Conquering sulphuric acid plant limitations with TOPGUN and caesium-promoted VK catalyst

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Agenda

- Case study at Southern Peru Copper (SPC)
- Steps in the study at SPC
  - Defining the challenge(s)
  - Defining the goal of the study
  - Performing the study – investigations and design
  - Tailor made solution
- Result of the study at SPC after implementation of the solution
Southern Peru Copper (SPC)

- The Southern Peru Copper (SPC) facility in Ilo operates two sulphuric acid plants – both units are treating the off-gasses from the Peirce-Smith Converters and ISASMELT furnace.
Southern Peru Copper (SPC)

- Capacity plant no. 2 is 3780 MTPD
- Commissioned in Feb. 2007
- Catalyst loading 698 m³ – 185 l catalyst/MTPD
- Topsoe was contacted in end of 2009 for making an optimizing study of the performance of the converter
- Turn around scheduled in September 2010 including screening and partly catalyst replacement
Original design and operation parameter during start of the study

Dilution air
- From gas cleaning - mixing chamber
- 275,000 Nm$^3$/hr

Dry tower
- Feed gas
  - Design ≈ 13% SO$_2$
  - PV ≈ 8% to >13%
- T inlet
  - Design ≈ 390°C
  - PV ≈ 410°C

Bed 1
- Top layer of Cs catalyst
  - T outlet
    - Design ≈ 615-620°C
    - PV > 630°C

FAT
- Acid production
  - Design = 3780 MTPD

Bed 2-4
- IAT, HEX
  - Acid production
    - Design = 3780 MTPD
### SO₂ conversion rates – TOPGUN 2010

<table>
<thead>
<tr>
<th>Production rate [%]</th>
<th>SO₂ feed gas concentration [mole%]</th>
<th>Conversion [%]</th>
<th>SO₂ emission [ppm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>65%</td>
<td>8.49%</td>
<td>99.63%</td>
<td>360</td>
</tr>
<tr>
<td>88%</td>
<td>11.54%</td>
<td>99.44%</td>
<td>780</td>
</tr>
<tr>
<td>100%</td>
<td>13.13%</td>
<td>99.37%</td>
<td>1020</td>
</tr>
<tr>
<td>112%</td>
<td>14.75%</td>
<td>99.24%</td>
<td>1435</td>
</tr>
</tbody>
</table>

Design: Maximum 300 ppm SO₂ emission at 100% load
Consequences of the limitations for SPC

- High SO$_2$ emissions
- Risk of damaging the catalyst and converter due to high temperatures outlet bed 1
- Forced to lower the SO$_2$ feed gas concentration
- Excess dilution air through the plant
- More attention to operating the dilution air
- Less flexibility in operating the acid plant
- Bottleneck in the operation of the Cu-smelter

→ Extra cost for SPC
Goal of study

Dilution air

Feed gas
Design = 13% SO₂

Dry tower

T inlet
Design = 390°C

Bed 1
Top layer of Cs catalyst

T outlet
Design ≈ 615-620°C

SO₂ emission
Original design = 300 ppm SO₂
New design = 250 ppm SO₂

From gas cleaning

Acid production
Design = 3780 MTPD

FAT

Bed 2-4
IAT, HEX

Design = 3780 MTPD
How to get an accurate basis for the study?

Troubleshooting & TOPGUN
Troubleshooting - TOPGUN

- **T**Opsoe’s Portable **G**as analysis **U**nit
- On-site technical service – executed during operation
- Portable **SO**₂ and **O**₂ gas analyser – No requirement for calibration gas
- Topsoe’s catalyst simulation program of the plant and catalyst performance
- Ideal tools for obtaining data for studies
Troubleshooting - TOPGUN
**Troubleshooting - TOPGUN**

- **Measurements at the inlet of bed 4**

<table>
<thead>
<tr>
<th>No</th>
<th>Sample point</th>
<th>SO₂ (%)</th>
<th>O₂ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Inlet IAT</td>
<td>0.905</td>
<td>7.9</td>
</tr>
<tr>
<td>2</td>
<td>Inlet inter reheat HEX</td>
<td>0.874</td>
<td>8.5</td>
</tr>
<tr>
<td>3</td>
<td>Outlet inter reheat HEX</td>
<td>0.931</td>
<td>7.8</td>
</tr>
<tr>
<td>4</td>
<td>Inlet bed 4</td>
<td>1.466</td>
<td>7.9</td>
</tr>
</tbody>
</table>

- **Thesis**
  - Centre column in the converter
  - Pre-heater by-pass non blinding valves
Summary of study

- **Catalyst performance**
  - Low catalyst activity in all beds - TOPGUN
  - Catalyst samples confirm the low catalyst activity
  - The conversion in bed 1 turn-off at inlet temperature at 400°C

- **Mechanical performance**
  - No leaks in the external heat exchangers
  - IAT and FAT tower operates satisfactory
  - Feed gas by-passing into the inlet of bed 4
Solutions for SPC

- Tailor made catalyst loading
  - Only the necessary amount of catalyst is replaced to achieve the goal

<table>
<thead>
<tr>
<th>Bed no.</th>
<th>Type</th>
<th>Installed</th>
<th>Volume [m³]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bed 1</td>
<td>VK59, 12 mm Daisy</td>
<td>2010</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>VK38, 12 mm Daisy</td>
<td>2010</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>Existing screened catalyst, non-Topsøe</td>
<td>2007</td>
<td>50</td>
</tr>
<tr>
<td>Bed 2</td>
<td>Existing catalyst, non-Topsøe</td>
<td>2007</td>
<td>158</td>
</tr>
<tr>
<td>Bed 3</td>
<td>VK48, 12 mm Daisy</td>
<td>2010</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>Existing screened catalyst, non-Topsøe</td>
<td>2007</td>
<td>117</td>
</tr>
<tr>
<td>Bed 4</td>
<td>VK69, 9 mm Daisy</td>
<td>2010</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td>Existing screened catalyst, non-Topsøe</td>
<td>2007</td>
<td>133</td>
</tr>
</tbody>
</table>

- Check and rectify mechanical problem around bed 4
Advantages of VK caesium catalyst

- **VK59 in bed 1** – replacement of the existing Cs-promoted catalyst in bed 1
  - Operating with higher SO₂ strength
  - Increase the flexibility of operating
  - Cleaner and faster start-ups due to the low ignition temperature of VK59

- **VK69 in bed 4** – partial replacement of the existing standard catalyst
  - Significantly reduction of the SO₂ emission at full load
  - Increased sulphuric acid production rate
  - Cleaner and faster start-ups due to the low ignition temperature of VK69
  - Possibility of eliminating the preheat exchanger to bed 4 during start-ups due to the very low ignition temperature of VK69
Performance prediction

<table>
<thead>
<tr>
<th></th>
<th>Before catalyst replacement</th>
<th>Performance prediction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas to bed 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flow rate SO$_2$</td>
<td></td>
<td>275,000 Nm$^3$/hr</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13 mole %</td>
</tr>
<tr>
<td>Acid production [100% H$_2$SO$_4$]</td>
<td>3768 MTPD</td>
<td>3786 MTPD</td>
</tr>
<tr>
<td>Bed 1 inlet/outlet temperatures</td>
<td>410°C/ &gt;630°C</td>
<td>390°C/615-620°C</td>
</tr>
<tr>
<td>Overall conversion efficiency</td>
<td>99.35%</td>
<td>99.85%</td>
</tr>
<tr>
<td>SO$_2$ exit bed 4</td>
<td>&gt;1000 ppm</td>
<td>250 ppm</td>
</tr>
</tbody>
</table>
Performance after catalyst replacement

- Plant was started up in again in Sept/Oct 2010
- The results of the new performances is based on results received from SPC
  - More flexibility in operating the plant due to low inlet temperature of bed 1 down to 390°C
  - General improvement of the performance of bed 4 due to the low ignition and lower operating temperature
- No rectifying of the by-pass to bed 4
Performance after catalyst replacement

- Data from SPC at a daily production rate of 80%
Summary

- Identify challenges and limitations
- Troubleshooting
- Implementation of tailor made solution
- Performed in closed corporation between Topsøe and the plant

Results for SPC:
- More flexibility in operating the acid plant
- Enable operation at optimal and design conditions
- Lower SO$_2$ emission
- Achieved the goal
Thank you for your attention

Special thanks to
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Questions