Advanced Instrumentation for Improved Plant Operation

Presented to: McIlvaine Webinar
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“New” Instrumentation for Boiler Optimization

Steam generator

Burners

Secondary air

Air preheater

Primary air

Electrostatic precipitator

Coal bunker

Combustion Air

Fly ash Silo

Fly ash

Coal mill

FD Fans

Flue gas

MECONTROL Air/FG

MECONTROL Coal

MECONTROL UBC

(Air Monitor Corporation)
Extended spatial filter (MECONTROL PSA)

Based on evaluation of the shadows of a laser beam created by moving particles

Properties:
- Measuring range 30µm to 6mm
- Recording of particle velocity and particle size
- In-situ measurement on PF pipes
- Chord length measurement
Particle Size Analysis (PSA)
Test Data: PS Reuter West, Berlin

MECONTROL Coal Measurement with Feedersignal and Particlesize Distribution

10.06.2007

MECONTROL Coal Measurement with Feedersignal and Particlesize Distribution

- Massflow [t/h]
- Particle Frequency [%]

- Sum Burner 1-4 [t/h]
- Feeder [t/h]
- > 200 µm [%]
- 90 - 200 µm [%]
- < 90 µm [%]
Efficiency Optimization Principle

Minimize energy losses from unburned carbon & flue gas -- function of excess air levels

Excess Air

Losses

UBC

Optimum

Flue gas
Key Functions

- **SAMPLING**
  Instrument must collect a representative sample

- **MEASUREMENT**
  Instrument must accurately measure the amount of unburned carbon in the sample
Sampling Approaches

- **Extractive** (remove ash from handling system to make measurement)
  Classical approach used for early instrument design

- **In-situ** (measurement made within ash handling system)
  New approach – providing significantly better reliability

**PROMECON APPROACH**
Sampling Location

Not representative  Representative

Weak Correlation to Silos  Strong Correlation to Silos

Flue gas Sampler (Extractive)  Bulk ash Sampler (PROMECON)

0.00015%
Sampling of the Ash Flow

Ash and gas not uniform

Cross sectional coverage: 0.000005%
Fly ash concentration: 5g/m³

Ash discharged in dense quantities

Cross sectional coverage: 2-8%
Fly ash concentration: 200,000 g/m³
Typical Fly Ash Loading Distribution
Typical Fly Ash LOI Distribution
Extractive Measurement

Ambient Temperature

320°F

Flue gas duct

Cyclone separation/classification

Transport through heated pipes

Measurement of Air/Ash mixture

Static weighing of 5g sample

In-Situ Measurement

ESP Hopper

140°F

Sampling and measurement in the hopper:

✓ no extraction
✓ no cyclone separation
✓ no static weighing
✓ no heating elements

Fly Ash to the Silo
Measurement Approaches

• Microwave
  – Basis: Response to microwave radiation
  – Pros: Simple; Accurate; Infrequent calibration
  – Cons: Higher initial cost
  – Insensitive to fuel type or blend
  – Can be performed in-situ
  – Multiple sampling points w/ one instrument
  – (# sampling points?)
Dielectric constant of fly ash is a function of the carbon content. Measuring the shift of frequency (microwave) in a resonator ($\Delta f$) enables the carbon content to be calculated.

$$UBC = A + B \cdot \Delta f$$

A and B are the calibration coefficients.
Typical Measurement Data Accuracy
Boiler/Mill Optimization w/ UBC Monitoring

Data from Reuter West power station, 11/12/2001

- UBC Fly ash (PROMECON UBC)
- UBC Fly ash (Lab analysis)
- \( \text{O}_2 \) Boiler @ SCR outlet

UBC [%]

Time

0 0.5 1 1.5 2 2.5 3 3.5 4 4.5

0 2 4 6 8 10 12 14 16 18

7:00 7:30 8:00 8:30 9:00 9:30 10:00 10:30 11:00 11:30 12:00 12:30 13:00 13:30 14:00 14:30 15:00 15:30 16:00 16:30 17:00
MECONTROL UBC Design

Measurement Cabinet

Power supply

Signals

HF-signals (Microwaves)

Power supply Motor

Sensor box

Sensor
Kanawha River UBC Data

Standard Deviation of UBC Measurements

Channel 0: 0.17%
Channel 1: 0.15%
Channel 2: 0.28%
Channel 3: 0.15%
Channel 4: 0.10%
Channel 5: 0.16%
Channel 6: 0.25%

All Channels = 0.18%
Benefits to the Power Plant

- Accurate measurement of a very key combustion parameter (UBC)
- Optimization of mill/boiler performance
- Improvement of NOx, CO, O₂ and UBC (quantity and consistency)
- Operating cost savings by reduction of primary losses and increased fly ash sales
Air/Flue Gas

Hot Gas Flow Measurement
How accurate is your air flow measurement?

-Venturi measurements usually control dampers to a fixed set point. Therefore the venturi measurement indicates this set point during normal operation. Any deviations of inaccuracies therefore can not be observed from the measurement value itself, because it indicates the desired value. The damper curves usually do not allow the detection of deviations of the venturi measurement. But they often are not plausible (see picture).

-Since the O₂ control loop usually corrects the deviations caused by a faulty air flow measurement, the problem can not therefore be detected by a flue gas O₂ monitor.

This problem causes loss in efficiency as well as unnecessary damper wear!!
MECONTROL Air/FG flow measurement

- No measurement drift, reduced damper control error and wear
- Accurate air distribution to each burner
- Unaffected by dust and dirt in the gas stream
- No pressure drop at the measurement location
MECONTROL Air/FG

Measurement Principle

Air Duct or Pipe

Signal Sensor 1

“Signature”

Signal Sensor 2

Sensor 1

$X(t)$

Sensor 2

$Y(t) = X(t-T)$

S = const.

correlation

Time $T$

Example

$S = 2$ ft

$T = 25$ ms

$V = 80.0$ ft/s (average velocity)

“Correlation”

Optimum correlation

$T = 25$ ms

Cross correlation

Distance of the two sensors: 54 cm

Measured velocity: 20.77 m/s

Previously measured velocity with Prandtl's pitot tube: 20.52 m/s
MECONTROL Air/FG Overview

Duct

Sensor 1

Sensor 2

Sensor box
max. 4 Sensors/2 Channels

Sensor 3/4

Main Cabinet

4 x raw signals

Power Supply
24 VAC
A venturi measurement is highly non-repeatable when exposed to dust contamination in secondary air ducts. This leads to a wrong stoicheometry as well as to increased wear of the damper actuators. The problem does not become apparent on the venturi values themselves or the O2 values at the boiler outlet, but mainly on the dynamic behaviour of the dampers themselves.
Case Study: wall-fired boiler

Despite constant O2 values, combustion conditions vary from day to day!

Venturi measurements indicated the same air flow on both days.

However damper position showed large variations. This result is not plausible as the air ducts come off the same main duct which showed the same static pressure on both days.
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