fbmhudsonitaliana
Air Coolers - S & T Heat Exchangers - Waste Heat Boilers

KPS TECHNOLOGY & ENGINEERING

Waste Heat Boilers and Sulphur Condensers in the Sulphur Process Industry

Facing the Large Capacity Trend

Gennaro Natali-Sora
Giovanni Manenti
FBM Hudson Italiana SpA

David K. Stevens
Mark Tonjes
KPS Technology & Engineering LLC

Large is awesome…

…and, likely, cost effective.

Presentation Overview

1 **Sulphur Plant Capacity Trends**

2 Design Basis for Realizing SR and SA Waste Heat Boilers and Condensers

3 Conclusions

1.1 General Trend

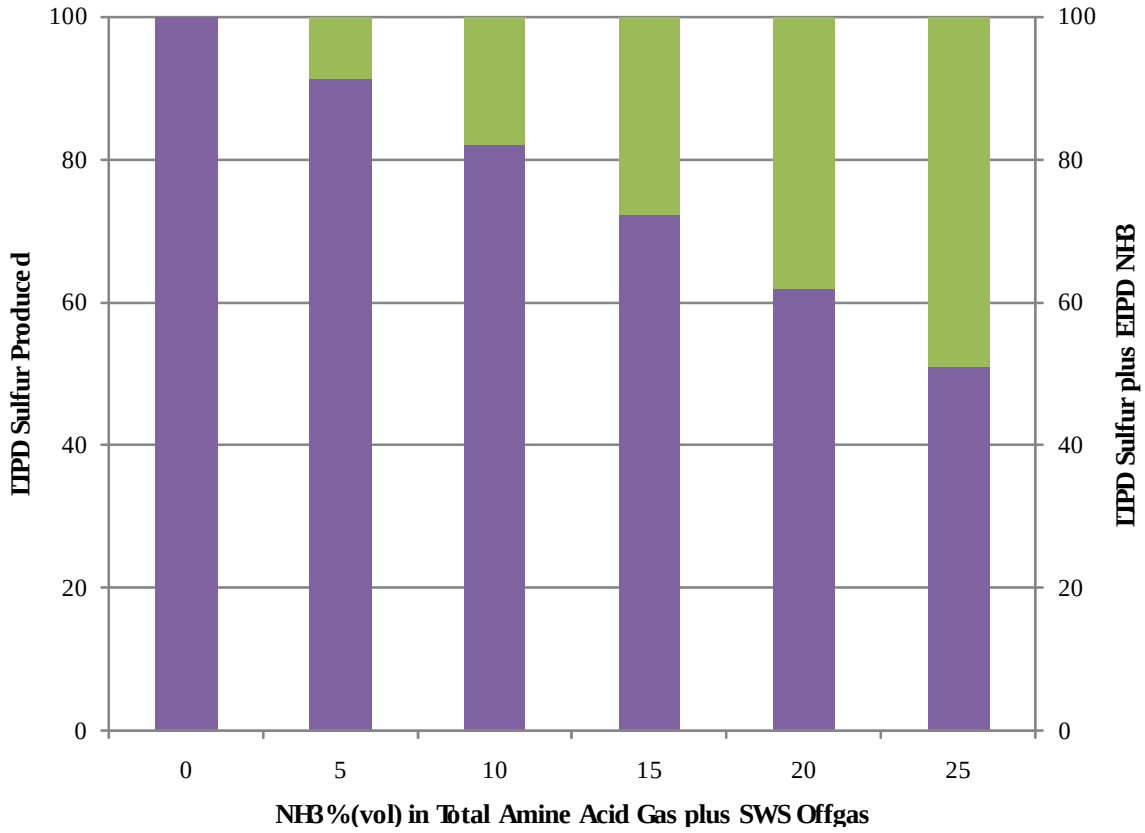
While it is impossible today to predict with certainty the future of Oil&Gas demand and the resultant quantity of the recovered sulfur, it is seen that there is a clear trend of increasing “sourness” of available Oil&Gas reserves and that the resultant size of the sulfur recovery (SR) units is increasing.

Sulphuric acid (SA) plants are not excluded from this rise in dimensions, due to an economy of scale.

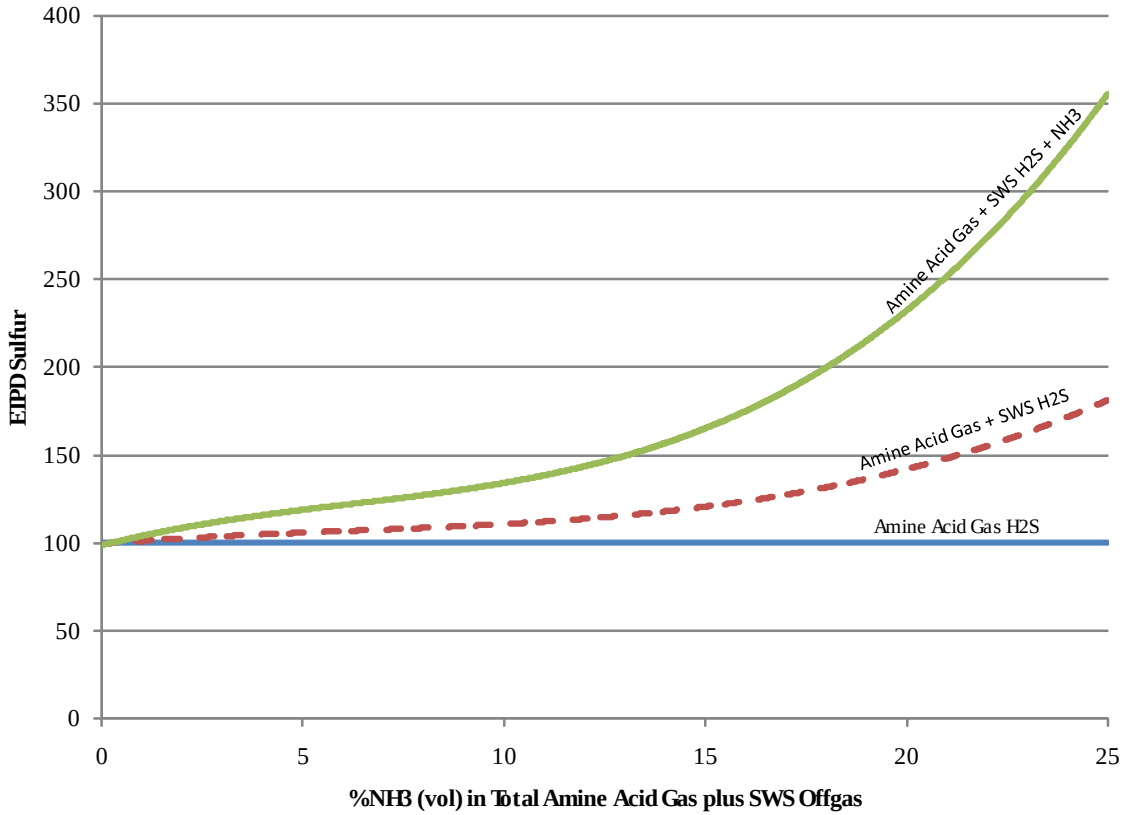
1.2 Plant Capacity Trends

- More sour reserves are being considered
- Sulfur recovery and acid gas injection (AGI) economics and technical limitations of AGI is complex
- Average throughput of new facilities is increasing to take advantage of economies of scale
- Energy and environmental issues boot economy of scale

1.3 Calculated Effect of Processing Sour Water Stripper Offgas on Claus / Tail Gas Capacity at Constant Air Demand



1.4 New Plant Construction – Size Impacts



1.5 Conceptual Thinking About Size & Capacity

- WHB and SC are the most critical items with respect to increase of plant size
- Absolutely minimize the number of equipment (merge 2 items in parallel into a large one)
- Move from two kettles to one large waste heat boiler and steam drum package
- Utilize oxygen enrichment of combustion air to replace the inert nitrogen in air
- Increase the gas operating pressure profile

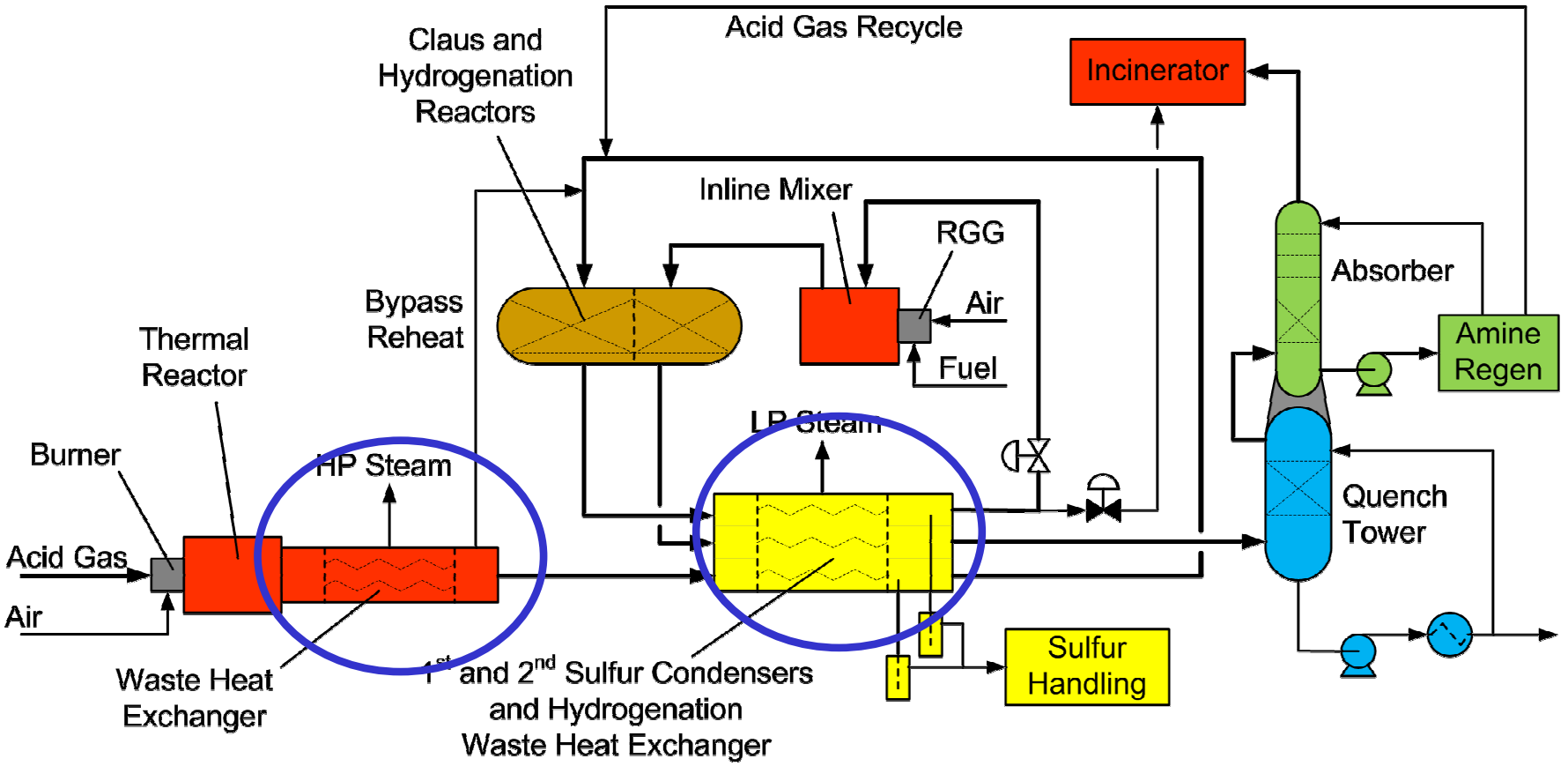
Presentation Overview

1 Sulphur Plant Capacity Trends

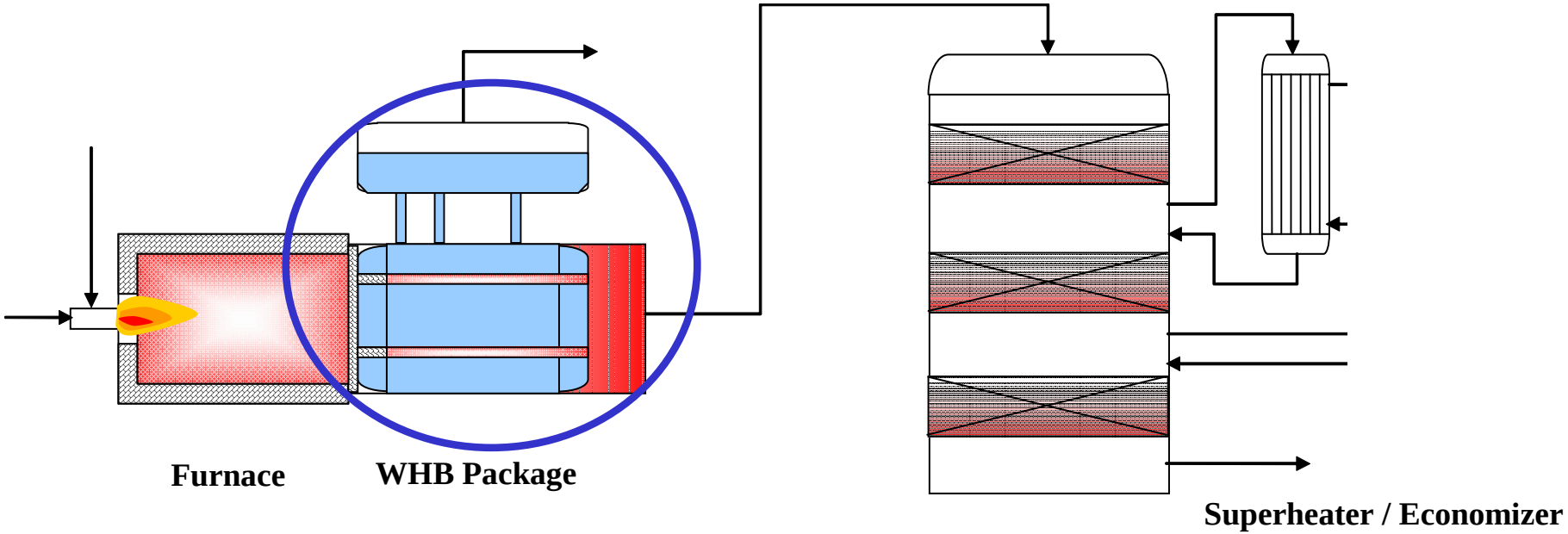
2 **Design Basis for Realizing SR and SA Waste Heat Boilers and Condensers**

3 Conclusions

2.1 Simplified SRU/TGTU Flowsheet



2.2 Simplified SA Flowsheet



2.3 Typical Large WHB Characteristics

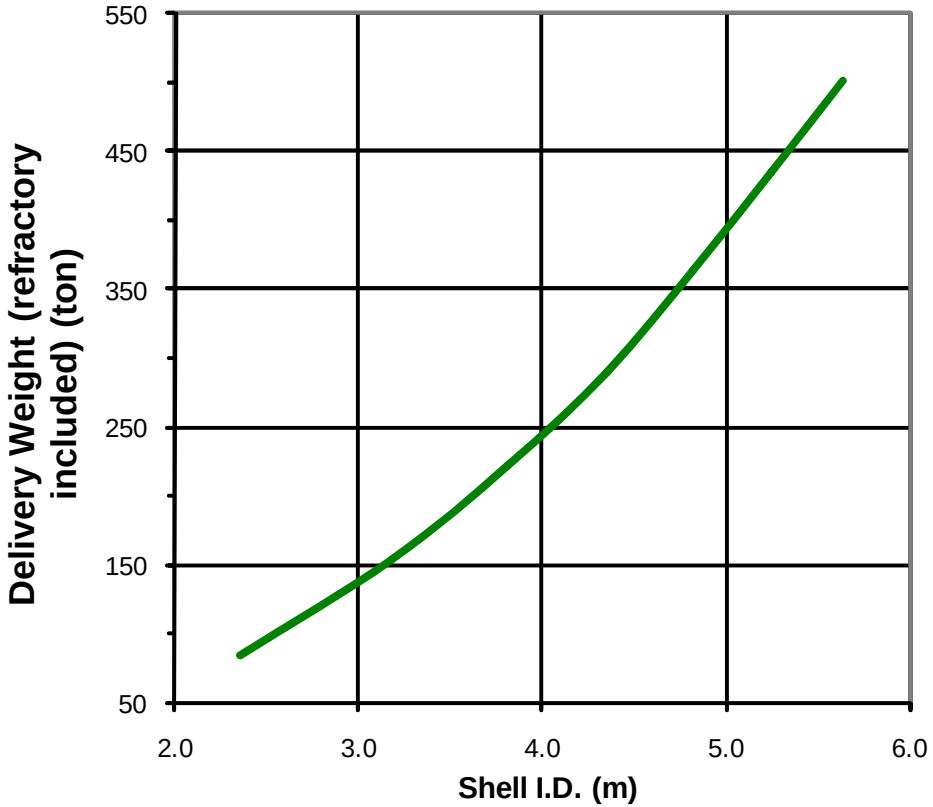
Current projects require SR and SA trains up to 350 t/h (1000 to 2000 tpd S_1) of gas flow-rate and 4000 MTPD of product respectively.

Relevant WHB's typical sizes, with steam at 45 bar(g):

- 450 tons + refractory
- 6000 ID
- 2600 tubes (63,5mm OD x 7500mm L)

5500mm I.D. WHB…

2.4 WHB Weight versus Shell Diameter



2.5 Design Considerations for a Safe Design

- Critical heat flux (it decreases with tube bundle diameter)
- Differential elongation between the tube bundle and the shell
- Thermal load on tubes and design of the tubesheet
- Pressure drop tubeside

2.6 Differential elongation between tubes and shell

- Average tube & shell wall temperatures are very close (Δ T = 15 to 20℃)
- Tube lengths up to 14m are not mechanically critical
- Pressure drop may be a limitation and actual lengths typically do not exceed 10m

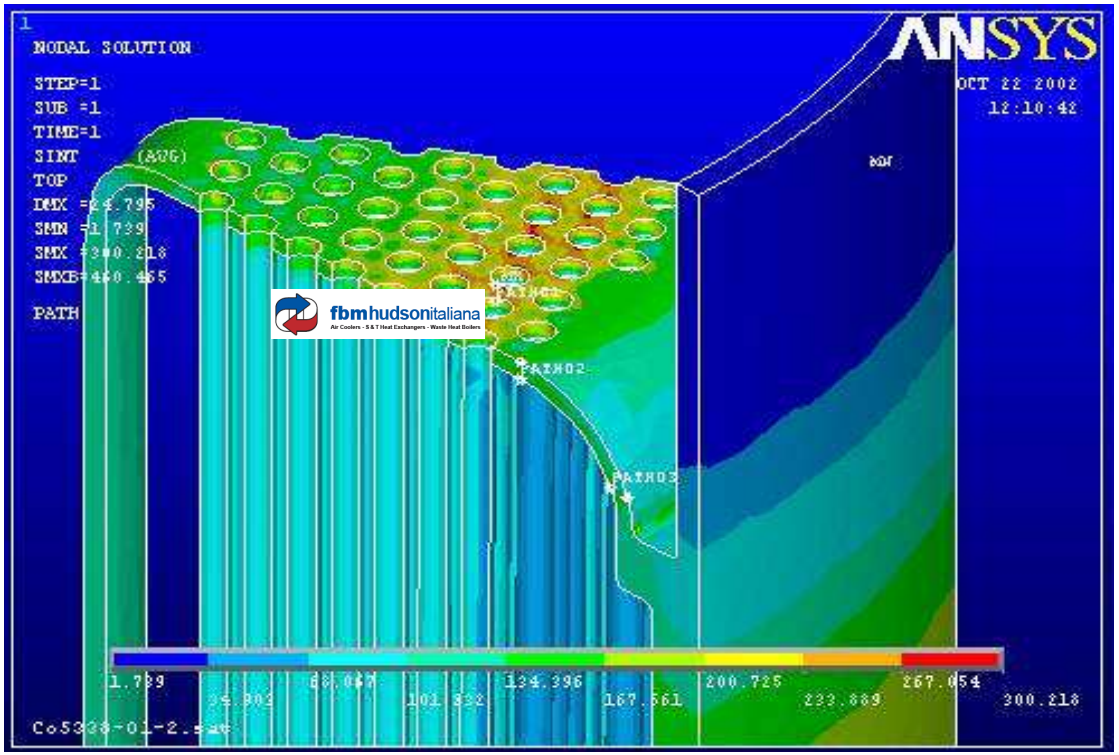
2.7 Tube Wall Temperature

- This parameter must always be considered

- The controlling variables are:
  a) Design thermal flux at the boiler inlet
  b) Thickness of the tubes
  c) Design water side fouling factor

- It is quite unusual for the tube wall temperature to limit the overall size of a boilers when the design flux is kept low due to the limit on the critical flux

2.8 Tubesheet Stress Analysis



Special calculations may be necessary for special (large dimensions).

2.9 Tube Side Pressure Drop

- This process limitation has a significant impact on WHB and SC size
- Ferrules account for up to 30% of tubeside pressure drop depending on tube diameter
- Use cold drawn tubes

2.10 Selection of Shell Plate Material

- Cost and availability of steam side shell material may be a practical limitation to optimum design
- With steam at 45 bar(g), SA516 Gr.70 is acceptable up to 6500 mm
- SA302 Gr.B is a cost efficient selection for larger diameters and higher steam pressures.
- ASME Section VIII Div 2 is also an option for some materials

2.11 Fabrication of large diameter bundles

- Shell itself is not a limiting factor
- Handling equipment and supports are essential
- Tube-to-tubesheet joint longest duration operation
- Local PWHT to be considered
- Welded plate vs single plate
- Forged external ring

2.11 Trial Fit-up & Final Tests

- Trial fit-up is a recommended practice in spite of size problems
- Temporary support structures always to be considered
- Modularised delivery remains a viable option for shops located on port areas
- Furnace-to-WHB weld and hydro-test done at workshop greatly speed-up erection at site. Always check WHB manufacturer capabilities

3 Conclusions

- Trends in sulphur plants require large Waste Heat Boilers and Sulphur Condensers
- Large equipment poses design and manufacturing issues
- These problems can be overcome, provided they are dealt with competence and experience
- Today, WHBs and Sulphur Condensers of 7m to 8m diameter can be safely manufactured and operated (shell-side pressure to be checked)

Sulphur 2008 International Conference and Exhibition

fbmhudsonitaliana
Air Coolers - S & T Heat Exchangers - Waste Heat Boilers

KPS TECHNOLOGY & ENGINEERING

KNM™