CH1019 Chemical Process Technology

Lecture 4a

Chapter 3 Fertilizer Industries

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Overview of topics

Chapter 3 FERTILIZER INDUSTRIES

1. Nitrogen industries
2. Phosphorous industries
3. Potassium industries

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Fertilizer industries – Nitric Acid

Nitric acid is an acid which is completely miscible with water; forms a constant boiling mixture at 120^{o}C .

End uses of nitric acid

- Used in the manufacture of ammonium nitrate
- Used in the manufacture of explosives
- Used in the manufacture of adipic acid which is one of the precursors for plastics and fibers.
- Used in the manufacture of nitobenzene (aniline)
- Used in the manufacture of sodium, potassium, and calcium nitrates.

Fertilizer industries – Nitric Acid

Methods of production

- Ammonia oxidation process
- $NaNO_3 + H_2SO_4$ process
- N_2 fixation from air
- Nitrogen fixation by nuclear fission fragments

Fertilizer industries – Nitric Acid

Ammonia oxidation process for the manufacture of nitric acid

The major steps involved are:

① Oxidation of NH_3 to NO

② Oxidation of NO to NO_2

③ Absorption of NO_2 in water

④ Concentration of HNO_3

Fertilizer industries – Nitric Acid

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Fertilizer industries – Nitric Acid

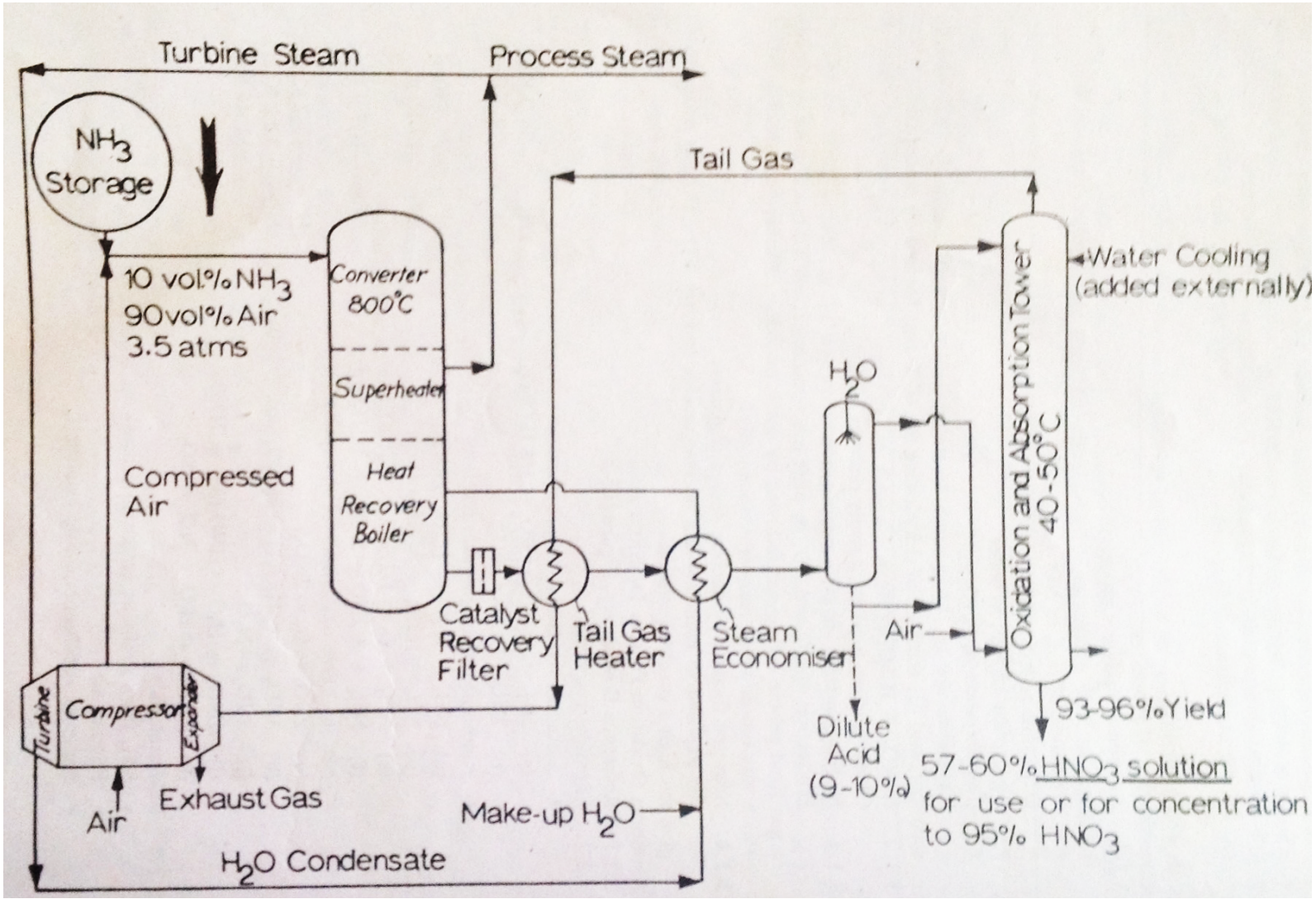
Ammonia oxidation process for the manufacture of nitric acid

The main reactions and side reactions involved are:

- **Ammonia oxidation—major reactions**
  - (a) $NH_3 + 5/4\ O_2 \rightleftharpoons NO + 3/4\ H_2O(g)$; $\Delta H^\circ = -54.0$ Kcal
  - (b) $2NO_2 + O_2 \rightleftharpoons 2NO_2$; $\Delta H^\circ = -27.2$ Kcal
- **Ammonia oxidation—side reactions**
  - (c) $NH_3 + 3/4O_2 \rightleftharpoons 1/2N_2 + 3/2H_2O(g)$; $\Delta H^\circ = -75.7$ Kcal
  - (d) $NH_3 \rightleftharpoons 1/2N_2 + 3/2H_2$; $\Delta H^\circ = -11$ Kcal
  - (e) $NH_3 + O_2 \rightleftharpoons 1/2N_2O + 3/2H_2O(g)$
  - (f) $NH_3 + 3/2NO \rightleftharpoons 5/4N_2 + 3/2H_2O(g)$; $\Delta H^\circ = -107.9$ Kcal
- **Nitrous oxide oxidation and absorption**
  - (g) $2NO + O_2 \rightleftharpoons 2NO_2$; $\Delta H^\circ = -27.2$ Kcal
  - (h) $3NO_2(g) + H_2O(1) \rightleftharpoons 2HNO_3(aq) + NO$; $\Delta H^\circ = -32.2$ Kcal
  - (i) $2NO_2 \rightleftharpoons N_2O_4$; $\Delta H^\circ = -11.46$ Kcal
  - (j) $2NO_2 + H_2O \rightleftharpoons HNO_3(aq) + HNO_2$
  - (k) $2HNO_2 \rightleftharpoons H_2O + NO + NO_2$

Fertilizer industries – Nitric Acid

Ammonia oxidation process for the manufacture of nitric acid



Fertilizer industries – Urea

- Urea is a nitrogen compound with the largest production volume in the world

- Its utilization is increasing steadily, it being the preferred nitrogen fertilizer world wide.

Fertilizer industries – Urea

End uses of urea:

- Used as solid fertilizer
- Used as liquid fertilizer
- Used in the manufacture of formaldehyde resin, melamine and adhesives.

Fertilizer industries – Urea

Manufacture of Urea by ammonia decarbamate decomposition:

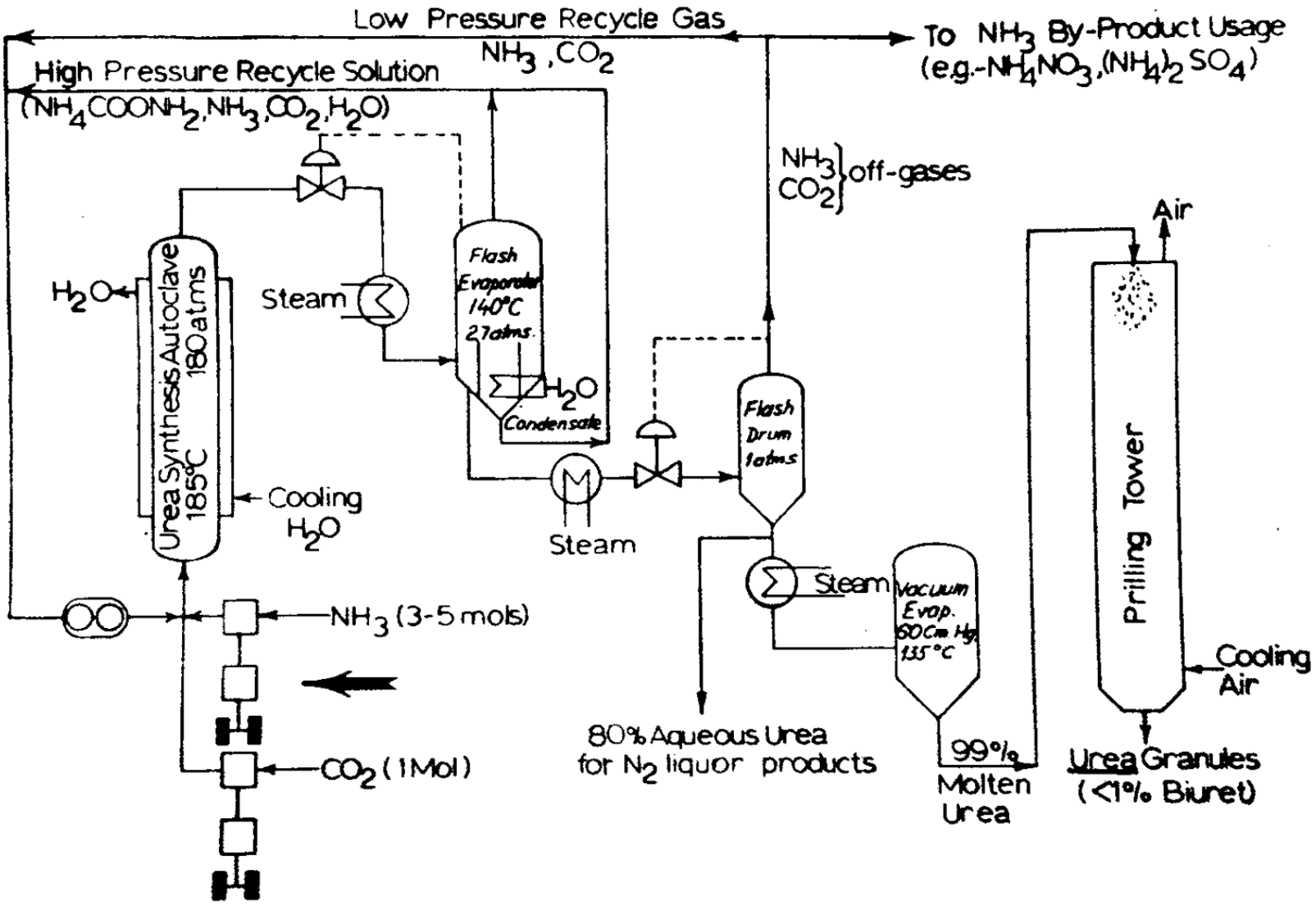
Main steps involved:

① Formation of ammonium carbamate ($NH_4.COO.NH_2$)

② Decomposition of ammonium carbamate into Urea ($NH_2.CO.NH_2$)

③ Formation of biuret

Fertilizer industries – Urea



Fertilizer industries – Urea

- **Biuret** is a chemical compound with the chemical formula $C_2H_5N_3O_2$.

- It is also known as **carbamylurea**. It is the result of condensation of two molecules of urea and is an impurity in urea-based fertilizers.

- This white solid is soluble in hot water.

Sulfur Industries

References

1. Dryden C. E, *Outlines of Chemical technology – for the 21st Century*, 3rd edition, East-West Press (2004)

2. Austin G. T, *Shreve's Chemical Process Industries*, 5th edition, Mc Graw Hill International editions (1984)