Continuous On-line Monitoring of Unburned Carbon Case Study on a 650 MW Coal-Fired Unit

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Summary

MK Engineering Inc. developed a new MPV-1 Combustion Diagnostic System for continuous on-line monitoring of unburned carbon. The system is based on analysis of flue gas turbulence in the post-flame zone.

The system receives information from several optical sensors positioned in the boiler observation ports in the furnace exit zone. Signals are connected to a data acquisition system in the MPV computer. The new MPV-1 is a stand-alone PC-based system. It generates output signals characterizing combustion characteristics across the width of the furnace and enables the boiler operator to monitor the distribution of LOI and temperatures across the furnace, to identify and correct combustion imbalances and to achieve the optimum compromise between NOx and products of incomplete combustion (LOI and CO). The output signals are presented to the operator in bargraph and stripchart form.

The MPV dual optical sensors require no cooling air, no power supply, no extraction nor sampling, and are virtually maintenance-free.

The system was tested on a 650 MW coal-fired unit (No. 3) at Homer City Generating Station. This B&W boiler is equipped with 48 dual register burners, arranged in 3 elevations with opposite-wall firing (6 groups by 8 burners), and with an OFA system for NOx reduction. The MPV-1 system has been in operation on Unit #3 since August 1997. Based on positive results, the plant installed a similar system on Unit #2 (620MW with a Foster Wheeler boiler) and plans to do the same on Unit #1(620MW, similar to Unit #2). The MPV sensors on Unit 3 were installed in the 8 front observation ports at the furnace exit area, using special sensor mounting boxes. Each sensor is positioned above the corresponding front burner column.

This paper describes a case study to illustrate the MPV-1 operation. In the course of our analysis of the LOI distribution profiles, recorded by the MPV-1 system, we determined two significant factors, specific for this particular boiler:

a) High LOI bar, which corresponded to the first sensor on the left, indicated an abnormal situation near the Southern (S) wall (South is on the left);

b) Both LOI and temperature profiles indicated a heavy South vs. North (S/N) bias that exists in the furnace; this bias has been a long-term feature of this boiler, and was also confirmed by other boiler measurements.

Using the LOI profiles as a guide, an effort was made to adjust the boiler to correct both these abnormalities.

High LOI Bar on the Left.

Initially, we made sure that this problem was not caused by a defective left MPV sensor: the sensor and connecting wires were double checked and found in good condition. During careful visual inspection of the 6 left burners (left “burner column”), positioned near the S wall (3 front burners and 3 opposite burners), we determined that 3 rear wall burners (D1-E1-F1) had normal well-shaped flames, but all 3 front burners had bad flame conditions. Particularly, the top burner (A1 burner) had a cloudy, dark, chaotic and shapeless flame. Two lower burners (B1 and C1), also had cloudy flames. The efforts to improve the situation by shutting down individual burners or by adjusting burner registers on the individual front burners were not successful: we were not able to improve the situation or identify the root cause of the problem. However, the definite conclusion was that the combustion situation in this front S corner was definitely abnormal and the high LOI bar correctly identified the problem.

The South vs. North Bias in LOI and Temperature Profiles.

During the initial testing of the MPV-1 system, it was confirmed that the LOI profiles across the furnace could be balanced using the individual OFA dampers. This time, we tried to balance the LOI profiles across the furnace using the secondary air (SA) dampers to individual burner groups. Each burner group of 8 burners is fed from one coal mill, and SA is supplied from both S & N sides. The regular combustion control system allows adjustment of the S/N bias for each burner group.

By changing this S/N bias and providing more air to the S burners, we observed significant transformations of the LOI and temperature profiles. The best results (the best S/N balance) were achieved at the increased S bias on A and D (upper level) burner groups. At different combinations of burner groups with S bias, we received different profile configurations. Examples of different profile configurations received at SA biasing to various burner groups are included in the paper. It was particularly interesting that when we shut down individual burners, the profile indicated a reversed bias. When the “bad” A1 burner was shut down, the left bar returned to the normal level.

These remarkable transformations of the MPV profiles have confirmed that the MPV-1 system:

a) properly reflects the actual combustion situation and provides correct and adequate response to combustion disturbances;
b) provides guidance to the boiler operator to help him balance and optimize the boiler;
c) correctly indicates abnormal combustion conditions and identifies the affected zone(s) in the furnace;
d) can be used as an effective tool for on-line combustion diagnostics and optimization.