Petrobras using Topsøe SNOX™ sulphuric acid technology for flue and sour gas treatment in the new RNEST oil refinery in Pernambuco, Brazil.

COBRAS 2013, Brazil. Rodrigo Lavich, Petrobras and Torben Christensen, Haldor Topsøe
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Presentation - main contents

- Introduction to the SNOX™ technology / similar WSA
- The SNOX™ process for treating SO₂ gases
- The Petrobras integrated solution
- Why PETROBRAS chose a technology like SNOX™
- SNOX™ environmental performance and the Brazilian regulation
- Sulphuric acid in Petrobras
- SNOX™ contribution to the energy balance in the refinery
- Pictures from installation at site
SNOX™ technology - “the concept”

- Converts SO₂ in flue gases into commercial-grade sulphuric acid
- Reduces NOx in flue gases into harmless N₂
- No consumption of chemicals or other additives
- No production of waste products
- Simple, efficient and reliable SO₂ and NOx treatment process
- Increases power plant thermal efficiency by additional energy recovery
Why SNOX™?

More Sulphur in crude oil

Less Sulphur in refined products

What to do with the sulphurous refinery residues?

Clean the flue gas in a SNOX™ plant

Burn them to produce steam and power

Clean flue gas

Sulphuric acid

Energy recovery

Steam

Power

Other sulphurous waste streams

High SO₂ flue gas

Sulphuric acid

Clean flue gas

Energy recovery

Steam

Power
SNOX™ for combustion of petcoke and heavy residue oil in boilers

*) Troublesome compounds in conventional FGD

Combustion of petcoke or residual oil

Cleaned gas

Sulphuric acid

Dry dust

O₂
N₂
CO₂
H₂O
SO₂
SO₃*
NOₓ
VOC
C
V₂O₅*
NiO*
**SNOX™ – flow diagram**

Reaction:
\[ \text{H}_2\text{SO}_4(\text{g}) \rightarrow \text{H}_2\text{SO}_4(\text{liq}) \]

Clean flue gas to stack

**SO\textsubscript{2} < 200 \text{mg/Nm}^3**
**NO\textsubscript{x} < 75 \text{mg/Nm}^3**
**Dust < 2 \text{mg/Nm}^3**

**Steam turbine/generator**

Steam to process plants

**Cooling air blower**
**Cooling air**

**Steam turbine/generator**

Steam to process plants

**Flue gas**
**ESP**

**Flue gas blower**

**Heat exchanger**

**SO\textsubscript{2} converter**

**SO\textsubscript{2} + 0.5 \text{O}_2 \rightarrow \text{SO}_3**

**Ammonia or SWS gas**

**Heat exchanger**

**Clean flue gas to stack**

**Reaction:**
\[ \text{SO}_3 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_4(\text{g}) \]

**SO\textsubscript{2} converter**

**Ammonia or SWS gas**

**Heat exchanger**

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**SO\textsubscript{2} converter**

**Ammonia or SWS gas**

**Heat exchanger**

**Clean flue gas to stack**

**Reaction:**
\[ \text{NO} + \text{NH}_3 + 0.25 \text{O}_2 \rightarrow \text{N}_2 + 1.5 \text{H}_2\text{O} \]
The advantages of taking refinery waste gases (H$_2$S and SWS) to SNOX™ plant

- Reduced requirement for fuel gas
- Smaller or no Claus plant required
- Direct production of more valuable product
- No problems with high content of NH$_3$ in SWS gas
- No problems with fluctuating hydrocarbons content in SWS gas
- Direct utilization of heat from H$_2$S gas and SWS gas for HP steam generation
- Limited CO$_2$ emission as there is no gypsum formation
- Better fuel economy in boiler
SNOX™ references

- **NEFO, Aalborg, Denmark** (1991)
  Coal-fired 300 MW power plant

- **Ohio Edison, Niles, Ohio, USA** (1991)
  Coal-fired 35 MW demonstration project

- **Raffineria di Gela, Sicily, Italy** (1999)
  Petcoke-fired 300 MW steam and power plant

- **OMV Refinery, Schwechat, Austria** (2007)
  Residual oil-fired steam and power plant
  SNOX™ also treats Claus tail gas

- **Petrobras RNEST Refinery, Brazil** (2014)
  Residual oil/petcoke fired steam and power plant.
  2 SNOX™ plants also treat Claus tail gas, H₂S gas, SWS gas and other sulphur-containing waste streams

- **125 WSA plants, same as SNOX, not for power prod.**
Petrobras RNEST SNOX™ configuration

- Petcoke
- Heavy fuel oil
- SWS gas (4 units)
- H₂S gas (4 units)

BOILERS (3)

- Flue gas
- Steam
- Power

CLAUSS (2)

- Tail gas
- Elemental sulphur

SNOX™ (2)

- Superheated HP Steam
- Sulphuric acid
Petrobras RNEST SNOX™ – birds view
Petrobras RNEST SNOX™ – birds view
Why PETROBRAS chose a technology like SNOX™

- Avoid lime stone and gypsum in the refinery
  - Infrastructure, storage
  - Avoid dust and CO₂ emission
- Limited water consumption
- Handling of other sulphur waste streams
  - H₂S and SWS gas
  - Claus tail gas
- Energy efficiency
  - Recycle of hot, preheated air to the boilers
  - Production of medium pressure steam
SNOX Treatment Performance compared to Brazilian Legislation for Atmospheric Emissions

- CONAMA requirements and SNOX performance guarantees:

<table>
<thead>
<tr>
<th>CONAMA 382</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Oil Boilers (&gt;70MW)</strong></td>
<td><strong>Ammonia Converter</strong></td>
</tr>
<tr>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>1800</td>
<td>-</td>
</tr>
<tr>
<td>1000</td>
<td>-</td>
</tr>
<tr>
<td>-</td>
<td>720</td>
</tr>
<tr>
<td>-</td>
<td>98</td>
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Sulphuric Acid Handling Facilities

- Three tanks of 7,000 m³;
- Ship Loading (70% of the acid production);
- Truck Loading Station;
- Stainless Steel Pipeline;
- Pump Station.

- Approx. 80% of total sulfur is recovered from crude oil as $\text{H}_2\text{SO}_4$ (700MTPD)
SNOX Contribution for Refinery Energy Saving

<table>
<thead>
<tr>
<th>Energy Balance - Utility (MWe)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Production</strong></td>
<td></td>
</tr>
<tr>
<td>MP Steam</td>
<td>+6.7</td>
</tr>
<tr>
<td>Hot Air</td>
<td>+10.4</td>
</tr>
<tr>
<td><strong>Consumption</strong></td>
<td></td>
</tr>
<tr>
<td>Fuel Gas</td>
<td>-1.3</td>
</tr>
<tr>
<td>Electricity</td>
<td>-5.5</td>
</tr>
<tr>
<td><strong>Balance</strong></td>
<td>+10.3</td>
</tr>
</tbody>
</table>

- Positive net balance of 10.3 MWe
- 3% of fuel oil consumed by the power plant
- Contribution energy efficiency index.
Assembly and construction figures

- Piping: 698 t
- Steel Structure: 3.166 t
- Concrete: 7.204 m³
Pictures
Boilers, SNOX and Sulphur Block - Overview
Sulphur Block - Overview
Boilers - Overview
SNOX Overview
SNOX – ESP front view
SNOX – ESP side view
SNOX – Gas/Gas H.Ex.
SNOX - Reactor (base)
Combustor 2 and Structure for Steam System
SNOX - WSA Condenser
SNOX - Stack (external wall)
SNOX – Stack View – Plume Directions
Questions

- Thank you for your attention.

- Any questions?