WSA technology for treatment of low and fluctuating SO$_2$ gases from smelters and roasters

Presentation - main contents
- Treatment of low SO$_2$ gases
- WSA for smelting/roasting applications
- WSA plant layout and equipment
- WSA for low and fluctuating SO$_2$ gases
- WSA case story “Enami Paipote”
- Conclusion/summary
Low SO₂ gases

- Authorities require stricter SO₂ removal efficiency which might require treatment of gases like:
  - single absorption plant tail gases
  - dilute fugitive/hood off gases
  - (strong gases from new smelter/roaster expansions)
  to fulfil specific requirements and/or “bobble” requirements

- These combined demands can be met by use of the WSA technology

WSA/SNOX™ technology applications

- Metallurgical and minerals industry
- Oil refining
- Petrochemical industry
- Natural gas treatment
- Coal gasification
- Coke and coke chemicals industry
- Viscose production
- Power plants
Chemical reactions – WSA for SO₂ gas

- **SO₂**
  - Conversion: SO₂ + 0.5 O₂ → SO₃ + heat

- **SO₃**
  - Gas cooling: SO₃ + H₂O → H₂SO₄ (gas) + heat

- **H₂SO₄ (gas)**
  - Condensation: H₂SO₄ (gas) → H₂SO₄ (liquid) + heat

- **H₂SO₄ (liquid)**

Principles of the WSA process, SO₂ gas

- **Pre-heating**
- **SO₂ conversion**
- **Gas cooling**
- **Acid condensation**

- **SO₂ rich off-gas**
- **Cooling water**
- **Clean process gas to drying**
- **Atmospheric air**
- **Cooling water return**
- **Steam**
- **Acid cooling**

- **No fuel consumption with an SO₂ content above 2.5 % vol**
- **Low cooling water consumption, 8-9 m³/ton acid produced**
**WSA process lay-out, SO₂ gas**

- **SO₂ gas**
  - Feed gas preheater
  - Fuel gas
  - Steam
  - BFW
  - Boiler/salt cooler
  - Salt tank and pump
  - Process gas blower
  - Process gas heater

**SO₂ Converter**
- Start-up burner
- Interbed cooler
- Interbed cooler
- Gas cooler
- WSA condenser
- Blower
- Air
- Acid cooler
- CW
- Product acid
- Reaction: $	ext{SO}_2 + 1/2	ext{O}_2 \rightarrow 	ext{SO}_3$
- Reaction: $	ext{SO}_3 + 	ext{H}_2	ext{O} \rightarrow 	ext{H}_2	ext{SO}_4$
- Reaction: $	ext{H}_2	ext{SO}_4(g) \rightarrow 	ext{H}_2	ext{SO}_4(\text{liq})$

**SO₂ converter**
- CW
- HALDOR TOPSOE
Heat transfer system

WSA condenser - operation

- Clean gas outlet
- Cooling air inlet
- Hot air outlet
- Acid gas inlet
- Sulphuric acid
WSA condenser – modular construction

WSA condenser erection
WSA condenser erection

Installation of WSA condenser module
WSA condenser internals

WSA advancements in treatment of cyclical gas

- Hot Salt Tank (>450°C)
- Cold Salt Tank (270°C)
- Process Gas to WSA Condenser (290°C)
- Process Gas Cooler
- Interbed Cooler
- Process Gas Heater
- Preheated Feed Gas (180°C)
- SO₂ Converter
- 420°C
WSA/SNOX™ references

Gas flow: 2,000 – 1,200,000 Nm³/hr
Acid production: 8 – 1,140 MTPD
More than 115 units

WSA references

Contracted plants:
34 in oil refining
- 12 H₂S/SWS gas
- 15 spent acid regeneration
- 2 Claus tail gas
- 4 flue gas desulphurisation (SNOX™)
- 1 RFCC off-gas
13 in metallurgical industry (Mo, Zn, Pb, Cu, Mn)
28 in coking industry
25 in gasification
7 in viscose industry
8 in other industries (including 2 SNOX™)
115 in total
Typical scope of supply

- License package
- Basic engineering
- Proprietary equipment
- Catalyst
- Supervision during erection and commissioning

Optional:
- Detailed engineering
- Supply of other equipment

- WSA condenser internals
- Acid vessel, pumps and cooler
- Acid piping and instruments
- Interbed heat exchangers
- Process gas cooler
- Mist control units

WSA/SNOX™ references
The “Enami Paipote” case

- Enami Paipote has a Pierce Smith (CPS) converter and a Teniente (CT) converter
- Enami Paipote has two old single absorption acid plants
- Enami Paipote uses approx 100,000 Nm$^3$/h of hot air at some 200°C which is generated by burning fuel oil
- Enami Paipote asked Topsøe to study a solution able to:
  - treat gases from CPS and CT instead of single absorption
  - treat dilute fugitive/hood gases from the smelter
  - produce minimum 100,000 Nm$^3$/h air at 200°C for drying

The “EP” case / WSA plant design/operation

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Operation mode</th>
<th>Configuration</th>
<th>Operation hours per day</th>
<th>Gas flow, Nm$^3$/h</th>
<th>SO$_2$, % vol.</th>
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<tbody>
<tr>
<td>Without fugitive gases</td>
<td>1</td>
<td>CT + CPS</td>
<td>17.1</td>
<td>117,441</td>
<td>9.8</td>
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<tr>
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<td>2</td>
<td>Only CT</td>
<td>5.6</td>
<td>80,423</td>
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<tr>
<td>With fugitive gases</td>
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<td>CT + CPS</td>
<td>17.1</td>
<td>170,225</td>
<td>6.8</td>
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<td>Only CT</td>
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<td>112,155</td>
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<tr>
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<td>Only CPS</td>
<td>1.3</td>
<td>58,070</td>
<td>5.43</td>
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</tbody>
</table>
The “EP” case (CT + CPS) / WSA plant design

- WSA plant design capacity is 170,225 Nm³/h and 1,235 MTPD acid at 98 % wt
- Stack content of SO₂ is below 300 ppm
- Cooling water consumption (delta T = 10 °C, re-circulated) is 460 m³/h
- Fuel gas consumption is 0 m³/h
- Electricity consumption is approximately 4,500 kWh/h

The “EP” case / hot air fuel savings

- Hot air usage is 103,325 Nm³/h at 200 °C produced by burning fuel oil (temperature from 20 °C to 200 °C)
- At a price of 640 USD/ton of fuel oil with 1.5 % S content and LHV = 9,400 kcal/kg the savings are:
  - Fuel oil cost saving is **USD 3,450,000** per year
    (640 USD/ton x 0.615 ton/hr x 8760 hr/year)
  - SO₂ saving to the atmosphere is **162 ton** per year
    (103,325 Nm³/h x 179 mg/Nm³ SO₂ x 8760 hr/year)
Why choose WSA?

- Very high degree of heat recovery in the process gives autothermal operation from an SO\textsubscript{2} content of 2.5 % vol.
- Quick restart after power failure
- Very low cooling water consumption
- Hot air return for drying purposes removes supplementary fuel consumption and SO\textsubscript{2} flue gas generation
- Suited for gases with variations in off gas flow and SO\textsubscript{2} concentration due to the WSA heat buffer system
- No waste products, chemicals consumption or dilute acid generation
- Simple, efficient and easy to operate technology