Detailed Design Solutions for Residue Hydrocracking Purge Systems

REFCOMM Galveston
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FLUOR®
Safety

- Residue hydrocracking operates under severe conditions
- Industry trend towards higher conversion
- More severe conditions lead to:
  - Increased operational complexity
  - Decreased reliability

Key Points:
- Residue hydrocracking presents unique engineering design challenges
- Operability and reliability are closely linked to safety
Fluor Energy & Chemicals

Serves global oil and gas production/processing for the upstream, downstream and integrated petrochemicals industries.

- Full range of services including design, engineering, procurement, fabrication and construction
- Global execution platform
- Project and program management
- Proprietary and commercially available technologies (e.g., carbon capture, sulfur recovery, gas processing & gas treating)
- Operations & maintenance/sustaining capital
- Chemicals & petrochemicals
- Heavy oil upgrading & oil sands
- Hydrocarbon transportation – pipelines
- Liquefied natural gas
- Onshore & offshore oil and gas production
- Petroleum refining
- Utilities & offsites

FLUOR.
## Residue Hydrocracking Experience Highlights

<table>
<thead>
<tr>
<th>OWNER</th>
<th>LOCATION</th>
<th>CAPACITY, KBD</th>
<th>UNIQUE FEATURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>KNPC</td>
<td>Shuaiba, Kuwait</td>
<td>25x2=50</td>
<td>Word’s first commercial unit in 1968</td>
</tr>
<tr>
<td>Motiva</td>
<td>Convent, Louisiana, USA</td>
<td>43 (Axens)</td>
<td></td>
</tr>
<tr>
<td>Slovnaft</td>
<td>Bratislava, Slovakia</td>
<td>25 (CLG)</td>
<td>First European LC Finer</td>
</tr>
<tr>
<td>Shell</td>
<td>Scotford, Alberta, Canada</td>
<td>2 x 41 = 82 (CLG)</td>
<td>World’s first LC Finer w/ Integrated HT</td>
</tr>
<tr>
<td>North West</td>
<td>Redwater, Alberta, Canada</td>
<td>30 (CLG)</td>
<td>Latest generation LC Finer</td>
</tr>
<tr>
<td>Sincier</td>
<td>China</td>
<td>46 (CLG)</td>
<td>World’s first LCMax unit</td>
</tr>
<tr>
<td>Eni</td>
<td>Sannazaro, Italy</td>
<td>24 (Eni Slurry)</td>
<td>Re-engineering post fire</td>
</tr>
</tbody>
</table>
Why Purge Systems?

KEY RELIABILITY AND ON STREAM FACTOR ASPECTS
✓ Solid management
✓ Fouling due to asphaltenes precipitation
✓ Fouling due to coke formation
✓ Services subject to erosion (i.e. letdown valves)
✓ Frequent upsets
✓ High viscosity fluids prone to plugging
✓ Unreliable measurements

SOLUTIONS: ‘Tools in the Toolbox’
✓ Reliability, Availability & Maintainability Analysis (RAM Model)
✓ Minimum particles settling velocities in line sizing
✓ Selection of specific instruments and equipment for severe fouling conditions (i.e. Spiral exchangers, slurry valves, ball valves)
✓ Design to avoid dead zones
✓ Online maintenance of letdown valves
✓ Upset automated process control management system: Cutback System
✓ Continuous purging of critical instruments, equipment and piping
Purge or “Continuous Flushing” System Features

- **Purpose**
  - Minimize or eliminate plugging due to coke accumulation or other solids deposition
  - Enhance reliability and availability of critical services
  - Reduce maintenance time by improving service life of components
  - Avoid thermal shock from high temperature differentials

- **Typical applications**
  - Piping dead legs
  - Valves (seat, body, throat)
  - Pump seals
  - Instruments impulse lines

- **Key design basics**
  - Liquid flushing medium shall be compatible (composition and process conditions)
  - Gas phase (H₂, N₂) or liquid phase (VGO, ATM GO, cycle oil, etc.) flushing fluid
  - Minimum velocity of the flushing fluid to guarantee effectiveness
  - Applicable for high pressure and low pressure sections in continuous service
Purge System: Applications

- Hydrogen purges
  - Instrument impulse lines
  - ‘Bubbler’ level instruments
  - High temperature hydrogen service isolation valves potentially oil contaminated

- Steam purges
  - Fractionator bottoms systems (instruments and tower dead-space)
  - Vacuum bottoms systems (instruments and vacuum tower dead-space)

- Oil purges
  - PSV inlet lines (dead-legs)
  - Ball valves (body, seat and/or throat)
  - Instrument impulse lines
  - Control valve stem
  - Spare high pressure letdown valve station
Purge System: Applications

- Purging applications applied to:
  - Outlet of reactor heaters through reaction section
  - High temperature systems of the low pressure separation section
  - Catalyst/solids slurry system

- In these services, purge applications include: piping dead legs, valves (seat, body, throat), pump seals and instruments impulse lines

- Considering the above, leads to **500+** purge connections
  
  *(3x the number of drain connections in the same unit)*
Oil Purge System: Typical Scheme
Oil Purge System: Typical Scheme

- Simple scheme hot VGO system
- Can be integrated with wash oil, quench oil or seal oil services
- Low capacity (typically <1-2% of unit rates)
- Purge rates set by licensors and vendors
  - Typically 0.5-1 ft/s for dead legs
  - Rates for valves proportional to size
Oil Purge System: Example

- High pressure letdown valves
  - Hot standby of the spare branch to avoid thermal stress
  - Online flushing and depressuring
  - Limit personnel exposure to high pressure/temperature components
  - Increased availability of the plant with online maintenance

Source: MOGAS Industries

other Vendors can provide purged severe service ball valves i.e. Valve technologies
Purge System Design

- A well designed purge system considers
  - Temperature
    - Above heavy oil pour point
  - Pressure
    - Above injection point pressure
    - Avoid overpressure
  - Layout and footprint limitations
  - Installation, testing and commissioning
  - Operability and maintenance
  - Cost

- Both piping and tubing designs are proven in industry
## Piping vs. Tubing

<table>
<thead>
<tr>
<th>Piping vs. Tubing</th>
<th>Piping</th>
<th>Tubing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>1”-2” governed by span</td>
<td>½”-2” governed by flow req.</td>
</tr>
<tr>
<td>Material</td>
<td>CS or SS depending temperature application</td>
<td>Stainless steel</td>
</tr>
<tr>
<td>Rating</td>
<td>600# - 2500#</td>
<td>Tubing rating – wall thickness selection</td>
</tr>
<tr>
<td>Distance between supports</td>
<td>10 ft for 1”, 20 ft for 2” typ.</td>
<td>Tubing routed in tray (20 ft for tray typ.)</td>
</tr>
<tr>
<td>Elbows</td>
<td>Fittings</td>
<td>Tube bending</td>
</tr>
<tr>
<td>Connection Fittings</td>
<td>Flanges and bolt up</td>
<td>Compression fittings</td>
</tr>
<tr>
<td>Stress Analysis</td>
<td>Stress analysis where required</td>
<td>Included in installation detail (Additional stress analysis where required)</td>
</tr>
<tr>
<td>ASME B31.1 &amp; B31.3</td>
<td>Compliant</td>
<td>Compliant</td>
</tr>
</tbody>
</table>
Safety and Reliability

- Piping and tubing both fabricated and tested compliant with applicable piping design code (ASME B31.1 and B31.3)

- Advantages of tubing
  - Fewer connections reducing potential leak points
  - Minimal welding, minimizing hot work requirement
  - Tubing tested burst pressure significantly higher than allowable working pressure (21000 psig vs. 4900 psig for 1 ½ in. x 0.188 wall)
  - Compression fitting joint integrity exceeds burst pressure of the tubing
Layout and Footprint
Tubing Purge Panel Design
## Installation, Testing, Commissioning

<table>
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<tr>
<th>Piping</th>
<th>Tubing</th>
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<tbody>
<tr>
<td>1. Pipe fitting scope including piping QC/QA (weld mapping, component verification, torque records, etc.)</td>
<td>1. Purge panel and tubing scope including QC/QA (component verification, compression fitting verification, etc.)*</td>
</tr>
<tr>
<td>2. Piping system pressure test program and reinstatement</td>
<td>2. System pressure test program and reinstatement</td>
</tr>
<tr>
<td>3. Extensive EHT installation scope and electrical QC/QA</td>
<td>3. EHT termination scope and electrical QC/QA</td>
</tr>
<tr>
<td>4. Full system insulation installation scope and associated QC/QA</td>
<td>4. Soft cover installation at system boundaries</td>
</tr>
<tr>
<td>5. Oil flush and system inventory</td>
<td>5. System inventory (oil flush optional)</td>
</tr>
</tbody>
</table>

*Purge panels purchased as preassembled and tested units. Tubing is available pretested, traced and insulated.
Operability and Maintenance

Tubing design advantages

- **Operability**
  - Compact design
  - Purge panels heated in extreme climates
  - 100% stainless steel

- **Maintenance**
  - Small fittings
  - Connections for component removal
  - No hot work
  - No welding, no grinding

*However, tubing fittings are not universal*
Cost

Piping Purge System Design

Material 12%
Labor 88%

Tubing Purge System Design

Material 63%
Labor 37%

2:1

*Cost data courtesy of Swagelok
Conclusions and Take-Aways

- Purge systems **improve integrity** of instruments and translate to reliability and overall plant safety.
- Use **tubing** for purge systems to:
  - optimize layout and accessibility
  - facilitate installation
  - improve operation and maintenance
  - reduce capital cost
- Fluor offers **innovative solutions** for delivering residue hydrocracking projects with best-in-class safety and reliability.