Coatings for Delayed Coker Heater Tubes

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What can **C2** Technology do for Delayed Cokers?

- **Extend Run Lengths**
  - Stabilize Coke Formation
  - Eliminate Metal Sulfdiation
  - Reduce Metal Carburization
  - Lower Heater Duty
  - Reduce Greenhouse Gases
  - Extend Equipment Life
Questions Addressed Here

☐ What is it?
☐ Does it stay bonded to the surface?
☐ Is it stable at high temperature?
☐ Why does it work?
☐ How is it applied?
☐ How long will it last?
☐ How can it be applied at your facility?
M.I.S.T.

Ultra-Thin Film

Diffusion Layer

Substrate Material
### Periodic Table of the Elements

<table>
<thead>
<tr>
<th>Element</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>Hydrogen</td>
</tr>
<tr>
<td>Li, Na</td>
<td>Alkali metals</td>
</tr>
<tr>
<td>Be, Mg</td>
<td>Alkali earth metals</td>
</tr>
<tr>
<td>K, Ca</td>
<td>Transition metals</td>
</tr>
<tr>
<td>C, N, O</td>
<td>Poor metals</td>
</tr>
<tr>
<td>B, Si, P</td>
<td>Nonmetals</td>
</tr>
<tr>
<td>Ar, Kr</td>
<td>Noble gases</td>
</tr>
<tr>
<td>Ne, Xe</td>
<td>Rare earth metals</td>
</tr>
</tbody>
</table>

Elements are arranged bytheir atomic number and atomic weight.
TEM Image by Dr. Jane Howe, Oak Ridge National Laboratory
SAM of C2

Sputter rate ~20nm/min

SAM Profile by Dr. Harry Meyer,
Oak Ridge National Laboratory
Strong Surface Bonding Example

Shot Sleeve (Cold Chamber)
Erosion and Wear Resistance Example

Untreated Roll, 1 Week
Erosion and Wear Resistance Example

C2 Treated Roll, 10 Weeks
Thermogravimetric Analysis (TGA)

Temperature (°C)

TGA %

Diamond

C2

Temperature (°C)
Graph of data from fouling results

Fouling (delta T, °F) vs. Time (minutes)

- C/S 1018
- Coated 1
- Coated 2
- Coated 3
Untreated

“C2” Treated

Coke Stabilization Achieved
Half-Way Through Testing
Virtually Eliminated Sulfidation

Typical of 9Cr Furnace Coke Deposit

Eliminated by C2

Coke Deposit
Iron Sulfide Layer
Tube Metal
Conclusions

- Calculated Effectiveness of the coating in mitigating fouling effectiveness **60%**
- C2 Stabilizes Temperature Increase
- C2 Retards Coke Formation
- C2 Prevents Metal Sulfidation
- C2 is Stable at Delayed Coker Furnace Operating Temperatures
- C2 does not Spall off and Contaminate the Product
Ethylene Cracker Testing at DOE’s Oak Ridge Nat’l Lab
75% Less Coke Deposition

1,000 Hours at 900°C
Other Petrochemical Applications:

- Hydrocrackers
- Hydrotreaters
- Reformers
- Venturi Scrubbers
- Caustic Attack
- H₂S Attack
- ... and many others
Polish  Apply  Heat  Cool  Repeat
Polish
Apply

Tube Wall

Nitrogen or Air

Saturated

C2 Liquid
Apply
Heat
Cool
Repeat

4-6 Times

- Application cycle 8-12 hours

- Total onsite time 96 hours (max)
  - Includes rig in/out time & polishing
  - Incremental to typical pigging time
Risks
Field Application
How can you verify this technology at your site?

- Tube Segment
- Single Cell Treatment
- Whole Heater Treatment
Tube Segment

20’ Tube Segment

~4’

~12’
Single Cell
Or
Whole
Heater
In situ
Low Risk/High Reward Proposition, providing:

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