Ultra-Thin Antifouling Surface Treatments for Industrial Heat Exchangers

Contract Number DE-SC0003355
Applied Thin Films Inc.
Project Period 2010 - 2012

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ATFI
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U.S. DOE Advanced Manufacturing Office Peer Review Meeting
Washington, D.C.
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Problem Statement
• Fouling of heat exchangers is a serious problem in various energy intensive industries causing significant energy and productivity loss

Challenges
• Identifying surface treatment that is durable in high temperature harsh environments
• Suitable process to apply anti-fouling treatment on internal pipe surfaces of existing industrial infrastructure

ATFI Approach / Technology
• Develop and demonstrate anti-fouling properties of Cerablak® ultra thin films through field application installations
Technical Approach

How is it done today?

ATFI Approach

Cerablak® UTF Glass Diffusion Barrier

- Pin-hole free, hermetic quality ultra thin film
- Alumina rich phosphate glass
- Under 1 µm thickness eliminates thermal shock, CTE issues
- Film prevents iron sulfide formation and coking

Catalytic Coking Prevention

304 Stainless Steel Tube ID: Tulsa University Delayed Coking Project (TUDCP)

Micro Coker Test Evaluation

Uncoated Cerablak® UTF Coated

Digital Refining PTQ Q3 2013

Routinely Cleaned (Pigged) Units
Technical Approach

Laboratory Flow Coating Process

(1/4" AUS304 tubing)

Continuous Pigging

Continuous Flow Coating

Batch Coating

Technology Comparison:

C2 MIST coatings
- Rare-earth Oxides
- C3 LLC / ORNL
- Field Tested
- Exclusively Licensed?

C2 Mist
- Chemical solution based coating
- Crystalline Oxide
- Yes
- 9 / 9
- Multi-Step

Cerablak® UTF
- Chemical solution based coating
- Amorphous Glass
- No
- 9 / 9
- One Step

General Description

Film Type

Heavy metals

TRL / MRL

Process Cost Economics
Who Cares?

- O&G (Initial Target)
- Hydrogen Processing / Production
  - Nuclear
  - Electric power gen
- Waste heat recovery
- CSP / Solar
- Coal Fired Power
- Olefins Processing / Production
- Transportation
  - Turbochargers
  - Fuel Systems / Lines
Transition and Deployment

Applied Thin Films Inc. Anti-Fouling Technology → Chemical Supply → Spinout “NewCo”

- Sales and Marketing
- Toll Service Centers
- Service Contractors
- OEMS

Application
- As-Manufactured
- In-service
- Continuous
- Batch
Measure of Success

Delayed Coking Economics

**US Crude Slate**

<table>
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<th>Year</th>
<th>Canadian Light</th>
<th>Canadian Heavy</th>
<th>Domestic Heavy</th>
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<td></td>
<td></td>
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**Delayed Coking Process Heater (DCU)**

- **Throughput Losses**: 2-5% ~ $5M
- **De-Coking Costs**: $25-$50M/Coil
- **Reduced Flexibility**: Can be >$5M

**Annual Unit Costs**

- **Conversion Losses**: 1% ~ $3M
- **Increased Fuel Usage**: 2% > $200,000 = 40-60 BBTU

**DCU Productivity Loss Profile**

- **Downtime Savings**
- **Throughput Savings**

All values based on typical 40,000 B/D unit.

Source:

1. Wright, B. AiChE Chicago Symposium 2007
2. Downstream Today Feb 9 2012
Project Management and Budget

- **DOE Funding Request**: $2 – 3M
- **Private Investment**: $X M
- **NEWCO Profitable and Self-Sustaining**
  - Global Sales
  - Expansion – Beyond O&G
  - Regional Franchise Model

- **Technology Validation for Other Markets**
- **Process Improvements**
- **Field Trials**
- **O&G Sales and Marketing**
- **Partnerships Chemical Production Coating Applicators**
- **Field Installations**

- **$6M Invested in technology to date**
- **Initiation of Commercial Revenue for NEWCO**

Timeline:
- 2010
- 2012
- 2014
- 2016
- 2018
- 2020

- 2012
  - R&D PROOF OF CONCEPT DEMO
  - DOE SBIR TECH SCALE-UP
  - O&G DCU FIELD VALIDATION
Results and Accomplishments

Successful Customer Field Demonstration

- Two 3000 ft. long pipe assembly fired heaters
- Operating US delayed coker unit
- Refinery site approved installation process
- SOP established
- OSHA, EPA, EH+S regulatory approvals
- Full scale chemical manufacturing, handling, and disposal

O&G Delayed Coker Unit: Spring 2013

= Industrial Simulation Tests (customer funded @ Univ. of Tulsa) (totaling ~$450,000)

Customer commitment for field testing ($2M - $5M)

Commercialization Milestone
Oil Refinery Field Installation

R&D PROOF OF CONCEPT DEMO

Phase II ARRA DOE SBIR

Field Testing

2010 2011 2012 2013 2014