Coal Fired Boiler Optimization and the Impact on Emission Control Devices

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Typical Emissions Controlled via Backend Equipment

- Particulate matter
  - Electric Static Precipitator (ESP), Baghouse, Mechanical Collectors
- NO\textsubscript{X}
  - SCR, SNCR
- SO\textsubscript{2}
  - Scrubbers
- SO\textsubscript{3}
  - Lime Injection
Factors Affecting Performance of SCR

- Stoichiometric ratio of NH3 to NO\textsubscript{x}
- Temperature
- Oxygen
- SO\textsubscript{x}
- Ash
SNCR Performance Factors

- The reaction is dependent on temperature, residence time, \( \text{NO}_x \) levels and amount of reducing agent used.

Inlet \( \text{NO}_x \) Concentration vs. Reduction Efficiency

Typical three levels of injection to fit best reaction temperatures at varied loads.
Particulate Collection Efficiency Factors

- Electric Static Precipitator (ESP) Performance Factors
  - Elevated temperatures
  - Carbon in ash content
  - Air In Leakage
- Fabric Filters
  - Condition of bags
- Mechanical Collectors
  - Particle Size
How Do We Optimize Boiler Performance?

• Need to ensure we have a balanced excess oxygen and temperature profile across the furnace exit!
• Requirements for a balanced furnace
  • Pulverizers must be optimized
  • Airflows must be staged correctly to the boiler
  • Burners must be in good condition
  • Furnace must be oxidizing

Areas where $O_2$ is less than 1%
Areas of CO over 4,000 PPM
What is Optimum Pulverizer Performance?

- Dirty air balance within ±5%
- Primary air flow accuracy within ±3%
- Correct primary air curve and air/fuel ratio
- Fuel fineness ≥75% passing 200 mesh and ≤0.1% retained on 50 mesh
- Fuel balance within ±10%
Effect of Pulverizer Performance on Carbon in Ash

- Flyash LOI is related to pulverizer performance
- Poor pulverizer performance results in increased LOI’s

### Pulverizer Performance

<table>
<thead>
<tr>
<th>Mesh Size</th>
<th>Test 1</th>
<th>Test 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>200 Mesh</td>
<td></td>
<td></td>
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<tr>
<td>140 Mesh</td>
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<tr>
<td>100 Mesh</td>
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<tr>
<td>50 Mesh</td>
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</tbody>
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### LOI Test Results

- Test 1: Composite LOI (%)
- Test 2: +200 Mesh LOI %
- Test 2: -200 Mesh LOI %
How Do You Maintain Optimum Pulverizer Performance?

- Quarterly performance testing programs
  - Evaluate fuel fineness, fuel balance, air/fuel ratios, dirty air balance
All Airflow Must Be Accurately Measured and Managed!

- Airflow management is key to optimizing combustion
  - Secondary airflow must be balanced within $\pm 10\%$
  - Primary air should account for $\sim 15\% - 20\%$ of total air
  - Secondary air should account for $\sim 60\% - 70\%$ of total air
  - OFA should account for $\sim 15\% - 20\%$ of total air
How Do We Accurately Manage the Airflow?

- Airflow measurement devices to each area of the boiler
  - Hot “K” calibrations of each device
  - Periodic airflow testing
How Do We Quantify Air In Leakage?

- Oxygen rise from the furnace to the stack on balanced draft boiler
  - Point by point traverses should be conducted
- Adverse affects:
  - Heat rate penalties
  - Increased auxiliary horsepower
  - Decreased combustion efficiency
  - Increased flue gas volume
  - Fan limitations
  - Reduced generation
Condition of Firing Components Must be Optimized!

- Burners, OFA nozzles and mills must be blueprinted
How Do We Quantify Combustion Performance?

- Furnace exit traverses by a High Velocity Thermocouple (HVT) probe
  - Excess oxygen, Furnace Exit Gas Temperatures (FEGT’s), CO & NO$_x$

>700°F Temperature Imbalances!
Results of Boiler Tuning and Optimization

- Improved excess oxygen, CO, NOₓ and FEGT balance

Excess Oxygen

Carbon Monoxide

Furnace Exit Gas Temperature

NOₓ
Neglecting Combustion Performance can Result in…

In Conclusion
• Installing backend flue gas cleanup equipment can provide instant reductions in regulated emissions

However….
• By neglecting the fundamentals of combustion, efficiencies of SCR’s, FGD’s and particulate control equipment will sacrificed!
Thank You

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