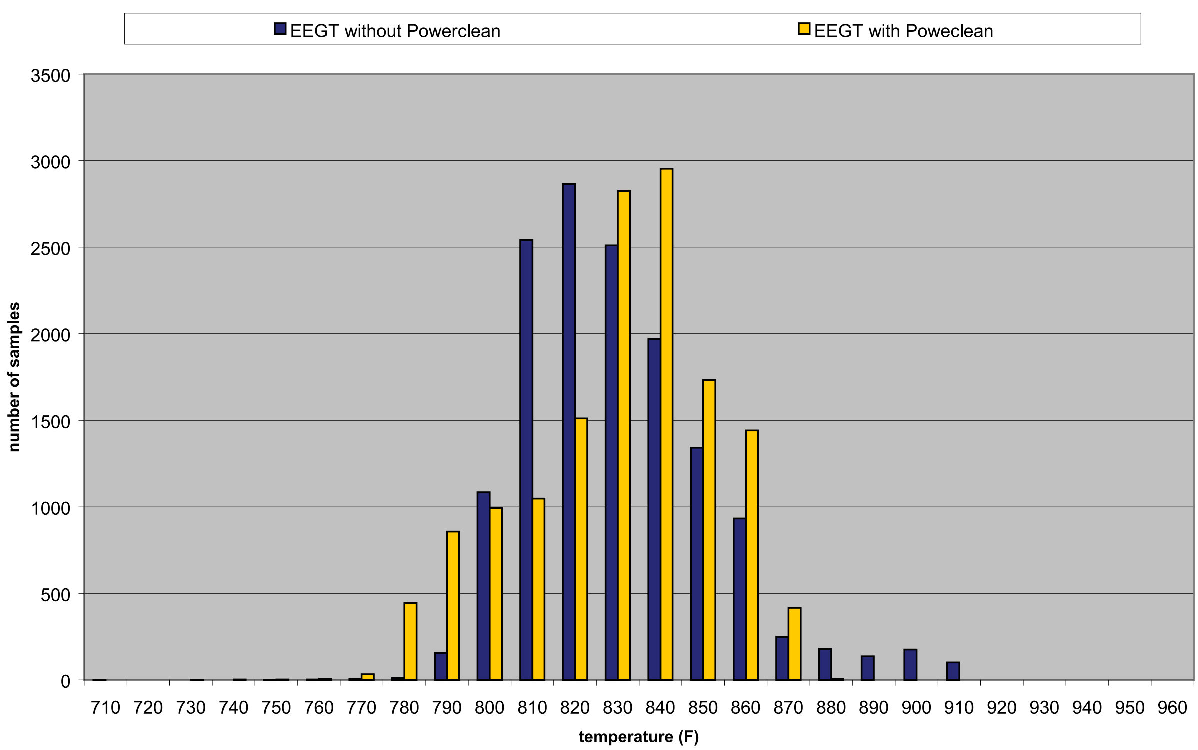

Figure 14 Economizer exit gas temperature - February 2005 and June 2005.

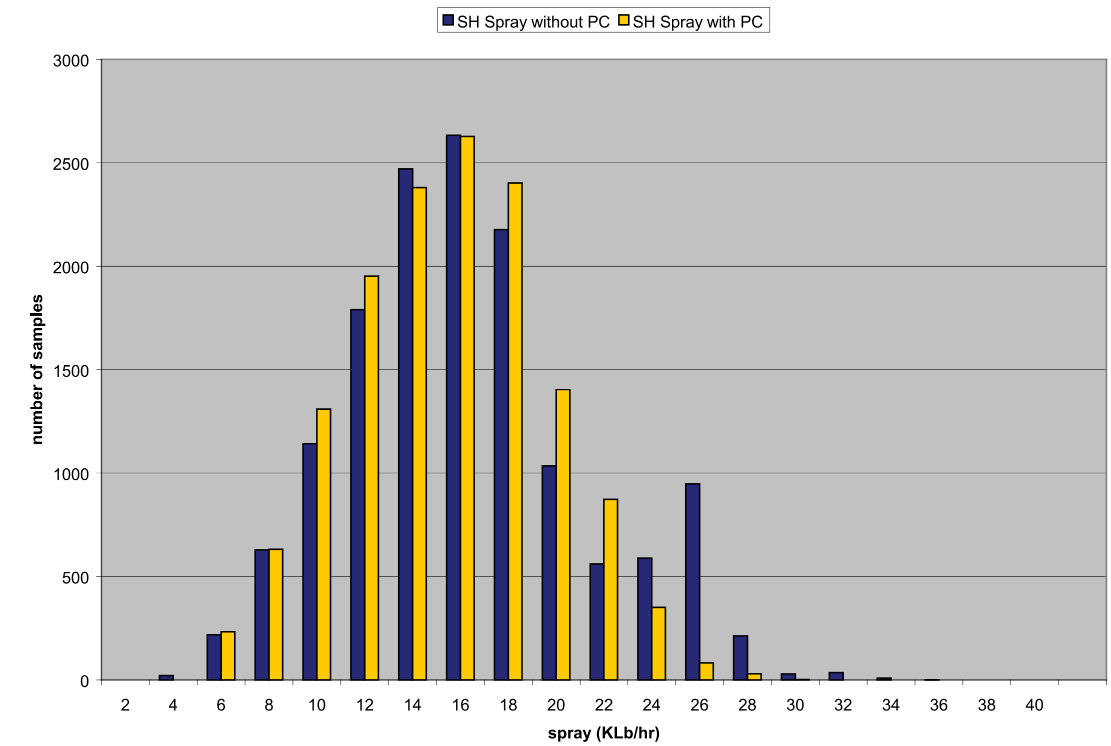

Figure 15 Superheat spray flow - February 2005 and June 2005.

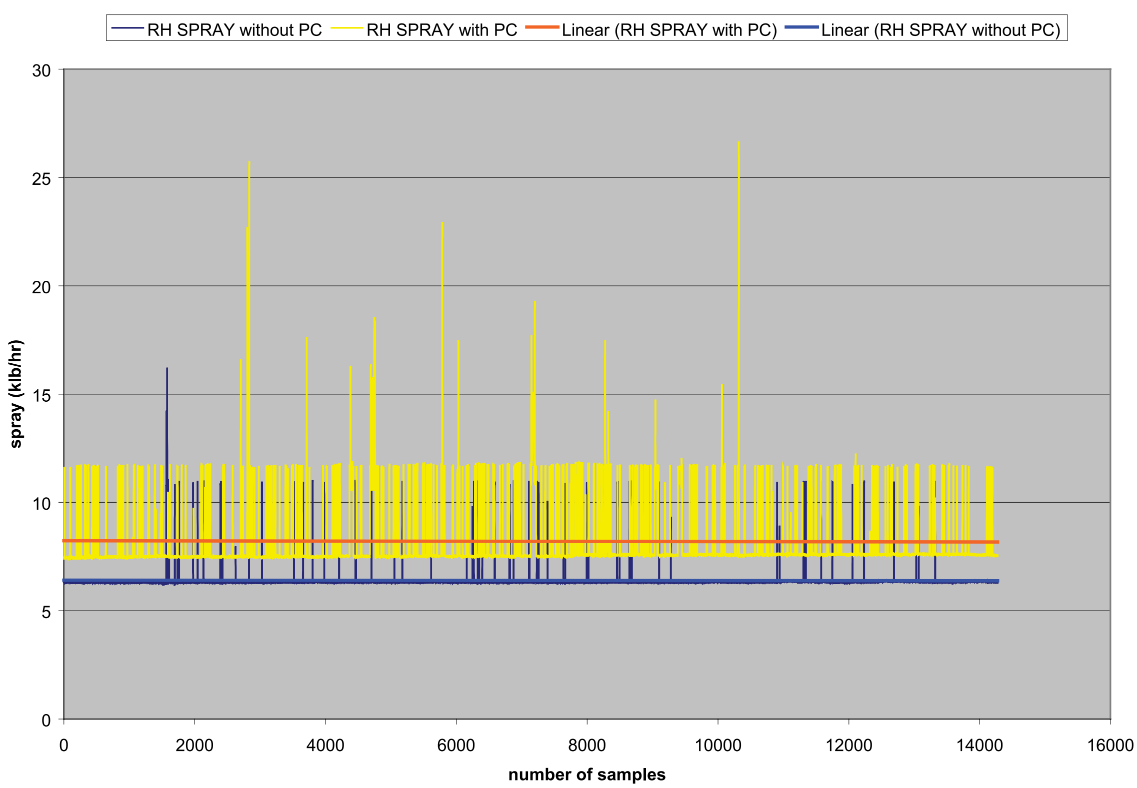

Figure 16 Reheat spray flow - February 2005 and June 2005.

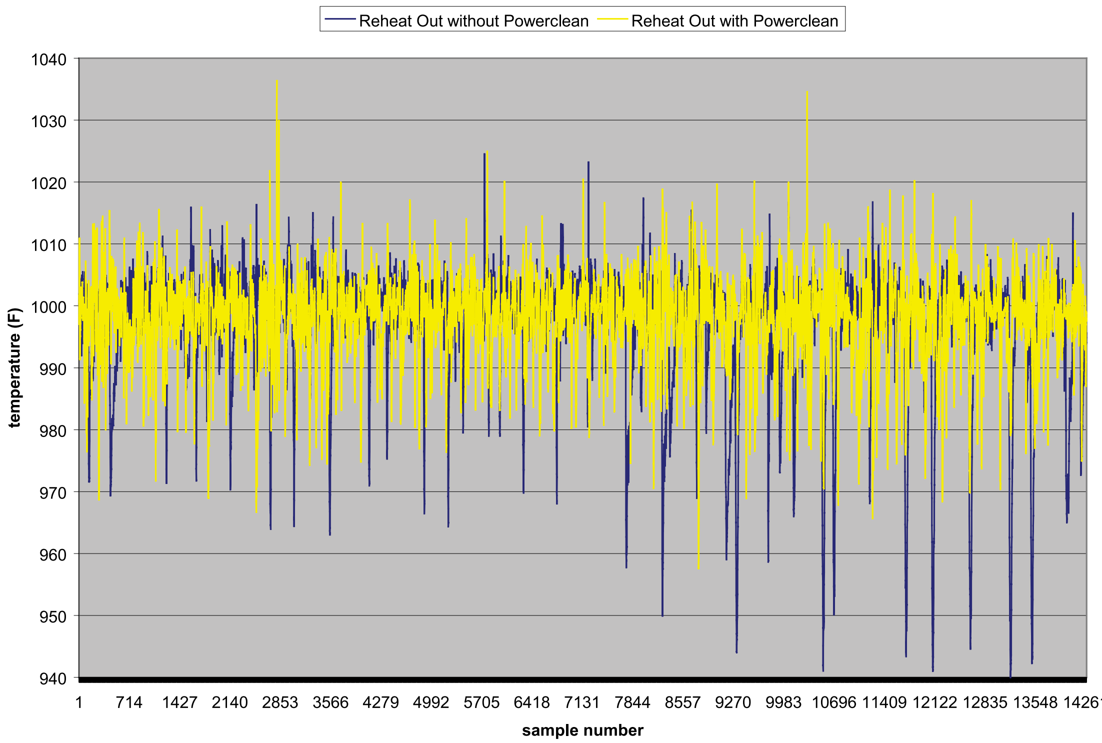

Figure 17 Reheat outlet temperature - February 2005 and June 2005.

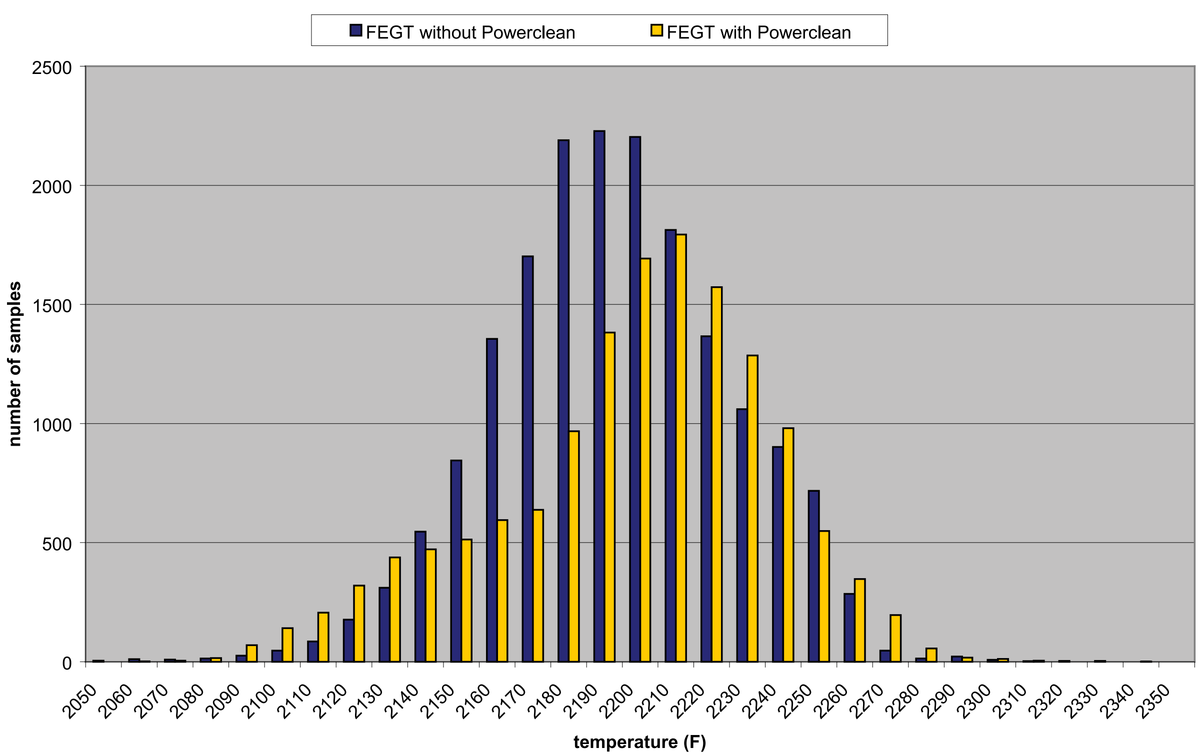

Figure 18 Furnace exit gas temperature - February 2005 and June 2005.

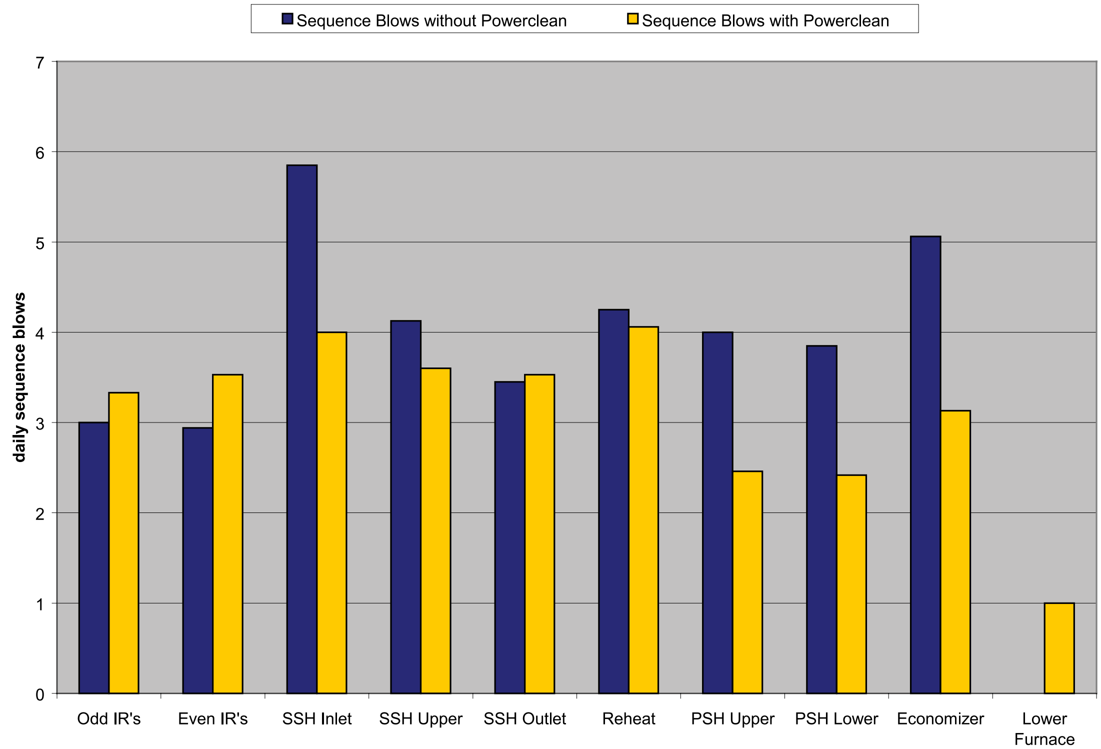

Figure 19 February 2005 and June 2005 daily sequence sootblowing frequency.