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

**Coking.com Safety Seminar**

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## Overview

- Objective
- Key Coker Heater Operating Variables
- Benefits of Ceramic Coatings
- How Ceramic Coatings Improve Furnace Performance
- Coker Heater Coating Application
  - Impact of Refractory Coating
  - Impact of Process Tube Coating
  - Combined Impact
- Conclusions
- Q&A

## Objective

- *Identify a potential low cost, rapid payback project that improves a Coker heater and Coker unit performance.*

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## Coker Heater: Key Operating Variables

- *Residence Time*
- *Furnace Profile*
  - *Temperature Profile*
  - *Pressure Profile*
  - *Velocity Profile*
- *Coking Factor*
- *Heat Flux*
- *Peak to Average Flux*

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## 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 removing all scale and installing a uniform ceramic coating layer.*
- *Easy coking detection using infrared camera or pyrometer through the elimination of uneven scale delta T.*

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## Benefits of Ceramic Coatings Applications

- *Increased Throughput*
- *Longer Heater Run Lengths*
- *Lower Fuel Consumption*
- *Lower Bridgewall and Convection Section Temperatures*
- *More Reliable Infra-red Tube Skin Temperature Readings*
- *Longer Tube and Refractory Life*
- *Lower NOx Emissions*

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## How Ceramic Coatings Improve Furnace Performance

### Ceramic Coatings

- Theory & Applications on:
  - Refractories (high emissivity coatings)
    - NOx Emission Reduction (up to 30%)
  - Process Tubes (elimination of oxidation, scaling & fouling)
  - "Matrix Coating System" (manipulation of heat flux)
    - Application to MiRO's Coker Heaters

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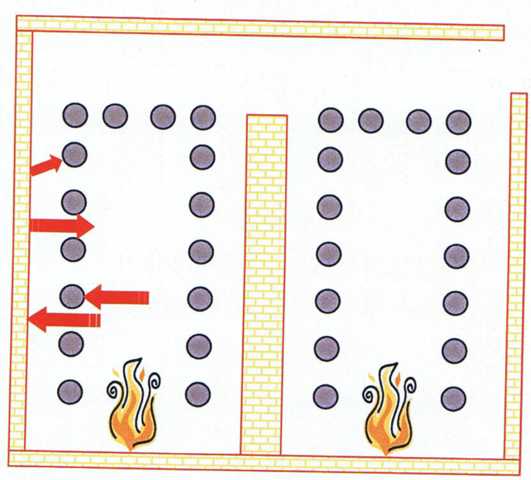
## Furnace Radiation



*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

**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 Properties
    - Increased Radiant Heat Exchange Efficiency
      - More Heat Available to the Process
      - Slightly Lower Flue Gas / Bridge Wall Temperatures
    - 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

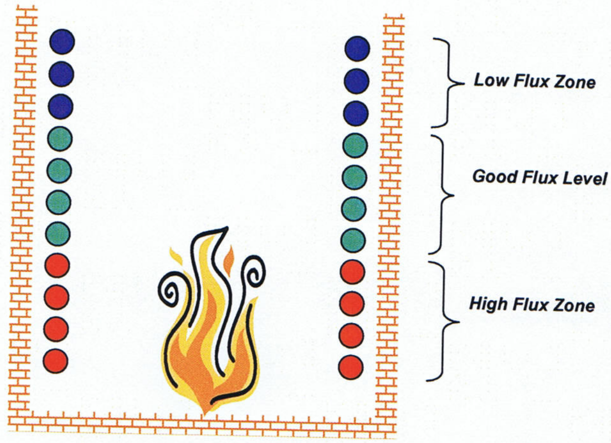
- **Coatings for Process Tubes:**
  - Elimination & Prevention of Oxidation (Scale) + High Emissivity
    - Increased Conductive Heat Transfer
      - More Heat Available to the Process
        - » Lower Bridge Wall Temperatures
    - Back of Tubes Can Accept More Heat
      - In combination with high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

## Matrix Coating System - Dual Emissivities

- Manipulate heat flux distribution in single fired heaters
- Design coatings application based on coking pattern of the 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

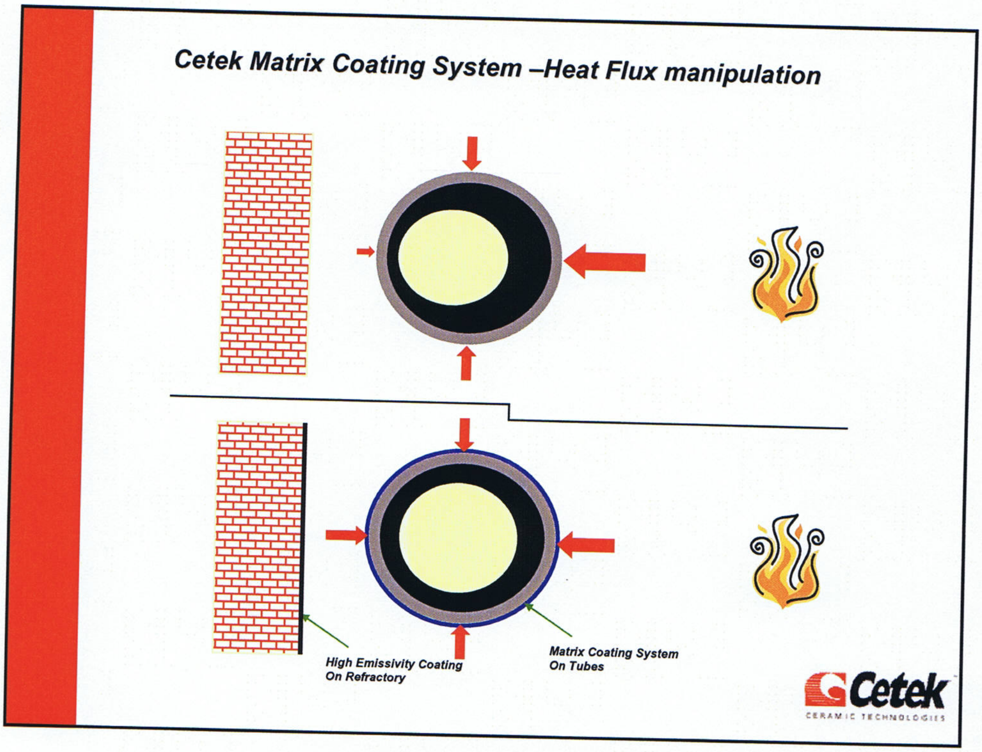
## Heat Flux Problems…?

For example:




## Cetek Matrix Coating System (US Patent # 6,626,663B1)

- Differential 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
  - Increases "Effective Tube Surface Area"
  - Manipulates Heat Flux Zones
    - Reduces High Heat Flux
    - Increases Low Heat Flux


Cetek Matrix Coating System –Heat Flux manipulation
High Emissivity Coating
On Refractory
Matrix Coating System
On Tubes
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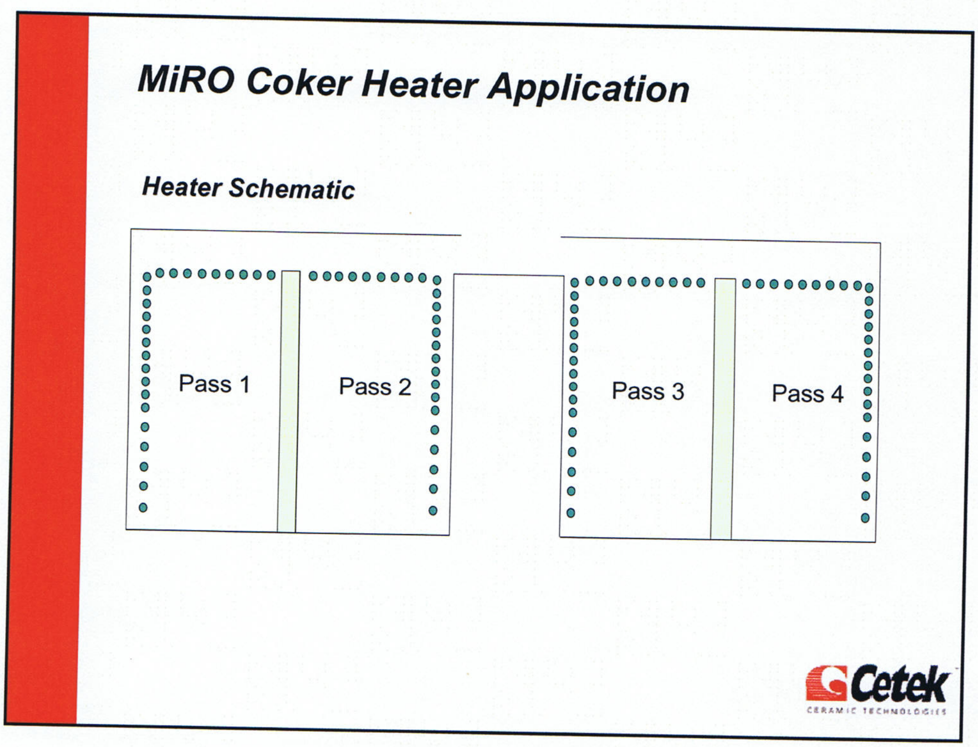
MiRO Coker Heater Application
Heater Schematic
Pass 1
Pass 2
Pass 3
Pass 4
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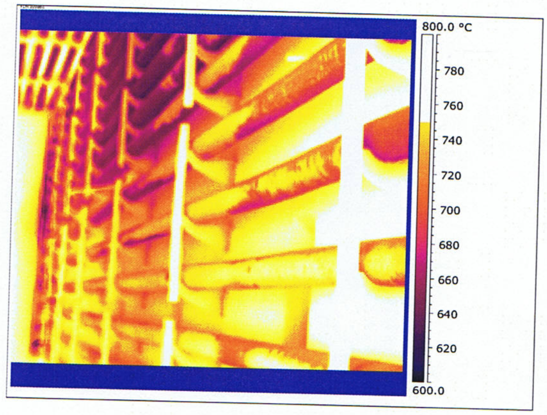
## IR Thermography Inspection




**Observations:**

- *High Tubes Surface Temperatures on Lower Side Tubes*
- *Lower Tube Surface Temperatures on Upper Wall Tubes*
- *High Tube Surface Temperatures on Roof Tubes*

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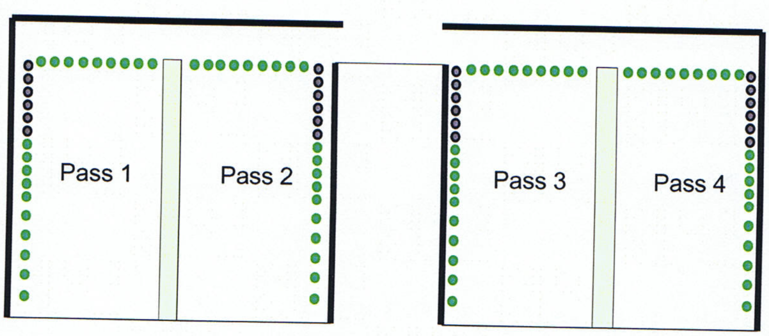
## Matrix Coating System Design

**Heater Schematic**




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

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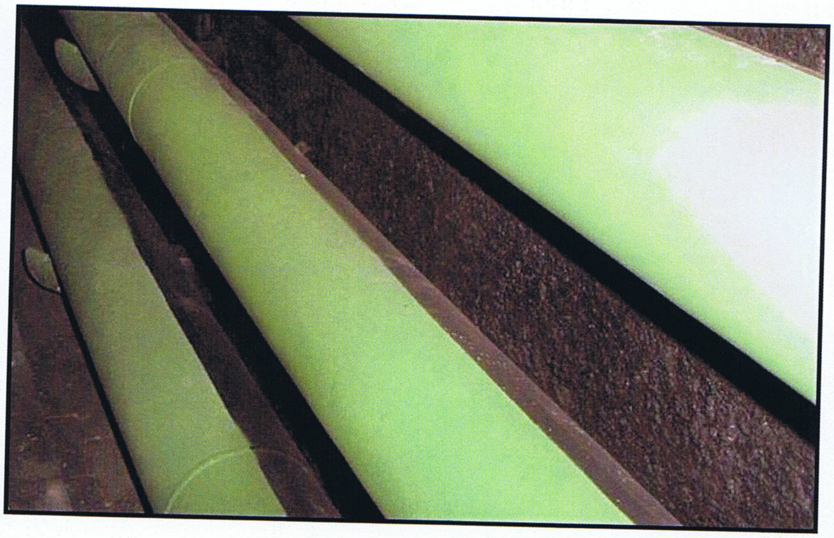
## Matrix Coating System



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## Heater Simulation Results

| | Units | Before Coating | After Coating |
|---|---|---|---|
| Average Flux of the Upper 6 Wall Tubes | KW/m² | 40.1 | 43.1 |
| Average Flux of the 9 Roof Tubes | KW/m² | 40.1 | 39.7 |
| Average Flux of the Lower 10 Wall Tubes | KW/m² | 40.1 | 38.8 |
| Front 180° Tube Heat Flux – Upper 6 Wall Tubes | KW/m² | 57.0 | 60.9 |
| Front 180° Tube Heat Flux - Roof Tubes & 10 Lower Wall Tubes | KW/m² | 57.0 | 49.0 |
| Flux Ratio of Front 180° / Average Flux | Ratio | 1.42 | 1.25 |
| Bridge Wall Temperature | °F | 1503 | 1481 |

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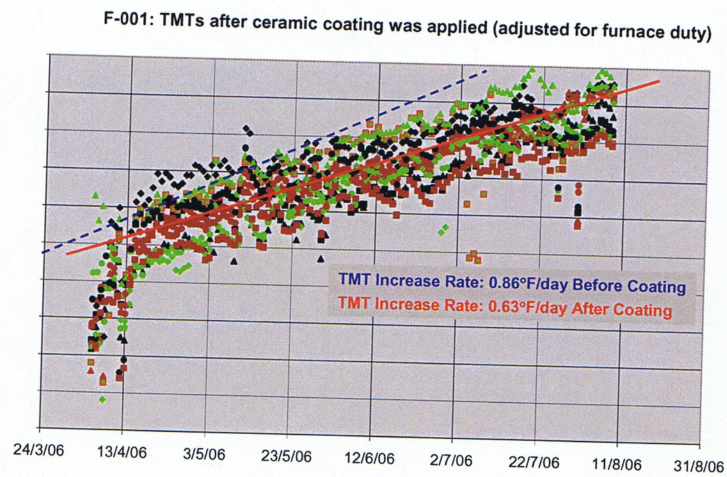
# Tube Skin Temperatures After Coating

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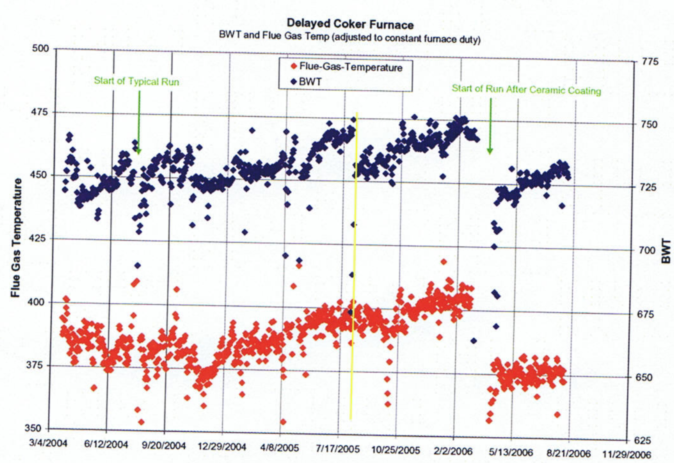
# Flue Gas & Bridge Wall Temperature

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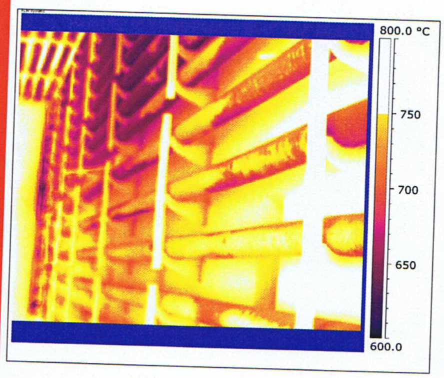
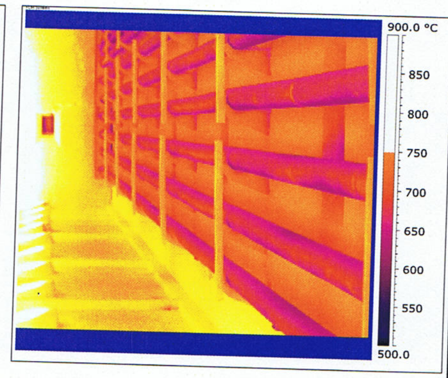
## IR Thermography Inspection Comparison




*Before Coating*




*After Coating*

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## Summary of Results & Conclusions

- *Rate of TMT Increase Reduced from 0.86°F/day to 0.63°F/day*
- *Maximum TMT Reduced*
- *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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# Acknowledgements


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