Flue Gas SO_3 Stratification At ESP Inlets

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Background

Flue gas SO_3 concentrations can have a significant impact on the performance of coal-fired utility boiler air heaters and electrostatic precipitators. Areas of concern are cold-end air heater corrosion potential, electrostatic precipitator (ESP) performance, and plume opacity. CONSOL R&D has conducted utility SO_3 sampling programs to determine the effect of SO_3 on air heater corrosion, ESP performance, and plume opacity. The SO_3 measurements were obtained with a modified miniature acid condensation system developed by CONSOL R&D.

The role of SO_3 in ESP performance is well documented. It is generally accepted that higher flue gas SO_3 concentrations lead to lower resistivity ash, which is more easily collected in the ESP. ESPs are designed assuming an SO_3 conditioning effect, which is often estimated based on fuel sulfur content. This approach has several limitations because ESP performance can be affected by other factors including:

- Changes in coal source
- Changes in coal seam properties
- Changes in coal characteristics due to blending
- Changes in SO_2 to SO_3 conversion rates
- SO_3 loss across air preheater

Any of the above conditions can result in changes in the ash loading and particulate collection efficiency. In these cases, SO_3 measurements can be useful in diagnosing the problem. In this presentation, the results of a case study involving poor precipitator performance will be reviewed.

Plant Problem

An extensive field test program was conducted at a coal-fired boiler firing a 3% sulfur Pittsburgh Seam coal. The plant was experiencing opacity-related derates. The test program was designed to determine the cause for intermittent changes in ESP performance. As a part of this study, flue gas SO_3 measurements were conducted at the Ljungstrom air preheater inlet, exit, and in the primary and secondary air ducts.

Results

The major findings of this test program are:

- Approximately 40% of the flue gas SO_3 present at the air preheater inlet is removed by the air preheater. This removal is due to a condensation-revolatilization mechanism consistent with the rotation of the air preheater.

- The SO_3 removed across the air preheater was revolatilized and detected in the primary and secondary air streams.

- The flue gas entering the ESP displays severe SO_3, temperature, and resistivity stratifications that are consistent with the rotation of the air preheater (see Figure 1).

- The gas channels between plates in the ESP behave as discrete units with different sensitivities to changes in flue gas temperature and SO_3 concentration.

Conclusion

The air preheater is responsible for the temperature and SO_3 stratification observed at the ESP inlet. The SO_3 stratification causes one side of the ESP to exhibit performance as though a low-sulfur coal is being fired, resulting in an ash resistivity increase and reducing ESP collection efficiency. If the coal sulfur content drops, less SO_3 is generated and the situation worsens. The result is higher particulate penetration and opacity. Accurate flue gas SO_3 measurements were an essential part of the program to correct opacity-related derates.

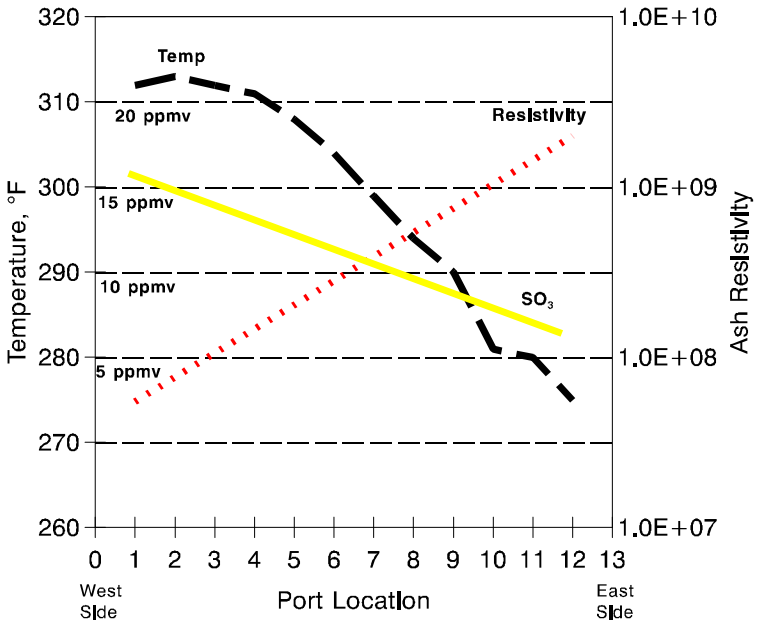

Figure 1. Temperature, SO_3, and Resistivity Stratification Across the ESP Inlet Duct.