Improving Efficiency and Safety in Metallurgical Acid Plants
• Why and how maximizing power generation?
  • Gas phase: LUREC™
  • Acid circuit: HEROS/HEROS+™

• Case Study
  • Case Study I: Reference plant of HEROS™
  • Case Study II: HEROS™ together with LUREC™ technology

• Adding digitalization
  • Motivation and value
  • PORS expert system
Power production in acid plants

“Add on value generation”

- Plant configuration
  - Capacity
  - Location
  - Technology

- Operation & Maintenance
  - Personnel
  - Electricity, Water & Steam

- Others
  Financial concept

- Specifics
  - Environmental Regulation
  - Clients requirements

€ / t H$_2$SO$_4$
### Area
1. Gas cleaning (cooling)
2. SO2 conversion
3. SO3 Absorption

<table>
<thead>
<tr>
<th>Area</th>
<th>Temp.</th>
<th>Use</th>
<th>Alternative</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>approx 40°C</td>
<td>none (cool. Water)</td>
<td>None</td>
</tr>
<tr>
<td>(2)</td>
<td>400 – 500°C</td>
<td>Air, Economizer, Steam production</td>
<td>Increasing SO2 strength</td>
</tr>
<tr>
<td>(3)</td>
<td>80 – 100°C</td>
<td>None, pre-heating</td>
<td>Steam production</td>
</tr>
</tbody>
</table>
Heat recovery from gas phase in Metallurgical plants

Design Considerations

- SO2 content (“as higher as better”)
- Fluctuations (re flow and SO2)
- Heat recovery “infrastructure” (re potential user, redundant system)

- Typical solutions:
  - Economizer after 4th pass connected to Boiler to pyrometallurgical process (e.g. roaster, smelter)
  - Process air pre-heating (e.g. for roaster)
  - At sufficient high concentration and stable conditions boiler for steam production (e.g. smelter/Lurec combination)
Outotec strong gas technology: LUREC™

- Strong gases (30 – 60 % vol. SO2) e.g. from smelter processes available
- Use of oxygen enriched air strategy for smelter capacity increase

Maximizing Power Generation – Gas Phase

Strong \( \text{SO}_2 \) gas

1

\( T \geq 630 \degree \text{C} \)
Maximizing Power Generation – Gas Phase

Outotec strong gas technology: LUREC™

- Strong gases (30 – 60 % vol. SO2) e.g. from smelter processes available
- Use of oxygen enriched air strategy for smelter capacity increase

Recycling of $SO_3$ suppresses the oxidization of incoming $SO_2$ gas, thus limiting gas temperature
Outotec strong gas technology: LUREC™

- Strong gases (30 – 60 % vol. SO2) e.g. from smelter processes available
- Use of oxygen enriched air strategy for smelter capacity increase

Processing strong gases
- Smaller equipment → reduced investment cost
- Lower gas flow → less energy demand
- Higher SO2 content → higher energy recovery potential
- Max. operating temperature of catalyst → approximately 630° C
- Existing plants: design concept/layout

Recycling of SO₃ suppresses the oxidization of incoming SO₂ gas, thus limiting gas temperature
Yanggu Copper Smelter/China

- Capacity: 2.300 tpd
- Gas Flow: 136.000 Nm³/h
- Gas Strength: 16 – 18 vol.-% SO2
- O2/SO2: 0,8
- Steam Production: 27 t/h (25 bar, g)
- Plant commissioned in 2007

Second plant (3.050 tpd) in operation (2009)
Efficiency and complexity

• Heat is available
  (~1,900 MJ/t H₂SO₄)

• Typical temperature level 70 - 120°C

• Standard: transferred to cooling water (approx. 40% of total chemical energy available)

• Better options are available, but come with an impact on the plant layout
Acid phase: HEROS/HEROS+™

Design specifics for improved safety and reliability:

- **MoC**: Bricklined equipment preferred (→ corrosion), Alloy 3033 for wide operation range
- **Leak detection**: Redundant instrumentation, expert system (digitalization)
- **Leak risk mitigation**: Drainage of equipment by gravity into bricklined tank
- **Plant availability**: IAT designed for 100% plant load, heat recovery unit separate plant unit
HEROS™ retrofit in metallurgical acid plant

**Design Data:**
- Gas flow: approx. 80,000 Nm³/h
- SO2 strength: 10 – 12 vol.-%
- Acid Production: approx. 1,000 mtpd
- Steam production: 18.6 t/h @ 10bar, sat.

**Experience:**
- Prior to tie-in to existing plant, HEROS™ was commissioned / checked without interfering with normal operation.
- HEROS™ operational (incl. spade swing) within two hours.
- Two unplanned stops within first month of operation only, due to pump failure (restart after 6h) and leaking valve (restart after 2h).
- No noticeable increase in condensate collection at cold heat exchanger.
- During repair work at HEROS™ equipment, acid plant was in operation.

Follow-up order received – new plant to be in operation in 2015.
• Why and how maximizing power generation?
  • Gas phase: LUREC™
  • Acid circuit: HEROS/HEROS+™

• Case Study
  • Case Study I: Reference plant of HEROS™
  • Case Study II: HEROS™ together with LUREC™ technology

• Adding digitalization
  • Motivation and value
  • PORS expert system
Case Study: Maximized Heat Recovery in metallurgical acid plant

- Gas Source:
  - Outotec Flash Smelter & Flash Converter

- Plant Basis (key data):
  - 18 vol.-% SO₂ with 14 vol.-% O₂
  - Ratio: SO₂/O₂ = 0.77
  - 220,000 Nm³/h
  - 4,250 t/d H₂SO₄
  - Steam Conditions: 40 bar(a), 480° C (HP); 10 bar(a), 180° C (LP)

- Cases:
  - Baseline: Standard plant with 12 vol.-% SO₂
  - Alternative I: LUREC™ with 18 vol.-% SO₂
  - Alternative II: LUREC™ with 18 vol.-% SO₂ and HEROS™
  - Alternative III: LUREC™ with 18 vol.-% SO₂ and HEROS+™
Case Study: Maximized Heat Recovery in metallurgical acid plant

<table>
<thead>
<tr>
<th>Basis 4250 mtpd</th>
<th>Standard</th>
<th>LUREC™</th>
<th>LUREC™/HEROS™</th>
<th>LUREC™/HEROS+™</th>
</tr>
</thead>
<tbody>
<tr>
<td>LP steam generation: 100 kPa, saturated [t/h]</td>
<td>-</td>
<td>-</td>
<td>62</td>
<td>72</td>
</tr>
<tr>
<td>HP steam generation: 400 kPa, 480°C [t/h]</td>
<td>36</td>
<td>46</td>
<td>46</td>
<td>53</td>
</tr>
<tr>
<td>Power generated [MW]</td>
<td>9.5</td>
<td>12.1</td>
<td>21.1</td>
<td>24.2</td>
</tr>
</tbody>
</table>

Converter Section Steam System
Deaerator
Acid Coolers
Condenser

Converter Section Steam System
Deaerator 160°C
HEROS
Acid Coolers
Condenser

Converter Section Steam System
Deaerator
HP stage 100 kPa
LP stage 7 kPa
72 t/h 180 °C (saturated)
Crossflow & Product Cooler
Acid Coolers
150 °C
160 °C
Deaerator
160 °C
Condenser

Converter Section Steam System
Deaerator
HP stage 100 kPa
LP stage 7 kPa
53 t/h 480°C
Crossflow & Product Cooler
Acid Coolers
150 °C
160 °C
Deaerator
160 °C
Condenser

Power generated [MW]
9.5
12.1
21.1
24.2
## Case Study: Maximized Heat Recovery in metallurgical acid plant

<table>
<thead>
<tr>
<th>Basis 4250 mtpd</th>
<th>Conventional 12 %-vol. SO₂</th>
<th>LUREC™</th>
<th>LUREC™/HEROS™</th>
<th>LUREC™/HEROS+™</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas flow to converter [Nm³/h]</td>
<td>330,000</td>
<td>220,000</td>
<td>220,000</td>
<td>220,000</td>
</tr>
<tr>
<td>Power Consumption [kWh/t]</td>
<td>55</td>
<td>43</td>
<td>45</td>
<td>46</td>
</tr>
<tr>
<td>Power Generation [kWh/t]</td>
<td>53</td>
<td>68</td>
<td>119</td>
<td>137</td>
</tr>
<tr>
<td>Net Power Export [MW]</td>
<td>-</td>
<td>4.5</td>
<td>13.1</td>
<td>16.1</td>
</tr>
<tr>
<td>Cooling Water [m³/t]</td>
<td>37</td>
<td>29</td>
<td>26</td>
<td>25</td>
</tr>
<tr>
<td>Emissions [%] (250 ppm)</td>
<td>100</td>
<td>75</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td>Plant Cost LSTK [%]</td>
<td>100</td>
<td>85</td>
<td>105</td>
<td>115</td>
</tr>
<tr>
<td>Sulphuric Acid cost [%]</td>
<td>100</td>
<td>~50</td>
<td>~35</td>
<td>~30</td>
</tr>
</tbody>
</table>
• Why and how maximizing power generation?
  • Gas phase: LUREC™
  • Acid circuit: HEROS/HEROS+™

• Case Study
  • Case Study I: Reference plant of HEROS™
  • Case Study II: HEROS™ together with LUREC™ technology

• Adding digitalization
  • Motivation and value
  • PORS expert system
Case Study: Maximized Heat Recovery in metallurgical acid plant

- Potential for heat recovery linked to $\text{SO}_2$ content
- Variety of heat recovery technologies available

**Efficiency vs operational availability & operational window**

- **Task:** Give better overview of plant operation.
- **Solution:** Automated interpretation of operating process data.
Digitalization

“Value derived from usage of digital data for improvements”
Digitalization

“Value derived from usage of digital data for improvements”
“Value derived from usage of digital data for improvements”
Outotec PORS-System
Functional principle

PORS

Operational Data

Process know-how

Awareness of key operational trend / upset

Plant Operability Reliability and Safety System
Outotec PORS-System
User Interface

- Simple & fail prove interface
- No need for interaction
- Additional information is available in deeper layers
Outotec PORS-System
Example: Acid cooler module

Sulphuric Acid Plant

Absorption

Acid Cooling

Acid Cooler 1

Area

System

Sub-System

Signals

Temp. Water in
Temp. Water out
Temp. Acid in
Temp. Acid out
pH Water out
Flow Water
Flow Acid
Outotec PORS-System
Example: Acid cooler

Outotec

PORS
OK

Sulphuric Acid

Q(Acid)

pH Trend

Cooling Water

Q(Water)

Acid Cooler 1

Q(Acid Expected)

Plant load

Not Equal

Check Acid Cooler 1 for leaks

Equal

PORS
OK

PORS
ALARM

Q(Cooler)
Outotec PORS-System
Example: Acid cooler

• Trend analysis

• Trends are checked for realistic values

• Deviations cause alarms with indications for operators
Outotec PORS-System
Live Demonstration

• Acid cooler module

• Based on real life plant data

• PORS deep layer view

• Acid leak scenario with
  • Falling pH value
  • Detection by heat quantity comparison
Outotec PORS-System Demonstration
Summary

Efficient Technology

Digitalization
Summary

Efficient Technology

Digitalization

Safety

€ / t

H₂SO₄
HEROS™ retrofit in metallurgical plant

LP-steam production with Outotec's HEROS™ system in a 1000 t/d acid plant

Two unplanned shut-downs due to pump failure and leaking valve

Passivation: Relative Cr and Ni content

Maximizing Power Generation – Acid Circuits
LP steam production aspects

- Operational scenario changes:
  - Acid temperature >200°C
  - Operational window reduced
  - Continuous steam production – usage?
  - Instrumentation and control
  - Skilled operators
  - Corrosion: impurities to be avoided

- Production rate depending on SO₂ strength and gas temperature

- Careful evaluation on risk mitigation, operator support in planning and design of heat recovery systems.

Maximizing Power Generation – Acid Circuits

27.11.2014
Outotec Expert View
Digitalization in acid plants

• With process plants increasing in complexity there is a need for a better plant overview
• Plant equipment failure can and will happen, possibly resulting in severe damage and extended downtime
• This situation is exacerbated by today’s lack of skilled operations and maintenance resources
• Clearly no system can make up for good operating and maintenance practices
• However there is a need for a simple method of interpreting operating process data
• Understanding the consequences of potential equipment failures
• This has led Outotec to developing an expert system:

• PORS – Plant Operability Reliability and Safety System
• Why and how maximizing power generation?
  • Gas phase: LURECTM
  • Acid circuit: HEROSTM/HEROSTM+

• Case Study
  • Case Study I: Reference plant of HEROSTM
  • Case Study II: HEROSTM together with LURECTM technology

• Adding digitalization
  • Motivation and value
  • PORS expert system