This presentation does not contain any proprietary, confidential, or otherwise restricted information.

Ultra-Thin Antifouling Surface Treatments for Industrial Heat Exchangers

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

Sankar Sambasivan
ATFI
Founder, President & CEO
www.afinet.com

U.S. DOE Advanced Manufacturing Office Peer Review Meeting
Washington, D.C.
May 6-7, 2014

atfi
Surface Science Solutions

Project Objective

Problem Statement

•Fouling of heat exchangers is a serious problem in various energy intensive industries causing significant energy and productivity loss

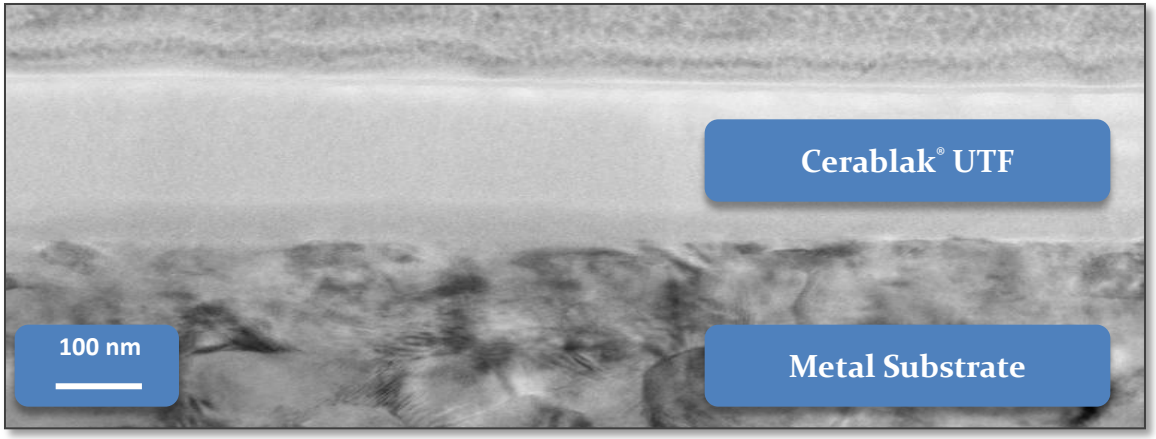
Challenges

•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

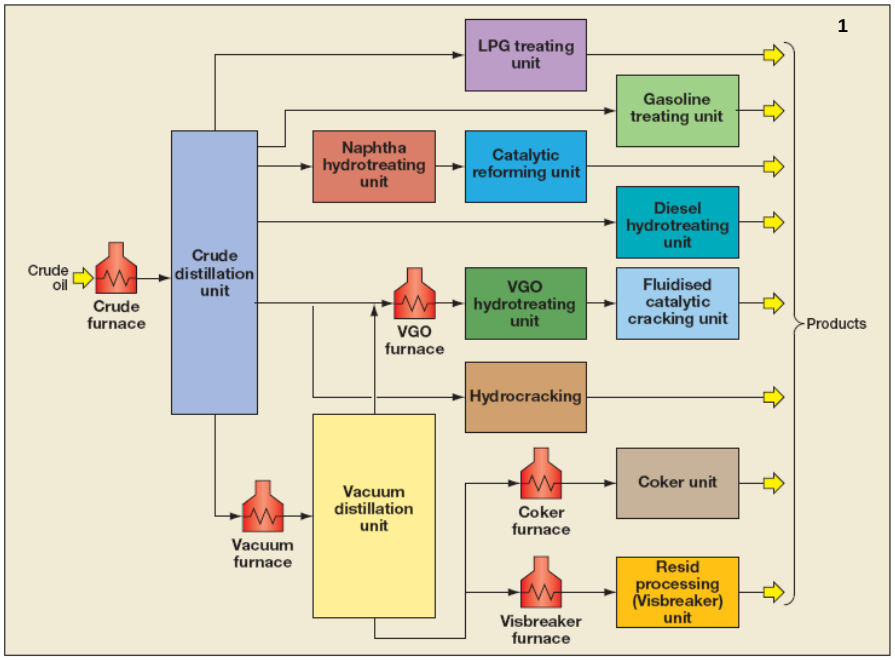
ATFI Approach / Technology

•Develop and demonstrate anti-fouling properties of Cerablak® ultra thin films through field application installations



Technical Approach

How is it done today?



[1]Digital Refining PTQ Q3 2013

Routinely Cleaned (Pigged) Units

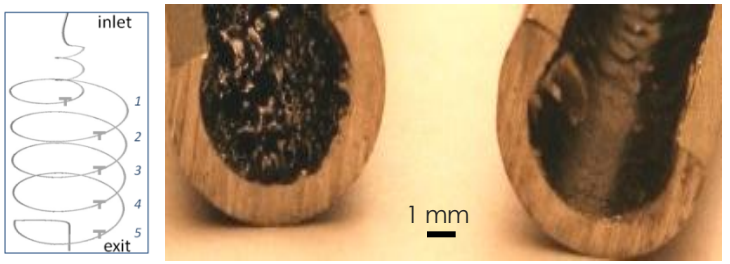
ATFI Approach

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[4]

Catalytic Coking Prevention

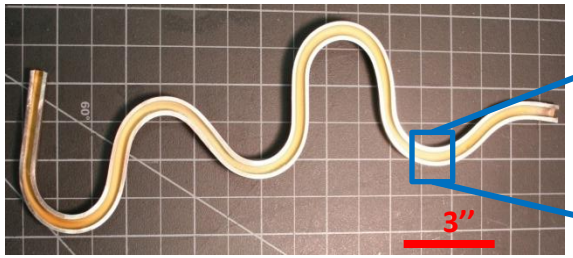
304 Stainless Steel Tube ID:
Tulsa University Delayed Coking Project (TUDCP)
Micro Coker Test Evaluation

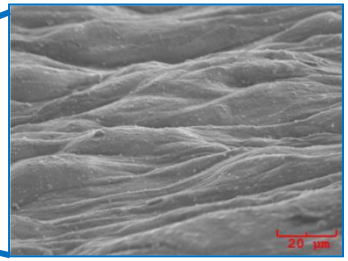


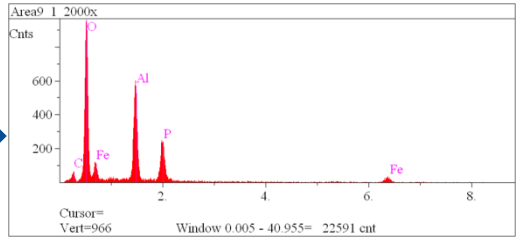
Uncoated Cerablak® UTF Coated

Technical Approach

Laboratory Flow Coating Process

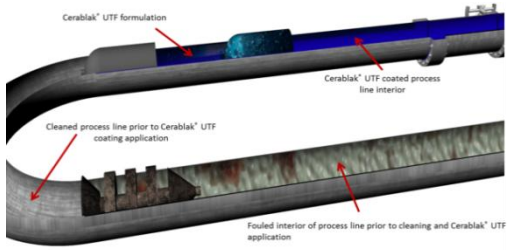




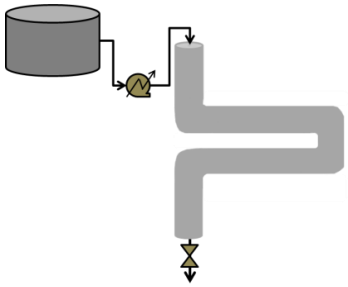


(1/4” AUS304 tubing)

Continuous Pigging



Continuous Flow Coating



Batch Coating

Technology Comparison:

C2 MIST coatings

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

	C2 Mist	Cerablak® UTF
General Description	Chemical solution based coating	Chemical solution based coating
Film Type	Crystalline Oxide	Amorphous Glass
Heavy metals	Yes	No
TRL / MRL	9 / 9	9 / 9
Process Cost Economics	Multi-Step	One Step

Transition and Deployment

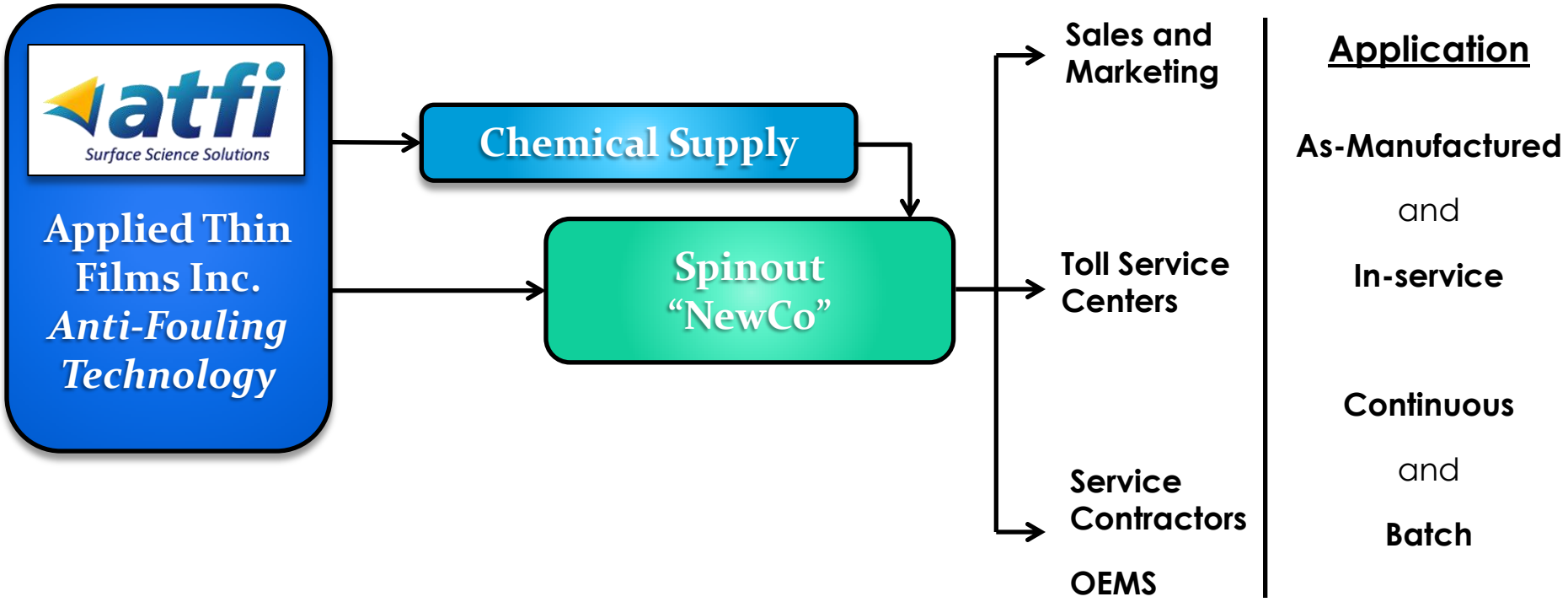
Who Cares?

- 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

Compact Welded Plate Heat Exchanger
Aqueous Corrosion of Aluminum

Coal Fired Power Plant, Fireside Fly Ash Corrosion
Midwest Generation, Homer City, PA
(still in service >3 years)

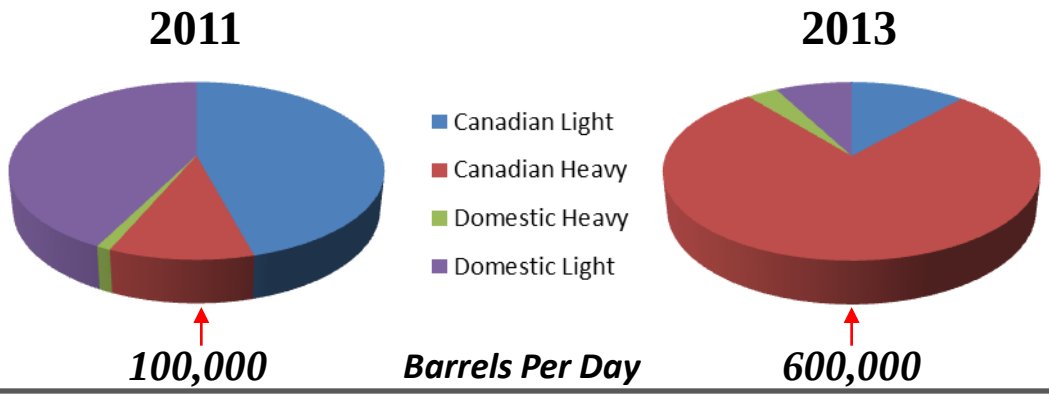
Transition and Deployment



Measure of Success

Delayed Coking Economics

US Crude Slate[3]



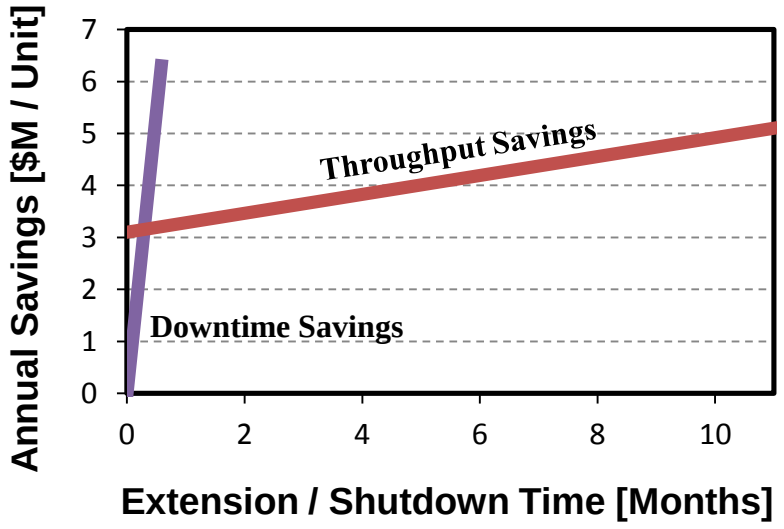
Delayed Coking Process Heater (DCU)

Annual Unit Costs[2]

Throughput Losses: 2 -5 % ~ $5M	Conversion Losses: 1% ~ $3M
De-Coking Costs: $25-$50M/Coil	Increased Fuel Usage: 2% > $200,000 = 40-60 BBTU
Reduced Flexibility: Can be >$5M	EH & S Concerns

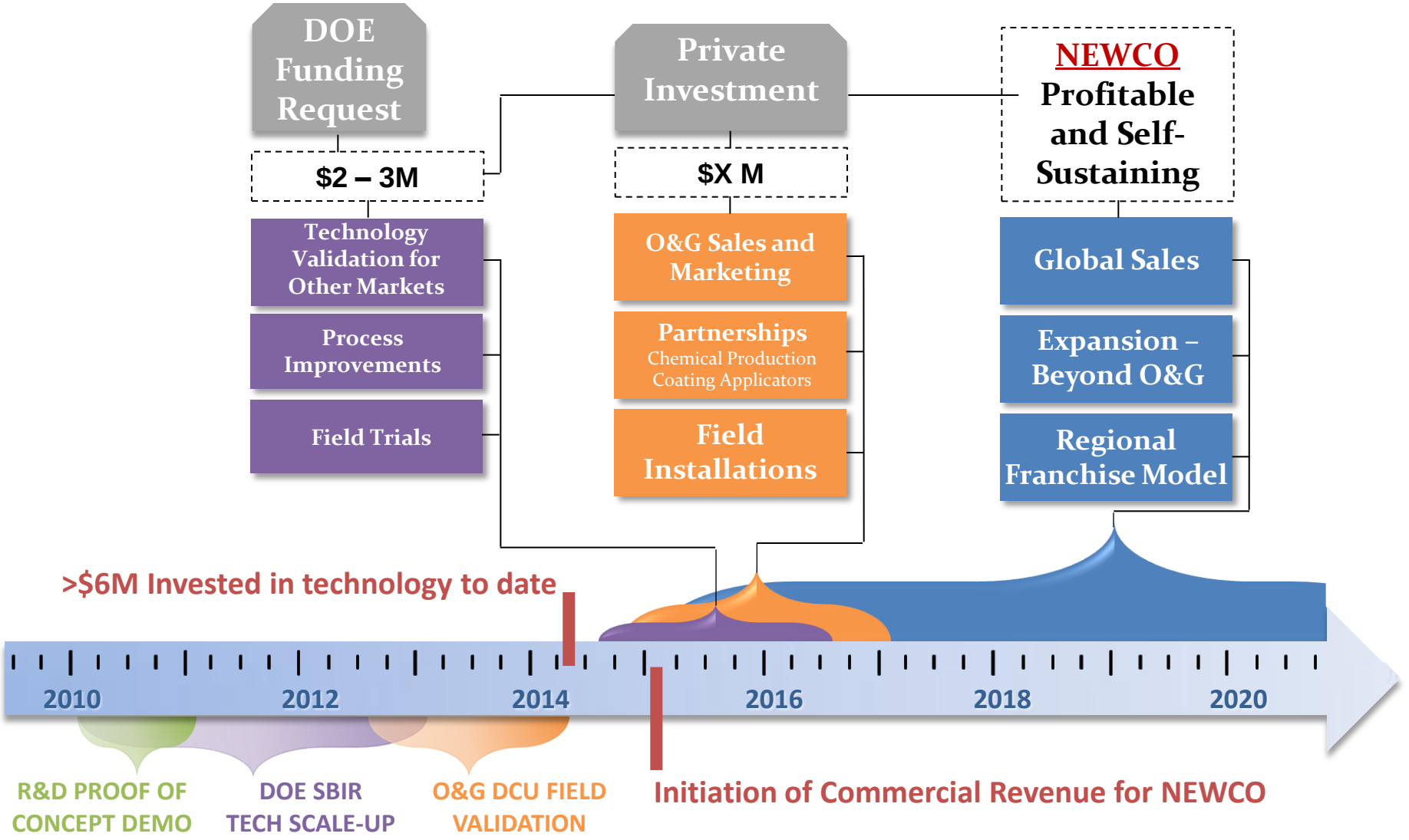
All Values Based on Typical 40,000 B/D Unit

DCU Productivity Loss Profile



[2]Wright, B. AiChE Chicago Symposium 2007 [3]Downstream Today Feb 9 2012

Project Management and Budget



Results and Accomplishments

Successful Customer Field Demonstration

O&G Delayed Coker Unit: Spring 2013

- 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