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WELDED PLATE-BLOCK HEAT EXCHANGERS IN AMINE SYSTEMS AND SWS
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**REFCOMM Conference**  
Budapest 2017  
October 2017
HEAT EXCHANGER POSITIONS IN AMINE SYSTEM

- ABSORBER
- SOUR GAS
- LEAN COOLER
- FLASH GAS
- LEAN | RICH INTERCHANGER
- REBOILER
- STRIPPER
- CONDENSER
- ACID GAS
- SWEET NATURAL GAS
- SOUR GAS
TECHNOLOGY CHOICE IN MANY AMINE SYSTEMS

- **SHELL & TUBE (S&THE) for:**
  - Regenerator Reboiler (Kettle or Themosyphon)
  - Overhead condenser (when water cooled)
    - Or Aircooler

- **PLATE & FRAME HEAT EXCHANGER (P&FHE) for:**
  - Lean Rich Amine Exchanger
  - Lean Amine Cooler (when water cooled)
    - Or Aircooler

- **P&FHE International standard API 667**
  (under development) replacing API 662 part 2

- Experience with P&FHE?
WHAT CAN GO WRONG WITH P&FHE IN AMINE SYSTEMS?

- Purchase of wrong incompatible gaskets
- Wrong glueing:
  - Cold glueing was done although hot oven curing was required
- Many sites have experienced leakage issues with P&FHE

Paint is peeling off the pipe
WELDED PLATE-BLOCK HEAT EXCHANGER: A ROBUST ALTERNATIVE

- Up to 350°C design temperature
- Up to 42 barg design pressure
- Up to 860 m² HTA
- Totally accessible for inspections and maintenance
- Compliant to the main international PV Codes and Standards
- API 810 under development
K°BLOC - BAFFLE

- Countercurrent flow approach by many cross passes
- Temperature approach down to 5 °C
# K*BLOC – STD PLATES MATERIAL

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<th>TRADE NAME</th>
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<td>1.4404</td>
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<td>Titan Gr.1</td>
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REFINERY IN USA

- Refinery in USA
- 3 units BT50-250
- with AISI304L plates
- Lean-rich Amine Exchanger
- Design P: 13.8 barg (200 PSIG)
- Design T: 177°C (350°F)
HYDROBLASTING K°BLOC
ULTRASONIC BATH CLEANING

- Tank filled with cleaning/degreasing solution (typically aqueous based)
- Transducers create ‘ultrasonic waves’ in the liquid medium (20 – 50 KHz)
- Cavitation ‘bubbles’
- Cleaning occurs due to two separate actions:
  - Dissolution of the contaminant in the solution through the continuous removal of any saturated solvent layer
  - Displacement and removal of loosely held contaminants
- Equipment is removed and rinsed to remove any loose residue and cleaning agent
EXAMPLE: INSTALLATION OF 3 x 50% (2 ONLINE, 1 SPARE)

- Because of fouling performance decreases.
- Operation decides to put 3rd unit online. What happens?

UA FACTOR
- OHTC goes down, Reynolds decreases with factor 2/3 and film coefficient decreases roughly with factor (2/3)^0.7 = 0.75
- Area increases factor 3/2.
- U*A is increased with 3/2 * 0.75 = 1.125, or an improvement of 12.5%

SHEAR STRESS
Assuming turbulent flow, the pressure drop goes down with a factor (2/3)^2 = 0.44 and therefore also your shear stress goes down with factor 0.44

RESULT: increased fouling rate ► soon performance will be even worse
WBPHE AS AMINE REBOILER

- Block placed horizontally
- Channels vertical
- Thermosyphon principle
- Minimum turndown ~ 50%

Once-through type reboiler

Recirculating type reboiler
ADVANTAGES WPBHE AMINE REBOILER

- Smaller footprint

- Smaller holdup volume leading to:
  - Lower operating weight than S&THE
  - Lower amine inventory
  - Shorter residence time, hence less amine degradation

- Lower weight than S&THE and therefore easier handling in maintenance activities

- Lower CAPEX than S&THE (~ 50%)
WPBHE REBOILER – SOME GUIDELINES

- WPBHE can work on higher vapor quality than S&THE – up to 15% (w/w) outlet quality is very feasible
- Make sure vendor provides sufficient review data
  - Pressure drop breakdown
  - Amine recirculation rate
  - Area
  - Plate grouping
  - etc.
- Assess all design cases and simulate these in their process-controlled condition
  - What is the steam pressure in min. turndown and clean condition?
  - What are the thermosiphon flow regimes in this condition?
- Combination of steam pressure and steam level control is advised
Business Case for Floating Application

Influence on Topsides Module When Replacing S&THE by a WPBHE Reboiler
(Unfortunately capacity data cannot be shared)

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Details</th>
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<tbody>
<tr>
<td>Weight</td>
<td>~50% reduction in equipment wt. vs S&amp;T. Total module wt. savings of 250 tons</td>
</tr>
<tr>
<td>CAPEX</td>
<td>~50% reduction (FOB). Savings of ~$7M module cost (EDM 2014)</td>
</tr>
<tr>
<td>Installed vol. size</td>
<td>~30% reduction</td>
</tr>
<tr>
<td>O&amp;M</td>
<td>Increased options for equipment lifting e.g.:</td>
</tr>
<tr>
<td></td>
<td>• Lifting options include blue sky access &amp; lifting by means of pedestal crane (current)</td>
</tr>
<tr>
<td></td>
<td>• Move with local beams over the deck towards the ‘maintenance ally’</td>
</tr>
<tr>
<td>Performance</td>
<td>Lower likelihood of fouling due to less residence time and hence solvent degradation and higher velocities.</td>
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</tbody>
</table>
REFINERY IN BULGARIA

- Installed beginning 2015
- BT-75-150H
- Heat transfer area of 126.5 m²
- Plate material 316L.
- Capacity is 7.04 MW
- Overall heat transfer coefficient is 2449 W/m².K
INITIAL PROCESS DESIGN – KEY VALUES

- Typical Heat Transfer Coefficients for WPBHE

<table>
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<tr>
<th>Service</th>
<th>OHTC (W/m2.K)</th>
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<tbody>
<tr>
<td>Lean / Rich Amine Exchanger</td>
<td>2000</td>
</tr>
<tr>
<td>Lean Amine Cooler</td>
<td>1200</td>
</tr>
<tr>
<td>Condenser</td>
<td>1500</td>
</tr>
<tr>
<td>Reboiler</td>
<td>2000</td>
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</tbody>
</table>

- CAPEX of WPBHE approx. factor 3-4 of P&FHE
- Maximum heat transfer area WPBHE 860 m² per unit
- L/R Exchanger dP 3 bar for reaching 75 Pa shear stress
- Min temp. approach 10 °C
- Reboiler – define max. skin temperature solvent degradation
TOPICS FOR INTERNATIONAL STANDARDS

- Maximum temperature difference process steams (100 °C)
- Temperature changes max. 60 °C per hour
- Maximum velocity head
- Fouling margin guidelines
- Shear stress guidelines
- Welding requirements
- Nozzle load requirements
- Testing and inspection requirements
TO SUMMARIZE...

- Operating sites have experienced leakages with Plate & Frame Heat Exchangers
- Welded Plate-Block Heat Exchangers (WPBHE) are a more robust, gasket-free alternative
- Number of references is growing
- Best practices for cleaning WPBHE exists
- International standards are being developed (API 810)
- There is a business case for WPBHE as Amine Reboiler
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