SMART & Multifunctional Tubacoat Technology For CAPEX,OPEX and CO2 Reduction in Refining and Petrochemical And Other Applications

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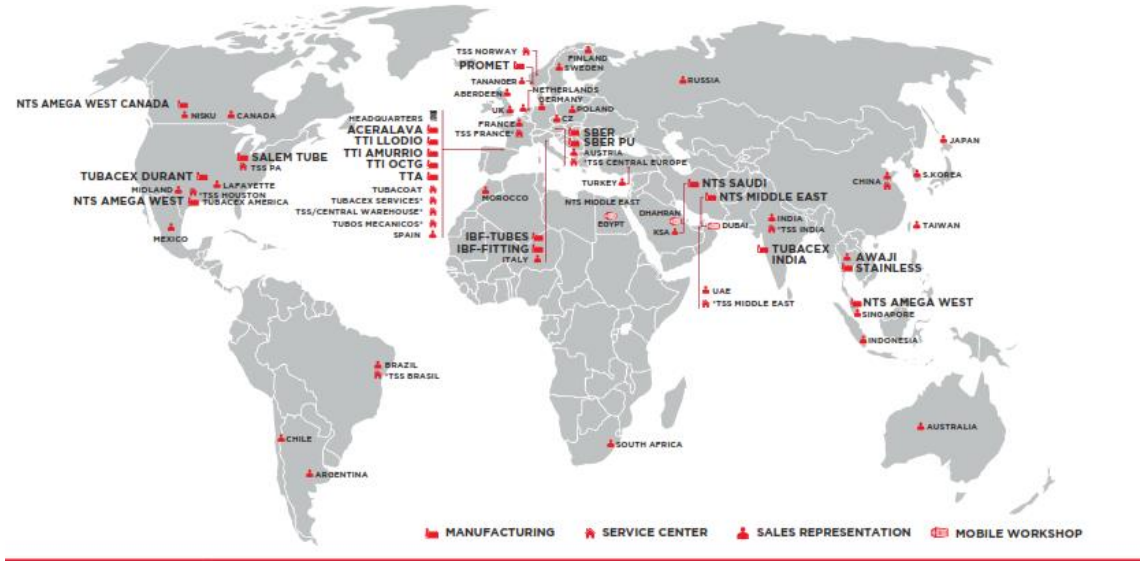
BIOMASS POWER

OCTOBER 11-12,2023

STOCKHOLM, SWEDEN

- Tubacex Group
- Tubacoat Technology
- Coke deposition in fired heater tubes
- Field applications/Case Studies- Fired Heaters, Heat Exchangers and others
- Pyrolysis/Biomass Application
- Anti Corrosion Commercial Application
- Conclusion

Global Presence



KEY FACTS

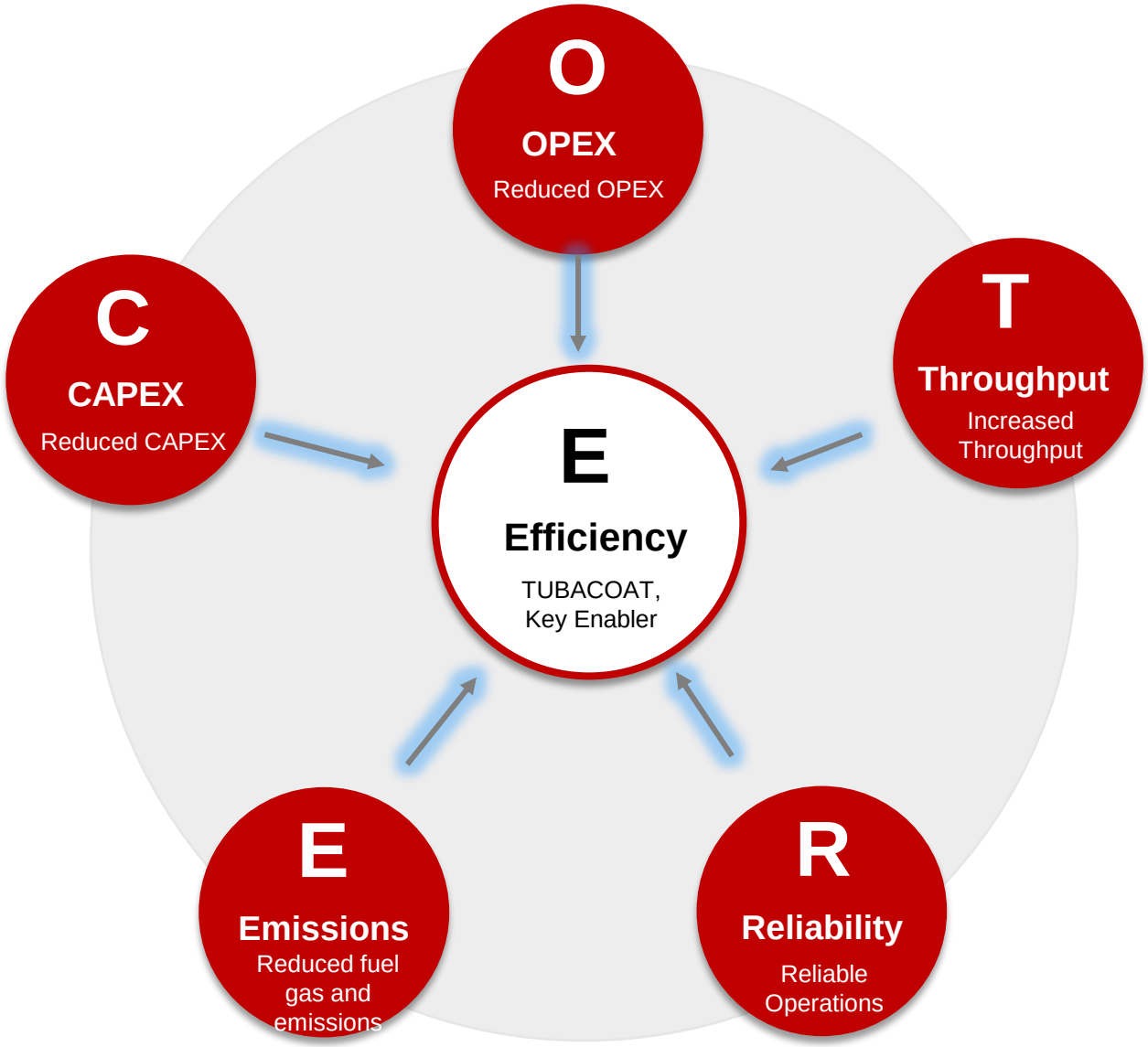
- **Sales: 750 million euros ***
- **2500 professionals**
- **Full Range of Seamless Stainless tubular Products**
- **20 mills** in Spain, USA, Austria, Italy, India, Thailand, Norway, KSA, Dubai, Canada, Singapore
- **Commercial presence** in over 30 countries
- An own **global master distributor** (TSS) with 12 service centers

*Pre-COVID-19

Steel billets & bars ▶ Extrusion ▶ Cold finishing ▶ Pipes & tubes fittings ▶ Master distribution ▶ Commercial network

A worldwide leading supplier of Seamless Stainless Tubes

Tubacoat – Efficiency Enabler



Advantages

PROFITABLE

- Avoids profit loss caused by shutdown for cleaning or replacement
- Reduced OPEX due to easier and less frequent cleaning
- Increased heat transfer efficiency reduced heating costs

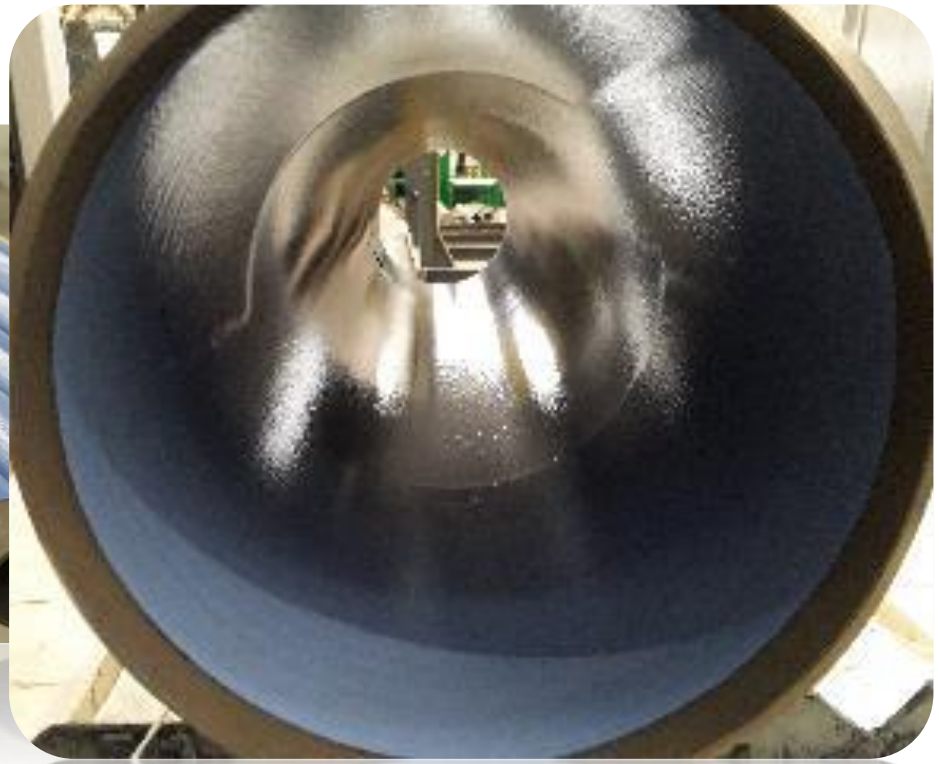
SAFE

- Corrosion resistant
- Reduced number of shutdowns & start-ups
- Slower tube temperature increase
- Avoids hotspots

CLEAN

- Increased Heat transfer efficiency
- Reduced fuel consumption and CO_2 emissions
- Longer tube life

Tubacoat

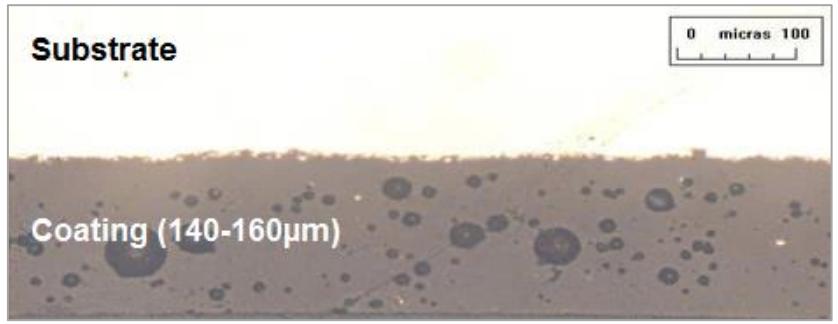


CAN WITHSTAND TEMP UPTO 800 0C (1470 0F)

Advanced coating solutions 100% Tubacex group

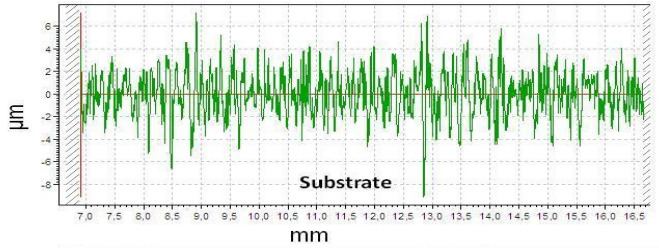
Product Characterization

Continuous **coating layer**
Thickness control based on suspension parameters & rheological properties



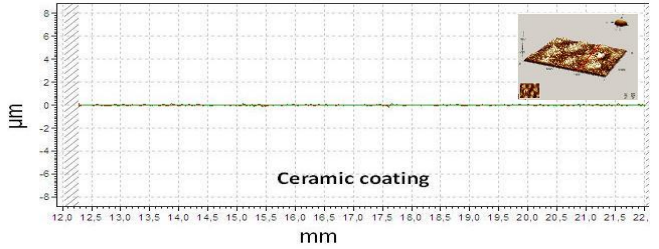
Typical coating thickness range: **100-150 µm**

Roughness



Substrate

Ra ≈ 1.5 µm and Rz ≈ 7.8 µm

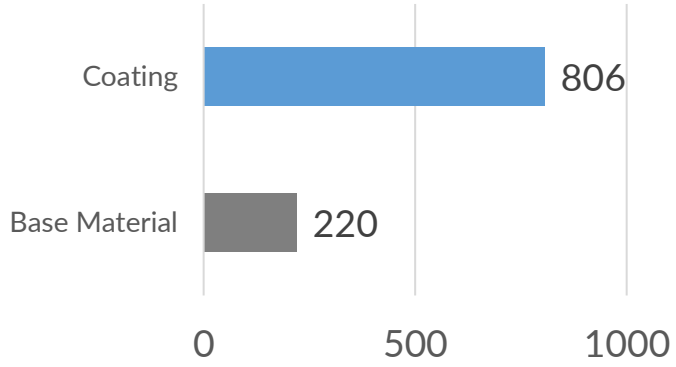


Ceramic coating

Ra < 0,04 µm and Rz ≈ 0,2 µm

Ra and Rz decrease ≈ 97% minimizing **particle adhesion**

Hardness [HV]

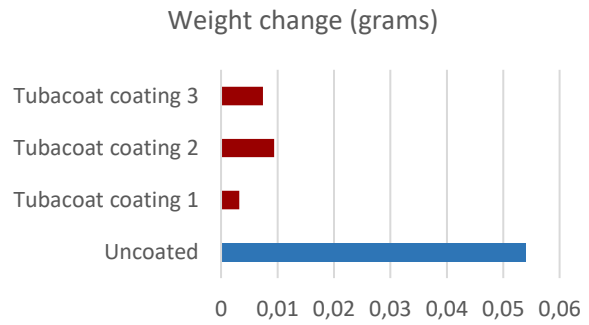


Abrasion resistance is significantly higher than in Carbon or Stainless steel based on 4 times higher hardness

Product characterization

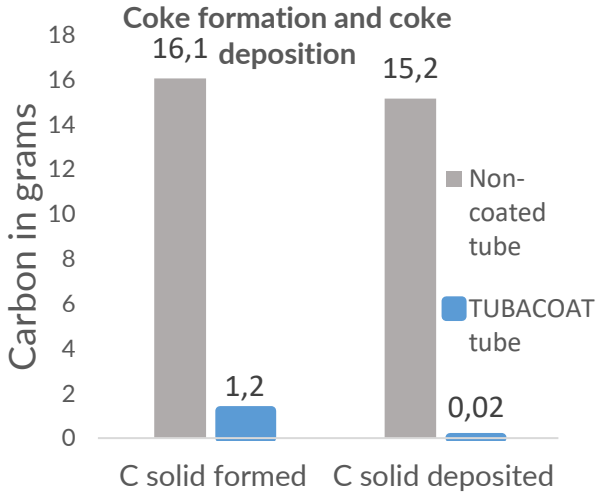
Fouling

Test run of 40 hours for each sample with crude oil, comparing weight difference after cleaning.



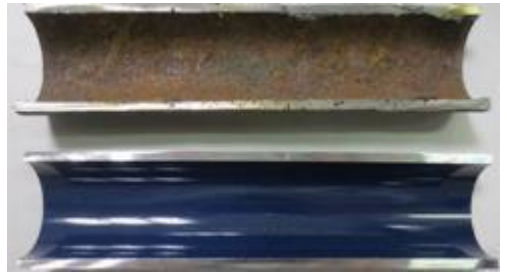
Test result showed uncoated tube had between 6 to 17 times more foulant and was more difficult to clean

Chemical inertness



- **Carbon formed is >10 times lower in coated tube vs non-coated tube**
- **Carbon deposited is >100 times lower in coated tube vs non-coated tube**

Corrosion



- **Effective protection for different corrosion applications:**
- Tube & Shell HEX
- Sulfur condenser in SRU
- Nitric acid cooler condenser
- CDU overhead condenser
- Flue gas condenser

Key Properties

Value-added products with…

- ✓ **Outstanding Anti-fouling** properties reduce deposition and increase heat transfer
- ✓ **Chemical inertness** minimizes **coke formation** and reactions with base steel
- ✓ **Excellent corrosion resistance** in different media and thermal conditions
- ✓ **Abrasion resistance** based on hardness 4 times higher than base material

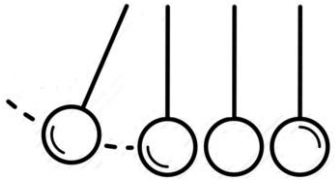
Specifically developed to…

Provide **long term reliable & competitive solutions** to industrial applications under **high temperatures**, severe working conditions and extreme environments

Engineering, industrial development and commercialization of tubular solutions based on advanced innovative coatings

Coke deposition problems

As coke layer grows….



Efficiency loss

- ↓ Heat transfer & ↑ Tube skin temp
- ↓ Effective area & ↑ Pressure drop

- **Mechanical Pigging**: requires shutdown Average pigging cost: **1.6 million USD**
- **Online Spalling**: requires throughput reduction Average spalling cost: **0.6 million USD**
- *Average profit of 20,000 BPD Delayed Coker unit

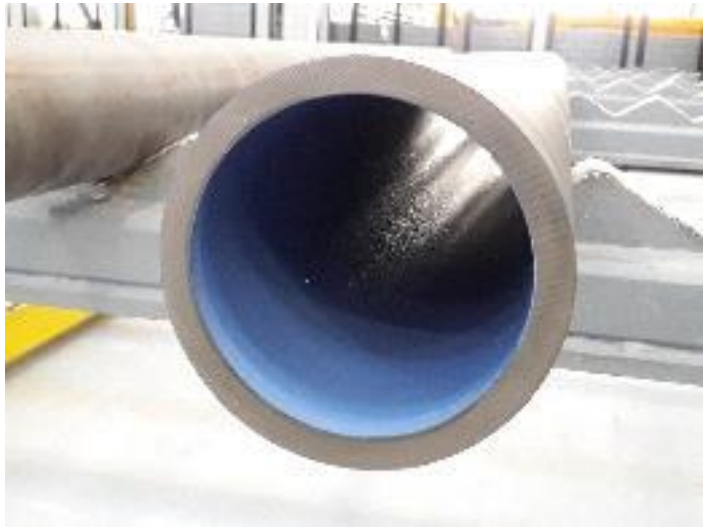
NEED FOR FREQUENT DECOKING

Production loss & Higher OPEX

Anti-coking Solution For Fired Heaters

When the coating is applied to the inner surface of heater tubes:

- **Minimizes coke formation** (chemical inertness)
- **Minimizes coke deposition** (anti-fouling)



Fired heater with coating applied will obtain:

- **Longer run lengths**
- **Lower fuel consumption**
- **Increased safety and reliability**

Visbreaker Unit

PROBLEM DESCRIPTION

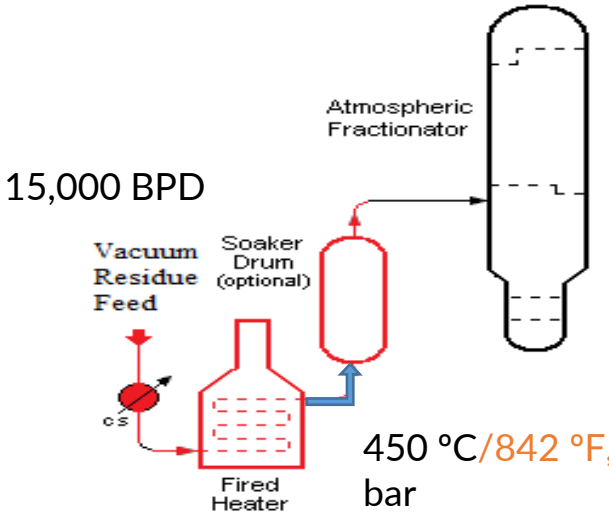
Coke deposition inside the tubes causing:

- **Fired heaters** frequent shutdown for pigging
  → **Huge loss of production cost**
- **Preheat exchangers** constantly taken out of service due to coke accumulation
  → **Tube deformation related to hot spots**
- Poor **Heat transfer efficiency** due to coke layer → **High fuel consumption in the furnace**

TUBACOAT TRIAL

ID coated tubes, bends and flanges installed at the furnace outlet line to prove anti-fouling properties.

Dimensions: OD 4”, Sch. 80 - 317L SS

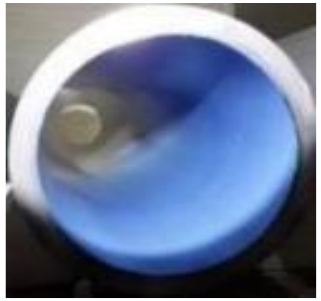


Visbreaker Unit

TRIAL RESULTS (after 12 months)

Coke deposition inside the tubes causing:

- **Very thin coke layer** - not detected by Radiographic test - 75% reduction in coke deposition.
- **Coke was much easier to remove** - 3 times lower water pressure than before was enough to remove all the coke.
- **Decoking services** - may use softer pigs and cleaning will be less frequent



CONCLUSIONS

- **Run lengths without decoking**/online spalling can be **increased between 3 and 4 times**

- **Savings** by Customer **1.5 Million USD per year**
  - 1.1 M$ higher throughput (reduced shutdown time 7days/yr)
  - 0.15 M$ furnace online spalling/pigging,
  - 0.15 M$ fuel consumption,
  - 0.10 M$ Heat Exchanger cleaning

Delayed Coker

Current Configuration

- Refinery operates 1 Delayed Coker, with normal capacity 124,000 barrel/day.
- Delayed Coker has 3 furnaces. Each furnace 6 passes. Each pass 30 radiant tubes
- Heater tube material: P9

Decoking Problem and Financial Impact

1

FREQUENT DECOKING IS REQUIRED

due to coke layer build up leading to:

2

PIGGING & ONLINE SPALLING

every 3 months and every 30-45 days in 2 passes/furnace, respectively

3

FURNACE IS OUT OF SERVICE FOR 3-4 DAYS

during pigging operations

Unit at 70% capacity. During Online Spalling, unit capacity at 93% for one day/pass.

- Pigging Service Economic Impact **3.6 MM USD/furnace**
- Spalling Service Economic Impact (2 passes of 1 furnace), **125 KUSD/furnace**

Tubacoat Technology : 2-3X cycle length; US $7M/year savings

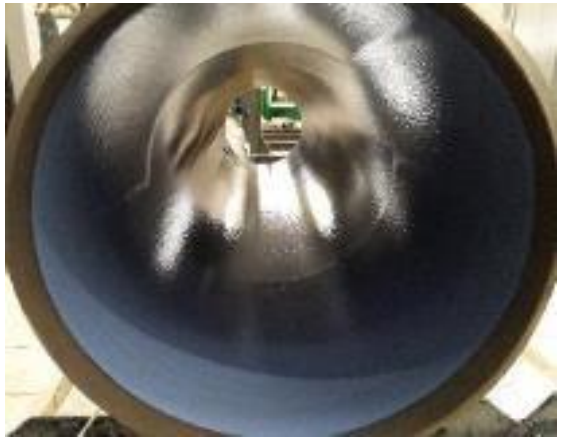
Delayed Coker

TUBACOAT Solution

DCU Fired Heater coated tubes in operation since Sept 2020

Initial Performance feedback (15 months):

- Coated tubes cleaned **easier and faster** – Coke not adhered to tube
- **Effective Spalling**: After OLS, coated tubes wall temperature **Reduced to SOR temperature.** Non-coated tubes 15-20°C higher after OLS.
- **Fuel gas Savings: 2% savings on fuel gas usage.**
- **Increased run length : 2X run length** if applied in full radiant section.



USA Refinery 3: Pine Bend Refinery

Current Configuration

- **Location**: Minneapolis, MN USA
- **Capacity**: 375 bbpd
- **Grade**: Alloy 800 Material
- 2 Radiant Section Pases
- (+400 tubes, +180 Rbends, 40 Fittings)
- **Size**: 3 ½ NPS Sch 80

Problem

- Severe Fouling/Coking, OLS every other month, Pigging 2 times per year. **Profit loss US $6 million/year.**
- **Re-tubing**: Every 3 years

Tubacoat Solution

DCU Furnace – Tubacoat Full Solution for Alloy 800 Fired Heater Tubes

- **Scope:** Tubacoat ID Coating on tubes, bends and fittings
- **Delivery** 4Q'22
- **Installation**: 2Q'23

Expected return : Less than one year

ID Coated DCU Fired Heater Tubes Radiant Coil

ROI < ONE YEAR

USA Refinery 1

DETROIT REFINERY
147 kbpd
DCU 28 kbpd

Information:

3 Fired Heaters: 2 Passes / 24 Lines

OLS every 25-35 Days / 12-14 full OLS per Year

Mechanical pigging every 2 years (5 days duration)

- Grade: A213 **T9 Low Cr.**

Delivered: Sept'22

USA Refinery 2

TOLEDO REFINERY
155 kbpd
DCU 32 kbpd

Information:

3 Fired Heaters: 2 Passes / 28 Lines

OLS every 30-45 Days

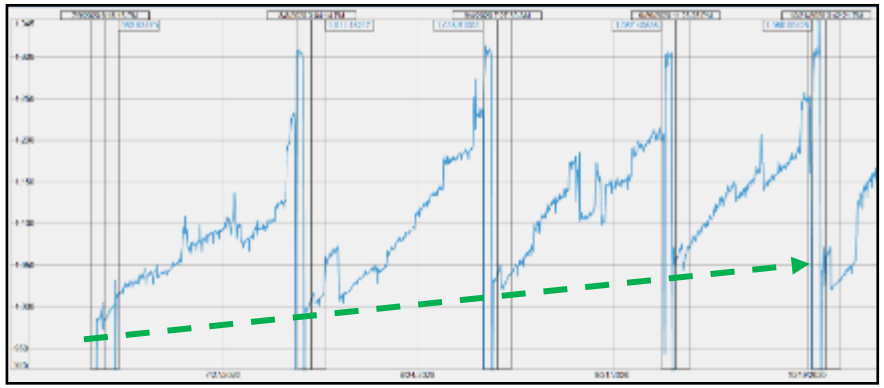
Mechanical pigging every year (5 days duration)

- Grade: A213 **347H SS**

Delivery: Sept'2

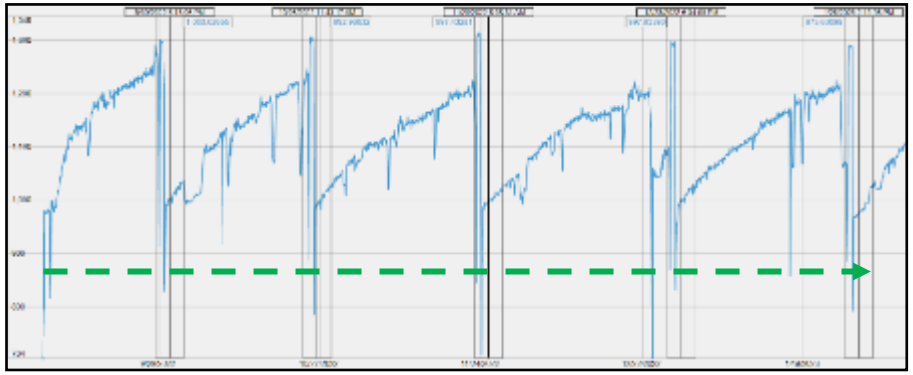
Tubacoat Benefits (Bare vs Tubacoat)

OLS Performance – Bare Tubes



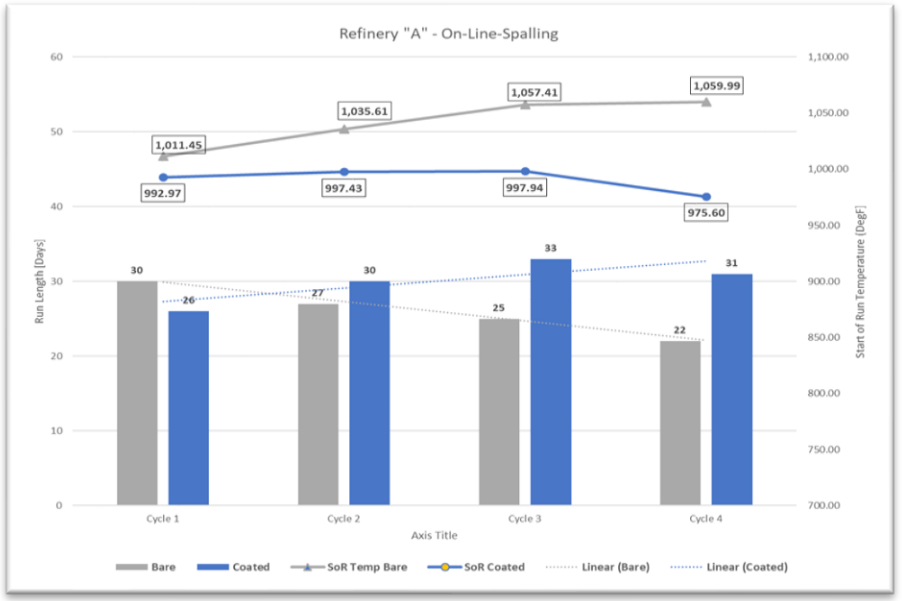
- Run Length (RL) reduction 2-3 days per cycle
- Temperature increase at Start of Run (SoR)

OLS Performance – Coated Tubes



- After OLS, temperatures going back to SoR Temperature (as clean condition)
- RL Cycle improvement, operating longer period of time

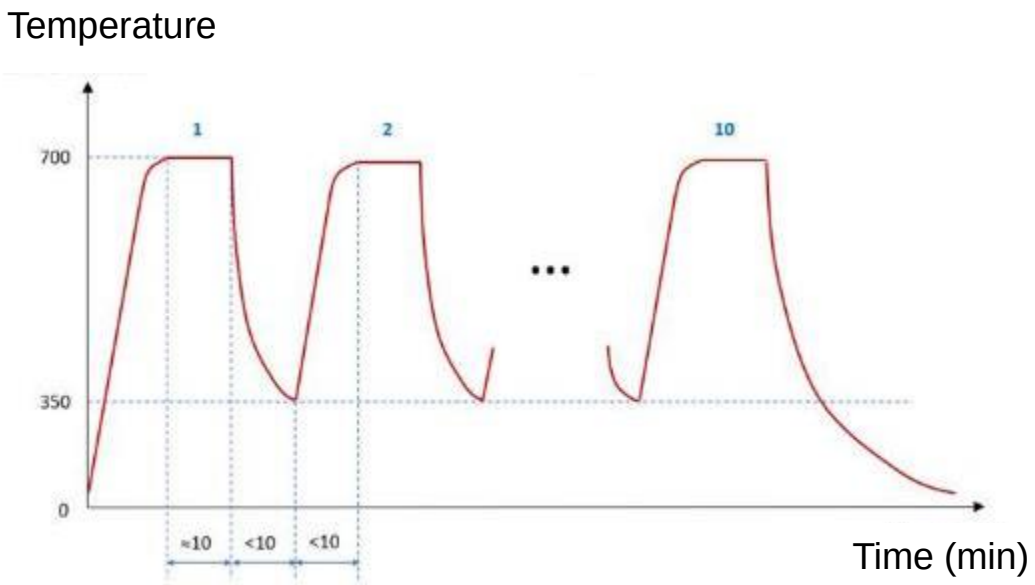
Analysis



TUBACOAT Technology provides:

- Sustained temperatures each cycle
- Increased Run Length (RL)
- Reduction in fuel consumption
- Reduction in CO2 Emissions

Thermal shock resistance



- **Excellent coating performance** after spalling operations – no damage
- Coating has **same expansion coefficient** as base material
- **Spalling more effective** with coated tubes

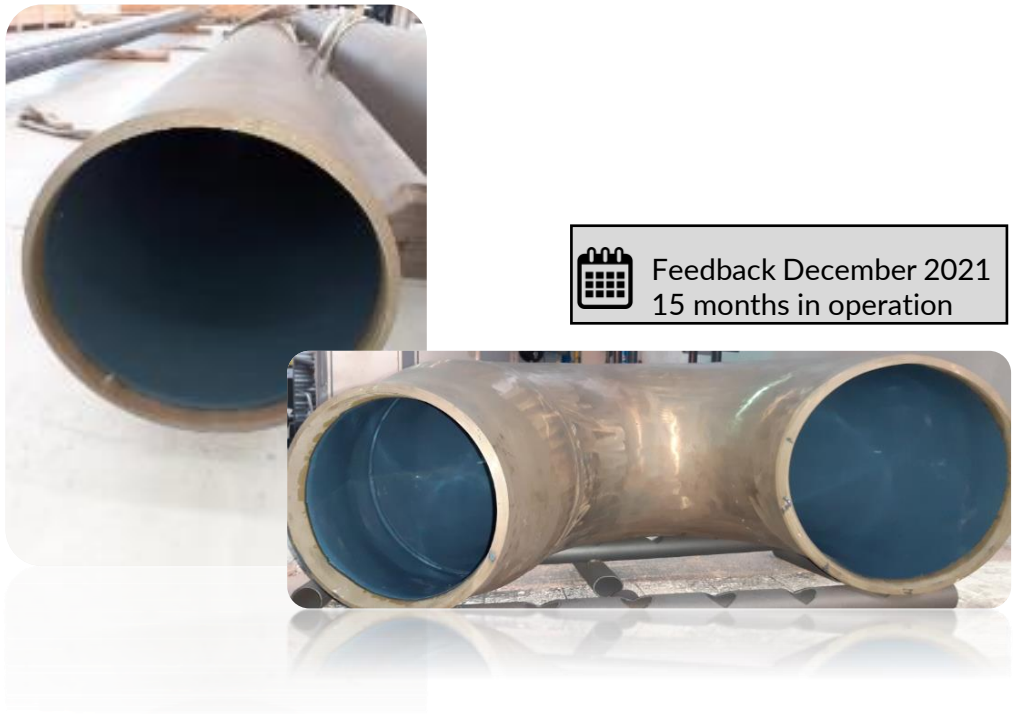
Online spalling/SAD:

Coating designed to withstand online spalling (high temperature and thermal shock) and steam air decoking.

Mechanical pigging:

Mechanical pigging can be done using decoking pigs with stainless steel studs

VDU (America)



Feedback December 2021
15 months in operation

"The ceramic coating can protect the tube ID surface from deposition and, more specifically, prevent coke formation.
The ID examined surfaces do not appear to have appreciable amounts of coke"

PROBLEM DESCRIPTION

- Furnace bottom lines with severe coke fouling causing frequent **decoking operations by mechanical pigging**
- **Outlet line replacement (8",10" and 12" OD Tubes)** every year

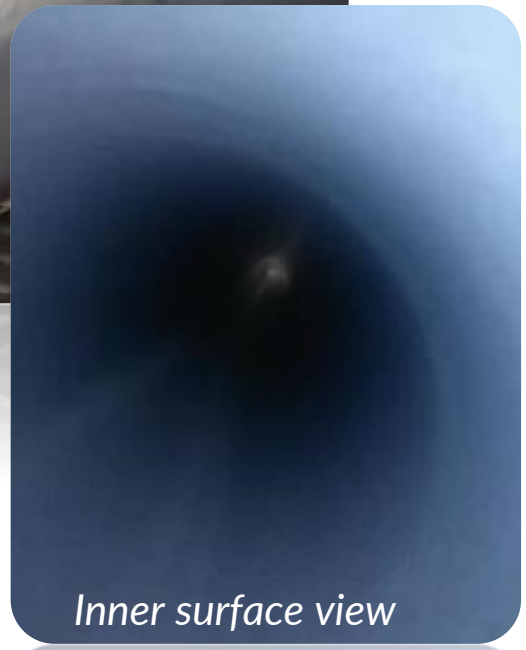
Tubacoat Solution

- Tubacoat inner coated **tubes, bends and reducers** installed at furnace radiant section in October 2020
- Base material: 317L SS @ Dimensions: 8" and 10"

ROI : ONE YEAR

2) VDU unit (Europe)

Tubes installed in VDU furnace



Inner surface view

Tubacoat Solution

- Tubacoat inner coated tubes
- Base material: 317 SS @
  Dimensions: OD 5”, Sch. 40

Conclusion

- Running for **more than 3 years without need for decoking or cleaning.**

Resid HydroCraker Risers - Canada

LC Fining - ebullated-catalyst-bed reactor

PROBLEM DESCRIPTION

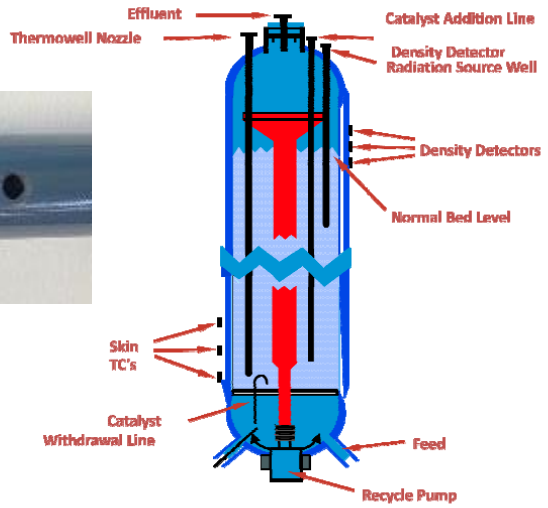
- **Severe Fouling** with Metallic (Ni, V, Mo, Fe, Al) and Non-Metallic (S and hydrocarbons) deposits
- Performance Unit Conversion Reduction
- Higher Opex

TUBACOAT SOLUTION

- **TUBACOAT** produced OD Coated 840 Risers (2 Reactors) with HT Anti-fouling formula
- TA Spring 2023

EXPECTED RESULTS

- Based on fouling test performed by operator, **TUBACOAT** is expected to reduce 85% Fouling on risers.
- At least 2% yield conversion increase expected



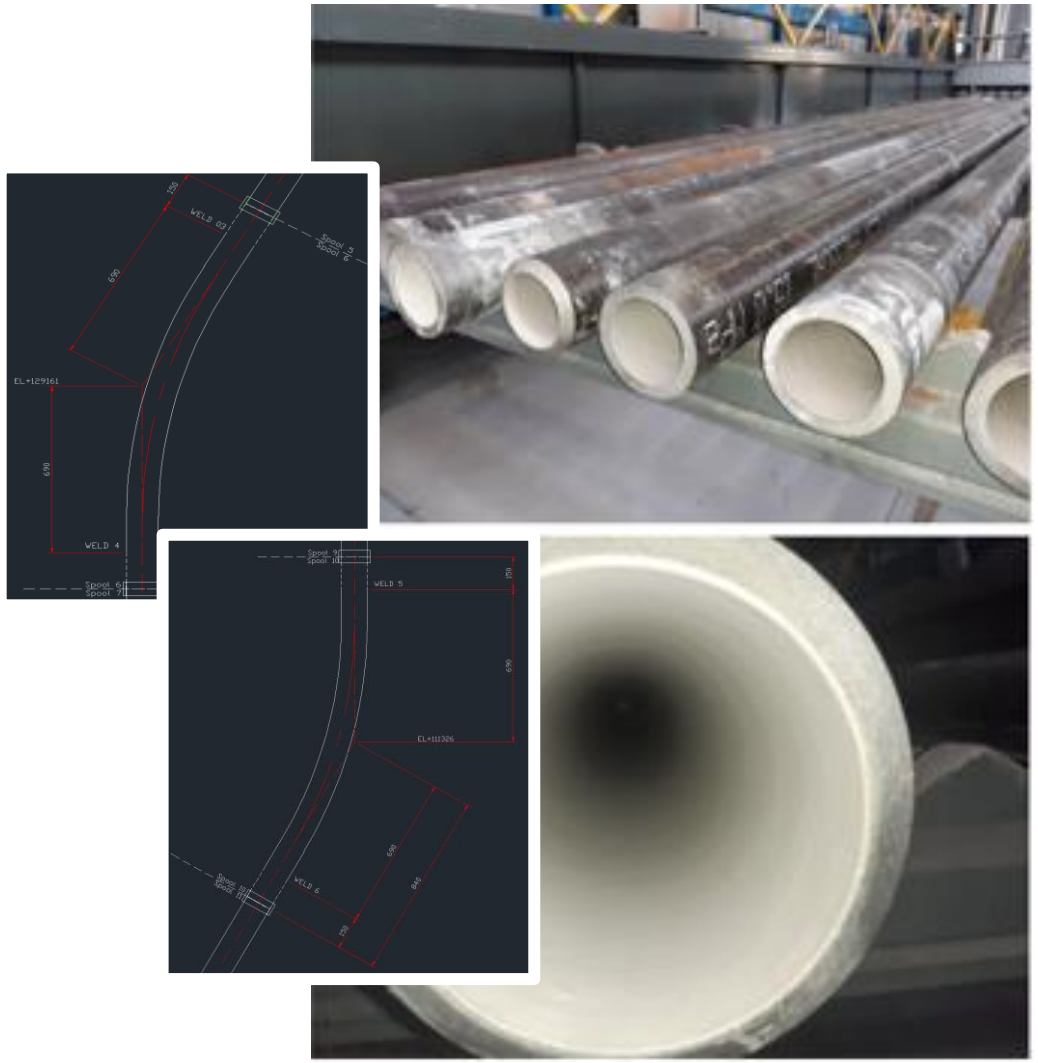
Continuous catalytic reformer (CCR)

Problem description

- Severe erosion of catalyst transfer lines
- Tube base material: P11

TUBACOAT SOLUTION

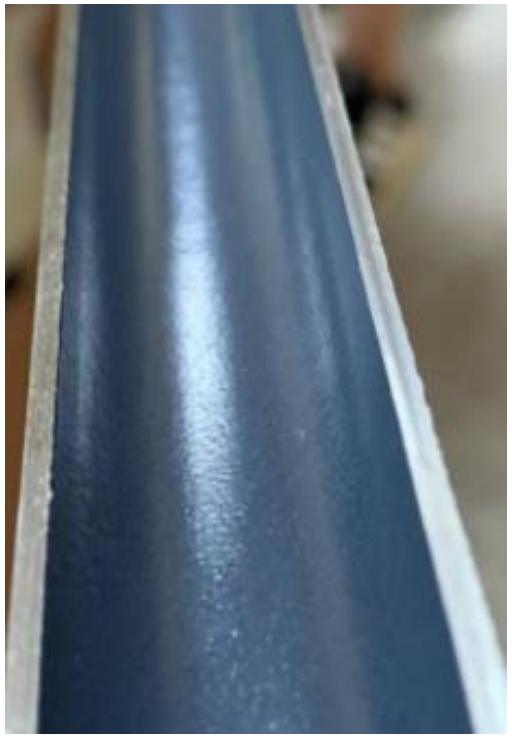
- Tubacoat anti-abrasion coating for tubes and bends – **Order under production**
- **Complete service** including welding, bending and beveling

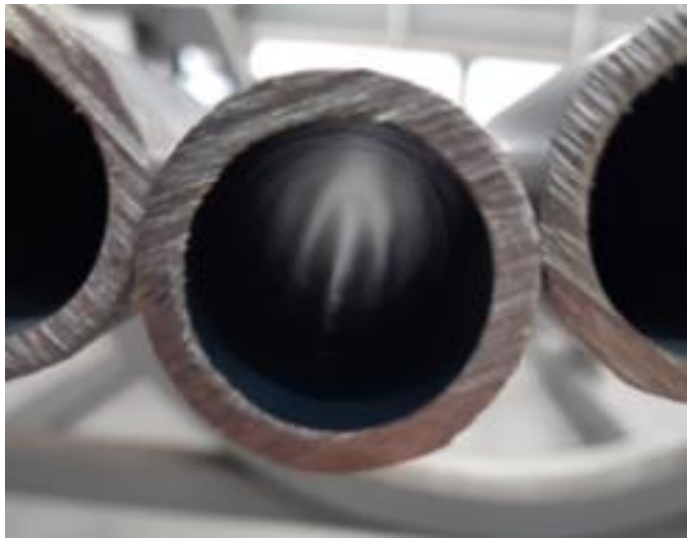


Fouling in heat exchangers

TUBACOAT SOLUTION

TUBACOAT anti-fouling inner coating

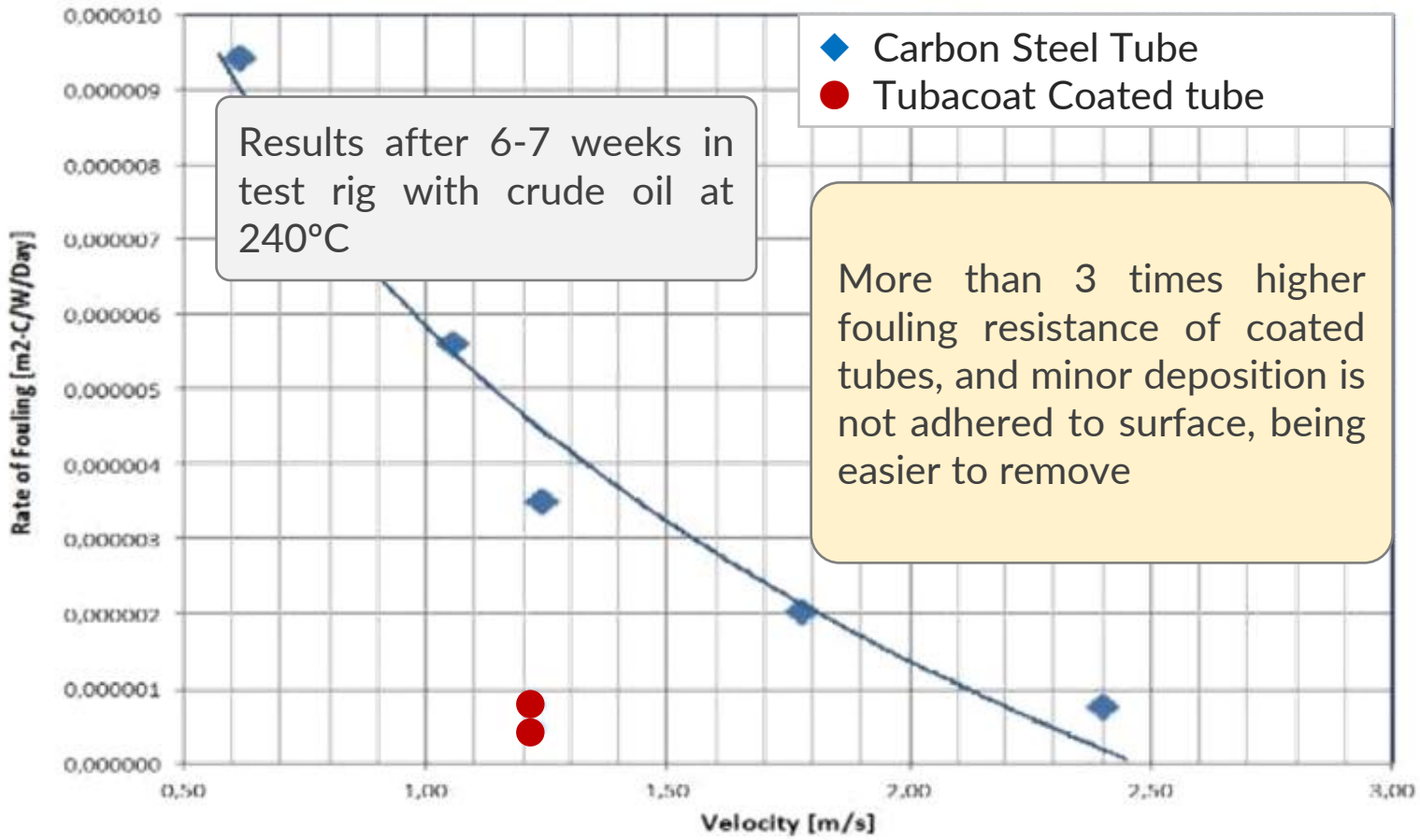




Minimum diameter for internal coating: **3/4 inch**

Anti-fouling

Fouling tests performed by major Oil&Gas company



CDU heat exchanger - Europe

Process information

- **Fluids**: Crude/HGO
- **Temperature.:** 240-270 C
- **Pressure:** 30 bar.
- **Material:** Carbon steel
- **Dimensions**: 25.4 x 2.77 mm, 6 m long

Problem description

Fouling

- Reduced coil inlet temperature
- **High pressure drop** due to internal fouling
- Frequent **cleaning** required **every 7 months**

Order received for **full internal coated bundle (≈400 tubes)**

Delivery scheduled in January 2022

End user is looking to extend its cleaning frequency from 7 months to more than 14 months.

ROI expected in less than 1 year

Potential Issues in Processing Biomass in Refineries

- **Corrosion:** Biomass contains corrosive components that can degrade equipment and pipelines.
- **Fouling/plugging:** Biomass processing can lead to the formation of deposits on heat transfer surfaces, reducing efficiency.
- **Chemical Attack:** Biomass processing may involve aggressive chemicals that can attack and degrade equipment.

Role of Tubacoat

- **Corrosion Resistance:** Tubacoat can protect equipment surfaces from corrosive elements in biomass.
- **Anti-Fouling/anti-plugging Properties:** Tubacoat can prevent the buildup of deposits on heat transfer surfaces.
- **Chemical Resistance:** Ceramic coatings can withstand exposure to aggressive chemicals used in biomass processing.

Pyrolysis Process Issues

Tar Formation and Condensation:

During pyrolysis, volatile organic compounds are released from the biomass, forming tar, a sticky and viscous substance. Tar can condense on the walls of the pyrolysis reactor, pipes, and other equipment surfaces, leading to **fouling and clogging**. Tar condensation reduces the efficiency of the process, decreases the throughput, and can eventually lead to unplanned shutdowns for cleaning and maintenance.

Biochar Agglomeration:

Biochar is the solid residue left after the pyrolysis process. If the process conditions are not optimized or the biomass contains impurities, biochar particles may agglomerate and form large clumps. These clumps obstruct biomass flow through the pyrolysis reactor and downstream equipment, resulting in **plugging and reduced process performance**.

Ash Deposition:

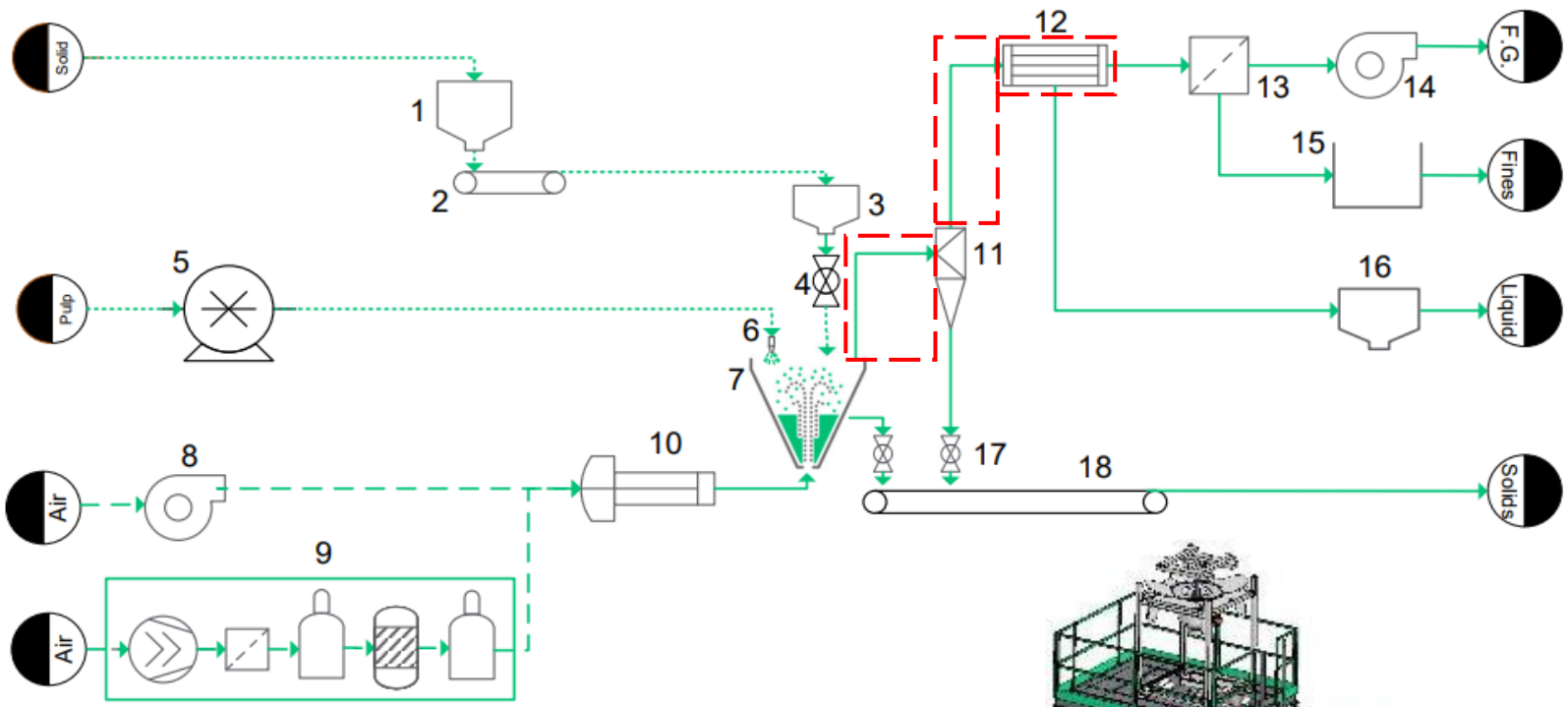
Biomass feedstocks typically contain mineral impurities, which result in ash formation during pyrolysis. The ash can be abrasive and lead to erosion of the reactor and equipment surfaces. Moreover, the molten ash can adhere to the reactor walls, heat exchangers, and other components, causing **fouling issues.**

Incomplete Biomass Decomposition:

Only complete decomposition of biomass can occur if the pyrolysis conditions are well-controlled or the biomass feedstock is adequately prepared. This can lead to char formation and agglomerate and **foul** the pyrolysis reactor and downstream equipment.

- **Tubacoat Technology minimizes these plugging/fouling issues for the efficient and continuous operation of the biomass pyrolysis process, ensuring optimal biochar and bio-oil production while mitigating equipment damage and downtime.**

SBS Pilot Plant Diagram



1- Primary feed Hopper
2- Feeder
3- Secundary feed Hooper
4- Feed VAlve
5- Slurry pump
6- Atomizer
7- 2 HECO reactors
8- Air Blower
9- Nitrogen Generator

10- Electric Heater
11- Cyclone
12- Condenser
13- Bag Filter
14- Fan
15- Fine solid tank
16- Liquid Tank
17- Discharge Valves
18- Solid product Conveyor

The pipelines framed with red lines were coated with Tubacoat.

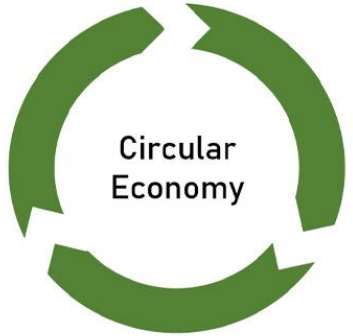
Plastic pyrolysis heat exchanger - Europe

Process information

- **Fluids**: Pyrolysis oil / water
- **Temperature.:** 600-400 °C
- **Material:** 316L
- **Dimensions**: 60.3 x 2.77 mm

Problem description

- **Severe fouling** when heavy fraction condensates
- **Very short plant availability**



Order received for **full internal coated bundle**

Delivered in **March 2022**

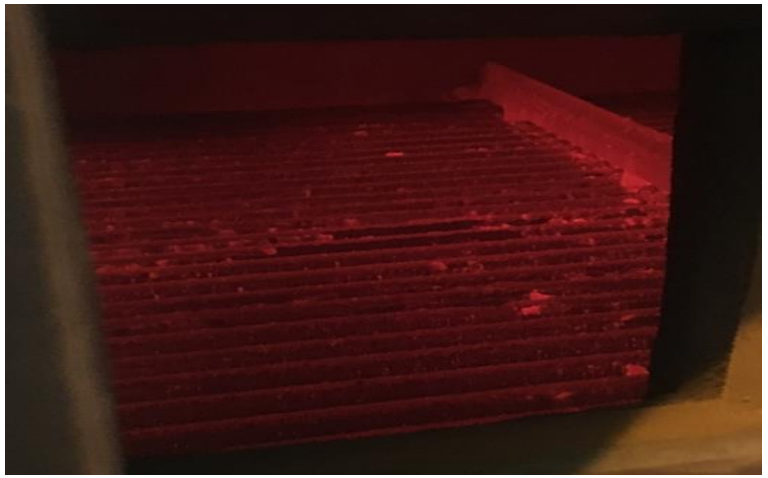
Positive Results Awaiting Detailed Performance data

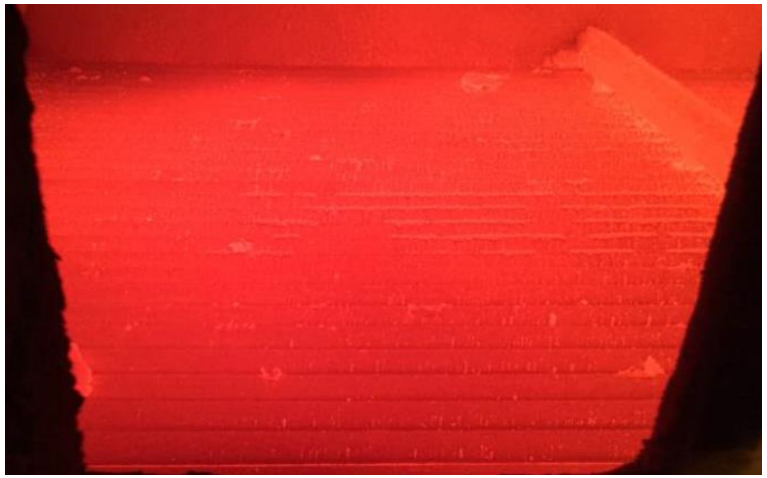
Coke calciner

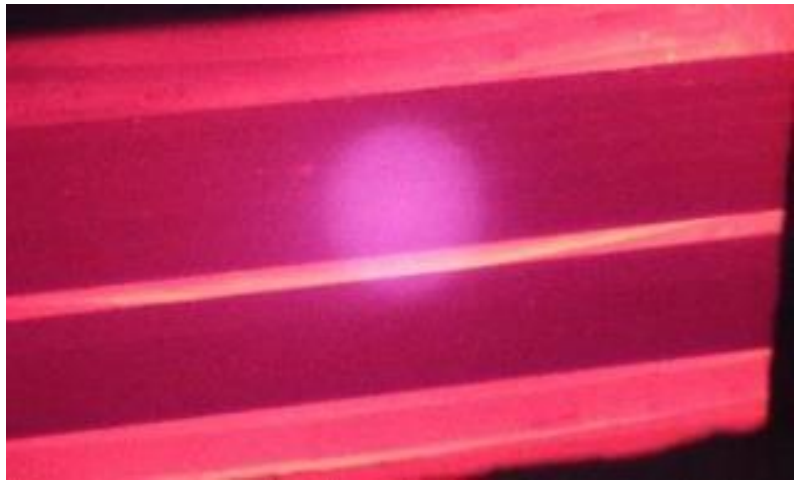
TUBACOAT solution

This refinery received 3 times cycle length, savings of US $2 million/yr.

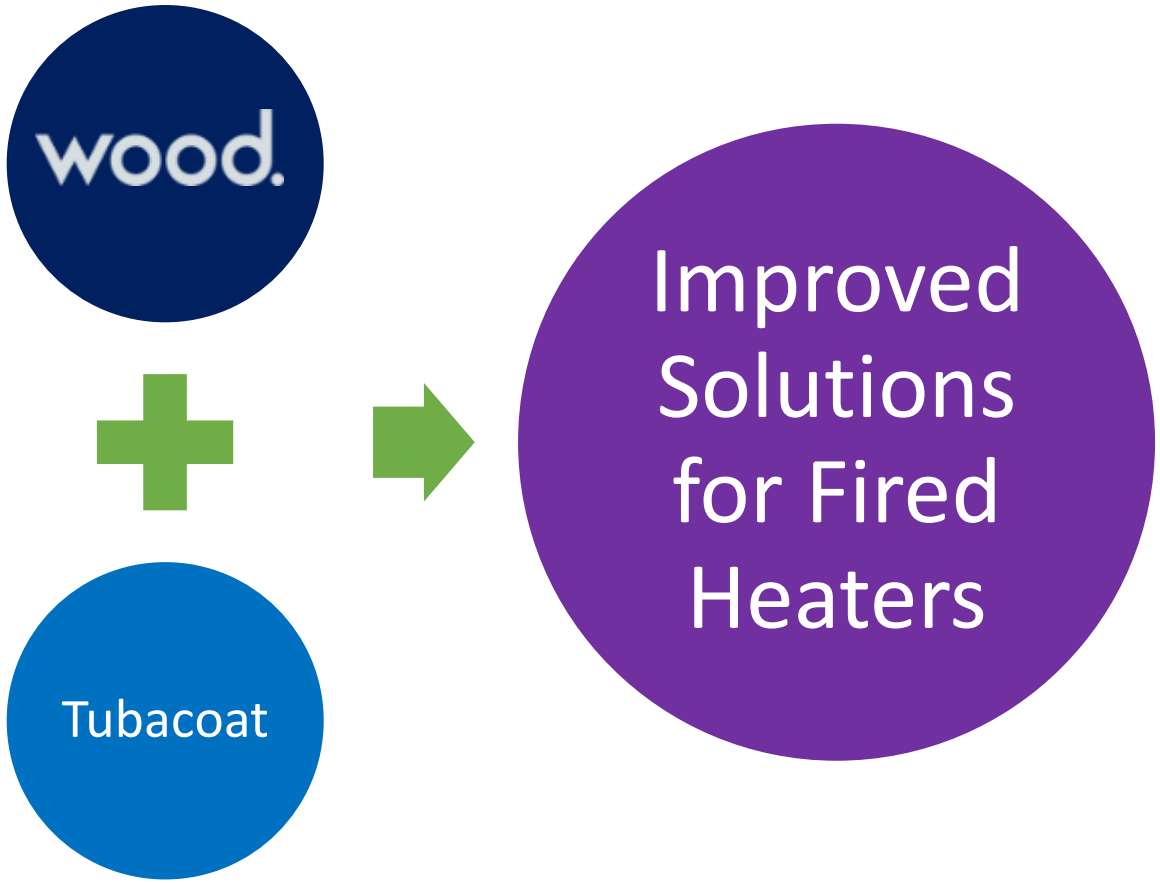
Real pictures of coated tubes in coke calciner recuperator after 15 **months** running in full operation







Wood & Tubacoat Technology



- In 2021, Tubacoat and Wood signed a Strategic Agreement to apply **Tubacoat Technology in Fired Heaters to minimize coking and extend heater run length.**
- The Scope covers new and existing units for DCU and Visbreaker Units.

References

RELIABLE

Refinery & Petrochemical

References – Licensors and Fabricators

RELIABLE

Refinery & Petrochemical

wood.

Axens
Powering integrated solutions

BECHTEL

CLG
Chevron Lummus Global

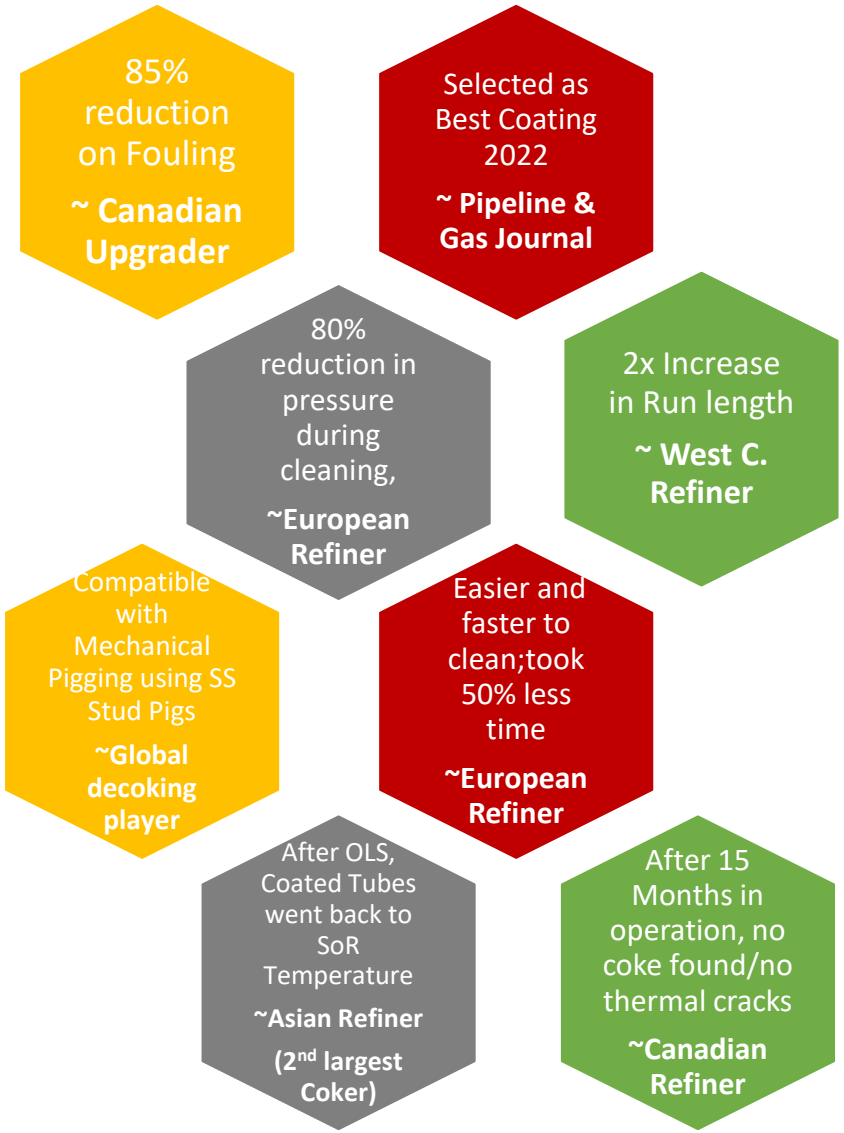
Heurtey Petrochem
SOLUTIONS

PSC
Primoris
OnQuest

THI TULSA HEATERS INC.

GREAT SOUTHERN TECHNOLOGIES

Commercially Proven Technology



FOULING/COKING

EROSION

CORROSION

Applying inner coating in DCU/ VU/VDU/RHC tubes is:

1

PROFITABLE

- **Longer run lengths** improving overall throughput
- **Easier** and much **less frequent cleaning operations**

2

SAFE

- Increased safety by **reducing the number of shutdowns and start-up operations** and avoidance of hotspots

3

CLEAN

- **Reduced fuel consumption** due to increased **heat transfer efficiency and CO2 reduction**

4

RELIABLE

- **Major Oil & Gas players using it successfully**
- Coating layer **brings additional protection** to existing base material.

Tubacoat is the answer to improved operations and reliability

THANK YOU!

TUBACOAT

TUBACEX GROUP

TUBACOAT PLANT IN CANTABRIA, SPAIN

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