Monitoring and Optimizing Fuel Feed, Metering and Combustion in Boilers

June 13, 2013
Coal Feed to the Unit is Critical to...
Efficiency, LOI, Emissions, Reliability

OFA

Burner line
Coalflow

CO and O2 Balance issues

Proven solutions for a tough industry
Coal Mill Feeder Control

Example where each mill feeds a burner row.

Poor control leads to (undesired) heavy and light burner rows – creating Nox, high LOI, CO, slagging, fouling, tube leaks…

Proven solutions for a tough industry
LOAD CELL WEIGHING
WITH MICROPROCESSOR CONTROL
Gravimetric Feeder Functions

- Load Cell feeders
  - Fixed height leveling bar - usually high center
  - Weight on weigh span varies with material density
  - Calibration of load tare, load span and belt speed using optical probes
  - Calculation of feed rate (lbs/sec) by multiplication of belt speed (in/sec) by weight (lbs/in)
  - DCS demand signal adjusts material feed rate
  - Microprocessor controls
Stock Gravimetric feeders provide coal delivery on a weighted basis in order to more closely match the combustion control requirements for heat input into the boiler. The Gravimetric Feeder automatically compensates for density variations and feeds coal to within 1/2% of the true weight.
Benefits of Coal Pipe Metering

Further Improve:

- NO$_x$ reduction
- Improve boiler efficiency
- Reduce CO and LOI
- Reduce waterwall corrosion and thus downtime (forced outages)

PLUS:

- Improve mill and burner performance
- Improve Primary Air Control
- Eliminate coal layout, mill pluggage, fires
- Allow operators to have more information
- Existing air and fuel (manual sampling) measurements are inaccurate
Coal Flow Measurement

Amplitude

Frequency shift

Mid amplitude

Frequency shift

Sensor distance
40 - 60 cm

Coal flow

Cross correlation method

Signal 1
\[ x(t) \]

Signal 2
\[ y(t) = x(t-T) \]

Pulse flow velocity
\[ \text{Pulse flow velocity} = \frac{\text{Distance}}{\Delta t} \]
When a mill is brought down and swept with air, the mill eventually is free of coal but there is still some residual dust/ash blowing through the pipes. There is no coal density so the MF=0 (Density x Vel = 0).

This “clean air” velocity was compared to clean air tests performed by Alstom. The accuracy of the Pf-FLO “clean air test” compared with the Alstom pitot traverse was within 1 to 4 fps. Shown is the SCADA data of the clean air test on Pf-FLO (see values on right from 113 to 118 fps). These are the values at 4:42 am on Jan. 18 after the mill was swept clean.
Primary Air and Mill Improvement

- Decreasing PA improves coal balance
- Optimum coal velocity for better combustion
Absolute Coal Flow
Adjustable Diffusing Coal Valves – Meter the Coal
Coal Pipe Balancing
Coal Pipe Balancing

[Image of a computer screen showing a graph of mass flow over time with labels for different mill locations and dates.]
Adjustable Valves for Riffles
Improving Coal Distribution Improves Temperature Dist.

Tertiary Splits

Primary Splits

Secondary split
....After Balancing Pipes

Tertiary mass flows

Secondary mass flows

primary Splits

primary Splits
Prevent Burner/Pipe Fires
Prevent Burner/Pipe Fires

Proven solutions for a tough industry
Proven solutions for a tough industry.
Crystal River Unit 4

- B&W Opposed Fire Pulverized Coal 770 MW
  - 6 MPS-89 Pulverizers with Stock Gravimetric Feeders
    - 9 Coal Outlets per Mill
  - 54 B&W DRB-4Z Low NOx Burners

- 6 Compartmentalized Windboxes
  - 3 x Front, 3 X Rear

- SCR, Cold Side ESP & Wet FGD
Coal Balancing

- **Problem**: Uneven Coal distribution
- **Solution**: Online coal measurement + adjustment
Why Automate SA Dampers?

- Dynamic windbox flow profiles
  - Fluctuating windbox pressure
  - Ash build-up
CRN O2 Distribution Comparisons

CR4 O2 Profiles

CR5 O2 Profiles

Note: Unit scales are different
New O2 Curve

- LOI benefit
Project Results

- Boiler Efficiency Increase = 0.5%
  - Annual fuel savings

- Combustion NOx Reduction
  - 7% at full load, 15-25% at part load
  - Annual Ammonia Reagent Usage Reduction
  - SCR Catalyst Life Extension

- Fan Auxiliary Power Savings
LOI Improvement

Crystal River Fly Ash Daily Report
July 9, 2010

LOI Trends (Past Rolling Month)

LOI Trends

*Note: Above 6% LOI is Off-Spec.

Highlights
Additional “Soft” Benefits

1. Reduced emissions
2. Reduced pulverizer wear
3. Reduced wear on Coal Yard equipment.
4. Reduced boiler tube & non-pressure part erosion due to lower flue gas velocities.
5. Improved ESP performance due to lower flue gas velocities.
6. Reduced potential for slagging and fouling events
7. Improved Pressure part life due to improved temperature profile
8. Reduced ash disposal costs
9. Reduced boiler tube failures due to reducing atmospheres