LUREC® Process

Sulphur & Sulphuric Acid 2009 Conference

Sun City South Africa, May 4 - 6th, 2009
Processing of Concentrated SO$_2$ Gas from Metallurgical Operations
Processing of Strong Gas

**Challenges:**
- Strong gases (30 – 60 %-vol. SO₂) from smelter processes available
- High SO₂ → High Temperatures

**Advantages of Processing Strong Gases**
- Smaller equipment → reduced investment cost
- Lower gas flow → less energy demand
- Higher SO₂-content → higher energy recovery potential

**Limitations**
- Thermostability of catalyst (approx. 640 °C)

**Solutions**
- Trivial solution, -dilute the gas with air to 12…13%-vol. SO₂
- Other, more sophisticated solutions
Operating temperature 1st bed

Catalyst operating limit = 640 °C (1,180 °F)

Equilibrium curve:
SO₂ + ½O₂ ⇌ SO₃

Conversion % vs Temperature °C

- 10% SO₂
- 14%
- 18%
- 22%
Concepts & History

Strong SO$_2$ Gas Processing
Other Concepts vs. LUREC®

- Separate air drying tower
- Developed in 1935 in France
- Never been built
- First bed only used "half"
- Emissions of SO₂ well above LUREC®
- Risk of heavy pollution (backflow)
- Multiple blowers of different performance in parallel
- Now being marketed again (new people generation)
2. Fluidized Bed Concept
Fluidized Bed Contact

30 vol.-% SO₂
21 vol.-% O₂

~450 °C

Drying Tower

Inter Absorber

410 °C
460 °C
400 °C
403 °C

Final Absorber
Fluidized Bed Issues:

- Earliest contemplation in the 1950th in Russia
- Developed in Germany in the 1970th
- 250 t/d plant build and operated at Bayer/Leverkusen for several years with SO2 concentrations up to 30%-vol.
- “Abrasion free” catalyst of small particle size developed
- Cyclone or other separation equipment efficiency downstream fluid bed is incomplete
- Impurities in the product acid, e.g. metals and/or alkali salts
3. Isothermal Concept
Inter Absorber
Final Absorber
Drying Tower

Isothermal Contact

22 vol.-% SO₂
16 vol.-% O₂

~100 °C

425 °C
540 °C
440 °C
520 °C
435 °C
465 °C
410 °C
445 °C
410 °C
412 °C

Inter Absorber
Conversion of SO₂ with Iso-Contact (22% -vol. SO₂, 16% -vol. O₂)

Temperature °C

Conversion %

Bed 1 - IsoContact

Bed 1 - Covent.

Bed 2 - Convent.

Bed 2 - 3 Cooling

Bed 1 - 2 Cooling

Catalyst Operating Limit

Equilibrium

Bed 3 - Convent.
Indirect Cooling Converter Issues:

- Difficult to control temperatures
- SO₂ concentration up to 22% vol.
- Better heat transfer through shorter distances between catalyst and tube surfaces
- At larger converters, uniform temperature profile not feasible
- “Sticky” catalyst difficult to remove/replace
- Operates at “normal” gas velocities
- Not suitable for larger acid plants
4. Tube Reactor Concept
Historical Tube Type Converters

Heat transfer improvement

Abb. 612. Einrichtung zur Herstellung von Schwefelsäureanhydrid.

US Patent Knietsch 1901

BASF Converter ~1915
Temperature profile semi-isothermal converter with 8 %-vol. SO$_2$ gas.

Chemico semi-isothermal converter ~1930

Temperature peak can not be avoided.
Adiabatic converter with catalyst in tubes ~1920
Tentelew, St.Petersburg

“Isotherm” converter ~1930
Jaeger, USA
Other Converters

Lurgi vertical converter
1980 Bayer Uerdingen

Isotherm / adiabatic
Tray type converter
in Russia, about 1960

Russian plate Type converter

Рис. IX-50. Схема контактного узла для переработки концентрированного газа:
Isothermal Tube Type Converter

Tube Type Converter Issues:

- Early design was 50 mm tube, later 250 mm
- Operation was with 4…6 % SO₂
- Acid plant capacities 20 …40 t/d
- No temperature issue, even adiabatic
- Extreme long residence time and small gas velocities used
- “Sticky” catalyst difficult to remove/replace
- Poor heat transfer from catalyst to tube wall
- Heat transfer improves with high gas velocity
- High velocity reduces reactivity of catalyst (diffusion based)
- Effective control of temperatures not possible
- Never used for larger size acid plants
SO₂ gas from drying tower

Recycling of SO₃ affects the equilibrium of the oxidation reaction thus limiting the gas temperature

LUREC® process – 18% SO₂

Outotec
LUREC® process

LUREC™ Contact 18% SO₂ - 13% O₂

Catalyst Operating Limit = 640 °C (1,180 °F)

Conversion %

Temperature °C

more recirculation

less recirculation
Client: Yanggu Xiangguang Copper Co., Shandong Province, China

- Design gasflow 136,000 Nm³/h
- LUREC® to operate at 16…18 %-vol. SO₂
- 5 bed converter with 3 integrated heat exchangers
- High pressure steam production: 27 t/h
- Low emissions < 100 ppm SO₂
- 2,340 mtpd plant capacity
- BAT – Best Available Technology
### Comparison Conventional Acid Plant vs. LUREC®

<table>
<thead>
<tr>
<th>Basis 2000 mtpd</th>
<th>12 %-vol. SO₂ Conventional</th>
<th>18 %-vol. SO₂ LUREC® Process</th>
<th>LUREC® Savings (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gasflow Drying Tower Nm³/h</td>
<td>158,000</td>
<td>105,000</td>
<td>- 34 %</td>
</tr>
<tr>
<td>Gasflow ex Absorbers Nm³/h</td>
<td>130,000</td>
<td>79,000</td>
<td>- 38 %</td>
</tr>
<tr>
<td>Gasflow Converter Nm³/h</td>
<td>158,000</td>
<td>135,000</td>
<td>- 15 %</td>
</tr>
<tr>
<td>Beds 1+2</td>
<td>149,000</td>
<td>96,000</td>
<td>- 36 %</td>
</tr>
<tr>
<td>Bed 3</td>
<td>130,000</td>
<td>79,000</td>
<td>- 39 %</td>
</tr>
<tr>
<td>Beds 4+5</td>
<td>130,000</td>
<td>79,000</td>
<td>- 39 %</td>
</tr>
<tr>
<td>Stack Gas Nm³/h</td>
<td>129,000</td>
<td>76,000</td>
<td>- 41 %</td>
</tr>
<tr>
<td>Heat Exchanger Surface m² (including air/gas coolers)</td>
<td>13,500</td>
<td>9,900</td>
<td>- 26 %</td>
</tr>
<tr>
<td>Acid Plant Cost EPC</td>
<td>100 %</td>
<td>79 %</td>
<td>- 21 %</td>
</tr>
<tr>
<td>Power Consumption kWh/t H₂SO₄</td>
<td>55</td>
<td>43</td>
<td>- 22 %</td>
</tr>
<tr>
<td>C/W Consumption m³/t H₂SO₄</td>
<td>37</td>
<td>29</td>
<td>- 21 %</td>
</tr>
<tr>
<td>Heat Recovery kWh/t H₂SO₄</td>
<td>165</td>
<td>205</td>
<td>+ 24 %</td>
</tr>
<tr>
<td>Emission kg SO₂/t H₂SO₄ (Basis 250 ppm v)</td>
<td>1.20</td>
<td>0.90</td>
<td>- 25 %</td>
</tr>
<tr>
<td>Emission kg SO₃/t H₂SO₄ (Basis 30 mg/Nm³)</td>
<td>0.076</td>
<td>0.046</td>
<td>- 39 %</td>
</tr>
</tbody>
</table>
Converter Design
Features
Sun Metals 1150 t/d, Zinc roaster gas, 1999
Atlantic Copper 1300 t/d, copper smelter gas, 1996
Oswal Fertilizer 2 x 3500 t/d, sulphur burning, 2000
Converter Examples

Converter with 'wrapped' around heat exchanger

Twin Converter
2 x 3,500 mtpd
SO$_2$ Converter – Core and Shell
Converter Internals

Catalyst bed
free access
no obstacles

Internal
heat exchanger
lower tube sheet
Converter Internals

Internal heat exchanger shell side
Converter Internals

Dividing plate
fully welded

Catalyst
support
Thank you for your attention!

www.outotec.com