Delayed Coking at MiRO Refinery

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Agenda

• Introduction: MiRO Refinery and Delayed Coking at MiRO

• Safety
  • Safety Review
  • Automation

• Process technology
  • COP Fractionator Revamp
  • Heater improvements

• Environment
  • Closed System

• Future Improvements / Outlook
Mineralölrefinerie Oberrhein in Karlsruhe

Largest Refinery in Germany and one of the most efficient refineries in Europe
An aerial view of MiRO
MiRO fulfills the fuel and heating oil needs of approx. 10 mil. customers

Main supply areas:

- Baden-Württemberg
- Southern Palatinate
- Southern Hesse
- Saarland
- Western Bavaria
- Northern Switzerland
- Western Austria
MiRO processes crudes from all over the world

Origin of crude oil 2004:
- Eastern Europe / Central Asia: 36.1%
- In the Middle East: 30.8%
- North Africa: 30.8%
- South America: 1.6%
- Central Europe: 0.4%
- North Sea: 0.3%
Simplified Flow Scheme of MiRO Refinery

Crude Oil

3 Atm. Dest.

3 Vac. Dest.

Naphtha

Gas Oil

Vac. Resid.

VGO

FCC-Gas

PrimeG

HDS

FCC-U

ICN (Naphtha)

Slurry Oil (HCGO)

HKS

Coke

Calciner

Oxidizer

HDS

Gas plant

C_{3n}

C_{n,Mix}

ETBE

Alkylation

 own consumption

LPG

Iso

Gasoline Pool

3 Reformer

Reformate

BHC

Benzene

HPF

Gasoline Pool

HDS

MD Pool

Propene

Gasoline Pool

HDS

Gasoline Pool

HDS

Gasoline Pool

Gasoline Pool

Gasoline Pool

Gasoline Pool

Gasoline Pool

Gasoline Pool

n-Butane

Green Coke

Calcinate

Bitumen

Dist.Bitumen (Bunker Oil)
### General MiRO Delayed Coker Data

<table>
<thead>
<tr>
<th>Year</th>
<th>Event/Improvement</th>
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<tr>
<td>1984</td>
<td>Start Up</td>
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<td>1989</td>
<td>18h – Project</td>
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<td></td>
<td>Automatic Control for DC Cycle</td>
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<tr>
<td></td>
<td>Combitool Drilling / Cutting</td>
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<td></td>
<td>Swivel Type Bottom Head</td>
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<td>1994</td>
<td>Preheat Furnace</td>
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<td>1997</td>
<td>COP Technology: HKGO-Draw</td>
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<tr>
<td>2000</td>
<td>COP Technology: New</td>
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<tr>
<td></td>
<td>Fractionator / FZGO-Draw</td>
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<tr>
<td></td>
<td>Hydraulic Operated Crushers</td>
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<td>2003</td>
<td>Parallel Onstream decoking</td>
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<td>2006</td>
<td>Redundant Slurry Pumps</td>
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<td></td>
<td>Dewatering Bin Modifications</td>
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<tr>
<td></td>
<td>Heater Ceramic Coating</td>
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</table>

- Foster Wheeler Design
- Closed Coke Handling System
- Start Up 1984
- 2 drums
- 24 h cycle time / act: 15 h
- Fresh Feed 120 t/h / act: 230 t/h
  - 18 mbpsd / act: 34.5 mbpsd
- Recycle rate 1.3 / act. 1.0
- High sulfur feed → Green coke
- Low sulfur feed → Calcination
Safety

- Successful Safety Review with COP
- Automation
  - Automatic Control of DC Cycle
  - Isolation valves remote controlled
  - Top and Bottom Head remote controlled
Safety Review

1st – Keep hazardous energy contained, specific to the semi-batch coking process, such as interlocks, double blocks.

- **3 items:** double blocks

2nd – Get worker out of line of fire - address high priority remote actuation issues, deluges, provide for high priority protected egress items like cutting deck.

- Control cabins on cutting deck and switch deck: improve as safe places of natural egress
- Protected egress routes required from points of natural egress to ground
- Water deluge system required
- Covering grating with solid checker plate

3rd – Items specific to protecting property.

- Fire proofing of steel structure required
- Fire monitors and fire fighting equipment issues
Safety Review

Proposal: Cutting deck egress route
Safety Review

Realization: Cutting deck egress route
Safety / Automation

Safety: Automatic Control of DC Cycle (1)

• Objectives
  – Assist Operator
  – Help avoid operating errors
  – Implement interlock system
  – Optimize drum decoking

• Operational steps
  – Drum switch - Hydrocarbon purge – Cooling - Coke Cutting - Pressure Test - Preheating
Safety / Automation

Safety: Automatic Control of DC Cycle (2)

• Communication: Operator – Automatic Control
  – Basis: Sequencing screen for operator action steps
    • Actions by automatic control / Actions by operator
  – Screen Messages
    • When valves in erroneous position
    • Missing operator action
  – Operator-Software-switch confirms readiness to proceed with next step

• Full acceptance by operators
Safety / Automation

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All isolation valves remote controlled

- **Main Switch Valve**
  - Wilson Snyder
  - Hydraulically operated
- **Feed Isolation Valves**
  - Wedge plug type
  - Hydraulically operated
- **Overhead Valves**
  - Forged wedge plug type
  - Hydraulically operated

Hydraulic actuator for plug lifting and rotation

Forged body
Z+J Double Disc Valve in blowdown line

- One Z&J isolation valve performs as two conventional block valves (capex savings)

- Installed in spring 2006

- Safe and reliable operation

- No additional maintenance needed

ZIMMERMANN & JANSEN

Patents pending
Safety / Automation

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ZIMMERMANN & JANSEN

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Safety / Automation

Automation: Semi-Automatic Bottom Head

- **Swivel-type bottom head**
- **Benefits:**
  - SAFETY: Bottom head is kept closed at full load by hydraulic system during unbolting of bottom flange
  - Reduced cycle time
Safety / Automation

Automation: Semi Automatic Bottom Head

• Swivel type bottom head

• Benefits:
  – SAFETY: Bottom Head is kept closed at full load by hydraulic system during bolting of bottom flange
  – Reduced cycle time

Improved Safety: Top and Bottom Head Valve
Process technology

• COP fractionator revamp
  - Zero natural recycle
• Heater improvements
  - Heater ceramic coating (Cetek / COP)
ConocoPhillips Process Technology

• COP Technology
  - 1.0 Recycle
    • HKGO draw to HDS / FCC
    • FZGO to VDU
  - Minimum drum pressure
  - Maximize product yields
  - Minimize coke yield
  - Throughput increase by 30%
  - Increase of the Unit On-Stream Factor
    • Replaced Fractionators Packing with Trays
    • Installed Flash Zone Spray System
Heater Improvements

Process Technology: Heater – Cetek Ceramic Coating

Coker Heater Schematic
Heater Improvements

Process Technology: Heater – Cetek Ceramic Coating

Basis: Heater simulation
- Cetek: fire box
- COP: product

High & Low Emissivity Tube Coating
High Emissivity Tube Coating
High Emissivity Refractory Coating
Heater Improvements

Process Technology: Heater – Cetek Ceramic Coating

Before                                After

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Heater Improvements

Process Technology: Heater – Cetek Ceramic Coating

After 2 years of operation
Heater Improvements

F-001: TMTs after ceramic coating was applied (adjusted for furnace duty)

TMT Increase Rate: 0.35°C/day
0.63 °F/day
Environment

- No hydrocarbons to atmosphere
- Closed coke handling system
Environment - Hydrocarbons

• Hydrocarbon recovery system
  • Vent gas compressor to recover all hydrocarbons during drum steam out and drum quench. HCs used as fuel gas.
  • Vent gas compressor used as flare gas recovery compressor if not used in coker service → no flare gas emissions during normal operation.
  • Compressor type: 2 stage liquid ring pump.

<table>
<thead>
<tr>
<th></th>
<th>Steam Out</th>
<th>Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure:</td>
<td>2 bar(g) → 5.5 bar(g)</td>
<td>25 mbar(g) → 5.5 bar(g)</td>
</tr>
<tr>
<td></td>
<td>29 psi(g) → 80 psi(g)</td>
<td>0.36 psi(g) → 80 psi(g)</td>
</tr>
<tr>
<td>Flow rate:</td>
<td>2000 Nm3/h</td>
<td>up to 700 m3/h</td>
</tr>
<tr>
<td></td>
<td>1.7 mmcsfd</td>
<td>up to 0.6 mmscfd</td>
</tr>
</tbody>
</table>

• Open drum to atmosphere at low pressure / low temperature
  • Pressure: Below 0.05 bar(g) / 0.7 psi(g)
  • Temperature: Below 95°C / 203°F
Environment – Coke

Typical coke handling system

- LPG
- Coker - Naphtha
- Light gas oil
- Heavy gas oil
- Flash Zone gas oil
- Vacuum residue
- Cutter stock
- Feed tank
- Pre Heat furnace
- Delayed Coker furnace
- Delayed coker coke drum
- Water tank
- Open Coke Pit
Environment – Coke

Benefits
- No coke dust emissions from open pit or coke storage facilities
- Coke fines in closed system
- Water in closed system

Disadvantages
- Coke dewatering is a challenge
- Limited hold up in coke handling system
- Coke drum cycle time influenced by coke handling and coke dewatering.
Reliability Challenges of Closed Coke Handling System

- Steady Coke Cutting
- Reliable Coke Crusher
- Redundant Slurry Pumps
- Dewatering Bins: Spare capacity
- Conveying System: Spare capacity
Automation / Safety / Environment

Automation: Automatic Coke Cutting (1)

• Coke Cutting System:
  – Pump: Byron Jackson (internal thrust balanced)
  – Pump Drive: Diesel 3.6 MW / 4800 hp
  – 280 bar / 4060 psi, 280 m³/h / 1230 gpm
  – Combi Tool for drilling and cutting
  – 3 Vibration Sensors at each drum
  – Signal of sensors is transformed into the information coke / no coke
  – Vertical movement of drilling stem is computer controlled and continuously optimized
Automation: Automatic Coke Cutting (2)

**Benefits:**
- Increased reliability of coke cutting.
- Higher cutting velocity
- Best cutting parameters can be reproduced
- Less manpower
- Cutting parameters give information about coke quality
**Future Improvements / Outlook**

- Valve interlock system independent of DCS
  Additional layers of protection on DC cycle valve operation -> SAFETY

- Completely closed and automated operation
  Full automation of drum decoking:
  - Remote controlled Top Head Valve  →  SAFETY
  - Remote controlled Bottom Head Valve  →  SAFETY
Outlook

Safe Operation and Clean Environment

It is possible in Delayed Coking:

COMPLETELY CLOSED AND AUTOMATED OPERATION

- Automatic control of drum cycle
- Drum unheading
- Coke cutting
- Coke dewatering
- Coke transportation