Measuring the Emittance of Ash Deposits in a Coal Fired Reactor

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Background

In a coal fired reactor, ash is formed and accumulates on the walls of the combustion chamber. This deposited ash can significantly affect the thermal transport in the boiler.

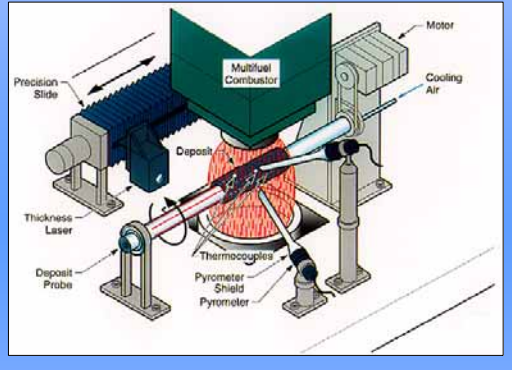
Objectives

1. Develop a method to simulate the deposition of ash on reactor walls
2. Develop a procedure to make accurate, *in situ* measurements of the emittance of the deposited ash

Importance

Knowledge of the properties of the ash deposits will result in better modeling capabilities and improved optimization of the design of coal fired reactors.

Simulating Ash Deposition

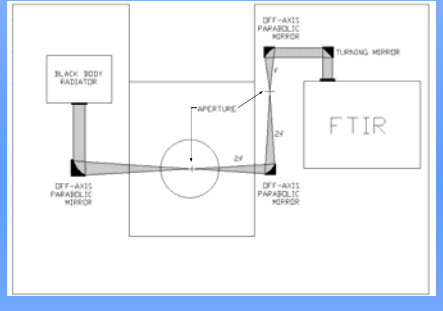


Method

An air-cooled, circular steel probe is placed at the outlet of a multi-fuel combustor. Coal is injected into the top of the furnace and the noncombustible ash constituents accumulate on the probe. Various *in situ* measurements may be made on the deposited ash layer.

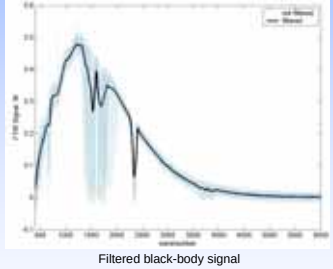
Instrument Calibration

An optical path directs the emission from a black body radiator into a Fourier Transform Infrared (FTIR) Spectrometer.

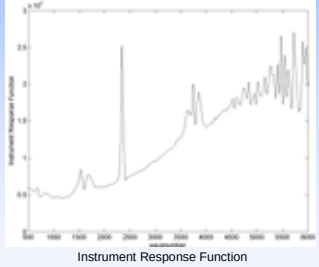


The gas absorption lines are filtered out of the black body emission signal and an Instrument Response Function (IRF) is determined by dividing Planck's function by the filtered signal.

$$IRF(\nu, T_b) = \frac{E_\nu(\nu, T_b)}{M_\nu}$$



Filtered black-body signal

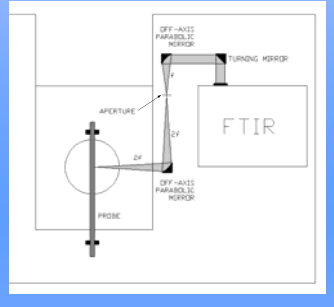


Instrument Response Function

The instrument response function provides a relationship between the signal measured by the FTIR and the emissive power of the radiation source.

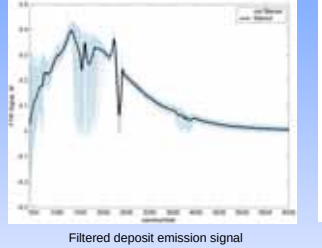
Calculating the Emittance

The same optical path directs the radiation from the ash deposit into the FTIR Spectrometer.

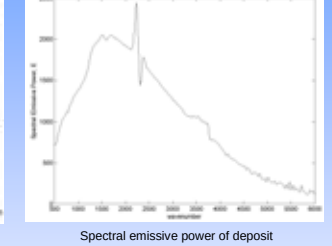


The filtered emission signal from the ash deposit is multiplied by the IRF to get the spectral emissive power of the ash.

$$E_\nu(\nu, T_s) = IRF(\nu) \cdot M_{\nu,f}$$

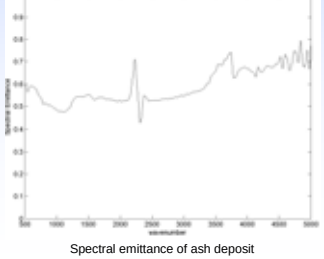


Filtered deposit emission signal



Spectral emissive power of deposit

The spectral emissive power is divided by that of a black body at the same temperature, resulting in the spectral emittance of the deposit.



Spectral emittance of ash deposit

$$\varepsilon_\nu(\nu, T_s) = \frac{E_\nu(\nu, T_s)}{E_{b,\nu}(\nu, T_s)}$$