

Combustion Tuning Systems for Control of Unburned Carbon

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ABSTRACT

Good combustion practices on coal-fired boilers can reduce the day-to-day variance and overall level of unburned carbon producing higher quality saleable ash as well as improved heat rate. Next to coal fineness, good combustion, characterized by good mixing, adequate air supplies and sufficient residence time-at-temperature is essential to minimizing unburned carbon. With NO_x regulations driving boilers towards more air-lean furnace operation, unburned carbon levels can increase. While total boiler excess oxygen (O₂) is generally sufficient to complete burnout, the day-to-day changes in fuel and air distribution within the furnace can cause local air-starved conditions and a substantial rise in unburned carbon levels. Unfortunately, increasing total boiler airflow to reduce carbon results in increased NO_x emissions and sensible heating losses. The preferred way to address carbon combustion losses is to tune the fuel and air distribution in the furnace and balance spatial combustion conditions. This has historically been done with manual tuning services but now can be accomplished using online combustion tuning systems.

The technologies featured include a burner coal flow balancing system and a combustion tuning system. With these systems, operators can manage unburned carbon without raising total boiler excess O₂ levels or increasing NO_x emissions and sensible heating losses. Other benefits of balancing spatial combustion and operating at minimum excess O₂ levels include minimizing fuel-rich zones and reducing average and peak furnace exit gas temperatures (FEGT), tube metal thermal fatigue, sootblowing and steam attemperation. All these benefits combine to reduce slag formation and tube wall degradation resulting in increased availability and output in addition to generally improving boiler operation and heat rate. GE will present results of implementing these combustion tuning systems and their performance impacts on a 380 MWe coal-fired boiler.

SUMMARY

Application of the coal flow balancing and combustion tuning systems provides capability to impact the zonal heat release and combustion performance in the furnace.

The coal flow balancing system, illustrated in Figure 1, combines continuous coal flow monitoring and adjustable coal flow dampers with automatic controls to optimize coal flow to burners. Figure 2 shows how the system is able to correct significant burner coal flow imbalances and achieves improved performance over manual tuning as well. The automatic controls were able to balance coal within the +/- 5 percent target and maintained the balance over time and changing mill loads. Balancing coal has a significant impact on reducing FEGT and by optimizing the coal distribution, peak FEGT was further reduced as illustrated in Figure 3. Optimization reduced peak FEGT over 60°F and average FEGT was reduced by 20°F.

While the ability of coal flow biasing to affect FEGT is an exciting development, its ability to reduce unburned carbon has been understood for some time. Coal flow balancing is key in ensuring uniform combustion is achieved. Because of the different fluid characteristics between the coals primary airflow and the burner combustion airflow, it can be very challenging to distribute air in the furnace to overcome poor coal flow distribution problems. Coal with its greater density and momentum will tend to distribute less equally within the furnace, while air is able to distribute more readily. This makes it challenging to use air adjustments to correct for significant coal flow imbalance. GE therefore recommends a two-step process of first controlling burner coal flow and then trimming burner airflow to respond to changes in spatial combustion performance.

Once the coal flow to burners is optimized, it is possible to trim combustion performance and control unburned carbon levels. GE's combustion tuning system overcomes the difficulties of making burner airflow measurement by applying spatial combustion sensors in the upper back pass elevation of the boiler and relating combustion zone performance back to burner airflow controls. This combustion tuning philosophy is illustrated in Figure 4.

In practice the systematic method of adjusting burner airflow demonstrated rapid reduction in carbon monoxide (CO). Figure 5, shows how initially high CO zones were reduced achieving a balanced combustion condition. Figure 6 illustrates the unburned carbon in fly ash distribution out of the furnace, as measured by loss-on-ignition (LOI). The high LOI zones corresponded with the high CO zones. By tuning combustion, the fly ash LOI was more balanced, reducing west side LOI by 3 times and overall LOI by 1 percent. These performance levels were achieved on a high volatile coal. Even greater absolute LOI reduction levels are achieved on boilers firing bituminous and petcoke fuels.

The combustion tuning systems reduces LOI but probably more importantly, the system balances LOI across the furnace zones. As mercury regulations drive the need for insitu carbon generation and mercury capture, higher fly ash LOI levels will provide an economical means of controlling mercury. In this case, high but balanced carbon levels across the boiler will be essential to maximizing mercury capture. And when this occurs, GE can provide a comprehensive solution to optimize and control insitu carbon generation, to restore ash quality for sale and to concentrate mercury in small waste streams to minimize disposal costs.

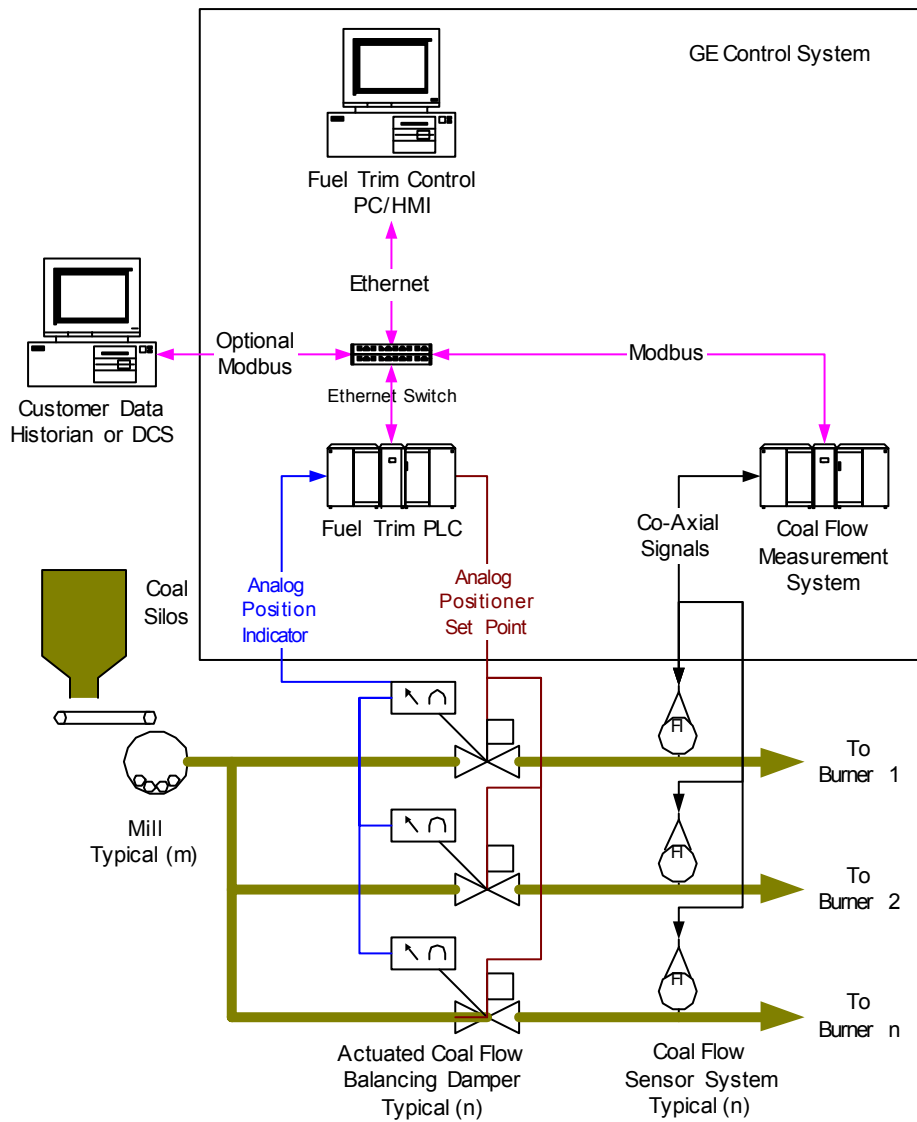


Figure 1. The automatic Coal Flow Balancing System.

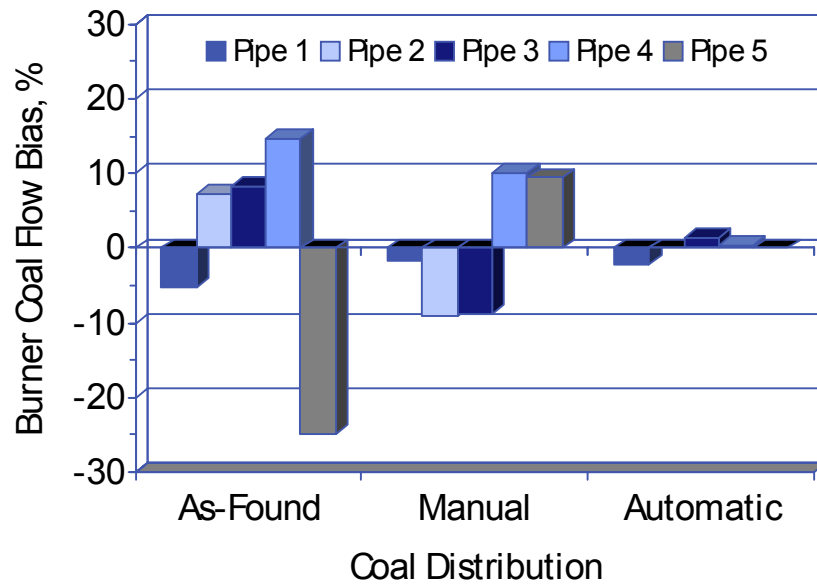


Figure 2. The automatic coal flow balancing system improves fuel control to burner.

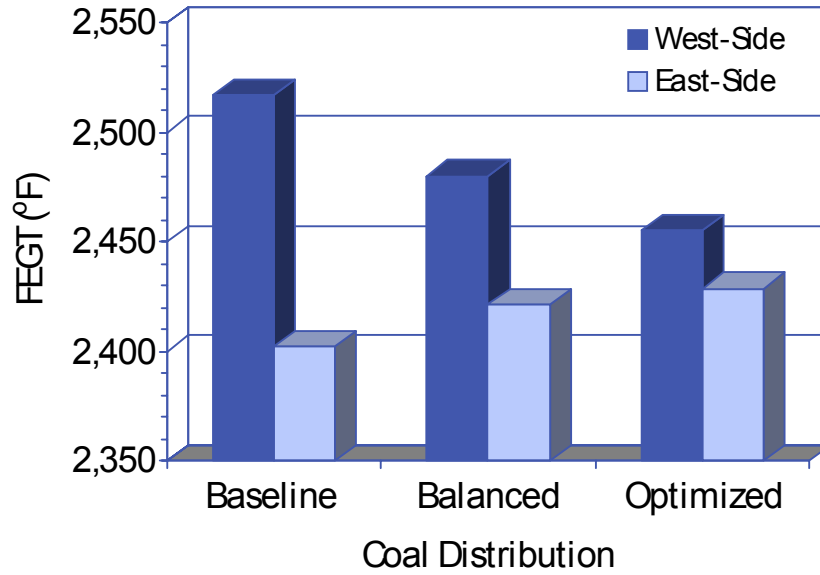


Figure 3. Balancing and prescribed optimization of coal flow to burners reduces peak and average FEGT.

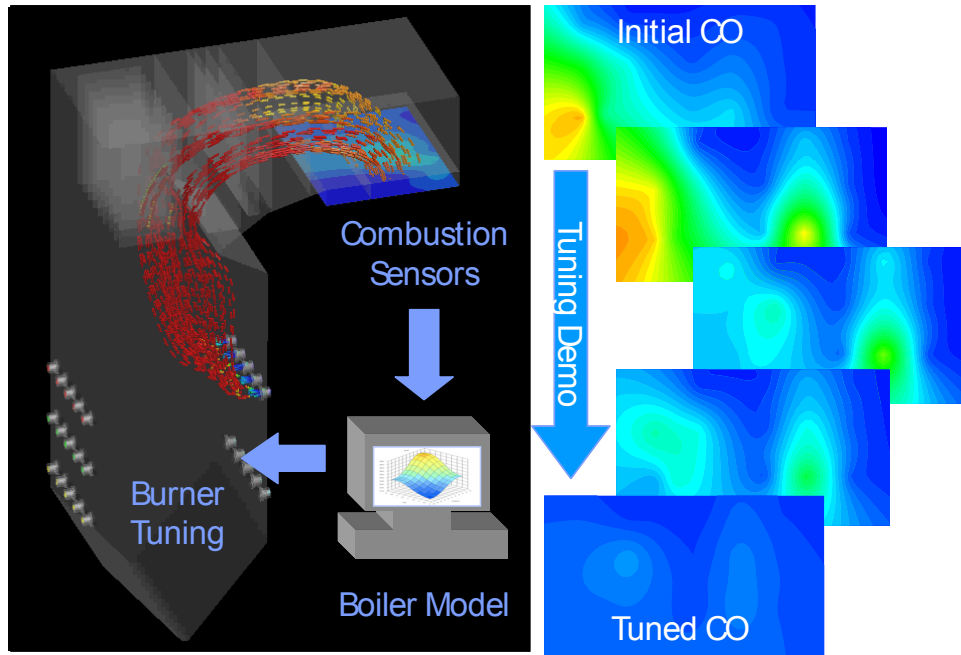


Figure 4. The combustion tuning system utilizes zonal sensor feedback and expert systems to adjust burner airflow.

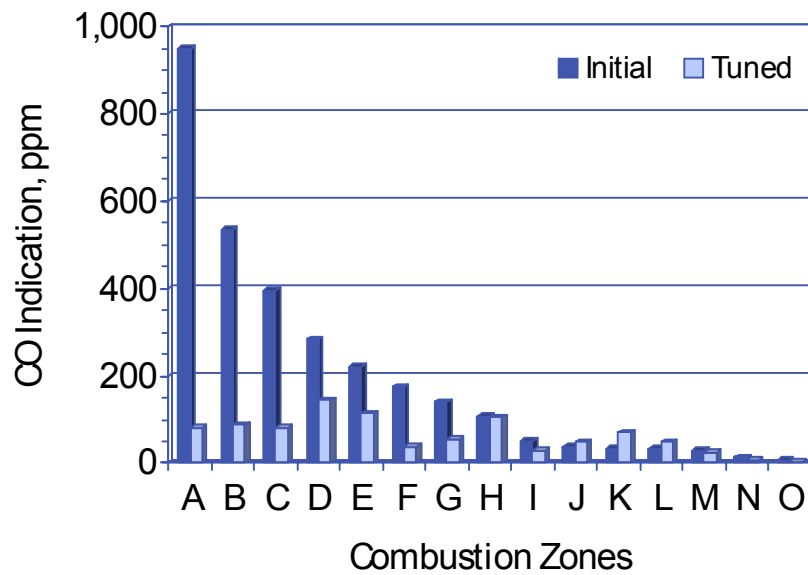


Figure 5. Combustion tuning systematically reduces high CO zones providing balanced combustion quality.

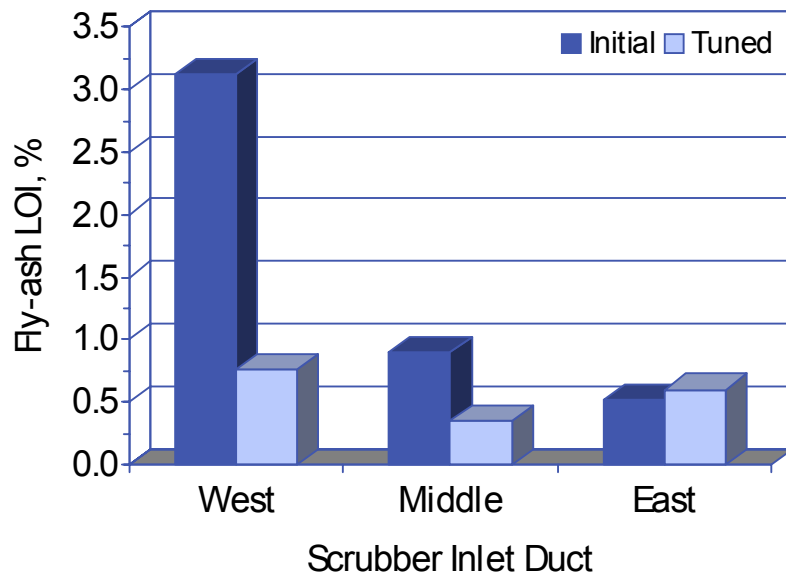


Figure 6. Combustion solutions balance and reduce unburned carbon levels.