Efficiently reducing SO$_2$ emissions on a smaller plot: A case study of MECS® DynaWave® technology at CPC Corporation, Taiwan

May 7-11, 2018

Galveston, TX, USA

Curt Hassler & Yves Herssens
Increasingly stringent SO$_2$ emission regulations

USA SO$_2$ NAAQs

<table>
<thead>
<tr>
<th>Year</th>
<th>1 hr</th>
<th>3 hr</th>
<th>24 hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>1971</td>
<td>600</td>
<td>500</td>
<td>100</td>
</tr>
<tr>
<td>2010</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

WHO SO$_2$ Air Quality Guidelines

<table>
<thead>
<tr>
<th>Guideline</th>
<th>1990</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interim Target 1</td>
<td>140</td>
<td>20</td>
</tr>
<tr>
<td>Interim Target 2</td>
<td>60</td>
<td>40</td>
</tr>
<tr>
<td>Air Quality Guideline</td>
<td>20</td>
<td>2</td>
</tr>
</tbody>
</table>

World Bank Standards aim to match WHO Guidelines

SO$_2$ Air Quality, 1990 - 2015

National Trend based on 140 Sites

1990 to 2015: 81% decrease in National Average
Increasingly stringent SO$_2$ emission regulations

- Government regulations
- World Bank Standards
- Company Policies and Objectives
  - Change Company to Company
- Local Considerations
  - Local Governments
  - Plant Location
  - Public Pressure

Regardless of which drivers are in control for a given installation, the trend for all such drivers seems to be increasingly stringent.
Typical approach to reach SRU emission targets

We will have our SRUs comply but.....

- Minimize CAPEX
- Minimize Maintenance Cost
- Minimize Operator Involvement
- Highest Reliability

Cost of ownership = Purchase + Cost of running + Cost of not running
Typical approach to reach SRU emission targets

Claus process: 96-98% of S recovered

<table>
<thead>
<tr>
<th>Traditional Method:</th>
<th>Case Study Method:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amine Based TGTU → 99.9+% of S recovered</td>
<td>Installation of a highly flexible Reverse Jet scrubber</td>
</tr>
<tr>
<td>Reliability - emergency shutdowns and startups? Malfunctioning?</td>
<td>→ Increase reliability / on-stream time</td>
</tr>
<tr>
<td></td>
<td>→ Further Minimize CAPEX</td>
</tr>
<tr>
<td></td>
<td>→ Minimize Maintenance Cost</td>
</tr>
<tr>
<td></td>
<td>→ Minimize Operator Involvement</td>
</tr>
<tr>
<td></td>
<td>→ Reduce plot space</td>
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</tbody>
</table>
CPC Corporation

- Large Taiwanese state-owned refining corporation
- 3 refineries in Taiwan, which had a combined capacity in 2015 of 720,000 bpd:
  - Kaohsiung Refinery – closed end 2015, for environmental reasons.
  - Taoyuan Refinery
  - Talin Refinery
CPC Talin Refinery

- Located in Kaohsiung, Taiwan
- Main products: gasoline and diesel
- Increasing capacity from 300,000 bpsd to 350,000 bpsd
- Total sulfur production capacity of 780 MTPD
  - 3 three-stages Claus Units, 4 trains
  - 1 two-stages Claus Unit (SRU #10), 2 trains
- Improved SO\textsubscript{2} removal reliability on SRU #10 simultaneously with capacity increase.
A highly flexible Reverse Jet scrubber

Whatever you do upstream,

at the end, you want to …

Avoid having the mosquito enter your home.

Avoid having the SO$_2$ enter the atmosphere.
A highly flexible Reverse Jet scrubber

Whatever you do upstream, at the end, you want to ...

Avoid having the SO₂ enter the atmosphere.
A highly flexible Reverse Jet scrubber

The challenges of an SRU/TGTU scrubbing solution:

- Guarantee low SO₂ emissions at all times (no lost production and low CAPEX)
  - Ability to handle a wide range of inlet SO₂ loadings
  - A high turndown required
  - Reliability and proven experience

This opens extra opportunities:

- Potentially save on stack height.
- Operate a more cost-effective SRU/TGTU process, as final SO₂ is captured anyhow before emitting to the stack.
DynaWave® Technology at CPC

A little background on the technology

- Developed by DuPont in the 1970s for TiO$_2$

- Used extensively in harsh environments
  - MECS sulfuric acid plants
  - Incineration tail gas treatment

- Installed and proven experience
  - Over 400 DynaWave installations globally
  - ~ 200 Refinery scrubbing references by Dupont Clean Technologies, including several at CPC in the last 10 years.
DynaWave® Technology at CPC

- Custom designed for CPC, based on specific design inlet conditions
- DynaWave technology allows to combine functions all in one vessel:
  - Quench the gas from the WHB
  - Eliminate particulates
  - SO$_2$ to <30ppmv (d)
  - SO$_3$ to <30ppmv (w)
- Additional plume suppression system for visual optimization.
DynaWave® Technology at CPC

DynaWave® Reverse Jet Scrubber

Dirty Gas In
Clean Gas Out

Path of Gas
Froth Zone
Reverse Jet Nozzle

Chevron/Mesh Pad
Path of Wet Gas
Path of Liquid

Reagent
Effluent

Pump
Make-up
Oxidation Air

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DynaWave® Technology at CPC
DynaWave® Technology at CPC

Inlet Barrel

Process Gas Inlet

Clean Gas Outlet

Brink® Mist Eliminators (Optional)

Droplet Separator Distributor

Packing (Optional)

In-Situ Oxidation

Liquid Level

Circulation Pumps

Large Bore Reverse Jet Nozzle

DuPont Clean Technologies
Benefits noted at CPC Talin Refinery

SO$_2$ emission reduction in **normal operation mode** - above expectations:

- Before DynaWave was installed: 1000 ppmv
- Guaranteed by DynaWave: < 30 ppmv
- Achieved by DynaWave:
  - Train 1: 9.15 ppmv
  - Train 2: 0.23 ppmv

In **bypass operation mode**:

- Before: 7000/8000 ppmv
- After: < 10 ppmv
Benefits noted at CPC Talin Refinery

DynaWave has allowed CPC to operate a more cost-effective TGTU process.

→ Fewer pieces of equipment needed, resulted in a **smaller overall footprint** and significantly less complexity(*).

→ Overall, CPC estimates a **30% TIC savings**(*).

(*) compared to a traditional amine based TGTU.

**Additional reliability**, compared to a traditional amine based TGTU only.
Little operator attention required:

- **Very easy** system to operate
- **Maintenance free** system (unpluggable nozzles)

Guaranteed **SO₂** emission reduction in the same process

No visible plume from the stack
Ending remarks

- Increased reliability: 24/7 low SO$_x$ emissions
- Significant CAPEX savings
- Minimal operator attention
- Smaller footprint
- No visible plume, which is appreciated by the surrounding community.
« If we have the opportunity to use the DynaWave® scrubber technology for other SRU plants in the company’s refining complexes, we will recommend it »

Mr Jinn-Kuen Lu, head of technical service sub-section at CPC