DEBOTTLENECKING METALLURGICAL AND SULPHUR-BURNING SULPHURIC ACID PLANTS: CAPACITY INCREASE AND REDUCTION OF EMISSIONS

Andrés Mahecha-Botero, Ph.D., P.Eng., Process Engineer
C. Guy Cooper, P. Eng., Director Sulfuric Acid
Igor Aksenov, P.Eng., Process Engineer
Kim Nikolaisen, Ph.D., Process Engineer

October 18-22, 2015
Fortaleza, Brasil
NORAM Engineering and Constructors Ltd., Vancouver, Canada
OUTLINE

1. Introduction

2. General Acid Plant Debottlenecking Concepts
   - Unplug the arteries
   - Performance enhancement
   - Energy recovery
   - Emissions reductions

3. Conclusions
NORAM Engineering

- Based in Vancouver
- Founded in 1988
- Approximately 200 employees
- Focus on Technology
- Own BC Research Laboratories
- Own Axton Fabrication Shop
- Own NORAM International AB (Sweden)
- Alliance with Tenova Minerals (formerly Bateman Engineering N.V.)
- Alliance with Turboscrubber (Osprey/FTL)
(2) GENERAL ACID PLANT DEBOTTLENECKING CONCEPTS
Can we just speed up the flow?

Analogy: Unplug the Arteries
Reduction of Pressure Drop

Strategies include the use of:

- **Low pressure drop Catalyst**
  - and larger diameter “dust protection catalyst”

- **Air filter and sulfur filter**

- **Equipment in parallel**
Reduction of Pressure Drop (Cont’d)

Strategies include the use of:

- Radial-Flow Gas Heat Exchangers
Reduction of Pressure Drop (Cont’d)

Strategies include the use of:
- Radial-Flow Gas Heat Exchangers

• Symmetric heat transfer
• Extended life
• Improved heat transfer
• Compact design
• Low pressure drop
• Metal temperature control
• Reduced condensation & fouling
Reduction of Pressure Drop (Cont’d)

Strategies include the use of:

- Radial-Flow Gas Heat Exchangers with Hot Sweep

![Upper Tubes](image1)

Sulfate Fouling In Conventional Cold Exchangers

![Top Tubesheet](image2)

Corrosion of Tubes

![Bottom Tubesheet](image3)
Reduction of Pressure Drop (Cont’d)

Strategies include the use of:

- **Radial-Flow Gas Heat Exchangers with Hot Sweep**

![Diagram showing conventional and hot sweep heat exchangers with temperature levels.]

**Conventional**
- From Bed 3: 450°C, 850°F
- To IPT: 180°C, 350°F
- To Hot Exchanger: 315°C, 600°F

**Hot Sweep to Prevent Sulfate Formation**
- From IPT: 80°C, 175°F
- To IPT: 180°C, 350°F
- To Hot Exchanger: 315°C, 600°F
- T = 510°F = 265°C
Simplot Pocatello New Cold Exchanger with Hot Sweep
Cold Reheat Pressure Drop

JR Simplot Company Don Plant
400 SA Cold Reheat Exchanger Pressure Drop
NORAM Design

Much lower number of tubes
• 2,800 vs. 5,400

Much lower overall weight
• 300,000 lbs vs 500,000 lbs

Shell diameter much smaller
• 16 ft vs. 20 ft

Per the salesman: It will do the same heat transfer as the current unit, won’t scale, won’t corrode, and last twice as long!!
Operation Post Installation

- The 400 Sulfuric acid plant operates on 2 year turnaround cycles.
  - From 2006-2008, no major increase in pressure drop
  - Turnaround inspection only. No planned cleaning!
Reduction of Pressure Drop (Cont’d)

Strategies include the use of:

- **Low Pressure Drop Acid Tower Packing**

Benefits:

- Low Pressure Drop
- Quality Porcelain Ceramic
- Strong, Few Chips

NORAM HP™ Saddle Packing
Reduction of Pressure Drop (Cont’d)

Strategies include the use of:
- Low Pressure Drop Acid Tower Packing.
Reduction of Pressure Drop (Cont’d)

Strategies include the use of:
- Acid distributor above packing
  (vs. Buried pipe distributors and spray catcher packing)
Did we get the arteries unplugged?

Yes → Good

No → Performance enhancement
Increase of SO$_2$ Gas Strength

- Increasing the concentration of SO$_2$ in the process gas is the **most cost-effective way to increase plant capacity**
  
  - **Example:**
    change from 9 to 12 Vol% SO$_2$ = 33% capacity increase
    change from 11 to 12 Vol% SO$_2$ = 9% capacity increase

- **Allows increased production, without significant changes to the main blower**
Increase of SO₂ Gas Strength (Cont’d)
Factors that may limit the maximum SO₂ concentration include:

- Temperature tolerance of the materials of construction
- Maximum temperature from outlet of converter bed #1. (1166°F)
- Formation of NOₓ
- Heat removal capacity
- Catalyst requirements
- O₂ availability (max ~ 12 vol% SO₂ sulfur burning)
- Maximum SO₂ strength from the smelter
Still need more Performance Enhancement? (= more acid production)

Strategies include:

- **Main blower location:** move from “sucker” to “pusher” (ducting only, not blower)
- **Furnace and Waste Heat Boiler Bypass**
- **Booster fan after the Interpass Absorption Tower**
- **Conversion from Double to Single Absorption with Tail gas scrubbing**
Conventional Sulfur Burning System

- Air 150°C (300°F)
- Sulfur 135°C (275°F)
- Furnace 10.75% SO₂
- Waste Heat Boiler
- Hot Jug Valve
- Steam 600 psig 254°C (490°F)
- 1093°C (2000°F)
- To Converter 10.75% SO₂ 420°C (790°F)

NORAM Furnace By-Pass System

- Air 150°C (300°F)
- Sulfur 135°C (275°F)
- Furnace By-pass
- Furnace 12.98% SO₂
- Waste Heat Boiler
- Cold Jug Valve
- Steam 600 psig 254°C (490°F)
- 1260°C (2300°F)
- To Converter 10.75% SO₂ 420°C (790°F)
Energy Improvements and Equipment Upgrades

Strategies include:

- **Main blower location relative to Drying Tower:**
  - “pusher” max steam production due to more acid produced
  - “sucker” max steam per unit of acid produced

- **Dew point analyzer**

- **Rotating equipment upgrades**
  - Blower motor VFD
  - Steam turbine upgrades
    - (steam conditions, jets, gear box, impeller, all new)
Steam System Improvements

Strategies include:

- **Recovery of heat from hot sulfuric acid:**
  - Preheating boiler feed water
  - Production of intermediate pressure steam

- **Heat recovery from boiler blowdown systems**

- **Replacement of SO$_3$ coolers with steam equipment**
Reduction of Emissions of Sulfur Dioxide

Review:

- Loading of the catalytic converter
- Catalyst activity, catalyst type, pressure effect on kinetics
- Design and mechanical conditions of catalytic converter and gas exchangers (gas bypass)
- Dedicated final tower pump tank to eliminate SO$_2$ stripping in Final Absorption Tower
Reduction of Emissions of $\text{SO}_3$ and $\text{H}_2\text{SO}_4$:

Review:

- Design and mechanical conditions of the final absorption tower, incl. acid distributor, tower packing, acid irrigation rates
- Operating conditions of the final absorption tower
- Gas bypassing
Reduction of Sulfuric Acid Mist or Sprays

Review:

- Design and sizing of the mist eliminators
- Mechanical conditions of the mist eliminators
- Add candles or use longer candles if extra space. Or candle-in-candle
- TurboScrubber system
Conclusions

Debottlenecking

- “Unplug arteries”
  - Reduce pressure drop (catalyst, gas-exchangers, packing, mist eliminators)
  - Increase heat exchanger capacity
- “Performance enhancement”
  - Increase SO₂ gas strength
  - Furnace/WHB Bypass
  - “Pusher” vs. “sucker”
  - Booster fan

Emission Reduction

- Catalyst
- Acid tower design
- Gas bypassing
- SO₂ Tail gas scrubbing

Efficiency

- Energy recovery and equipment design
THANK YOU!