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

2-6 October, 2017
Budapest Hungary
Yves Herssens
Increasingly stringent SO₂ emission regulations
Increasingly stringent SO$_2$ emission regulations

USA SO$_2$ NAAQs

SO$_2$ NAAQ (ppb)

- **1 hr**
- **3 hr**
- **24 hr**

- 1971
- 2010
Increasingly stringent SO$_2$ emission regulations

**SO2 Air Quality, 1990 - 2015**

(Annual 99th Percentile of Daily Max 1-Hour Average)

National Trend based on 140 Sites

1990 to 2015: 81% decrease in National Average
Increasingly stringent SO₂ emission regulations

World Bank Standards aim to match WHO Guidelines
Increasingly stringent \( \text{SO}_2 \) 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
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We will have our SRUs comply but we want to:

- 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

Traditional Method:
Amine Based TGTU: 99.9+% of S recovered

Reliability - emergency shutdowns and startups? Malfunctioning?
If your emission reduction process is not 100% reliable you run the risk that one day you will have to:

- **a.** Shutdown the plant during upset conditions
  - Lost production
  - No additional CAPEX

- **b.** Install a stand-by TGTU
  - No lost production
  - Double the CAPEX
Typical approach to reach SRU emission targets

With the installation of a highly flexible Reverse Jet scrubber, a refinery in Asia, was able to:

- Increase the reliability / higher on-stream time
- Further Minimize CAPEX
- Minimize Maintenance Cost
- Minimize Operator Involvement
- Reduce plot space
Presentation of CPC and the Ta-Lin refinery
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
Presentation of CPC and the 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$_2$ removal reliability on SRU #10 simultaneously with capacity increase.
A highly flexible Reverse Jet scrubber
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 \( \text{SO}_2 \) enter the atmosphere.
A highly flexible Reverse Jet scrubber

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

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

The challenges of an SRU/TGTU scrubbing solution:

- Guarantee low SO\textsubscript{2} emissions at all times (no lost production and low CAPEX)
  - Ability to handle a wide range of inlet SO\textsubscript{2} 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 SO\textsubscript{2} is captured anyhow before emitting to the stack.
DynaWave® Technology at CPC
DynaWave® Technology at CPC

A little background on the technology

- Developed by DuPont in the 1970s for TiO₂

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

- Installed and proven experience
  - Over 400 DynaWave installations globally
  - Over 100 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

Diagram showing the process of gas and liquid interaction in a reverse jet scrubber, including components such as Dirty Gas In, Clean Gas Out, Path of Gas, Froth Zone, Reverse Jet Nozzle, Reagent, Path of Wet Gas, Path of Liquid, Make-up, Oxidation Air, and Effluent Pump.
DynaWave® Technology at CPC
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Benefits noted at CPC Talin Refinery
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SO₂ 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.
Benefits noted at CPC Talin Refinery

Little operator attention required:
- Very easy system to operate
- Maintenance free system (unpluggable nozzles)

Guaranteed reduction in SO$_3$ emission in the same process

No visible plume from the stack
Ending remarks
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- Increased reliability: 24/7 low SO\textsubscript{x} emissions
- Significant CAPEX savings
- Minimal operator attention
- Smaller footprint
- No visible plume, which is appreciated by the surrounding community.
Ending remarks

« *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
Ending remarks

SPECIAL THANKS TO:

- Mr Jinn-Kuen Lu, Head of the technical service sub-section, CPC Corporation, Taiwan

- Mr Wei-Chen Ke, No.10 SRU Superintendent at the Ta-Lin refinery of CPC Corporation, Taiwan

- Mr William Lam, Senior Business Development Manager, MECS, Hong Kong