Smart Firing Control System

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Outline

• The challenges of firing optimization for a large coal fired boiler
• A novel approach
• Optimization results
• Conclusions
ISA Technical Papers-Search Results: 8 products found

- **Implementation and Benefits of Model Reference Feedforward (MRFF) Control** - **POWID 1989**, **Author:** D. E. Labbe
- **Automated Soot Blow and Model Based Control at MT. Storm** - **POWID 1993**, **Authors:** Donald Labbe, Larry Line
- **Optimizing Heat Rate With Model Predictive Control On Riley Turbo-Furnace Units** - **POWID 2002**, **Authors:** Donald Labbe; Darryl Roberts; Lewis Gordon
- **Field Test Results Of On-Line Coal Flow Control Technology Y** - **POWID 2005**, **Author(s):** Harun Bilirgen, Edward K. Levy, Aly Elshabasy
- **Optimizing Turbine Life Cycle Usage And Maximizing Ramp Rate** - **POWID 2006**, **Authors:** David Runkle, Don Labbe, John Lax, Robert Chapa
- **Soot Blow And Nox Optimization Enhance Once-Thru Unit Performance** - **POWID 2007**, **Authors:** Don Labbe, Don Andrasik, Andy Speziale
- **LOWERING NOX EMMISIONS AND CO2 AT OPG-THUNDER BAY** - **POWID 2010**, **Authors:** Don Labbe, Steve Carlson, Tony Gibbons, Bob Simpkins, Andy Speziale
- **SMART FIRING CONTROL SYSTEM** - **POWID 2012**, **Authors:** Corey Houn, Don Labbe, Bernie Begley, Tom Kinney, Alan Morrow and Andy Speziale
Challenges Of Large Coal Fired Boiler Burner Optimization

• When pulverized coal is fed to a utility boiler a phenomenon sometimes referred to as “roping” occurs
  – Impacts the distribution of coal flow to the coal pipes supplying the burners
  – Roping characteristics are unique mill to mill and dependent on primary air flow

• Coal maldistribution in turn causes some regions of the furnace to have more fuel and some to have less fuel
  – \(O_2\) imbalances
  – Regions of high CO and unburned carbon in oxygen depleted areas
  – High \(NO_x\) in regions of higher \(O_2\).
Typical APC Burner Optimization

- Advanced Process Control (APC) applications such as multivariable model predictive control and neural networks are frequently applied to bias furnace air flow distribution and address $O_2$ imbalances and regions of high CO.

- However coal pipe roping and other phenomena create a need for a recalibration of the APC models of the air register positions related to excess $O_2$, CO, and NO$_x$.
Furnace Air Distribution

55th Annual ISA POWID Symposium, 4-6 June 2012, Austin, Texas
Adapting APC burner optimization automatically

• The adapting system periodically tests the APC system on line without operator intervention and adapts the models to capture the characteristics of shifting relationships

• This solution has contributed to significant additional boiler efficiency improvements above and beyond the original APC application
System Deployed on Wisconsin Public Service Weston Unit 4

- Located in central Wisconsin
- 590 MW Gross coal fired once thru B&W supercritical unit commissioned in 2008
- Latest generation of high efficiency supercritical boiler and turbine
- Full complement of emissions reduction equipment
- Modern DCS with an integrated APC combustion optimization system (COS)
Wisconsin Public Service Unit 4 Emissions Control

• Features a full complement of emissions reduction equipment:
  – Dry scrubber for SO2 reduction
  – Selective catalytic reduction (SCR) using ammonia for NO\textsubscript{x} reduction
  – Bag house for particulate removal
  – Mercury removal controls
  – Modern DCS with an integrated APC combustion optimization system (COS)
  – Many auxiliary systems to address both production and emissions requirements

• DCS – over 80,000 tags and coordinates all unit controls
Original APC Combustion Optimization System

• Objective – further improve unit efficiency following extensive tuning process of this new unit by the boiler vendor, A&E and control vendor

• Results
  – delta Heat Rate Methodology indicates an average heat rate performance improvement in excess of 0.5% at all loads above minimum load
  – Weston 4 performance program indicates a full load heat rate improvement in excess of 1%
  – Additionally, a reduction in ammonia flow of ~8%
  – COS sustained these performance results, but did not reap further improvement
Adapting APC Combustion Optimization System

• Objective – Identify whether further improvements to unit efficiency were possible & if so, maintain these further improvements
  – Lower unit heat rate
  – Reduce furnace NO\textsubscript{x} emissions and reduce SCR ammonia consumption
  – Sustain benefits dynamically during both steady load and dispatching operation.

• Apply the Delta heat Rate methodology to quantify the heat rate benefits
  – Assessment included dry gas losses, FD & ID fan power, furnace NO\textsubscript{x} emissions and ammonia consumption
Adapting APC Combustion Optimization System

• Methodology
  – Utilize the existing APC COS as the base APC system
  – Provide automatic small amplitude modulation of the air registers without operator intervention
  – Automatically adapt the APC COS for tighter O\textsubscript{2} distribution and lower NO\textsub{x} and CO
Operator Graphic during Adapting System Commissioning

SFC Constraint Enabled
- Efficiency Increase
- O2 Setpoint lowers to 2.0%
- NH3 lowered
- O2 probes balanced

Manipulated Variables in service
- O2 SETPOINT BIAS - %
- NOx FLOW MASTER BIAS - %
- BURNER COLUMN BIAS - %
- MILL PRIMARY AIR FLOW BIAS - KPH
- MILL TEMP SP - DEG F

NH3 Typical
- 712 PPM
- 0 - 1000 PPM

NH3 Actual
- 612 PPM
- 0 - 1000 PPM

NH3 REDUCT
- 133 PPM
- 0 - 300 PPM

BURN STOCH

DCS LOGIC LOCATED ON PRINT FD-10A
COS PROGRAM HOSTED ON 4810AW
Adapting APC Combustion Optimization System – Results During Commissioning

- The trends illustrate the following
  - Reduction in $O_2$ minimum setpoint from 2.2% to 2%.
  - The transition to lower $O_2$ maintained average CO within constraint
  - Reduced SCR inlet NO$_x$
  - Reduced ammonia consumption
  - Increased efficiency due to lower $O_2$ and fan power and the equivalent ammonia savings
  - The reduction in CO followed the adjustment in COS constraints and models resulting from the operation of the system.
  - This reduction in CO allowed the operation at lower $O_2$. 
Adapting APC Combustion Optimization System – Performance Results

- Comparison of four weeks of operational data prior to commissioning of system operation to one week following Adapting APC operation

<table>
<thead>
<tr>
<th></th>
<th>Average $O_2$ (%)</th>
<th>Average $NO_x$ at SCR Inlet (% of Baseline)</th>
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</thead>
<tbody>
<tr>
<td>Base Case: COS running</td>
<td>2.371</td>
<td>100%</td>
</tr>
<tr>
<td>prior to Adapting System</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COS following Adapting</td>
<td>2.056</td>
<td>98.4%</td>
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<tr>
<td>System</td>
<td></td>
<td></td>
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<tr>
<td>Further Improvement</td>
<td>0.316%</td>
<td>1.6%</td>
</tr>
<tr>
<td>due to Adapting System</td>
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Adapting APC Combustion Optimization System – Benefits

• Incremental heat rate improvement of approximately 0.12% based on the Delta Heat Rate Methodology

• A reduction in ammonia flow of ~1.6% based on a comparison of performance data prior to and post system operation
Conclusions

• An automated method to adapt APC models provides an opportunity to achieve and sustain further benefits from and a combustion optimization system beyond traditional APC

• Such a system can adapt for coal roping and other phenomena that adversely influence coal distribution in large furnaces
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