The Role of On-line, Real-time Coal Analysis in Advanced Process Control & Optimization

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On-line Analyzers and Process Control

• Conservation of resources, for highest efficiency and proper control, are necessary for the continued and future success of power plant operations.
• Modern tools can help the plant operators maintain balance and optimize the return on investment.
• Today, almost all utility boiler operators are “flying blind” due to the absence of coal chemistry data in real time.
• The incorporation of online coal analysis into computerized optimization systems has lagged behind.
GOALS of our Multi-client study of OnLine Analysis:

Facilitate communication among industry segments through papers, meetings, conferences and panel discussions

Promote the integration of online coal analysis into boiler controls and optimization systems

Help the utility industry synthesize a vision of the use of online coal analysis in today’s competitive utility market environment.

Help on-line analyzer manufacturers understand utility motivations and problems
The Problem with Chemical Coal Analysis

• Plants worldwide have problems with low quality coal
  – *Unanticipated, unknown, and unmonitored* changes in coal quality
  – Coal quality varies *dramatically* from lot to lot
  – Large Lot sizes (over 1500 tons) can *hide variations in quality*
  – the operator must change boiler conditions, leading to *loss of efficiency*
  – If *boiler changes are based on guesswork*, the outcome can not be guaranteed and sometimes can make conditions worse.
Barriers to Entry

• Experience based on research units
• Poor reliability of sampling systems feeding OLA
• Upgrades to control software needed to get real time data to control system
• Coal quality impacts must be correlated (fed forward)
• Financial controls not generally available
• Status quo slows improvement processes
## Barriers and Aids to Acceptance

<table>
<thead>
<tr>
<th>Barriers</th>
<th>Aids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installation downtime</td>
<td>Through-belt design</td>
</tr>
<tr>
<td>Calibration</td>
<td>Multiple sensors, software</td>
</tr>
<tr>
<td>Bunker mixing</td>
<td>Silo flow modeling</td>
</tr>
<tr>
<td>DCS integration</td>
<td>Common data pipeline</td>
</tr>
<tr>
<td>Institutional</td>
<td>Innovation</td>
</tr>
<tr>
<td>– perceptions</td>
<td>– new information</td>
</tr>
<tr>
<td>– objectives</td>
<td>– financial not technical</td>
</tr>
<tr>
<td>– coal variability</td>
<td>– dual use (pre- and post)</td>
</tr>
<tr>
<td>– reactive analysis</td>
<td>– continuous coal quality data</td>
</tr>
<tr>
<td>– proof before purchase</td>
<td>– prompt resolution of problems</td>
</tr>
</tbody>
</table>
## Ways Coal Quality Impacts Controls

<table>
<thead>
<tr>
<th></th>
<th>Pulverizer power</th>
<th>Boiler Performance</th>
<th>Aux Power, EFOR</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ASH</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SULFUR</strong></td>
<td>Scrubber reagent</td>
<td>Scrubber Performance, CEMs compliance validation</td>
<td>Sorbent feed rate, Aux Power, SO2 Trading</td>
</tr>
<tr>
<td><strong>HEATING VALUE</strong></td>
<td>Stoichiometry</td>
<td>Heat Rate MW output</td>
<td>Cost per MW, Opportunity cost marginal price</td>
</tr>
<tr>
<td>Ash Chemistry</td>
<td>ESP control</td>
<td>Aux Power SO3 injection</td>
<td>Regulatory Costs</td>
</tr>
<tr>
<td>Short-term variability</td>
<td>Plant impacts</td>
<td>Close loop with Fuel Procurement</td>
<td>Contract price adjustments</td>
</tr>
<tr>
<td>Off-spec fuels</td>
<td>Pre-combustion blending</td>
<td>Plant spec performance Opportunity fuels during low load ops</td>
<td>Reduced fuel costs</td>
</tr>
</tbody>
</table>
# Uses for Real Time Coal Quality

<table>
<thead>
<tr>
<th>Uses for Real Time Coal Quality</th>
<th>ASH/MINERAL CONTENT</th>
<th>SULFUR</th>
<th>HEATING VALUE</th>
<th>MOISTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>COAL HANDLEABILITY</td>
<td>•</td>
<td></td>
<td></td>
<td>•</td>
</tr>
<tr>
<td>BOILER SLAGGING</td>
<td>•</td>
<td></td>
<td></td>
<td>•</td>
</tr>
<tr>
<td>SCRUBBER PERFORMANCE</td>
<td></td>
<td>•</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CEMS</td>
<td></td>
<td>•</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HEAT RATE</td>
<td></td>
<td></td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>SOOTBLOWERS</td>
<td>•</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CYCLING COSTS</td>
<td>•</td>
<td>1/2</td>
<td></td>
<td>•</td>
</tr>
<tr>
<td>NEURAL NETWORKS</td>
<td>•</td>
<td>•</td>
<td></td>
<td>•</td>
</tr>
<tr>
<td>FERC REPORTING</td>
<td>•</td>
<td>•</td>
<td></td>
<td>•</td>
</tr>
<tr>
<td>PI SOFTWARE</td>
<td>•</td>
<td>•</td>
<td></td>
<td>•</td>
</tr>
<tr>
<td>CMMS</td>
<td>•</td>
<td>•</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FLAME SCANNERS</td>
<td></td>
<td>•</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ESP</td>
<td></td>
<td>•</td>
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<td>•</td>
</tr>
</tbody>
</table>
Why doesn’t every plant use online analysis?

Potential benefits…

• Tracking coal quality impacts
  – Faster Troubleshooting
  – More accurate heat rate reporting
  – Real-time market timing
  – Safer usage of opportunity fuels

• Feedback for realistic quality adjustments
  – Requires continuous analysis at receiving point
  – Trend is toward vendor analysis at shipping point

• Close the loop - fuel cost, production cost, and market price
  – Improved maintenance predictions, plant diagnostics
  – Plants are “flying blind”
  – Possible real-time market cost (locational marginal price)
Multi-client Study of On-line Analysis

Methodology

- Survey plant operators
- Assess status
- Identify information gaps
- Review projects in progress
- Evaluate automation
- Quantify the value
- Develop generic specification
Analyzer Survey Results

6. If you have evaluated analyzers and decided not to purchase, what were some possible reasons? (check all that may apply)

☐ (Question type: Multiple-choice, select many)

<table>
<thead>
<tr>
<th>Answer</th>
<th>Amount</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost too much</td>
<td>4</td>
<td>40%</td>
</tr>
<tr>
<td>Too much time to install and commission</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Accuracy was too poor to be useful</td>
<td>2</td>
<td>20%</td>
</tr>
<tr>
<td>Output was not relevant to the problem</td>
<td>1</td>
<td>10%</td>
</tr>
<tr>
<td>Analyzer capabilities were not clearly defined or specified</td>
<td>1</td>
<td>10%</td>
</tr>
<tr>
<td>Analyzer delivery time too long</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Other reasons</td>
<td>6</td>
<td>60%</td>
</tr>
</tbody>
</table>

- Cost overruns for developmental technologies
- Projects whose principal objective was to prove accuracy
- Negative reports from early second-generation units
- Lack of knowledge of the current state of the art
## Analyzer Survey Results

8. How useful to your business is the data you receive, or could receive, from online analyzers?

(Question type: Multiple-choice, select one)

<table>
<thead>
<tr>
<th>Answer</th>
<th>Amount</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extremely Useful</td>
<td>4</td>
<td>40%</td>
</tr>
<tr>
<td>Very Useful</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Sometimes Useful</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Occasionally Useful</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Hardly useful</td>
<td>1</td>
<td>10%</td>
</tr>
<tr>
<td>Other</td>
<td>5</td>
<td>50%</td>
</tr>
<tr>
<td><strong>Number of respondents</strong></td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

- 40% see the usefulness of knowing coal quality in real time
- Half the respondents were not sure of usefulness of the data
- Only 10% say the data is not useful
### Analyzer Survey Results

9. Assuming you have used analyzers before, how satisfied are you with the performance of online analyzers, either your own installation, or the overall perception of performance.

(Question type: Multiple-choice, select one)

<table>
<thead>
<tr>
<th>Answer</th>
<th>Amount</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Satisfied</td>
<td>5</td>
<td>55.56%</td>
</tr>
<tr>
<td>Somewhat satisfied</td>
<td>2</td>
<td>22.22%</td>
</tr>
<tr>
<td>Somewhat less than satisfied</td>
<td>1</td>
<td>11.11%</td>
</tr>
<tr>
<td>Slightly satisfied</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Not satisfied</td>
<td>1</td>
<td>11.11%</td>
</tr>
</tbody>
</table>

Number of respondents: 9

10. Do you currently recommend the use of online analysis to your peers or superiors?

(Question type: Multiple-choice, select one)

<table>
<thead>
<tr>
<th>Answer</th>
<th>Amount</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>7</td>
<td>77.78%</td>
</tr>
<tr>
<td>No</td>
<td>1</td>
<td>11.11%</td>
</tr>
<tr>
<td>Don't Know</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Other</td>
<td>1</td>
<td>11.1111%</td>
</tr>
</tbody>
</table>

Number of respondents: 9
Survey Findings

• Perceptions biased on early failures
• Objectives unclear
• Coal variability not understood
• Reactive coal analysis post-event leads to lack of trust
• Proof before purchase
Current methods of sampling and analysis do not adequately measure variations in coal quality

- ASTM sampling methods "average out" variations
- Correlations of coal quality with boiler impacts are impossible
- Lack of knowledge of variability leads to lack of trust in coal quality data.
- Data not trusted won’t be used
Typical On-line Analyzer data. Coal constituents with strong correlations

- SiO2-B/A ratio
- CaO-SO3
- Ash-HV
Typical Online Analyzer Data - note sporatic times of readings
SO3 vs Date
Optimization Building Blocks

Advanced Process Control

Real-time On-line Fuel Analysis

Neural Network Optimization Software

Scrubber/SCR controls

Real-time Cost of Cycling Software

Sulfur, Ash, Btu

Boiler performance

Aligning real-time Costs with real-time Market prices

Knowledge Management

Vendors, Services suppliers, Remote personnel

Maintenance Advisories
Fuel Contracts

Sorbent Consumption, CEM check

Furnace tuning NOx emissions
Control, heat rate

META-ORGANIZATION

Plant Information And Data Pipeline
(Asset/Portfolio information Network)
The Promise of Online Analysis

- Convert receiving silos, **control feeders** based on signals from the analyzer.
- Maintain constant coal quality, **insure ash constituents do not exceed pre-set parameters**.
- Issues of **analyzer availability** have plagued OLA installations in the past. New designs are **robust, both mechanically and electronically**, and provide coal parameters on an hourly basis.
- The **elimination of coal sampling** by utilizing a through-belt design has improved analyzer availability to near 100%.
- Eliminate the sampling system once needed to **feed coal to the analyzer**. These systems have historically been major source of analyzer down-time.
- **Semi-annual servicing** and robust software systems allow operators to see coal variability and be proactive.
- Avoid burning blends controlled by **gross samples** of coal, based on laboratory analysis of large lots.
- **Blend** various coals to a single plant specification, or multiple plant specifications, using new analyzer technology.
Combustion Optimization

- Fuel – Lignite, Bituminous, PRB, Blends
- Controls – OSI PI, PLC, Honeywell, Emerson, ABB, Siemens, Fisher, Analog
- Firing Systems – Wall, Cyclone, Tangential
- Desired optimizations – MW, Steam Temp, Heat Rate
- Holistic Approach – Market timing, ISO, opportunity fuels
Integrating Online Coal Analysis with Boiler Controls

**INPUTS**
- FUEL
- AIR
- FEEDWATER
- Coal Quality
- Coal Costs

**BOILER**

**OUTPUTS**
- STEAM
- ELECTRICITY
- MW Load
- NOx,
- SO2
- LMP
- DCS – burner tilts
- SOFA, Coal/Air Ratios
- Outlet gas Temps

FEEDWATER
FIRING RATE
STEAM TEMP
Unit Operations Using Online Analysis

- Coal blending
- Combustion
- Performance
- Sootblowers
- ESP
- FGD
Needs at the Plant to Meet Higher Level Dynamic Optimization

- **Advanced Knowledge Management**
  - Better coal quality information
  - Feed forward control
  - Reliable emissions monitors
    - Feedback control
    - Balancing compliance with profit
  - Real-time cycling costs information
    - Match dynamic electricity market prices with dynamic plant costs
  - Better direct measurements and sensors
  - Integrating subsystem optimization into plant-wide capabilities

- **Adapting process optimization techniques to portfolio optimization**
  - Strive for cultural change
  - Focus on global, not local optimization
Conclusion

• **Utilities are a growing market for coal analyzers**
  – Improved **efficiency** from existing assets
  – More **consistent output** from aging units
  – Increased **net fuel sales** and mw output
  – Predictable **performance** for real time markets

• **Information and economics needed**
  – Provide a multi-client study to assist **justifications**
  – Provide **estimates** of analyzer installation and maintenance costs
  – Develop a generic OLA/controls interface **specification**

• **Multi-client study is continuing**
  – Two magazine **articles** completed
  – Interim **report** available now
  – **Final report** expected Fall 2006
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