ZoloBOSS: Laser-based Sensor for Real-time Combustion Optimization

Better Measurements, Better Results
Balanced Combustion $\rightarrow$ Optimized Combustion

- Balanced combustion (Temp, $O_2$ & CO) is better combustion
- Balanced combustion permits safe operation at lower excess $O_2$
- Lower excess $O_2$ $\rightarrow$ increases efficiency (heat rate)
- Lower excess $O_2$ $\rightarrow$ lowers NOx rates
- Subject to constraints on CO and slagging
Balancing: The Problem is Local

• Natural process variations will lead to local imbalances in furnace
  – “The right amount of ingredients don’t equal a good cake”
  – Proper air/fuel at burner is important but may not mean optimized combustion

• 80/20 rule:
  – 80% of emission/slag, 20% of furnace
  – CO Increases exponentially, Slag/fouling hot spots, NOx with high O2

• Problem gets worse as excess O₂ is reduced
The Solution: The ZoloBOSS System

- Uses laser light absorption to measure Temp, O₂, CO & H₂O
- Paths measure average concentration across furnace
- Real-time measurement directly in the furnace
- Multiple paths generate two-dimensional images or profiles
- Output used to balance and optimize combustion

Better Measurement, Better Results
Balancing: Optimization Concept

Target $\text{O}_2$: Maintain visibility at 0 to balance slag regions.

- **Pro**: Efficiency, NOx
- **Con**: Slag, CO

- **Pro**: Slag, CO
- **Con**: Efficiency, NOx

- **Pro**: Efficiency, Slag, NOx, CO
- **Con**: Effort to Balance

(A) 3.0% Avg $\text{O}_2$

(B) 3.5% Avg $\text{O}_2$

(C) 3.0% Avg $\text{O}_2$
Typical ZoloBOSS Layout

- Zolo Technologies
- Combustion Optimizer
- DCS
- VPN Internet
- Historian
- Control Unit
  - Rack mount
  - OPC Server
- Matrix Distribution Cabinet
- Furnace
- SensAlign TX
- SensAlign RX
- Distribution Node
- Up to 1000m (3000 feet)
- Up to 180 m (600 feet)
- Up to 20 m (66 feet)
Key Features of ZoloBOSS

• Real-time, in-situ measurements:
  – Temperature, H₂O, CO and O₂
  – Path average measurement for each path

• Spatial profiles and furnace balancing information

• Designed for Ultra-harsh Environments
  – Non-intrusive (nothing installed within furnace, nothing to plug)
  – Fiber coupled – key electronics are located in protected area
  – Auto-alignment keeps lasers aligned
  – Port rodder system to keep openings clear of slag
  – No cooling of heads required

• No field calibration required

• Low maintenance:
  – Periodic window cleaning is required
  – Work can be performed while boiler is operating
Typical ZoloBOSS Layout

- 15 path modular system
- Configuration based on Plant needs
- Plant supplies:
  - Membrane wall penetrations
  - Short outage & low cost
  - Conduits for fiber & ethernet
  - 120V Power @ <3KW
  - Instrument air @ ~90psig (6.2 bar)

3/8” x 3” (9.5 x 76mm) Slot

Slotted Opening in Membrane

Port Rodder

SensAlign™ Head

SensAlign Head w/ Port Rodder
Typical ZoloBOSS Layouts

Wall-fired

- Elevation below nose arch
- Orthogonal Grid
- Paths above each LNB column
- Paths near side walls
- Optional: SH/RH paths

T-fired

- Elevation below nose arch
- Orthogonal Grid
- Typical: 5x5 or 6x6
- Optional: SH/RH paths

Grid

Single Paths
The ZoloBOSS Interface

- ZoloBOSS data transmitted to historian via OPC or Modbus
- Interfaces available to operators & engineers
  - Tomography for each elevation and constituent
  - Trending data available for specific paths and constituents
  - BalanceApp targeted for operators
- Can integrate with Control System and/or Combustion Optimizer
Operator BalanceApp Interface

- T-Fired
- Wall-Fired

Zolo BOSS level 1 comb
Center Combustion: Why?

- Centered Combustion = Balanced combustion
- Goal = Centered Combustion (fireball)
  - Fireball center is a compass to direct combustion manipulations

Closer to center
Lower StDev, More balanced

Further away from center
Higher StDev, Less balanced
Summary: Combustion Optimization

**Measure**
- Plant data
- Furnace data

**Center/Balance**
- Balance/Center Temperature
- Balance \( O_2 \)
- Balance CO

**Correlate**
- Parametric Tests
- Model-based
- Rules-based
- Neural-net based

**Optimize**
- Manipulate Air/Fuel bias
- Reduce Excess \( O_2 \)

**Results:**
- Improve Heat Rate
- Lower Emissions: NOx & CO\(_2\)
- Minimize Slag
- Increase Fuel Flexibility

**Center/Balance**
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**Optimize**
- Manipulate Air/Fuel bias
- Reduce Excess \( O_2 \)
Questions?

Please visit our website at www.zolotech.com
Thank you for your time and your interest!

Better Measurements, Better Results
### Sensor Comparison

<table>
<thead>
<tr>
<th>Measurement Location</th>
<th><strong>ZoloBOSS</strong></th>
<th><strong>Extractive Sensors</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Direct in-furnace measurements (&lt;3000F)</td>
<td>• Back-pass: (&lt;1500F)</td>
<td></td>
</tr>
<tr>
<td>• Better correlation with combustion settings</td>
<td>• Subject to additional mixing and dilution</td>
<td></td>
</tr>
<tr>
<td>• Combustion not complete; measurements more sensitive to small operational changes</td>
<td>• Combustion complete; not sensitive to small changes in operational settings</td>
<td></td>
</tr>
<tr>
<td>• Measures in-situ – no impact of air leakage</td>
<td>• Impacted by air-in leakage in penthouse</td>
<td></td>
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</tbody>
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<table>
<thead>
<tr>
<th>Constituents</th>
<th><strong>ZoloBOSS</strong></th>
<th><strong>Extractive Sensors</strong></th>
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<tbody>
<tr>
<td>• Simultaneous Temp, H₂O, O₂ &amp; CO</td>
<td>• O₂/CO only</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Optional temperature but not useful</td>
<td></td>
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</tbody>
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<table>
<thead>
<tr>
<th>Path Average versus Point Measurement</th>
<th><strong>ZoloBOSS</strong></th>
<th><strong>Extractive Sensors</strong></th>
</tr>
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<tbody>
<tr>
<td>• Measures larger portion of furnace cross-section along entire path of laser</td>
<td>• Data collected at specific “points” only</td>
<td></td>
</tr>
<tr>
<td>• Captures impact of local “pockets” of T/CO/O₂</td>
<td>• No localized areas of CO/O₂ in between “points”</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Large number of “points” not economic</td>
<td></td>
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<table>
<thead>
<tr>
<th>Slag Control</th>
<th><strong>ZoloBOSS</strong></th>
<th><strong>Extractive Sensors</strong></th>
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<tbody>
<tr>
<td>• Maintain FEGT below ash fusion temps</td>
<td>• No temperature info in furnace</td>
<td></td>
</tr>
<tr>
<td>• Monitor Temp/CO/O₂ in SH/RH</td>
<td></td>
<td></td>
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<tr>
<td>• Integrate FEGT into intelligent soot blowing</td>
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<th>Water wall Corrosion</th>
<th><strong>ZoloBOSS</strong></th>
<th><strong>Extractive Sensors</strong></th>
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<tbody>
<tr>
<td>• Paths located near side walls can monitor for corrosive environments: low O₂ + high CO.</td>
<td>• No relevant data to monitor for corrosion</td>
<td></td>
</tr>
</tbody>
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<tr>
<th>Impact on NOₓ reduction</th>
<th><strong>ZoloBOSS</strong></th>
<th><strong>Extractive Sensors</strong></th>
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<tbody>
<tr>
<td>• Identify local areas of high O₂ &amp; temperature</td>
<td>• Not useful for localized NOₓ</td>
<td></td>
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<th>Maintenance</th>
<th><strong>ZoloBOSS</strong></th>
<th><strong>Extractive Sensors</strong></th>
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<tr>
<td>• Nothing installed inside harsh furnace</td>
<td>• Extraction grid installed inside convective pass</td>
<td></td>
</tr>
<tr>
<td>• Maintenance during boiler operation</td>
<td>• Maintenance requires unit shut down</td>
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<tr>
<td>• No calibration required</td>
<td>• Prone to failure at high (1500F) temps</td>
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<tr>
<td></td>
<td>• Aspirator nozzles frequently plug</td>
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<td></td>
<td>• Regular calibration required for good accuracy</td>
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