Syngas Treating for Stringent Product Specifications and CO₂ Capture

Dave Holbrook
UOP LLC
Agenda

- Selexol Technology Capabilities
- Flow-scheme Applications
- Optimization / Integration Benefits
- Commercial Operations Update
Selexol
Flow-scheme Applications

• Two Basic Flow-schemes
  - Sulfur removal only
    ✷ Typically for power applications where sulfur removal to 10 to 20 ppmv is adequate
    ✷ Can reduce treated gas sulfur to lower levels as needed
    ✷ One solvent absorber with solvent regeneration
  - Sulfur removal with separate CO₂ removal and capture
    ✷ Used for applications where separate treated gas and CO₂ product streams are required, e.g. hydrogen, chemical, SNG or coal to liquids applications
    ✷ Typically involves more stringent product specifications
    ✷ Independent solvent absorbers with common solvent regeneration
Selexol Process Capabilities

• **Selexol Treated Syngas Quality**
  - Total sulfur levels below 1 ppmv
  - CO$_2$ levels less than 1 mol% 

• **CO$_2$ Capture Capabilities**
  - Capture in excess of 90%
  - Total sulfur levels less than 10 ppmv
  - CO levels less than 0.1 %

• **Acid gas H$_2$S levels**
  - Typically 40% or higher
Selexol for Sulfur Removal

- **H₂S Absorber**
- **Lean Solution Filter**
- **H₂S Stripper**
- **Reflux Accumulator**
- **Reflux Pump**
- **Acid Gas**
- **Makeup Water**
- **Export Water**
- **Stripper Reboiler**

Flow diagram showing the process of sulfur removal with Selexol.
Selexol for H$_2$S Removal and CO$_2$ Capture
Use of Selexol Technology Results in Project Cost Savings

Integration results in significant project cost benefits

Targeted specific product qualities

Process integration minimizes energy usage

Essentially sulfur free treated gas, less than 1 ppmv

Flexibility to treat syngas from any gasifier

Recovery of significant CO$_2$ at elevated pressures

High CO$_2$ purity, greater than 95%

High levels of CO$_2$ recovery, greater than 90%
Many areas that should be optimized for a specific project, including:

- CO₂ flash section configuration
- H₂S flash section configuration
- Absorption column configuration
- Solvent temperature versus circulation rates

Up front optimization is an integral part of each Selexol project execution to assure Capex and Opex are minimized while achieving the project goals.
Integrating streams across the gasification complex can result in significant project savings:

- Minimization of off gas streams, such as PSA tail gas, SRU tail gas, flash gas, etc
  - Recycling to the right location
- Maximization of sulfur removal and recovery
  - Minimizing treating requirements in downstream processing
- Maximization of CO₂ removal and recovery
  - Targeted CO₂ destination and recovery level can impact complex design
Selexol Process
Commercial Experience

• 56 operating units
  - Both Natural Gas and Gasification applications

• Gasification Applications in Operation
  - Sarlux IGCC - Sardinia, Italy power plus hydrogen
  - API IGCC – Falconara, Italy - power
  - Coffeyville Resources – USA – ammonia/urea

• Gasification Applications In Pre-Commissioning Phase
  - Opti Long Lake L.C. - Alberta, Canada – power / steam

• Gasification Applications in Design
  - Oils Sands Upgrader - hydrogen
  - Coal to Liquids – liquid fuels
  - Petcoke to Ammonia and Methanol
  - Coal to Power
Coffeyville Gasification Ammonia Complex

Air Separation Unit
- Air
  - N₂
- O₂
  - High Purity Hydrogen

Ammonia Synthesis
- N₂
- O₂
  - Syngas Scrubbing
  - CO Shift & Gas Cooling
  - Raw CO₂
  - Tail Gas

UAN Plant
- NH₃ Product
  - Purified CO₂
  - UAN Product

Polybed PSA
- Raw H₂

Selexol
- CO₂ Vent
  - Acid Gas

Petroleum Coke

Claus Plant
Coffeyville Resources Ammonia Fertilizer Complex

Feedstock: 45 MT/H petroleum coke
EPC Contractor: Black & Veatch Pritchard
Commercial Operation: July 2000

Process Licensors
Gasification: General Electric
Gas Purification Block:
- Acid Gas Removal: UOP --- Selexol
- H₂ Purification: UOP --- Polybed PSA
Sulfur: Tessenderlo Kerley
Air Separation: BOC
Ammonia / UAN:
- Black & Veatch Pritchard
- Ammonia Casale / Weatherly

Gasifier and Selexol retrofit using existing equipment
# Feed Stream Specifications

<table>
<thead>
<tr>
<th>Feed Flowrate</th>
<th>169,000 Nm³/hr (151 MM SCFD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure</td>
<td>36.9 bar-a (535 psia)</td>
</tr>
<tr>
<td>Temperature</td>
<td>38 °C (100 °F)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Component</th>
<th>Mole %</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₂</td>
<td>&gt; 56</td>
</tr>
<tr>
<td>CO</td>
<td>~ 1.2</td>
</tr>
<tr>
<td>CO₂</td>
<td>~ 41</td>
</tr>
<tr>
<td>H₂S and COS</td>
<td>~ 0.6</td>
</tr>
<tr>
<td>CH₄, Ar, &amp; N₂</td>
<td>~ 1</td>
</tr>
<tr>
<td>H₂O</td>
<td>Saturated</td>
</tr>
</tbody>
</table>
Coffeyville Selexol Process for H₂S Removal and CO₂ Capture

- CO₂ Absorber
- Semi-rich CO₂ Solvent Flash Drum
- CO₂ Recycle Flash Drum
- Lean CO₂ Solvent Pump
- Semi-Lean Solvent Pump
- CO₂ to Purification
- CO₂
- Acid Gas to Sulfur Recovery Unit
- Reflux Condenser
- Reflux Drum
- Makeup/Purge Water
- Reflux Pump
- Acid Gas

- Sour Syngas
- Treated Syngas
- H₂S Concentrator
- Flash Gas KO Drum
- H₂S Stripper
- Stripper Reboiler
- Water
- Purification
- Semi-rich
- Semi-Lean
- Rich
- Lean
- KO Drum
- Condenser
- Reboiler
- Pump
- Absorber
- Concentrator
- Flash Drum
- Recycle
- Purification
- Make-up/Purge
# Selexol Commercial Data

## Sulfur Removal

### Feed Sulfur – 0.60 mol %

<table>
<thead>
<tr>
<th></th>
<th><strong>Plant Lab</strong></th>
<th><strong>UOP Lab</strong></th>
<th><strong>Predicted</strong></th>
<th><strong>CO₂ Product</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Treated Gas</strong></td>
<td>&lt;1</td>
<td>0.2</td>
<td>&lt;0.1</td>
<td>Not available</td>
</tr>
<tr>
<td></td>
<td>Not available</td>
<td>2.8</td>
<td>2.3</td>
<td>Not available</td>
</tr>
<tr>
<td><strong>CO₂ Product</strong></td>
<td>Not available</td>
<td>&lt;0.1</td>
<td>100</td>
<td>128</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>128</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------------</td>
<td>------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feed CO₂ Level, mol %</td>
<td>41</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product CO₂ Level, mol %</td>
<td>4.9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO₂ Capture, actual %</td>
<td>91.6</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**CO₂ capture limited by current equipment configuration**
Coffeyville Resources SELEXOL Unit
The Selexol technology has been used for many years to reduce sulfur in natural and synthetic gas. Extremely low sulfur levels can be achieved. CO₂ capture and quality requirements can be achieved while controlling capital and operating costs. An optimized design will minimize capital and operating costs in all applications. UOP has commercial experience in syngas treating to the stringent product specifications required to produce high value products.
Syngas Treating for Stringent Product Specifications and CO₂ Capture

Gasification Technologies Conference

Thanks for your time and attention