Low-NOx Burner Retrofit Challenge

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Presented by:
Ryan Roberts
Project Engineering Manager - Process Burners
Topics of Discussion

• Project Background
  – Existing System – Design Challenges

• Project Phases
  – **Phase 1:** Burner Design & CFD Modeling – GLSF Minimum Emissions Burner
  – **Phase 2:** Combustion Testing
  – **Phase 3:** Installation & S.A.T.

• Conclusion
Project Background

- Existing Burners: Conventional Raw Gas Burner
- Average Yearly NOx Level: 244 ppmv [500 mg/Nm3]
- Heater roof tubes are 16.4 ft above furnace floor
  - Existing burners were impinging on roof tubes causing hot spots and tube coking.
- Poor Combustion Air Distribution to Burners
Heater Geometry

- Twin Celled, Crude Oil Heater
- 17 Burner per Cell
- Forced Draft, Pre-Heated Air
New Burner Requirements
Thirty Four (34) Ultra Low NOx Burners
• Required Emissions:

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<tbody>
<tr>
<td>NOx</td>
<td>40 ppmv [82 mg/Nm³]</td>
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<tr>
<td>CO</td>
<td>40 ppmv [49 mg/Nm³]</td>
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• Required Heat Release:

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<tr>
<td>Maximum</td>
<td>6.980 MMBtu/hr [2.04 MW]</td>
</tr>
<tr>
<td>Normal</td>
<td>6.070 MMBtu/hr [1.78 MW]</td>
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<tr>
<td>Minimum</td>
<td>1.390 MMBtu/hr [0.407 MW]</td>
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• Required Flame Dimensions:

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<tr>
<td>Maximum Length</td>
<td>9.60 ft [2.92 m]</td>
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<tr>
<td>Maximum Width</td>
<td>2.51 ft [0.765 m]</td>
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Project Phases – Phase 1
Burner Design & CFD Modeling
• Custom burner geometry to match existing forced draft ducting and heater mounting

• Full furnace ducting modeling to improve combustion air flow

• Combustion modeling to ensure proper flame geometry
• GLSF Round Flame Minimum Emissions Burner was chosen for its ability to achieve Ultra Low NOx emissions while maintaining compact flame shapes and high flame stability on all fuels.
CFD proved uneven air distribution to each burner. Air flow varied by +13% to -30% mass flow [kg/hr]
Baffle plates and turning vanes were added to the simulation to improve the air flow to an acceptable level of +/- 3% [kg/hr] to each burner.

**Note:** Plane shown here is for the center plane of the extension ducts to burners.
• Combustion CFD proved acceptable flame dimensions and proper furnace heat distribution. No flame to flame interaction & No flame to tube interaction
Project Phases – Phase 2
Combustion Testing
• Two test burners were installed in one of Zeeco’s cabin style heaters
• Actual site heater conditions were matched in Zeeco’s Testing Facility to prove burner performance
• Results

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<tbody>
<tr>
<td>Fuel B</td>
<td>6.98</td>
<td>1776</td>
<td>3.0</td>
<td>27.0</td>
<td>27.5</td>
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<tr>
<td>Fuel E</td>
<td>6.98</td>
<td>1759</td>
<td>2.9</td>
<td>27.4</td>
<td>27.9</td>
</tr>
<tr>
<td>Fuel F</td>
<td>6.98</td>
<td>1740</td>
<td>3.0</td>
<td>30.4</td>
<td>31.6</td>
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Note: A single Fuel G test point was tested to prove flame stability on N.G.
Project Phases – Phase 3
Installation & Site Acceptance Testing
• Site supervision was provided by Zeeco engineers to ensure proper fit up and installation.
• Burner start up was performed in June, 2015
• Burner performance acceptance testing was performed in July, 2015
• Heater operation inspection at the time of acceptance testing showed tramp air inlets had not yet been sealed, excess oxygen was higher than the designed value of 15%. Both leading to higher NOx levels.
• NOx levels were still confirmed to be below the 49 ppmv [100 mg/Nm3] local legislation requirement. Tramp air and excess air reduction will reduce NOx further.
• Conclusions

• High NOx production, poor air distribution, uneven flame & furnace heating patters, and heater tube coking prompted a revamp of the combustion system and burners.

• The GLSF Minimum Emissions Burner design was selected to meet the new burner performance requirements.

• Bespoke burner geometries were utilized to match existing heater mounting and preheated combustion air ducting. Leading to minimal installation costs to the customer.

• CFD modeling of combustion air ducting was performed. CFD modeling of burner combustion was performed.
• Conclusions
  
  • Multi-Burner combustion testing was performed in Zeeco’s Testing Facility to accurately simulate on site conditions.
  
  • Burners were delivered to site and installed with Zeeco’s supervision.
  
  • On site burner performance testing was conducted and proved that the burners were meeting all required performance goals.
  
  • Further heater operation improvements can be performed to improve the burner performance even further.
Questions?