4000 mtpd Ammonia plant based on proven technology

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Overview

- Optimizing Plant Economics

- Plant Concept for 4000 mtpd Ammonia
  - Static Equipment
  - Rotating Equipment
  - Piping
  - Arrangement

- Cost

- Conclusion
Introduction
Optimizing Plant Economics

- improvement of energy efficiency
  → to a large extent done up to about 10 years ago
- plant relocation towards low-cost natural gas sites
  → in progress - almost no new plants at high cost sites
- capacity scale up aiming at "economy of scale"
  → persistent trend, expected to dominate the future

![Graph showing plant capacity over time](image)

- target (4000 mtpd)
- SAFCO IV (3300 mtpd)
- current world scale plant (~2000 mtpd)
4000 mtpd Ammonia Plant Concept
Overview

- checked capacity: 4250 mtpd
- based on SAFCO IV concept (Uhde Dual Pressure Process)
**Static Equipment**

**Reforming Section (1)**

- **Primary Reformer**
  - modular design
  - tube & burner groups remain unchanged
  - easy scale-up
  - cold outlet manifold ok

- **Convection Bank**
  - API / ASME compliant design
  - well proven in refinery service

<table>
<thead>
<tr>
<th>Plant</th>
<th>Capacity</th>
<th>Tubes</th>
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<tr>
<td>QAFCO 4</td>
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![Diagram of reforming section with primary and convection banks]
Static Equipment
Reforming Section (2)

- **Secondary Reformer**
  - similar to much larger ATRs (diameters of up to 8 m, i.e. 26.2 ft)
  - small span of refractory arch

- **Reformed Gas Waste Heat Boiler**
  - limited at 3800 mtpd
  - dual flow design with references for single boilers
Static Equipment
Gas Conditioning

- CO₂ Removal (BASF’s aMDEA Process)
  - well proven process
  - large columns, however, no problems during SAFCO IV erection
  - slightly prorated diameters (plus 13%)
  - similar dimensions currently being specified and built for acid gas removal units of LNG plants

  - logistics only for site locations close to the sea
Static Equipment
Ammonia Synthesis

- **Ammonia Converters**
  - Once Through Converter with references for operating conditions and dimensions in AMV plants e.g.: Terra Courtright (former CIL), Zhong Yuan Chem. Fert. Puyang
  - only slight prorating for loop converters
  - no significant technological risk

- **Synthesis Gas Waste Heat Boilers**
  - nitriding and embrittlement of the tube sheet may in principle become an issue at large capacities ...
  - however, conventional design for 4250 mtpd is fully feasible
Rotating Equipment
Natural Gas Compressor Train

- design depends on feed gas conditions

- typical (feed gas pressure: 20 bar)
  - barrel type compressor
  - 6 impellers
  - 5.4 MW @ 10500 rpm

- references exist e.g. in pipeline service

- feasible concept
Rotating Equipment
Process Air Compressor Train

- compressor dimensions considerable, however, relatively small train when compared to process concepts using autothermal reforming or excess air

- **option 1: constant number of casings**
  2-casing train without reference for flow and casing size respectively, however still feasible
  - horizontally split compressor
  - 2/2 // 3/3 impellers
  - 31 MW @ 4500 // 9000 rpm

- **option 2: constant casing size**
  3-casing train with references for each casing
  - 33 MW @ 4600 // 7300 rpm

- feasible concepts available
Rotating Equipment
Synthesis Gas Compressor Train

- operating conditions unique to NH₃ service
  => no references at 4250 mtpd

- relatively small duty due to Uhde Dual Pressure Process
  QAFCO 4
    (2000 mtpd, conv. process)  SAFCO IV
    5/4 // 8/1 impellers
    27.3 MW @ 9535 rpm
  (3300 mtpd, dual pressure process)
    4/4 // 6/1 impellers
    28.6 MW @ 9700 rpm

- feasible concepts of different manufacturers
  4/4 // 7/1 impellers
  38 MW @ 9000 rpm

- single flow steam turbine feasible,
  dual flow design may be preferable for reference reasons

- feasible concepts available
Rotating Equipment
Refrigeration Compressor Train

- ammonia refrigeration is customary technology
- scale-up is not expected to be critical
- expectation confirmed by feasible vendor concepts
- feasible concepts available
## Piping

- **600# and 900# (typical front-end)**
  - backed by ASME code
  - reasonable scale up

- **1500# (typical once through synth.)**
  - backed by ASME code

- **2500# (typical synthesis loop)**
  - already off standard at 2000 mtpd and below
  - size reduction due to Dual Pressure Process
  - fully feasible

### ASME WN-Flanges

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- **Qafco IV 2000 mtpd**
- **Safco IV 3300 mtpd**
- **4250 mtpd**

ASME WN-Flanges

- standardized
- off standard
plot space for an 4250 MTPD ammonia plant is expected to be
  - about 140% that of 3300 MTPD
  - only 77% that of 2x 2000 MTPD

dimensions of pipe racks and compressor house checked - not an issue
Cost

- capital expenditure
  - specific cost (cost per mtpd installed) of a 4000 mtpd plant is expected to be only 86% of a 2000 mtpd plant
  - further cost reduction on owners side
    (for example due to reduced plot space requirements)

- operating expenditure
  - Dual Pressure Process cuts gas cost by 4% due to lower energy consumption
  - further savings (e.g. personnel cost)

- significant savings to be expected
Conclusion

- clear market demand for ammonia plants with very large capacities
- first next generation plant already under construction by Uhde
- Uhde’s Dual Pressure Plant concept is fully viable for a capacity of 4250 mtpd (and shows potential for even larger capacities)
- 4250 mtpd plant represents only moderate upscale of the 3300 mtpd reference plant
- concept with best possible reference situation for a next generation ammonia plant ⇒ safe and reliable operation ⇒ safe investment
- “economy of scale” pays off
- 4250 mtpd ammonia plants are offered by Uhde on a lump-sum turn-key basis