Cetek "Matrix Coating System" & Its Use at MiRO - Karlsruhe, Germany
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Presentation Contents:

Ceramic Coatings

- Theory & Applications on:
  - Refractories (high emissivity coatings)
    - NOx Emission Reduction (up to 35%)
  - Process Tubes (elimination of oxidation, scaling & fouling)
  - "Matrix Coating System" (manipulation of heat flux)
    - Application to MiRO's Coker Heaters
Furnace Radiation

The radiation from the burners goes in all directions.

• Some goes directly to the process tubes.
• How the tubes accept the radiation has an influence on the efficiency of radiant heat transfer.
• Some of the radiation goes to the refractory lining.
• How that interacts with the radiation also has an influence on the radiant heat transfer efficiency.

Radiant Heat Transfer Mode in a Fired Heater

Heat Flux = C \times (T_s^4 - T_r^4) \times F_e \times F_a

- $T_s$: absolute temperature of radiation source
- $T_r$: absolute temperature of radiation receiver
- $F_e$: emissivity factor
- $F_a$: furnace shape factor
- $C$: constant

- It is therefore important to maintain the surface temperature of the tubes, $T_r$, as low as possible.
- It is important to maintain the Emissivity Factor, $F_e$
- as high as possible
Cetek Ceramic Coatings

• Coatings for Refractories:
  - High Emissivity Property
    • Increased Radiant Heat Exchange Efficiency
      - More Heat Available to the Process
      - Lower Flue Gas / Bridge Wall Temperatures
        » Reduces NOx Emissions (20% to 30%)
    • Higher Heat Flux to Back of Tubes in Single-Fired Heaters
      - Reduces Peak/Average Heat Flux
      - Increases “effective tube surface area”
    • More Uniform Heat Flux throughout the Heater
      - Helps to eliminate radiant “Hot Spots”

Cetek Ceramic Coatings

• Coatings for Process Tubes:
  - Elimination & Prevention of Oxidation (Scale) + High Emissivity
    • Increased Conductive Heat Transfer
      - More Heat Available to the Process
        » Lower Bridge Wall Temperatures
    • Back of Tubes Can Accept More Heat
      - In combination with high emissivity refractory coating
      - Reduces Peak/Average Heat Flux
    • No scale on tube surfaces to confuse thermography measurements
Cetek Matrix Coating System

What Cetek Coatings Can Do

- Manipulate heat flux distribution in single fired heaters
- Design coatings based on coking pattern of fire box
- Measure true tube metal temperature by removal of all scale and install uniform ceramic coating layer
- Easy coking detection using infrared camera or pyrometer through the elimination of uneven scale delta T

Heat Flux Problems...

For example:

- Low Flux Zone
- Good Flux Level
- High Flux Zone
Cetek Matrix Coating System (US Patent # 6,626,663B1)

- **Variable Emissivity Tube Coatings**
  - Increase, or Decrease Absorbed Heat Flux
  - Protects Tubes in High Flux Zones
  - Reduces Skin Temperatures

- **Reduction of Peak/Average Heat Flux in Single – Fired Heaters**
  - Use of Coatings on Both Refractory and Tubes
  - Reduces Heat Flux on Fired Side of Tubes
  - Increases Heat Flux on Back Side of Tubes
  - Effectively Increases “Effective Tube Surface Area”
  - Manipulates Heat Flux Zones
    - Reduces High Heat Flux
    - Increases Low Heat Flux

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Cetek Matrix Coating System – Heat Flux manipulation

[Diagram showing the application of high emissivity coating on refractory and matrix coating system on tubes.]

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[Logo and text for Cetek.]
MiRO Coker Heater Application

Heater Schematic

IR Thermography Inspection

Observations:
- High Tubes Surface Temperatures on Lower Side Tubes
- Lower Tube Surface Temperatures on Upper Wall Tubes
- High Tube Surface Temperatures on Roof Tubes
Matrix Coating System Design

- High & Low Emissivity Tube Coating
- High Emissivity Tube Coating
- High Emissivity Refractory Coating

Heater Simulation Results

<table>
<thead>
<tr>
<th>Units</th>
<th>Before Coating</th>
<th>After Coating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Flux of the Upper 6 Wall Tubes</td>
<td>40.1</td>
<td>43.1</td>
</tr>
<tr>
<td>Average Flux of the 9 Roof Tubes</td>
<td>40.1</td>
<td>39.7</td>
</tr>
<tr>
<td>Average Flux of the Lower 10 Wall Tubes</td>
<td>40.1</td>
<td>38.8</td>
</tr>
<tr>
<td>Front 180° Tube Heat Flux - Upper 6 Wall Tubes</td>
<td>57.0</td>
<td>60.9</td>
</tr>
<tr>
<td>Front 180° Tube Heat Flux - Roof Tubes &amp; 10 Lower Wall Tubes</td>
<td>57.0</td>
<td>49.0</td>
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<tr>
<td>Flux Ratio of Front 180° / Average Flux</td>
<td>Ratio</td>
<td>1.42</td>
</tr>
<tr>
<td>Bridge Wall Temperature</td>
<td>°C</td>
<td>817</td>
</tr>
</tbody>
</table>
**Tube Skin Temperatures After Coating**

F-001: TMTs after ceramic coating was applied (adjusted for furnace duty)

- TMT Increase Rate: 9.36°C/day
- (TMT Increase Rate: 0.48°C/day Before Coating)

**Flue Gas & Bridge Wall Temperature**

- Depressed Ceramic Furnace
- Bolt and Flue Gas Temp. were adjusted (furnace duty)

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Cetek Ceramic Technologies
IR Thermography Inspection Comparison

Before Coating

After Coating

Summary of Results & Conclusions

- Rate of TMT Increase Reduced from 0.48°C/day to 0.35°C/day
- Maximum TMT reduced & not limited Run Length
- Increased Run Length, at Maximum Throughput
- Lower Flue Gas & Bridge Wall Temperatures
- Improved TST Uniformity
- Consistent Temperature Gradient across Coating
- More Accurate Determination of TMT & Coke Formation
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