Coatings for Delayed Coker Heater Tubes

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President

Coking.com®
2009 Galveston Safety Seminar

What can C2 Technology do for Delayed Cokers?

- Extend Run Lengths
- Stabilize Coke Formation
- Eliminate Metal Sulfidation
- Flow Assurance
- Lower Heater Duty
- Reduce Greenhouse Gases
- Extend Equipment Life
Dr. Arvid Pasto – Director, C3|Oak Ridge

- 37 Years in Materials Science R&D
- Former Director of High Temperature Materials Laboratory, U.S. Dept of Energy (14 yrs)
- Collaborated with C3/C2 Scientists for 5 years prior to retirement

What is C2 Technology?

- Ultra-thin, ceramic film anchored to an inorganic surface at the molecular level—a Surface Modification and a Coating
- Film remains anchored despite “hostile” environments (sulfur, acid, heat, hydrocarbons, liquid metal, etc.)
- Film is versatile: Harnesses properties of 79 elements to impart customized properties
How do we know $C_2$ is thin & anchored at the molecular level?

TEM of $C_2$

SAM of $C_2$

TEM Image by Dr. Jane Howe, Oak Ridge National Laboratory

SAM Profile by Dr. Harry Meyer, Oak Ridge National Laboratory

Aluminum Die Casting

- Liquid Aluminum ($1292^\circ F$) is poured into the shot sleeve
- A plunger then ejects the liquid Aluminum into a die mold cavity
- 1 cycle takes <3 minutes. During this period the shot sleeve is exposed to temperatures from $600^\circ F$ to $1292^\circ F$
- With $C_2$ coating total cycles went from 19,000 to 98,309 (2 months to 9 months)*

*Sleeve was pulled because production run was finished, not because $C_2$ failed
Commercialized with:

Hot Rolled Steel Application

- Hot Steel moving at 1000 feet/minute rolls down conveyor belts as its thickness is being decreased
- Guide Rollers (seen at right) keep this steel on track on the conveyor and experience significant wear scarring
- Untreated rollers last 1 week while C2 treated rollers last 10 weeks and still have 5 times less mass loss than the untreated roller
- This is a 50x improvement in wear resistance*

*As determined by Dr. Peter Blau, Tribologist, Oak Ridge National Laboratory, using a Coordinate Measuring Machine to analyze depth profile of scars
Bench Testing conducted by Dr. Ghaz Dickakian of Fouling and Coking Technology, Inc. (F.A.C.T.)

- Dr. Dickakian worked for Exxon for 35 years in carbon technology & fouling and coking mitigation
- Expert in Fouling and Coking with 40 Years of Experience
- Extensive Library of Testing Data for Comparative Results
- Please refer to Paper for details

Thermogravimetric Analysis

- Fouling and Coking Technology determined the thermal stability of the C2 coating in air and nitrogen from 68°F to 1832°F
  - Found coating is thermally stable at 1832°F in both air and nitrogen
  - Thermal properties were similar to diamonds
Graph of data from fouling results

![Graph of data from fouling results](image)

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

Coke Stabilization Achieved Half-Way Through Testing

- Untreated Heat Exchanger
- “C2” Treated Heat Exchanger

Coke Stabilization Achieved Half-Way Through Testing
F.A.C.T. 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

Field Application
C2 Solution Application with Pig Train

Pig Train Direction

Furnace Tube

N2*

Solution Reservoir

N2*

"C2" Coating

*(or dry air)

Test Loop

[Diagram of test loop with various components and connections]
Application Procedure for Delayed Coker

*(DDT is subcontracted & overseen by C2)*

1. Finalize & Approve Detailed Coating Procedure with Site Representatives
2. Mechanical cleaning of the tubes
3. Standard polishing procedure
4. Fullkote techniques used to ensure the tube ID is dry
5. Compressed Nitrogen (or dry air) to propel a pig train carrying the C2 solution through the furnace, wetting the tube ID with the liquid
6. Equipment is removed, and heaters are fired so that tube ID reaches a temperature greater than 830°F
7. C2 Coating and Surface Modification is now in place
8. In field tests, steps 4 and 5 are repeated ~5 times to ensure full coverage
Summary: C2 is a **Low Risk/High Reward** Proposition, providing:

- Longer Runs before Decoking
- Flow Assurance
- Lower Heater Duty
- Lower Emissions
- Extended Equipment Life

How can you Verify This Technology at YOUR Site?

- Single Cell Coating
- Tube Segment
Single Cell Coating

Tube Segment

20’ Tube Segment

~4’ ~4’ ~12’
Other Test Options?
Other Petrochemical Applications:

- Hydrocrackers
- Hydrotreaters
- Reformers
- Venturi Scrubbers
- Caustic Attack
- H₂S Attack
- ... and many others
The Following are Backup Slides if Necessary for Technical Questions
Second, F.A.C.T. tests coated heat exchangers with same parameters for optimum fouling

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<th>Exchanger Heater</th>
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<th>3</th>
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<td>Exchanger temp (°F)</td>
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<tr>
<td>Unit pressure (psig)</td>
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<tr>
<td>Unit Atmosphere</td>
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<td>Oil flow rate (cc/min)</td>
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<tr>
<td>Test time (minutes)</td>
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**Thermal Fouling Measurements**

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<td>60 minutes</td>
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**Effectiveness (%)**

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