Nitrogen & Syngas Conference 2019

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Burner Revamp to Increase Primary Reformer Efficiency & Lower Emissions
Presentation Outline

- Application overview
- Zeeco Single Jet ultra-low NO_x emissions burner
- CFD study
- Combustion testing
- Burner installation
- Conclusion
Application Overview

- Downfired primary reformer furnace
- European ammonia production facility
- 105 downfired burners > 40 years old
- NO$_x$ emissions in range of 250-300 mg/Nm$^3$
- Customer wanted to reuse burner windbox and damper
Zeeco Solution

- Supply GB Single Jet ultra-low emissions kit:
  - Gas lance / tips
  - Stabilisation cone
  - Burner tile

- Retain existing:
  - Windbox
  - Damper / damper controls
  - Pilot

- Guaranteed NO\textsubscript{x} emissions of 120 mg/Nm\textsuperscript{3} on natural gas

- Design for 10% excess air (≈2.1% O\textsubscript{2} by vol. of dry flue gas)
Zeeco Solution
Zeeco Single-Jet Ultra-Low Emissions Burners
Zeeco Single-Jet Ultra-Low Emissions Burners

- IFGR Zone
- Combustion Air Zone
- Staged Air Zone
Primary Reformer Radiant Section - Plan View

Top View of Primary Reformer Radiant Section Burner Layout
### Radiant Section – Heater Process Information

<table>
<thead>
<tr>
<th>Type of Reformer Furnace</th>
<th>Ammonia Reformer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of Draft</td>
<td>Forced</td>
</tr>
<tr>
<td>Direction of Firing</td>
<td>Downfired</td>
</tr>
<tr>
<td>Primary Reformer Width, m</td>
<td>14</td>
</tr>
<tr>
<td>Primary Reformer Length, m</td>
<td>16.4</td>
</tr>
<tr>
<td>Primary Reformer Roof Area, m²</td>
<td>229.6</td>
</tr>
<tr>
<td>Total Number of Burner Rows</td>
<td>7</td>
</tr>
<tr>
<td>Distance Tube to Tube Between Tube Rows, m</td>
<td>2.2</td>
</tr>
<tr>
<td>Total Maximum Heat Release for Reformer, MW</td>
<td>158.19</td>
</tr>
<tr>
<td>Total Normal Heat Release for Reformer, MW</td>
<td>131.84</td>
</tr>
<tr>
<td>Heat Release per Roof Area at Maximum Duty, MW/m²</td>
<td>0.689</td>
</tr>
<tr>
<td>Heat Release per Roof Area at Normal Duty, MW/m²</td>
<td>0.574</td>
</tr>
</tbody>
</table>
Radiant Section – Burner Process Information

<table>
<thead>
<tr>
<th>Type of Burner</th>
<th>Zeeco GB Single Jet Inner Burners</th>
<th>Zeeco GB Single Jet Outer Burners</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Number of Burners</td>
<td>75</td>
<td>30</td>
</tr>
<tr>
<td>Number of Burners per Row</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Number of Rows of Burners</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Maximum Heat Release per Burner, MW</td>
<td>1.674</td>
<td>1.088</td>
</tr>
<tr>
<td>Normal Heat Release per Burner, MW</td>
<td>1.395</td>
<td>0.907</td>
</tr>
<tr>
<td>Turndown</td>
<td>6:1</td>
<td>6:1</td>
</tr>
<tr>
<td>Design Excess Combustion Air, %</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Combustion Air Temperature, degrees C</td>
<td>300</td>
<td>300</td>
</tr>
<tr>
<td>Furnace Temperature, degrees C</td>
<td>1200</td>
<td>1200</td>
</tr>
<tr>
<td>Total Heat Release at Maximum Duty, MW</td>
<td>125.55</td>
<td>32.64</td>
</tr>
<tr>
<td>Percentage of Total Heat Release, %</td>
<td>79.4</td>
<td>20.6</td>
</tr>
</tbody>
</table>
CFD Study

- Gas temperature contours
CFD Study

- CO contours confirmed minimum flame interaction
CFD Study

- Location A: Inert products of combustion drawn into fuel gas
Burner Testing at ZEECO

- Combustion test performed at Zeeco Global HQ.
- Multi-Burner testing to verify NO\textsubscript{x} emissions
- 80-90 mg/Nm\textsuperscript{3} NO\textsubscript{x} at 2.0% O\textsubscript{2}
- Confirmation of no flame-to-flame interaction
- Proven flame stability at 1.1% O\textsubscript{2} (dry basis)
Burner General Arrangement Drawing
Installation

- Burners were installed early 2018
- Retrofit kits minimised installation time and labour requirements
- Burners utilised Zeeco ProFlame™ scanners for flame detection
- Flexible hoses used for gas connections
Burner Performance

- Burners are achieving 90 mg/Nm³ NOₓ
  - Significantly lower than the guaranteed NOₓ (120 mg/Nm³)
- 3.0% O₂ measured in the flue gas; therefore, further reductions will improve NOₓ
- No flame-to-flame interaction
- Improved heat flux profile
Conclusion

- Zeeco supplied 105 GB Single Jet inserts for a downfired reformer at a European ammonia facility

- NO\textsubscript{x} emissions, heat flux profile, and flame-to-flame interaction were confirmed by CFD and burner testing

- Current NO\textsubscript{x} emissions average 90 mg/Nm\textsuperscript{3} at 3\% O\textsubscript{2} which meets European legislation and NO\textsubscript{x} guarantees

- Burners are operating with lower excess air; therefore, fuel gas consumption rate is lowered in the radiant section

- NO\textsubscript{x} emissions can be reduced further if the furnace excess air is trimmed
Questions?