EXPERIENCE WITH MICROWAVE-BASED SYSTEMS FOR MEASUREMENT OF LOI

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SUMMARY

The first microwave-based system for measurement of fly ash carbon was installed on a utility boiler in April 1993 and is still operating. Since then, sixteen Carbon-In-Ash Measurement (CAM) systems have gone into operation. Some of these systems automatically extract fly ash from the economizer duct and provide on-line fly ash unburned carbon contents in a timely fashion to the control room. Others have been utilized to continuously measure unburned carbon levels in the products of a fly ash beneficiation process in Korea. Another model has also been demonstrated and commercialized for quickly analyzing manually extracted fly ash samples. In addition, another model is being utilized to extract and analyze samples from precipitator hopper fly ash transport lines.

All of CAMRAC's analysis systems utilize microwave to measure fly ash unburned carbon or Loss-On-Ignition (LOI). The interrogated fly ash sample is neither altered nor destroyed by the microwave process and therefore the same sample can be analyzed by conventional laboratory means for accuracy verification purposes. The CAM system utilizes a microwave frequency of 2,450 Mhz, the same frequency that is utilized in the home kitchen microwave oven. The CAM system uses a power level of less than 150 milliwatts and the hardware is shielded for measurement purposes. For comparison purposes, the home oven power level is on the order of 400-1,000 Watts.

Microwave acts much like light in that it reflects off an object, is transmitted through an object, and is absorbed by the object. The CAM microwave interrogation system measures forward power, reflected power and transmitted power. The forward power that is emitted by the oscillator is fed into a waveguide that

contains the fly ash sample. The sample reflects a portion of the forward power, absorbs part of the power, and transmits part of the forward power. Absorbability is the difference between forward power level and the sum of the reflected and transmitted power components. We have found that accurate fly ash carbon contents can be inferred from these individual microwave power measurements.

The microwave interrogation method has been found to be very accurate for the measurement of fly ash unburned carbon. Accuracy levels of better than +/- 0.5% of the ASTM laboratory analysis have been demonstrated for combustion products from the major world coal reserves. Ash chemistries have little effect on analysis accuracy. This was concluded with early laboratory investigations and has been recently confirmed in Korea, where the electric utility coal supplies come from around the world.

The microwave interrogation method has also been tested with unburned carbon separator process products that ranged from 0.7 to 56.8 percent LOI. The residuals (difference between CAM and laboratory analysis) for this wide range of LOI's and chemistry were less than 0.5%.

With today's frequent changes in coal supply to meet cost and environmental constraints, the analysis system must not be effected by ash quality.

First and foremost to the boiler control room operator and ash marketer is that the analysis method is operating within its accuracy specification and communicating an appropriate LOI. This is true whether the analysis system uses a sampling system to extract fly ash samples or just monitors the combustion gas environment (non-extractive).

A leading reason for selecting an extractive sampling system for the collection of fly ash samples for analysis is that the interrogated sample is readily available for laboratory verification purposes. Non-extractive systems must rely on a surrogate sample from the process for proof of analysis performance. Acquiring a representative sample for performance testing is not an easy matter. Use of precipitator grab samples for calibration and performance testing purposes is flawed because of carbon carry-over in the electrostatic precipitator fields and the delay time between burn and sample collection. A significant number of samples must be acquired to determine the range of variability and the statistical mean. Of course, the samples must also be acquired during boiler steady state operation to decrease variability and improve measurement system accuracy.

The accepted method for monitoring combustion performance is to traverse the combustion duct with an isokinetic sampling system and collect a mass weighted average sample of the duct contents. Although the method is time consuming and expensive, the results have been scientifically proven to be accurate.

Non-extractive systems, because of their limited field of view and penetration depth, only capture a limited sample of the combustion duct contents. Multiple cameras are therefore required for good process replication. Like extractive systems, the non-extractive cameras must also be placed in appropriate locations to represent combustion performance conditions. A duct traverse is highly recommended for the determination of the view/sampler locations.

A properly designed extractive sampling system has all of the components that are necessary for the performance of a duct traverse and for the determination of the proper placement of samplers to represent combustion conditions. These systems are therefore cost effective because the original equipment can be utilized to perform a duct traverse instead of acquiring the services of duct sampling team to determine the ultimate location for the samplers.