Cetek "Matrix Coating System" & It's Use at MiRO - Karlsruhe, Germany May 2007

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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

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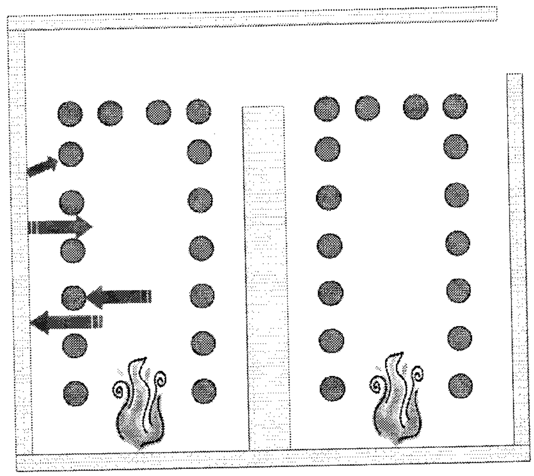
Furnace Radiation



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.*

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Radiant Heat Transfer Mode in a Fired Heater

$$\text{Heat Flux} = C \times (T_s^4 - T_r^4) \times F_e \times F_a$$

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*

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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"*

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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*

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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*

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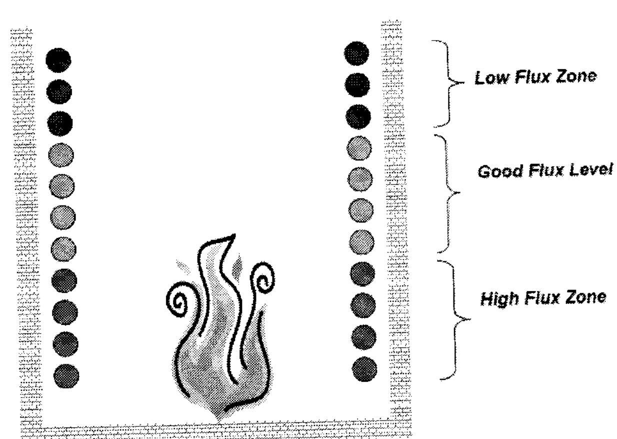
Heat Flux Problems...?

For example:



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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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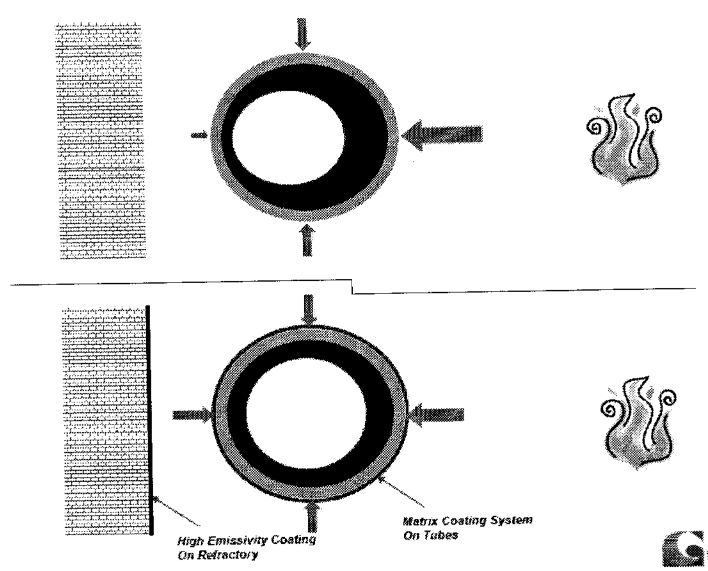
Cetek Matrix Coating System –Heat Flux manipulation



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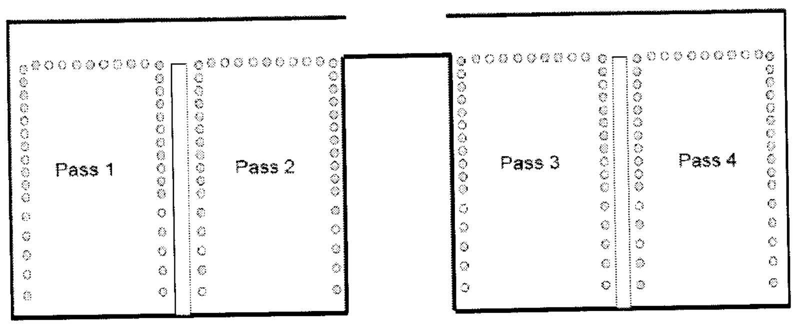
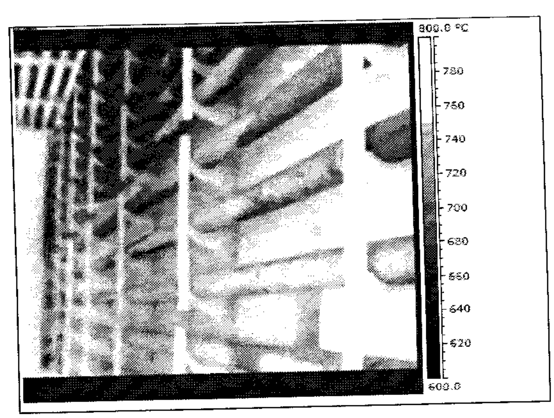
MiRO Coker Heater Application

Heater Schematic



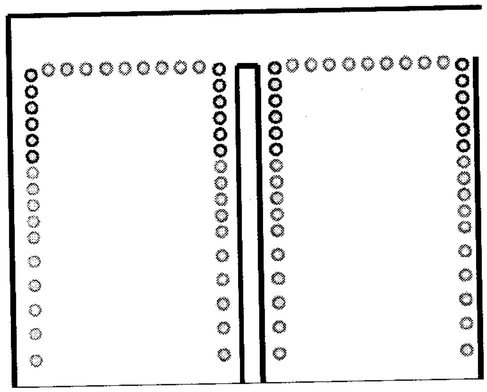
IR Thermography Inspection



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

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Heater Simulation Results

	Units	Before Coating	After Coating
Average Flux of the Upper 6 Wall Tubes	KW/m^2	40.1	43.1
Average Flux of the 9 Roof Tubes	KW/m^2	40.1	39.7
Average Flux of the Lower 10 Wall Tubes	KW/m^2	40.1	38.8
Front 180° Tube Heat Flux – Upper 6 Wall Tubes	KW/m^2	57.0	60.9
Front 180° Tube Heat Flux - Roof Tubes & 10 Lower Wall Tubes	KW/m^2	57.0	49.0
Flux Ratio of Front 180° / Average Flux	Ratio	1.42	1.25
Bridge Wall Temperature	°C	817	805

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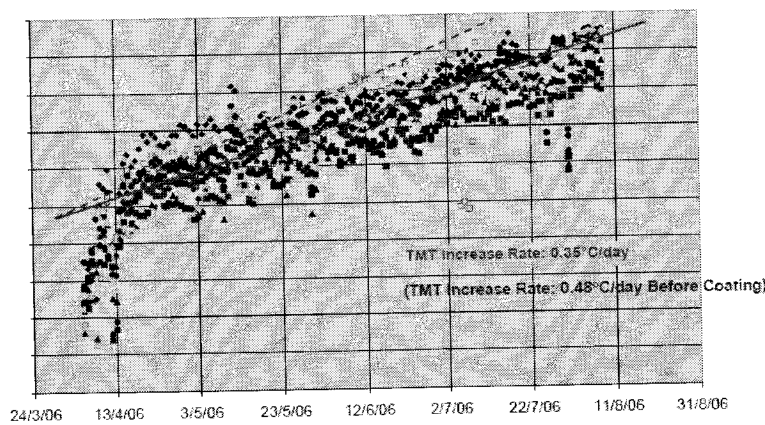
Tube Skin Temperatures After Coating

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



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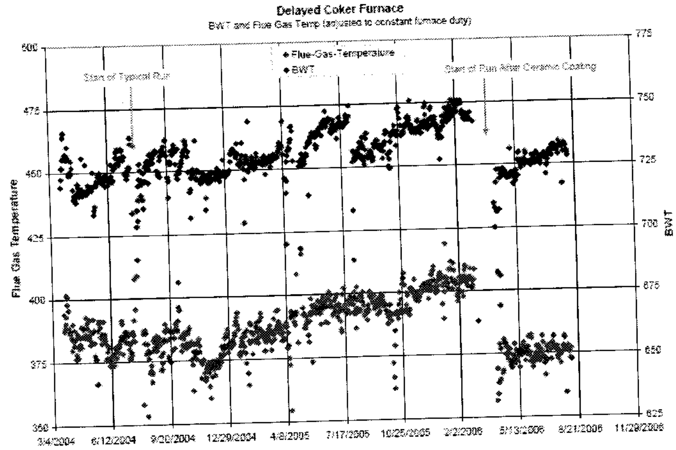
Flue Gas & Bridge Wall Temperature

Delayed Coker Furnace

BWT and Flue Gas Temp (adjusted to constant furnace duty)



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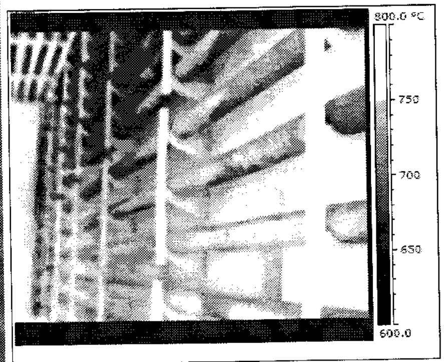
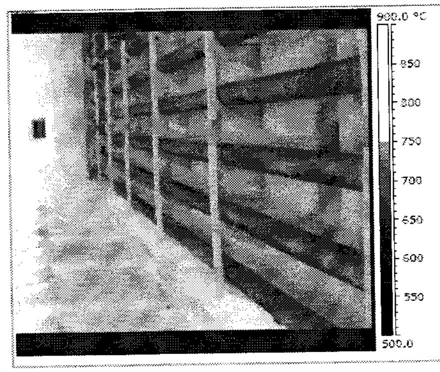
IR Thermography Inspection Comparison



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*

Acknowledgements

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