REFCOMM
BUENOS AIRES
5-9 November 2018

The Pursuit of Low Emissions

The Development of Catalytic Options for High Sulfur Recovery

November 5-9, 2018

Marco van Son
Technical Manager Sulfur
Jacobs Comprimo® Sulfur Solutions, Calgary, Canada

JACOBS®
Comprimo® Sulfur Solutions
www.jacobs.com | worldwide

Presented to:
REFCOMM, Buenos Aires

Disclaimer

Important

The material in this presentation has been prepared by Jacobs®.

Copyright and other intellectual property rights in this presentation vest exclusively with Jacobs. Apart from any use permitted under applicable copyright legislation, no part of this work may in any form or by any means (electronic, graphic, mechanical, photocopying, recording or otherwise) be reproduced, copied, stored in a retrieval system or transmitted without prior written permission.

Jacobs is a trademark of Jacobs Engineering Group Inc.

© Copyright
September 25, 2018
Jacobs Engineering Group Inc. All rights reserved.

JACOBS
Comprimo® Sulfur Solutions

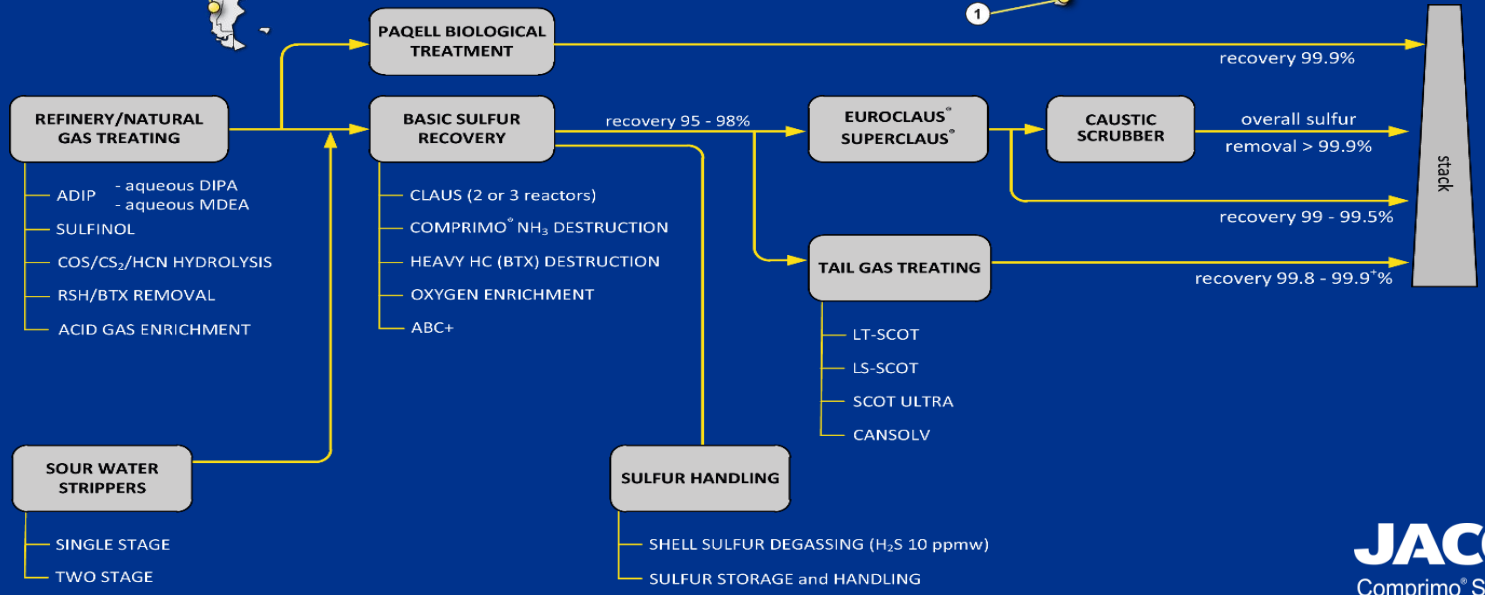
Agenda

- Comprimo® Sulfur Solutions
- SO_2 Regulatory Developments
- Development of Catalytic Sulfur Recovery Technologies
- Solutions and Cost for High Sulfur Recovery Requirements

Jacobs Comprimo® Sulfur Solutions

- A Dutch company Comprimo® in business since 1924
- Since 1959, have licensed, engineered and constructed over 550 gas treating and sulfur recovery plants globally
- Global Licensor Leader in gas treating and sulfur technology
  - Patents (SUPERCLAUS®, EUROCLAUS® and NH_3 Destruction)
  - Licensor for Shell Technologies, including LT-SCOT, LS-SCOT, Sulfur Degassing and Amine Treating Processes (ADIP and Sulfinol)
  - Expertise in Amine Treaters, SWS and Caustic Scrubbers
  - Continually seeking new technologies and third-party relationships
- Jacobs purchased *Comprimo*® (1999) and *Delta Hudson* (2000) and their technology portfolios

Location	#
Americas	95
Europe	165
Middle East	75
Africa	10
Oceania	7
India	20
Far East	65
China	40
FSU + Russia	25
Total	**>500**



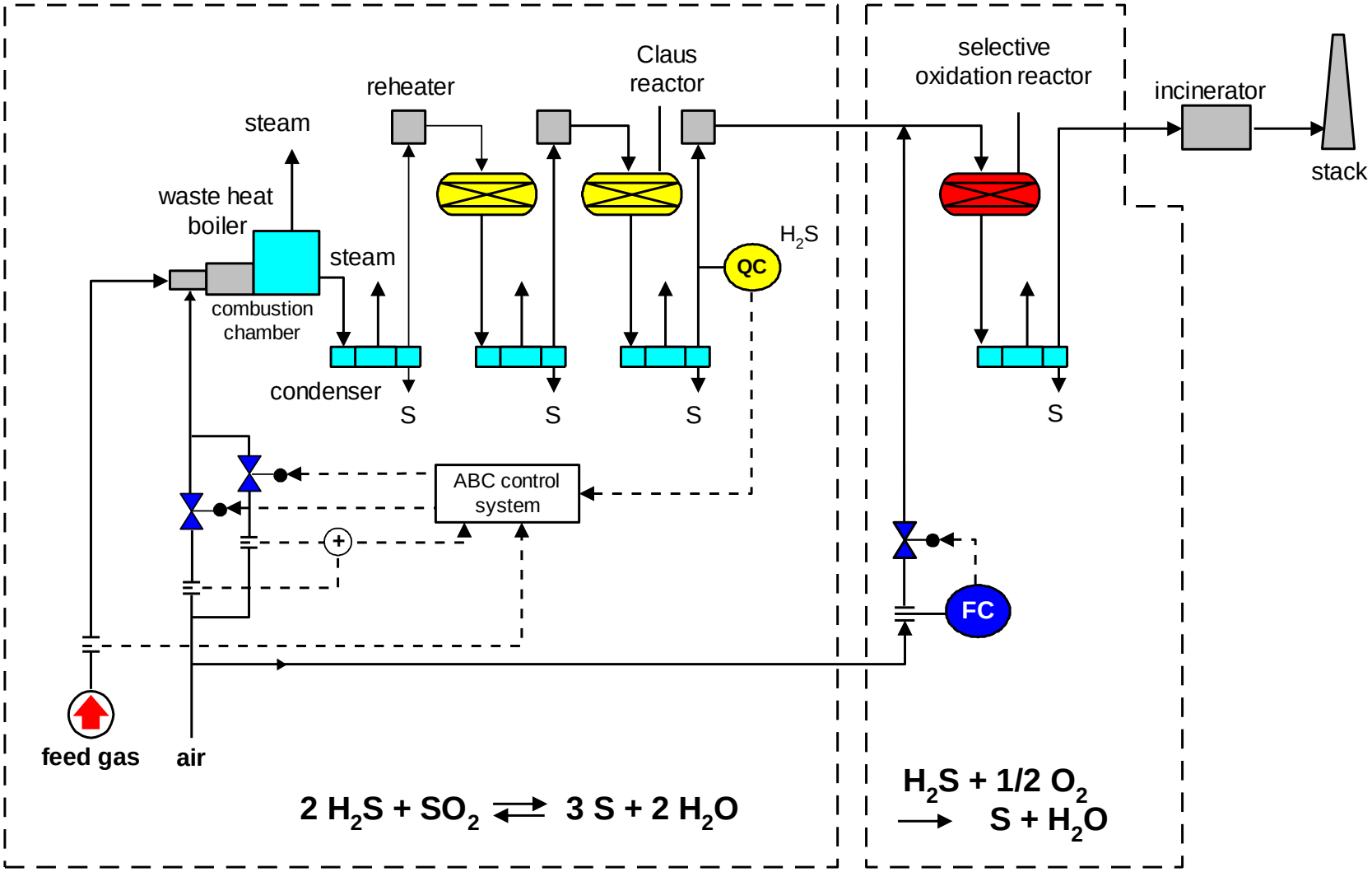
JACOBS®
Comprimo® Sulfur Solutions

Regulatory SO_2 Developments

Three different levels of Sulfur Recovery Efficiency

- <98% : Conventional Claus
  - Typically only for small SRUs
- 98-99.5% : Claus-like Solutions
  - Some European Countries/Canada/Middle East
  - South America
- >99.5% : Tail Gas Treatment Technologies
  - North America/Western Europe/China
- Worldbank Standard for SOx: 150 mg/Nm^3 = 99.9+%
  - Program will be stopped in 2019

Development SUPERCLAUS® Process



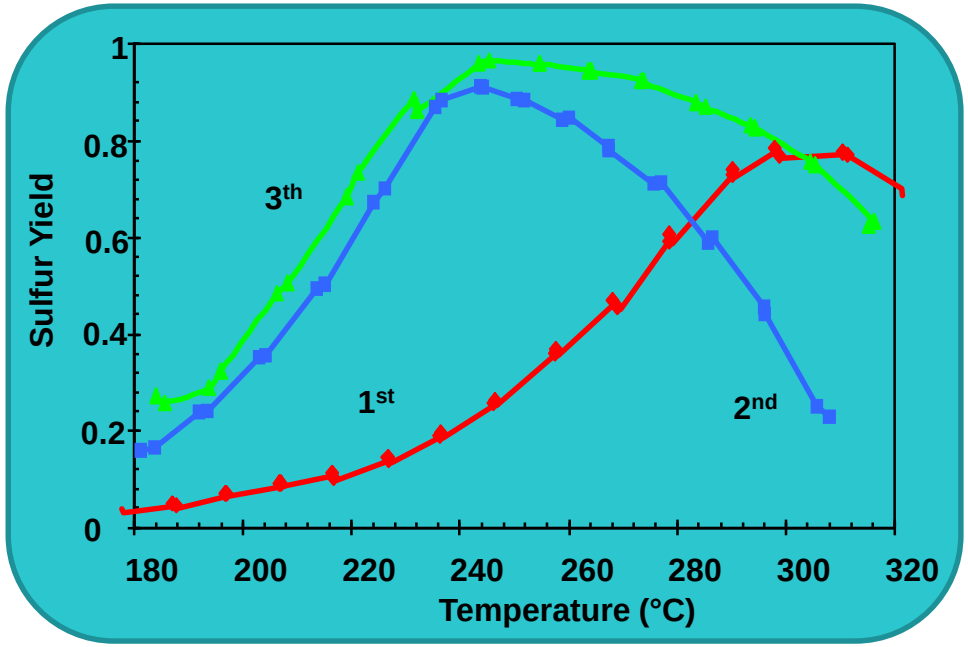
JACOBS
Comprimo® Sulfur Solutions

Characteristics of SUPERCLAUS®

- Claus Type Process
- Sulfur recovery efficiency of more than 99%
- Low energy consumption
- Low investment cost
- No waste streams
- Simple revamp
- Improved Combustion Air Control
  - Advanced Burner Control (ABC)

SUPERCLAUS® Catalyst Characteristics

- More than 85% conversion of H_2S to S
- Limited Sensitivity for excess O_2
- Not sensitive for high H_2O concentrations
- No Claus reaction
- No CO/H_2 oxidation
- No COS/CS_2 formation
- Long lifetime



JACOBS
Comprimo® Sulfur Solutions

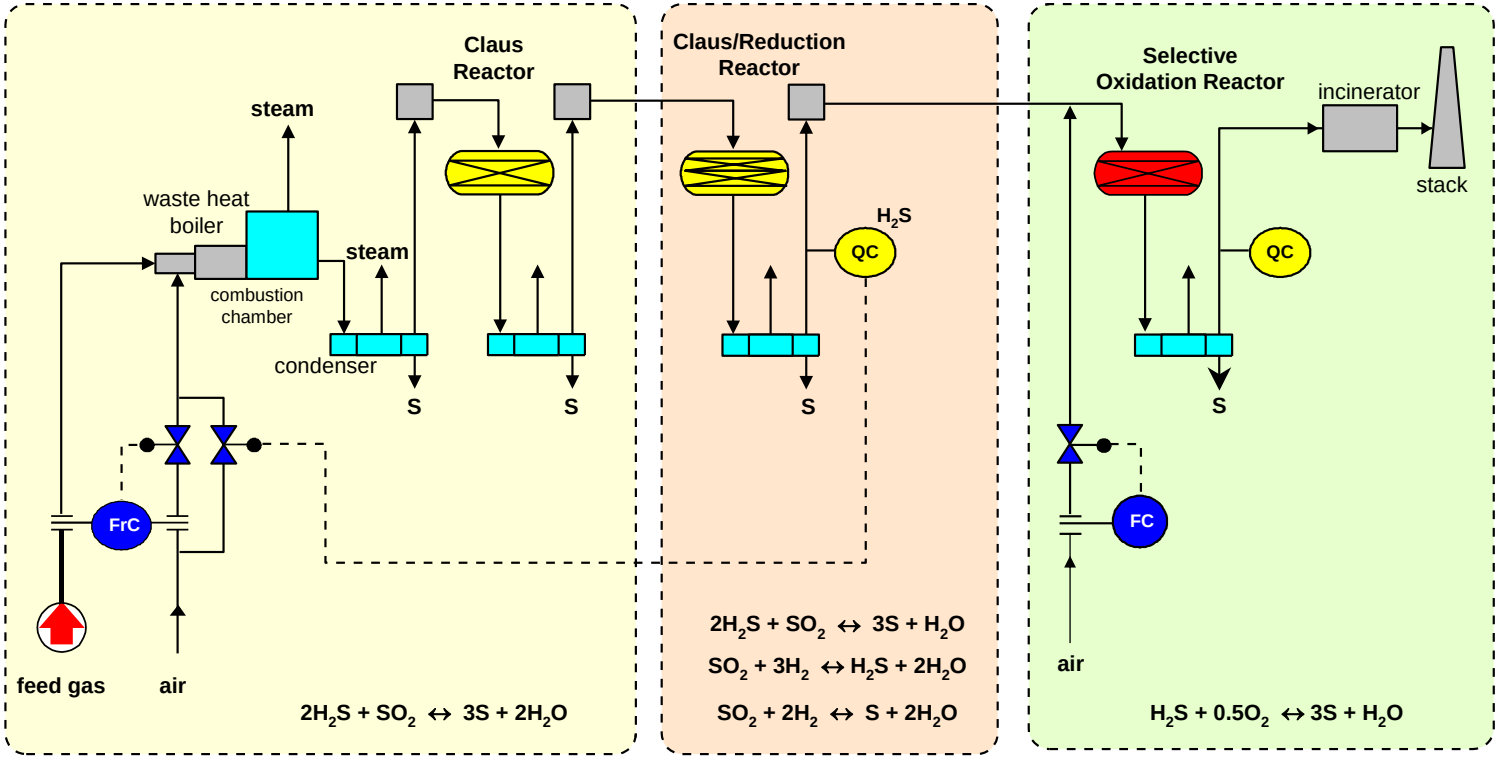
Analysis: Where do the Recovery Losses Occur:

- Formation of COS / CS_2 in the Thermal Reactor
- Slip of SO_2 from final Claus reactor
- Slip of SO_2 from SUPERCLAUS® reactor
- Slip of H_2S from SUPERCLAUS® reactor
- Slip of sulfur vapor/ mist in tail gas
- Process upsets due to varying acid gas quality

The EUROCLAUS® Process

Principles:

- Reduction of SO_2 in process gas from Claus Reactors
- No reduction of Sulfur vapor to H_2S
- Limited COS production in hydrogenation step
- Improved performance Selective Oxidation



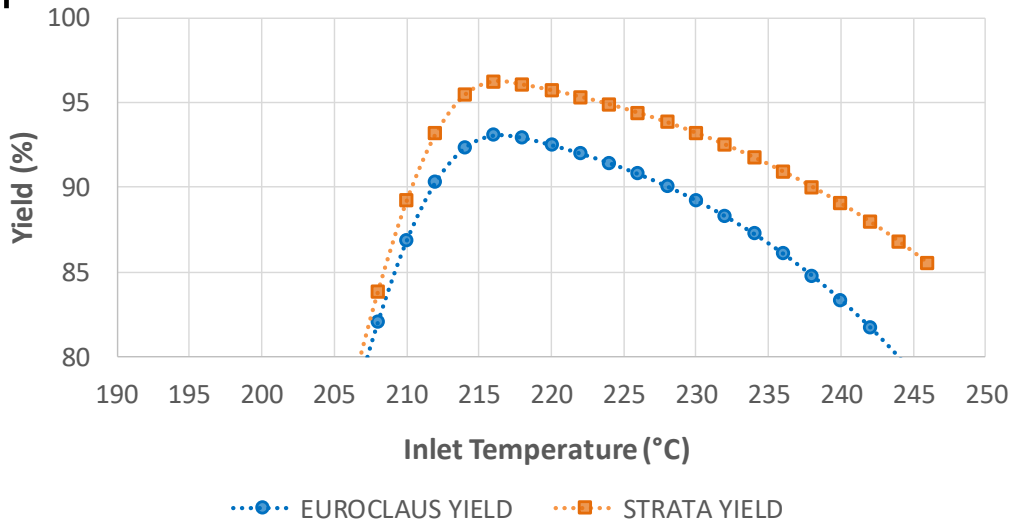
JACOBS
Comprimo® Sulfur Solutions

Targets Further Developments

- High recovery efficiency, ≥ 99.5 %
- Maximum four catalytic stages
- Fully continuous process
- Low investment cost
  - Minimal equipment modifications/additions
- Claus type operation
- No additional chemicals (like H_2) required

The STRATACLAUS™ Process

- Principles:
  - Taking advantage of two layers of catalyst
    - High activity for both layers
    - High activity for lower layer at higher temperatures
  - Improvement of yield of the Selective Oxidation Catalyst
    - Lower SO_2 formation and slip



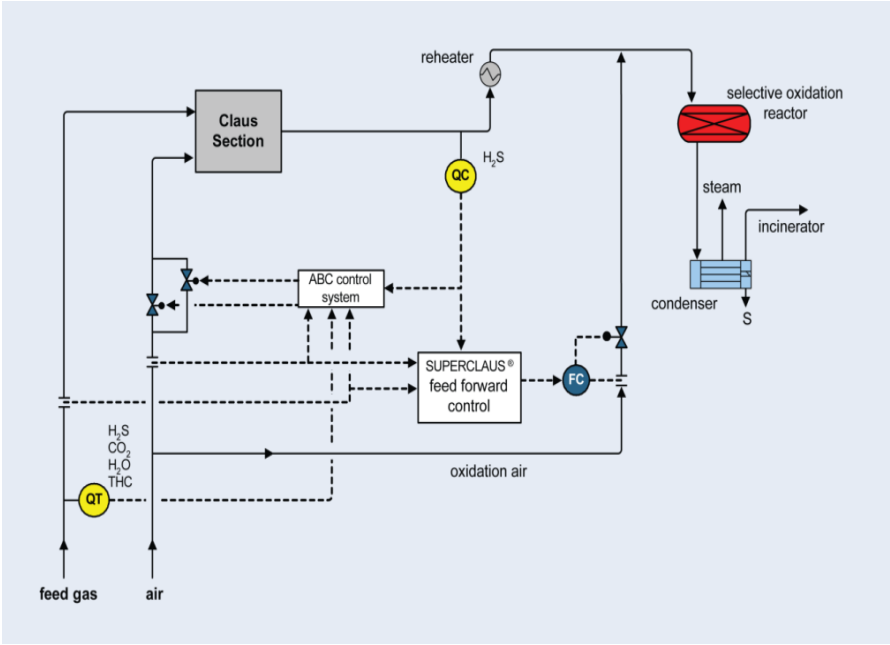
JACOBS
Comprimo® Sulfur Solutions

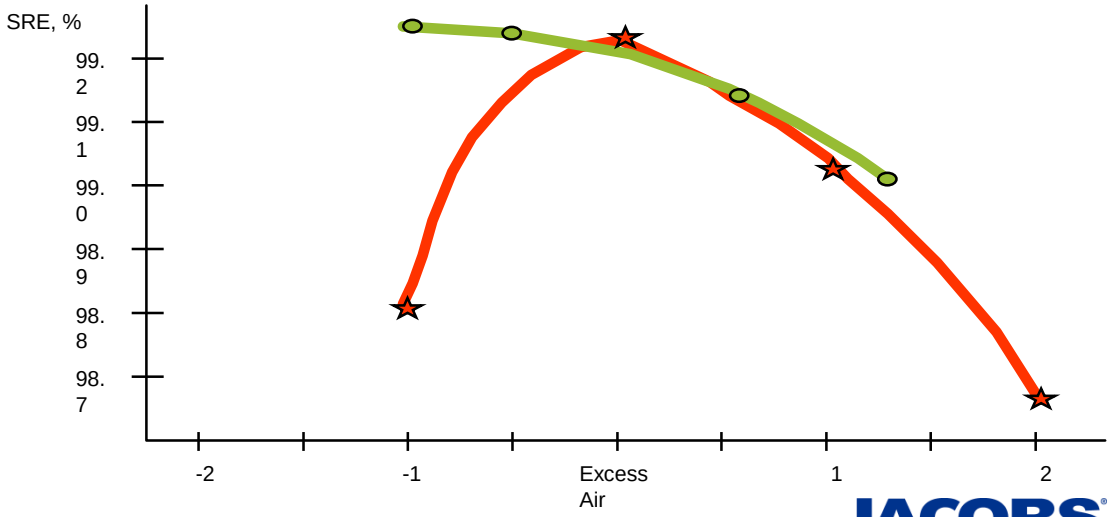
Further Improvements:

- Longer Final Condensers
- Titania in first and second Claus Reactor
- Installation of Oxygen Analyzer in Tail Gas from Selective Oxidation Reactor
- Improvement of sulfur vapour removal from tail gas
- Feed Forward Air Demand Control via ABC+

ABC+ Control Benefits

- Units with fluctuating feed compositions
- Complex refineries with multiple upstream units
- Units with (varying) high concentration of HC components
- Units with varying CO_2 concentrations
- Units with SWS gas
- 10 units designed

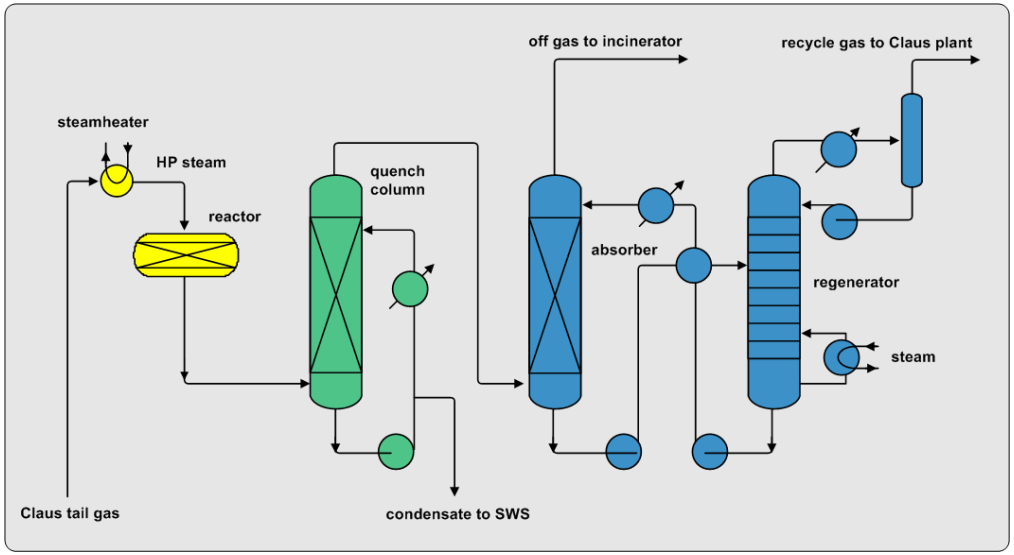




JACOBS
Comprimo® Sulfur Solutions

Deep Sulfur Removal

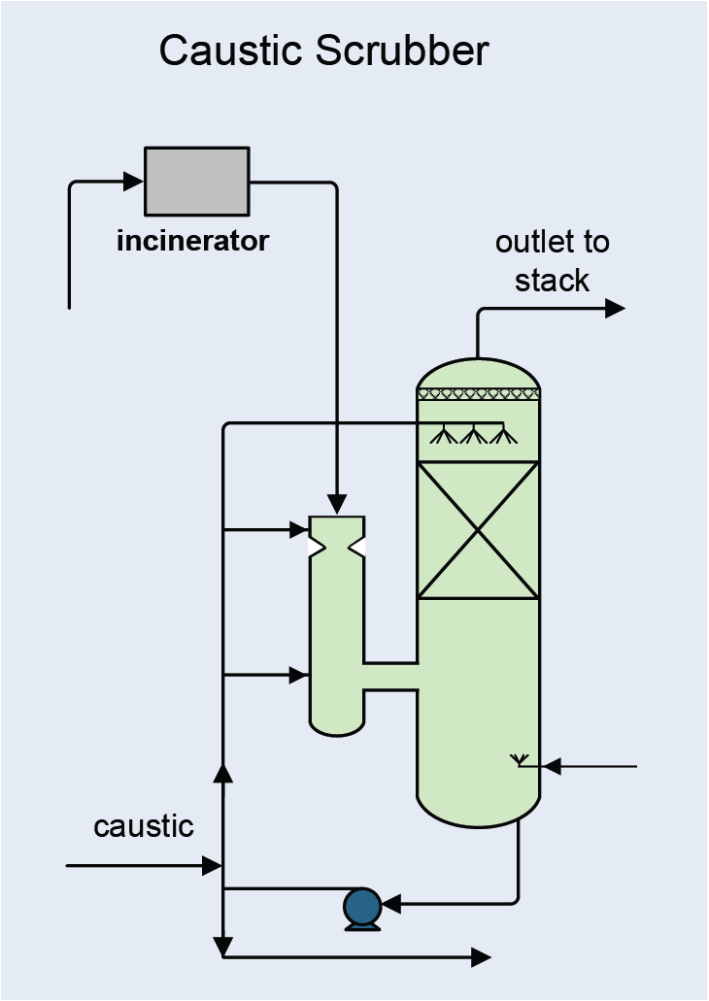
- Industry Standard:
  - Amine Based Tail Gas Treatment Unit (SCOT)
  - Hydrogenation of tail gas and absorption in Amine
  - Recycle of acid gas to Thermal Stage of Claus unit
  - Developments in solvent for improved operation and economics



JACOBS
Comprimo® Sulfur Solutions

Deep Sulfur Removal

- Viable alternative to Amine based TGTU
- Very high sulfur removal, very low sulfur emissions
  (down to 20 ppm SO_2 if required)
- Less capital cost
- Small plot footprint
- Simplified operation

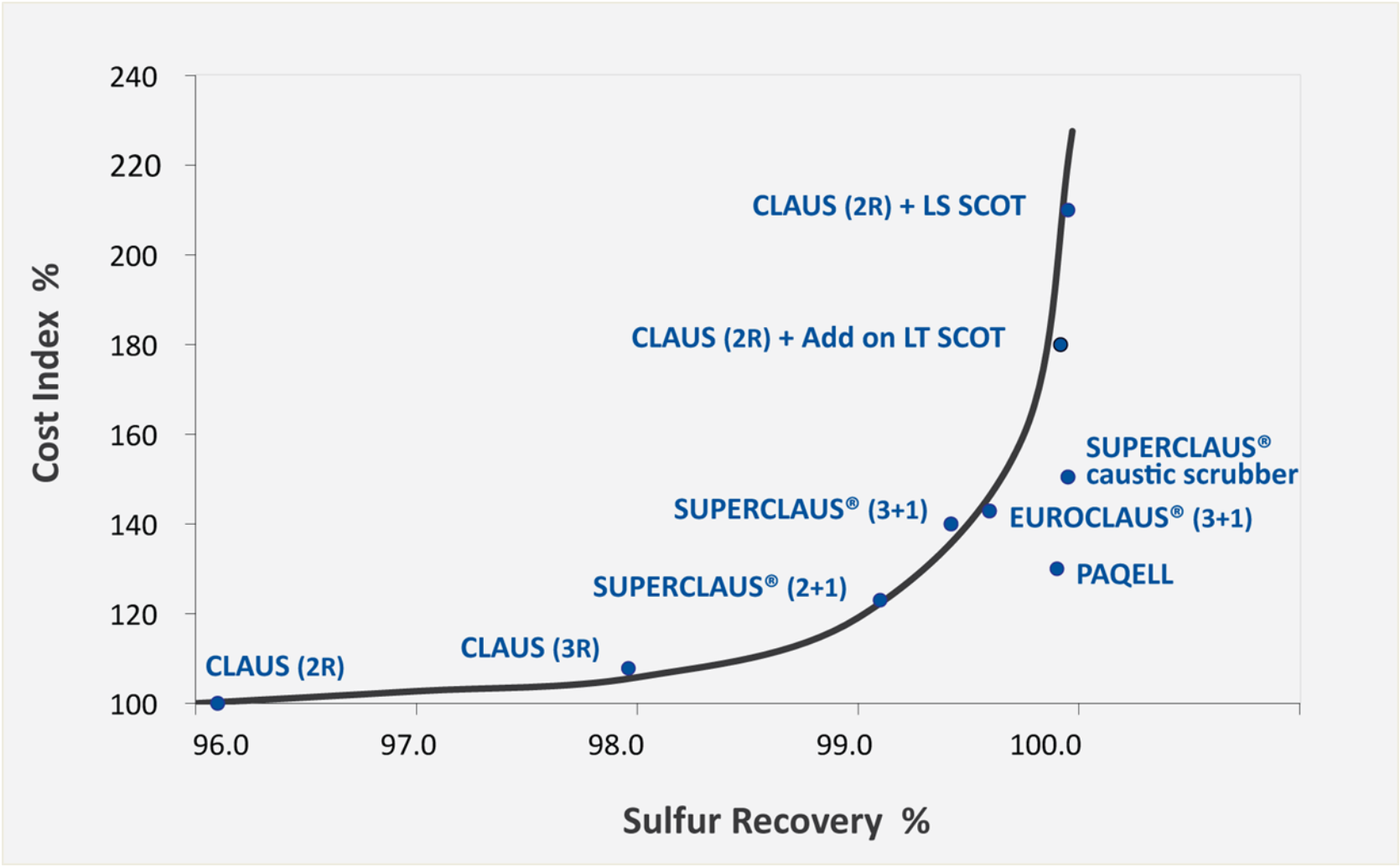


JACOBS
Comprimo® Sulfur Solutions

Summary of Technologies for Sulfur Recovery

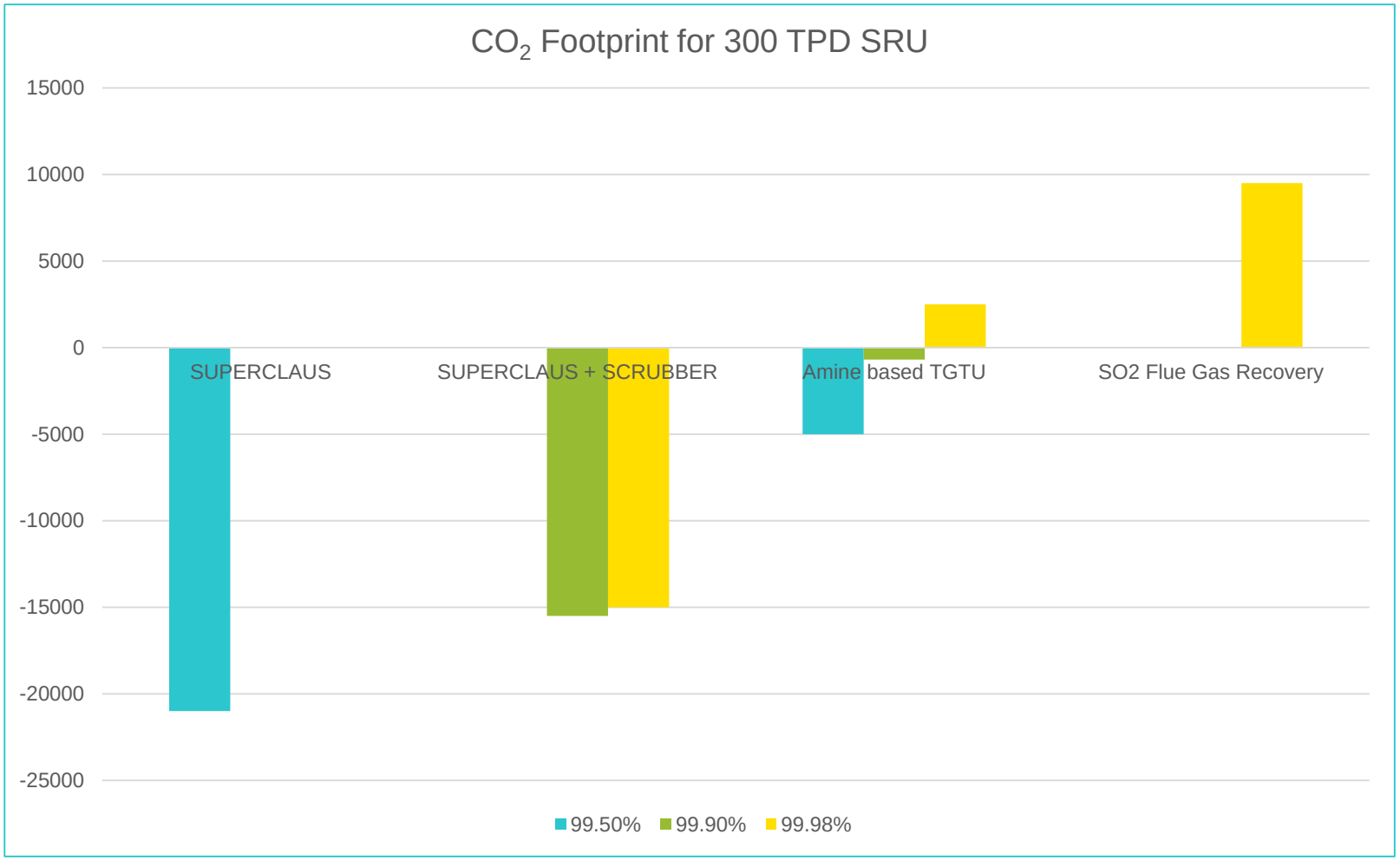
Type of Process	S-recovery
2 Stage Claus	95 – 96.5%
3 Stage Claus	96.5 – 98.0%
2+1 SUPERCLAUS®	98.5 - 99.2%
3+1 SUPERCLAUS®	99.0 - 99.4%
3+1 EUROCLAUS®	99.2 - 99.6%
3+1 STRATACLAUS®	99.3 - 99.7%
Claus + SCOT (TGTU)	99.8 – 99.95%
2+1 SUPERCLAUS® + Caustic Scrubber	99.9 - 99.99%

Cost Comparison



JACOBS
Comprimo® Sulfur Solutions

CO_2 Footprint Comparison



JACOBS
Comprimo® Sulfur Solutions

Conclusions

- Long way from simple Claus technology
- Possible to meet up to 99.5% SRE with catalytic options only
- Above 99.5%, different options are available with wide range of cost and environmental footprint
  - All options shall be evaluated during conceptual to determine optimal solution for Client taking into account capital cost, operating cost, operability and environmental footprint

Contact Information

- Dennis Koscielnuk – Director Comprimo® Sulfur Solutions
  - Dennis.Koscielnuk@Jacobs.com
  - (403) 692 2950
- Marco van Son – Technical Manager Comprimo® Sulfur Solutions
  - Marco.vanson@Jacobs.com
  - (403) 640 8353