Maximize performance of your FCC unit, using unconventional solutions

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Alfa Laval
CONTENT

- Maximize performance of your FCC unit, using unconventional solutions.

✦ Uptime & Availability
  - In your most fouling services – choose the right solution!

✦ Energy Efficiency
  - If it can be recovered, why waste it?

✦ Yield Improvements
  - When the rays of the sun make your assets sweat

✦ CAPEX Reduction
  - The best solution does not have to cost more….

✦ Reliability
  - In your most critical services, don’t take any risks!
UPTIME & AVAILABILITY

- In your most high-fouling services, choose the right solution!

- Slurry exchangers
  - Feed preheaters
  - Steam generators
  - Run Down Coolers

- Heavy fouling
  - Bottleneck
  - Frequent cleaning & repair
  - Downtime
  - Stand-by equipment
  - HSE issues
UPTIME & AVAILABILITY

- Spiral Heat Exchangers (SHEs)

- High Heat Transfer Efficiency
  - 2-3 times higher than S&Ts -> 2-3 times less HTA
  - Fully Counter-current flow with temperature approach of 5°C
    -> Single exchanger solution

- Self-Cleaning Design
  - Short hold-up time
  - No dead zones & uniform velocity
  - Single channel design
UPTIME & AVAILABILITY

- Slurry run-down cooler, Total Mider, Leuna, Germany (UOP license)

Duty:
- FCC Bottoms, 10-15 tph → 75 °C
- Warm water loop ← 45 °C

Heat load: 0.9 MW

Original installation:
Two double-pipe exchangers, cleaned 40 times during first year

Replaced by:
Two spiral heat exchangers, one in operation and one in stand-by,

Start-up: Beginning 1999.
2001 & 2002 – catalyst carry-over into MF. Spirals cleaned by flushing AGO.
2004 – internal inspection by TUV. No remarks.
No mechanical cleaning required.

Installed Cost = 360 kEUR
Annual savings in maintenance = 180 kEUR
UPTIME & AVAILABILITY

- Optimized performance control with closed loop cooling system module

- Optimize temperature of closed loop cooling media
  - Minimize size/cost of Spiral exchanger

- Keep constant temperature of closed loop cooling media
  - Avoid "over cooling" of Slurry oil
  - Avoid capacity issues
  - Avoid corrosion issues due to CW control (see below)

Corrosion risk when controlling duty on CW flow

180°C
>100°C
40°C

75°C
20°C

Slurry In/Out

CW Supply/Return

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## UPTIME & AVAILABILITY

- References – MF Bottom Slurry Coolers

<table>
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<tr>
<th>Country</th>
<th>Licensor</th>
<th>Equipment</th>
<th>Year</th>
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<td>UOP</td>
<td>1 SHE</td>
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<td>1 SHE</td>
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UPTIME & AVAILABILITY

- Slurry / Feed heat recovery, European Refinery, (KBR license)

Duty:

- FCC Slurry, 285 tph: 337 → 215 °C
- FCC Feed (UCO+VGO), 200 tph: 288 ← 135 °C

Total recovered heat: 23 MW

Original installation:
Two S&Ts, plugging on slurry side of solids from reactor, cleaning needed every 3-4 months, causing capacity bottleneck.

Replaced by:
Two spiral heat exchangers, 2 * 50%.
Plant capacity increase of 10%:
- Increased feed preheating with 20°C
- Increased cooling of main fractionator bottoms
- Increased cooling of finished products
Eliminate capacity loss during cleaning
Reduced cleaning cost

Start-up: November 2013.
UPTIME & AVAILABILITY

- Slurry / Feed heat recovery, European Refinery, (KBR license)

* Decant side opened once for inspection after 1 year operation
-> No fouling
# UPTIME & AVAILABILITY

## References – MF Bottom Slurry/Feed Interchangers

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![Image of interchangers](image-url)
ENERGY EFFICIENCY

- If it can be recovered, why waste it?

* Low grade energy CAN be efficiently recovered

- OVHD vapour ->
  Boiler Feed or District Heating Water pre-heating

- Hot run-downs & PAs ->
  Superheated steam
ENERGY EFFICIENCY

- Welded Plate Heat Exchangers (WPHEs)
  - Maximal Energy Recovery
    - 3-5 x higher heat transfer efficiency
    - Temperature approach of 3-5 deg C
  - Compact & Light Weight
    - 4000 m² S&T HTA* fits in 3 m² plate space
    - 5-10 x less flooded weight
  - Low Fouling Tendency & Easy to Clean
    - 3 x longer operating period in-between maintenance
    - 1-3 days down-time for cleaning
  - Cost-efficient in Corrosion-free Materials

* Equals 850 m² WPHE area
ENERGY EFFICIENCY

- MF OVHD condensers, Shell Sarnia, Canada (UOP license)

1st Stage – Heat recovery:
Overhead vapour  141 → 87°C
BFW  128 ← 43°C

Total recovered heat: 14 MW

Preheating of BFW required to de-bottleneck boiler to provide energy for a new diesel hydrotreater to produce ULSD. Plant energy footprint not allowed to increase.

2nd Stage – Trim Cooling:
Overhead vapour  87 → 29°C
Cooling water  45 ← 24°C

Original installation:
4 S&Ts in CS, without energy recovery, suffered from corrosion of bisulphides, cyanides and chloride salts.

Replaced by: 8 WPHEs in Hastelloy C276

Start-up: January 2003
ENERGY EFFICIENCY

- Steam generation from hot PAs and RDs

When WPHEs are used as steam generators, they can operate with a much closer temperature approach. This means that

1. Same amount of saturated steam can be generated at higher pressure

2. More saturated steam can be generated at same pressure

3. Same amount of Superheated steam can be generated
ENERGY EFFICIENCY

- SH Steam generation from fractionator MPA, European Refinery

Duty:

- MPA, 330 tph: 221 → 181 °C
- SH Steam, 15 tph: 215 ← 120 °C @ 11 bar (30°C SH)

Total recovered heat: 8.2 MW

Steam generations system comprises:
- BFW preheater
- Steam generator
- Separation vessel
- Steam superheater

Start up: 2002

Pay-back around 6 months, based on a steam cost of 10 USD/ton
## ENERGY EFFICIENCY

- References – Steam Generators from hot PAs and RDs

<table>
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<th>SH</th>
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YIELD IMPROVEMENTS

- When the rays of sun make your assets sweat

* Maximal cooling
  - De-bottleneck of processes/improve yield
  - Reduce size/cost of ejector/compressor system
YIELD IMPROVEMENT
– FCC OVHD vapour cooling, South American refinery

4 WPHEs were installed in a revamping/de-bottlenecking of FCC unit in Petrobras REPLAN

1. 1 WPHE in parallel to existing 8 S&Ts, providing 25% additional cooling capacity (10.5 MW)

12. 1 WPHE in parallel to existing 4 S&T, providing 5.1 MW additional cooling capacity, reducing compressor load

13. 1 WPHE replaced 2 S&Ts, providing 8.3 MW cooling capacity

18. 1 WPHE in parallel to existing S&T, providing additional cooling capacity
YIELD IMPROVEMENT

- FCC OVHD vapour cooling, South American refinery

Pos 1: Main Fractionator condensers, WPHE = 10,5 MW, start-up 2009

<table>
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<tr>
<th>S&amp;T</th>
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Pos 12: Compressor interstage condensers, WPHE = 5,1 MW, start-up 2009

Pos 13: Post compressor condenser, WPHE = 8,3 MW, start-up 2005
YIELD IMPROVEMENT

- FCC OVHD vapour cooling, South American refinery
CAPEX SAVINGS

- A better solution does not have to cost more….

* When Welded PHEs will save a bundle!
  - When 2 or more CS S&Ts are needed for one service
  - Any time high grade MOC is needed
  - When installation is on structure
  - When CAPEX can be saved in fired heaters, boilers and/or coolers due to better heat recovery
  - When CAPEX can be saved in compressor/ejectors due to reduced vapour flow and/or lower pressure drop
RELIABILITY

- Welded PHEs in the refinery market

- A well-proven solution
- Introduced to refineries in early 1990’s
- Gaining market share since beginning of 2000
- Around 2400 WPHEs sold to refineries world-wide

Around 2,400 WPHEs Sold to Refineries
RELIABILITY

- Welded PHEs to Refinery processes

* Used in all refinery processes
* Mainly used for heat recovery services, such as
  - ADU/VDU PHT
  - Amine & SWS F/B
  - Fractionator F/B
  - Fractionator OVHD to feed or BFW
  - Steam generation

Almost 50% delivered for ADU/VDU
RELIABILITY

- Spirals to heavy oil processing

★ Tailor-made for high-fouling services
★ A well-proven solution
★ Introduced to refineries in mid 80’s
★ Over 300 Spirals delivered to refinery processes, out of which more than 170 are for heavy oil processes

# Spirals

- Bitumen/SDA: 45
- Coker: 22
- FCC: 34
- HCK: 62
- VBU: 10

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SUMMARY

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