Delayed coking availability improving by means of ceramic coatings

José Francisco Fernández Bereciartua
TUBACOAT Technical & Development Director
jffernandezb@tubacex.com
Worldwide leading supplier of Seamless Stainless Steel Tubes

**KEY FACTS**

- Worldwide leading supplier of Seamless Stainless Steel Products with the widest portfolio in the market
- 12 mills, commercial presence and own stocks and service centers worldwide.
- Fully integrated manufacturing process.
- More than 300 customers in over 100 countries.
- 2300 professionals.
TUBACOAT

MORPHOLOGICAL

- Continuous coating layer
  Thickness control based on suspension parameters & rheological properties
- Roughness, decrease ≈ 97% minimizing particle adhesion
- Good chemical bonding between metal substrate and ceramic coating

MECHANICAL

- Hardness & Elasticity
  Coating is harder than substrate but less elastic
- Abrasion resistance
  ≈ 94% decrease in mass loss
- Good adherence. Impact test: No coating detachments at medium loads

CHEMICAL

- High corrosion resistance compared to base material

THERMAL

- Thermal resistance
  Good performance under thermal cycling
  No delamination – No cracks
- Thermal conductivity
  Thermal conductivity range = 5-8 W/mK = f(T) Average (reference) 6 W/mK

- High corrosion resistance compared to base material
Morphological

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

Roughness, decrease ≈ 97%
minimizing particle adhesion

Good chemical bonding
between metal substrate and ceramic coating

Interface EDX results

Rz ≈ 7.8 µm

Rz ≈ 0.2 µm
Product characterization

Mechanical

<table>
<thead>
<tr>
<th>Base Material</th>
<th>Ceramic coating</th>
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<tbody>
<tr>
<td>Hardness (HV)</td>
<td>220</td>
</tr>
<tr>
<td>Ceramic coating</td>
<td>840</td>
</tr>
<tr>
<td>Elastic Modulus EIT (GPa)</td>
<td>140</td>
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</tbody>
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Elongation ≈ 1.2-1.5%

1. **Hardness & Elasticity**
   Coating is harder than substrate but less elastic

2. **Taber test Abrasion resistance** ≈ 94%
   Decrease in mass loss

3. **Good performance.** Impact test: No coating detachments at medium loads
High corrosion resistance compared to base material

- **Pitting Corrosion Resistance** Solution: 5% NaCl, 25 ºC and electrode potential to 1 mA/cm²
- **Pitting Corrosion Resistance** Method A-Ferric Chloride
- **Seawater corrosion test Solution**: 3,5% NaCl at 22ºC
- **Acid corrosion test Solution**: 10% HCl at 22ºC
- **Molten salt corrosion test** NaNO₃ + KNO₃ (60/40)
Field applications & Experience CASE 1

Steam reheater & Thermocouple sheath

- **Working conditions**
  - Steam temperature: 300 °C
  - Pressure: 170 bar
  - Furnes temperature: 850 °C
  - Inner fluid media: Steam
  - Outer fluid media: W to E fumes
  - Other: Alkaline ashes

- **Applications**
  - Steam reheater
  - Thermocouple sheath

- **Chemical corrosion**
- **Efficiency loss**
- **High OPEX**
Field applications & Experience CASE 1

Steam reheater

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TP310H outer coated tubes vs 16Mo3 + Inconel overlay

Results

- Low ash adherence
- Glossy surface after 2 years in operation
- Negligible loss of mass

Conclusions

- Longer tube life expectation
- Improved thermal efficiency
- Possibility to increase thermal cycle temperature
Field applications & Experience CASE 2

Air preheater Coke calciner

● Application
  • Coke Calciner Recuperator

● Working Conditions
  • Oil fumes rich in vanadates at 850°C
  • Metal surface 570°C
  • Low pressure (welded tube)

Current solution TP310 (bare)

Source: Technip Germany. Coke Calcining Plants June 2008

Chemical corrosion  Efficiency loss
Field applications & Experience CASE 2

Coke calciner

10 months working

What is left on bare tubes

Tubacoat tubes

8 months working

The performance is being as expected
Field applications & Experience CASE 3

TUBACOAT Anti corrosion/erosion proposal

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Refinery sector OUTER COATING

5000 mm, OD 30, WT 2,5

Overhead Condenser Crude distillation (corrosion/erosion)
Why does the coke stick to the tube in the furnaces?
What are the consequences?
Have you ever thought about increasing the availability?
How much availability is lost in a coker annually?

DCU on-line spalling and offline pigging

Days offline for pigging
Did anyone observe a skin overheating
Did anybody detect, in the shutdowns, warped tubes
Could you imagine a furnace made up of tubes with inner ceramic coated?

Opportunity for new designs
1. The residues fed to the DCU are cracked at 900 F (500 ºC) or more.
2. The goal is to heat the residue in the DCU furnaces and to crack the residue in the coke drums and not in the furnace.
3. Steam, velocity, tube metallurgy, advanced furnace designs are used to minimize carbon lay in furnace tubes.
4. However, carbon (coke) lay down does still occur in furnaces, so periodic decoking is necessary to recover DCU furnace capacity and efficiency.

Will the ceramic avoid the adherence of coke particles?
Field applications & Experience CASE 4

TUBACOAT Anti coke value proposal

- Coker (clogging)
- Visbreaker (clogging)
- Crude distillation (clogging)
- IGCC downstream lines (clogging)

TUBACOAT SOLUTION

Vacuum Destillation Unit
Refinery sector

317 Grade
5500 mm, OD 141, WT 6,5

Inner COATING
We are entering a stage of advanced design of furnaces with great efficiency and, above all, with great availability.
THANK YOU!