IMPROVED SMR RADIANT FLUE GAS TUNNELS for OPTIMAL FLOW DISTRIBUTION

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INTRODUCTION

• BD Energy Systems and Blasch Precision Ceramics have developed a new flue gas tunnel system
• The new tunnel system has now been installed in two primary reformers
• This presentation is a summary of the benefits of the new tunnel design over traditional flue gas tunnel systems.
TUNNEL OVERVIEW

• Tunnels are required in down fired SMRs to collect flue gas
• Tunnels should collect flue gas in a uniform manner to aid heat transfer
• Conventional tunnels have inherent limitations that prevent uniform collection of flue gas
  – Expansion joints and buttresses create areas where tunnel openings cannot be located
  – Tunnel openings do not vary in size resulting in step changes in flow area
• Tunnels
  – Transport flue gas out of radiant section
  – Essential for uniform flow
Conventional Structure

Side Walls

- Tongue & groove (or flat)
- Built up from floor
- Mortared joints
- Discrete expansion joints
- Support buttresses
- 1/2 brick openings
Along the Length of the Tunnel:

• Uniform incremental flow
• Gradual increase in:
  – In-tunnel velocity
  – Across-wall static pressure differential
• Gradual decrease in required open area
Non-ideal Physical Features:

- Openings
  - Large increments
  - Large Step changes
- “No-flow” regions
  - Buttresses
  - Expansion Joints
- Non-uniform base course flow
BDE TOP Tunnel Design with Blasch StaBlox
Tunnel Components

• Base Plate – Laid above level insulating castable or silica block
Tunnel Components

• Wall Blocks
Tunnel Components

- Tunnel Covers
Tunnel Components

- Tie Rods
  (Normally for taller tunnels)
Tunnel Components

- Orifice Inserts
  - Several sizes and inserted in every block hole
The BDE Tunnel Optimum Performance (TOP) Program

- Patented flue gas flow control method
  - Uniformly distributes openings throughout tunnel system
  - Varies open area diameters
  - Achieves flue gas flow uniformity

- Eliminates catalyst tube early failures due to:
  - Non-uniform convective heating
  - Non-uniform flue gas flow
Calculated conventional system flow

- Non-uniform flow along tunnel length
- No-flow regions exist for some tubes
- Too much flow exists for other tubes
- Flow (per tunnel) is not proportional to burner row firing
- Non-uniform convective heating
Variable orifice diameters

- Small open area increments
- Engineered step changes
- Gradual open area reduction
- Uniform no. of openings/column
Steam Methane Reformer BDE Flue Gas Tunnel Technology

Conventional Flow per Column

BDE TOP Flow per Column
Installation & Realized Performance Improvements
Installation

• Each component can be carried by a single person
• Thermal expansion allowances are designed into the components – no discrete expansion joints are required
• Component mating features eliminate the need for mortar and buttresses
Installation

• System eliminates the need for cutting of brick
• After the floor was leveled:
  – 8 tunnels total
  – An average of 3 tunnels were installed in each 12 hour shift
  – Each tunnel was 5’ (1525 mm) high and 40’ (12,190 mm) long
  – One shift completed 4 tunnels
Performance Improvements
Tube Metal Temperatures

• Data indicated a noticeable improvement in both the temperature range and uniformity of the TMTs.

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<thead>
<tr>
<th></th>
<th>Avg TMT °F (°C)</th>
<th>TMT Std Dev °F (°C)</th>
<th>TMT Min to Max ΔT °F (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before</td>
<td>1556 (847)</td>
<td>42 (23.3)</td>
<td>222 (123)</td>
</tr>
<tr>
<td>After</td>
<td>1545 (841)</td>
<td>21 (11.7)</td>
<td>116 (64)</td>
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Performance Improvements
Tube Metal Temperatures
Performance Improvements
Tube Metal Temperatures
Performance Improvements

Methane Slip

• The plant also experienced:
  – A decrease in methane slip from 9.94 to 6.94
  – An increase in production of 3.3%
  – An increase of 3.7% in the production/feed-rate ratio
This increase is the result of reduced methane slip from the front end of the plant due to more uniform heating of the catalyst tubes. More uniform heating of the catalyst tubes enables operators to safely increase the outlet process temperature while still maintaining the maximum TMT within limits.

The increase in production experienced at this plant is relatively high. This SMR contains 7 rows of 24 catalyst tubes. It is estimated that larger plants would experience a smaller increase in the range of 1.3 to 1.8%.
Performance Improvements
Safety & Reliability

• Improved uniformity results in more uniform tube life, improved reliability of high temperature components.
• Improved uniformity results in less need for individual burner adjustment to address high TMTs.
• Stable tunnel system reduces collapses of tunnels
• Reduction in installation labor results in safer construction
  – elimination of the need for cutting
  – lighter components
Summary of Benefits

- Improved flue gas flow & heating uniformity
- Reduced catalyst tube temperature spread
  - Reduced methane slip / reduced feed stock costs
- Reduced maximum TMTs increases tube reliability
- More reliable tunnel structure
- Faster installation reduces reformer downtime
- Orifice sizing and distribution can be modified in the future if operation changes
Thank You

Questions?