An Application of Dynamic Classifiers in Pulverized Coal-Fired Boilers to Enhance Combustion Performance and reduce NO\textsubscript{x}, CO, and Unburned Carbon Emissions

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Preview of Presentation

• EC Large Combustion Plants Directive
  - NO$_x$, SO$_2$, and Particulates by 2008
• Proposed Solution at Ratcliffe-on-Soar Power Station, E.ON-UK PLC
  - Combustion Mods – Overfire Air and Dynamic Classifiers
• Four 500-MW Front Wall Fired Boilers
• Initial results
  - Dynamic Classifiers and impacts on Unburned Carbon, NO$_x$, and CO
• Future Plans
Compliance Considerations

- **SO₂** – Wet scrubbers already in operation
- **Particulate** – Electrostatic precipitators already in operation and fly ash sold
- **NOₓ** and LOI Considerations for 2008
  - ~35% Reduction required for compliance of 0.42 lb/MMBtu
  - SCR and new LNBs considered and rejected
  - OFA selected for NOₓ and DCs selected for LOI
Installation Program

• Dynamic classifiers
  - Single DC installed in July 2003 and tested
  - Additional 6 DCs installed in Summer 2004 and tested
  - Overfire Air System installed in and commissioning in progress
Ratcliffe Boilers

- Four 500-MW Babcock single furnace, dry bottom, natural circulation boiler
- Eight B&W 10E10 ring and ball mills normally using six mills for full load
- Two coal outlet pipes per mill with each split into 3 smaller pipes each feeding a Babcock Mark 3 LNB for a total of 48 burners in 4 rows of 12.
Ratcliffe Boiler
# Burner & Windbox Positioning

<table>
<thead>
<tr>
<th>Burner Elevation</th>
<th>Wing</th>
<th>Center</th>
<th>Center</th>
<th>Wing</th>
</tr>
</thead>
<tbody>
<tr>
<td>73’ 6” (top)</td>
<td>G1-3</td>
<td>E4-6</td>
<td>E7-9</td>
<td>G10-12</td>
</tr>
<tr>
<td>66’0”</td>
<td>B13-15</td>
<td>C16-18</td>
<td>C19-21</td>
<td>B22-24</td>
</tr>
<tr>
<td>52’ 0”</td>
<td>A25-27</td>
<td>F28-30</td>
<td>F31-33</td>
<td>A34-36</td>
</tr>
<tr>
<td>44’ 6” (bottom)</td>
<td>H37-39</td>
<td>D40-42</td>
<td>D43-45</td>
<td>H46-48</td>
</tr>
</tbody>
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Definitions

• **Classifier** is a device that separates coarse and fine coal, allowing fine coal to pass, while rejecting the coarse coal for regrinding.

• **Dynamic Classifier** is a device with an inner rotating cage and outer stationary vanes, which provides centrifugal and impinging classification.
Dynamic Classifier Capabilities

- Enhance grinding performance
- Improve boiler performance (Efficiency and Slagging/Fouling)
- Reduce Unburned Carbon and increase fly ash salability
- Reduce LOI, NO$_x$, and CO
Enhancement

Enhancement of grinding performance is achieved by one of three ways:

• Increasing fineness and thus reduce coarse particles,
• Increasing pulverizer capacity, or
• Increasing both fineness and capacity
Improvements

• Steeper fineness distribution slope angle (Rosin-Rammler Plot)
• Reduced amount of superfine and of coarse material
• Reduced internal product recirculation
• Reduced over-grinding and reduced wear, power absorption and mill vibration
• Reduced differential pressure across the mill and classifier potential for reduced mill gas flow
Fineness

Dynamic Classifiers can increase fineness and decrease coarse particles leading to:

- Better burnout (lower Unburned Carbon)
- Reduced Slagging and Fouling
- Reduced Excess Air operation resulting in:
  - Increased boiler efficiency
  - Decrease in emissions – $\text{NO}_x$, CO
Capacity

Dynamic Classifiers can increase capacity while maintaining fineness

- Applicable to high volatile coals such as PRB coals where burnout is not a problem but where lower heating value, higher ash and moisture content limit the coal throughput
- Increase the blend ratio of PRB where higher HHV coals are blended to maintain capacity
Fineness & Capacity

Dynamic Classifiers can increase both fineness and capacity, each to a lesser degree when each requires incremental increases.

- Benefits accrue from both fineness and capacity.
- Flexibility of operation allows maximum application of benefits across load range.
Brief History & Development

Classification technology R&D underway since 1906, when the initial Loesche coal mill was patented.

The experiences in grinding coal, pet coke, minerals, cement clinker, limestone, etc., contributed to the successful development of the LSKS Dynamic Classifier.
How does it work?

The newly developed Loesche LSKS High Efficiency Dynamic Classifier improves the performance of vertical roller mills.

- Redesigned air and product flow velocities
- New flow characteristics within the classifier
Arrangement of Dynamic Classifier for Ratcliffe
Dynamic Classifiers as Retrofits for Existing Mills
Comparison of Finenessness

Ratcliffe Rosin Rammler Size Distribution - 36 t/h

- Guarantee, Mean R-R Slope = 50.8°
- Preconversion - Loesche Sieve Results
- Preconversion - Loesche Sieve Results, Mean R-R Slope = 31.7°
- Postconversion - Loesche Sieve Results
- Postconversion - Loesche Sieve Results, Mean R-R Slope = 52.7°
Test Matrix

• Load – 510 to 520 MW
• Three different O₂ levels
• Three different DC speeds (100 rpm would be normal speed)
  - 65 rpm (Static classifier ~75 rpm)
  - 90 rpm
  - 110 rpm
• Six mills in service – 5 with DCs & 1 with SC
DC Speed vs LOI

R² = 0.246

R² = 0.9944

R² = 0.8894
DC Speed vs NO\textsubscript{x}

\[ R^2 = 0.9573 \]

\[ R^2 = 0.9528 \]

\[ R^2 = 0.9994 \]

**Graph:**
- 110 RPM - NO\textsubscript{x}
- 90 RPM - NO\textsubscript{x}
- 65 RPM - NO\textsubscript{x}
- Linear (65 RPM - NO\textsubscript{x})
- Linear (90 RPM - NO\textsubscript{x})
- Linear (110 RPM - NO\textsubscript{x})
DC Speed vs CO

- $R^2 = 0.9986$
- $R^2 = 0.9999$
- $R^2 = 0.976$

Oxygen % (Stack)

CO (ppm)

110 RPM - CO (ppm)
90 RPM - CO (ppm)
65 RPM - CO (ppm)

Expon. (110 RPM - CO (ppm))
Expon. (90 RPM - CO (ppm))
Expon. (65 RPM - CO (ppm))
Results

- LOI reduced by 61%
- NO\textsubscript{x} reduced by 15%
- Window of operation before excessive CO produced increased
- Operation at lower O\textsubscript{2} level possible while holding CO and potential for further NO\textsubscript{x} reduction of about 20%
Future Plans

• Overfire Air System with booster fans
  - Installed and in commissioning
  - Testing in Summer 2006
  - Install DCs and OFA on other units

• Dynamic Classifiers installed on other similar boilers in the UK including ball mills and arch furnace boilers