IN-SITU ANALYSIS OF CARBON IN FLY ASH USING FT-IR EMISSION SPECTROSCOPY

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An instrument capable of making on-line, in-situ measurements of the residual carbon content in flyash would be a valuable asset in the optimization of power plant efficiency and in achieving pollution control goals, particularly for low-NO_x combustion systems. Current instruments available to measure the residual carbon in flyash are based on extractive point samples. Measurements of this type are relatively slow, are prone to inaccuracies, and require significant maintenance and sample handling instrumentation. This project involves the development of an on-line carbon in flyash monitor based on in-situ infrared radiance measurements. The approach is based upon the principle that low-carbon ash and high-carbon ash have vastly different spectral emissivities. In the long wavelength infrared (~10 μm) both carbon and pure ash are strong absorbers, and therefore both low-carbon ash and high-carbon ash have high emissivities. However, at wavelengths shorter than 4 μm, pure ash is a weak absorber and carbon is a strong absorber, and therefore only high-carbon ash has a high emissivity in this region. As a result, the radiance (thermal emission) of flyash at long wavelengths (-long) will be representative of all of the material in the line of sight (ash + carbon), while the radiance at wavelengths shorter than 4 μm (-short) will only represent the carbon in the line of sight. Thus, by measuring the radiance at selected short and long wavelength bands, R(-short) and R(-long), respectively, a correlation can be developed between carbon concentration and the ratio R(-short)/R(-long) normalized for temperature.

Laboratory measurements of the spectral emissivities of flyash samples with varying carbon content have demonstrated that this correlation exists, and that it provides the best sensitivity in the concentration range of interest, 0 to 5% carbon. Additionally, data collected during a field test at a pilot-scale coal combustor demonstrated that the emissivity measurements could be made in-situ on a realistic facility. These measurements gave results which correlated with expected combustion efficiency trends based on the oxygen concentration in the main burner zone. The current paper is based on further testing of a prototype instrument at a pilot scale coal combustion facility in an effort to develop a quantitative calibration methodology.

The most recent tests were done at ABB-Power Plant Laboratories (PPL) in Windsor, CT in the Fireside Performance Test Facility (FPTF). Instruments were set up at two locations with nominal gas temperatures of 600°F and 1400°F respectively. Initial measurements indicated that the amount of ash radiance was low at the 600°F location and measurements here were subsequently discontinued. The ash radiance measurements were done with an On-Line Technologies Series 2100 FT-IR process monitor. Extractive measurements of gas concentrations were also made at a downstream location using an On-Line Technologies series 2000 Multi-Gas Analyzer. These data were supplemented with gas concentration measurements made by ABB-PPL using conventional CEM equipment. Ash samples were taken periodically by using an extractive probe for off-line measurements of carbon content. The paper will describe the results of these tests.