CHEMICAL PROCESS INDUSTRIES

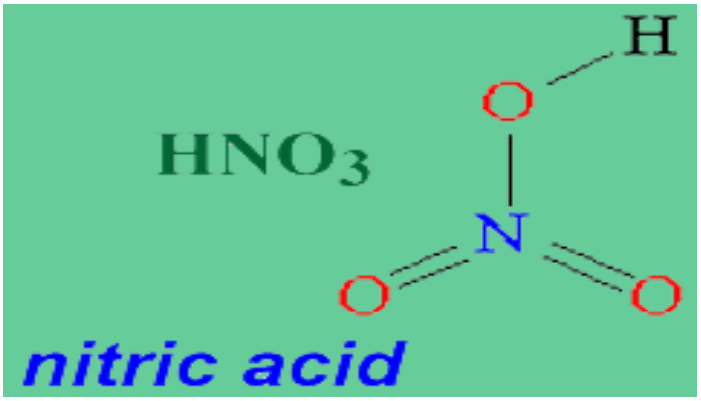
UNIVERSITY OF DIYALA

CHEMICAL ENGINEERING

DEPARTMENT

LECTURE (7)

NITRIC ACID

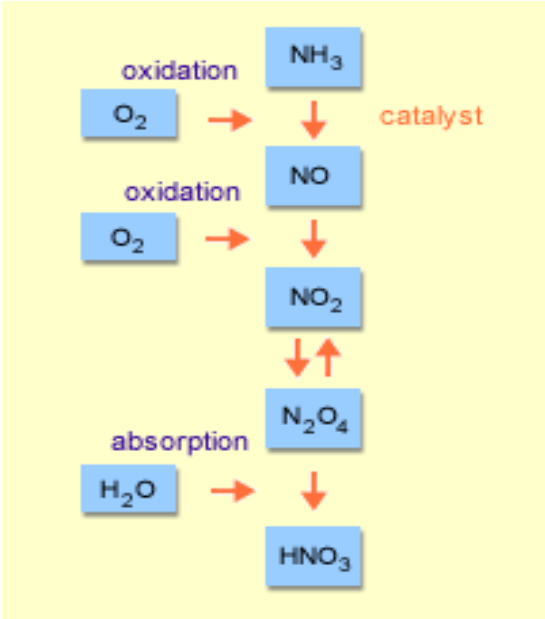


The production of HNO_3 in three main steps:

1) Oxidation of NH_3 to NO

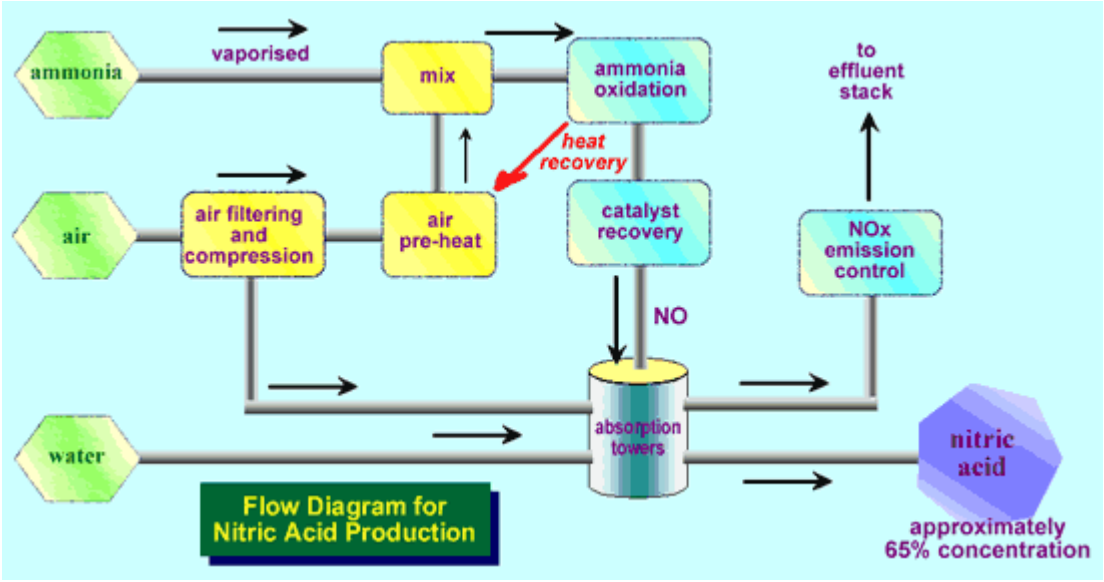
2) Oxidation of NO to NO_2

3) Absorption NO_2 in H_2O



Preparation of Nitric Acid:

All plants for the production of nitric acid are currently based on the same basic chemical operations: Oxidation of ammonia with air to give nitric oxide and oxidation of the nitric oxide to nitrogen dioxide and absorption in water to give a solution of nitric acid.



-Ammonia/air mixture is oxidized at high temperature, as it passes through a catalytic convertor, In **NH_3 oxidation stage** the main reaction is:

1) $4\ NH_3\ (g) + 5\ O_2\ (g) \rightarrow 4\ NO\ (g) + 6\ H_2O\ (g)$

Side reactions are:

2) $4NH_3 + 3O_2 \rightarrow 2N_2+6H_2O$

3) $4NH_3+4O2 \rightarrow 2N_2O+6H_2O$

4) $4NH_3+6NO \rightarrow 5N_2+6H_2O$

The most commonly used catalyst is made of 90 percent platinum and 10 percent rhodium gauze constructed from squares of fine wire. Under these conditions the oxidation of ammonia to nitric oxide (NO) proceeds in an exothermic reaction with a range of 93 to 98 percent yield. Oxidation temperatures can vary from 1380 to 1650 F. Higher catalyst temperatures increase reaction selectivity toward NO production. Lower catalyst temperatures tend to be more selective toward less useful products: nitrogen (N_2) and nitrous oxide (N_2O).

Nitric oxide is considered to be a criteria pollutant and nitrous oxide is known to be a global warming gas. The nitrogen dioxide/dimer mixture then passes through a waste heat boiler and a platinum filter.

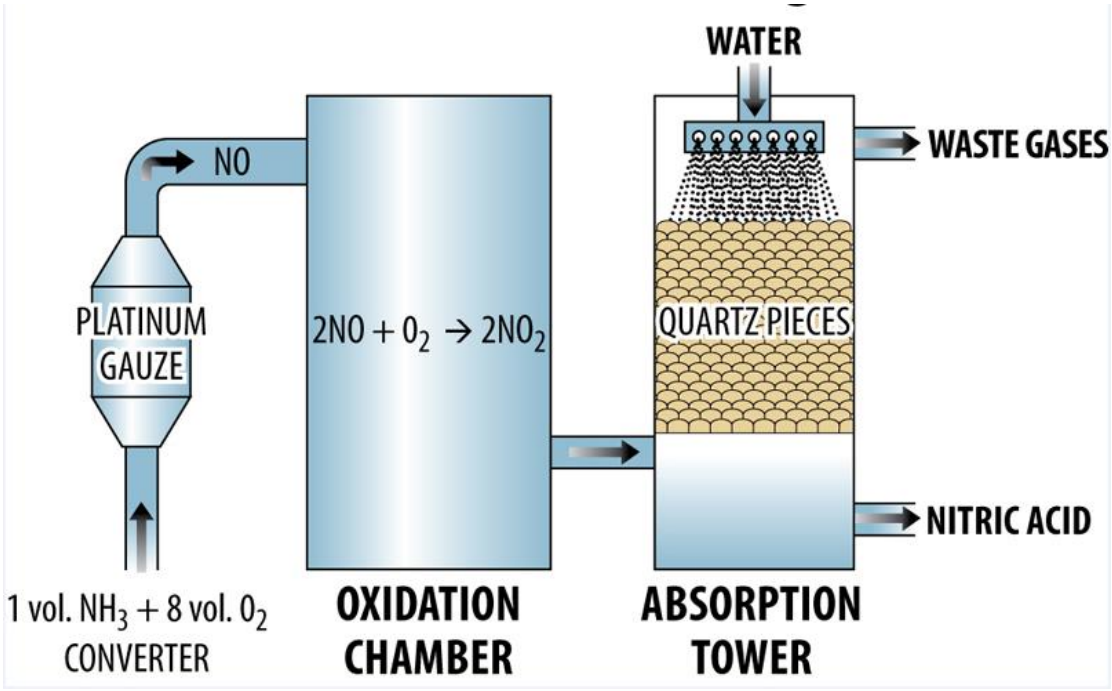
-Nitric Oxide Oxidation

The nitric oxide formed during the ammonia oxidation must be oxidized. The process stream is passed through a cooler/condenser and cooled.

The nitric oxide reacts noncatalytically with residual oxygen to form nitrogen dioxide (NO_2)and its liquid dimer, nitrogen tetroxide:

$$2NO + O_2 \rightarrow 2NO_2 \rightleftharpoons N_2O_4$$

This slow, homogeneous reaction is highly temperature- and pressure-dependent. Operating at low temperatures and high pressures promotes maximum production of NO_2 within a minimum reaction time.



-Absorption

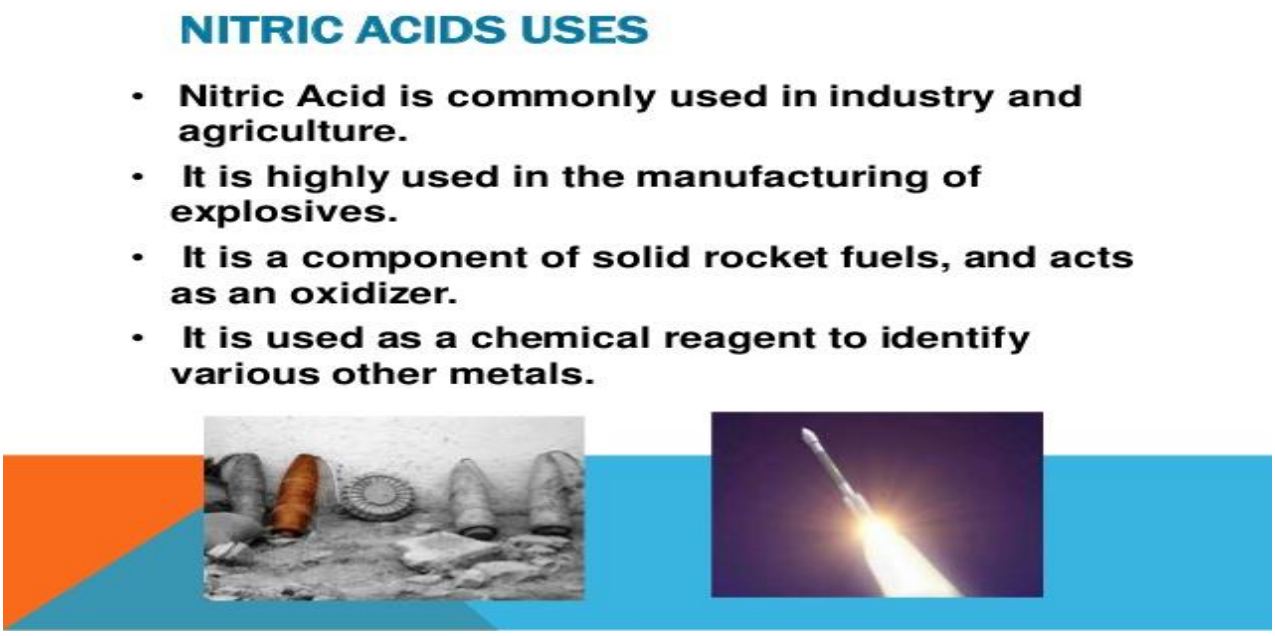
The final step introduces the nitrogen dioxide/dimer mixture into an absorption process after being cooled. The mixture is pumped into the bottom of the absorption tower, while liquid dinitrogen tetroxide is added at a higher point. Deionized process water enters the top of the column. Both liquids flow countercurrent to the nitrogen dioxide/dimer gas mixture. Oxidation takes place in the free space between the trays,

while absorption occurs on the trays. The absorption trays are usually sieve or bubble cap trays. The exothermic reaction occurs as follows:

$$3NO_2 + H_2O \rightarrow 2HNO_3 + NO$$

A secondary air stream is introduced into the column to re-oxidize the NO that is formed in Reaction.

This secondary air also removes NO_2 from the product acid. An aqueous solution of 55 to 65 percent (typically) nitric acid is withdrawn from the bottom of the tower. The acid concentration can vary from 30 to 70 percent nitric acid. The acid concentration depends upon the temperature, pressure, number of absorption stages, and concentration of nitrogen oxides entering the absorber.



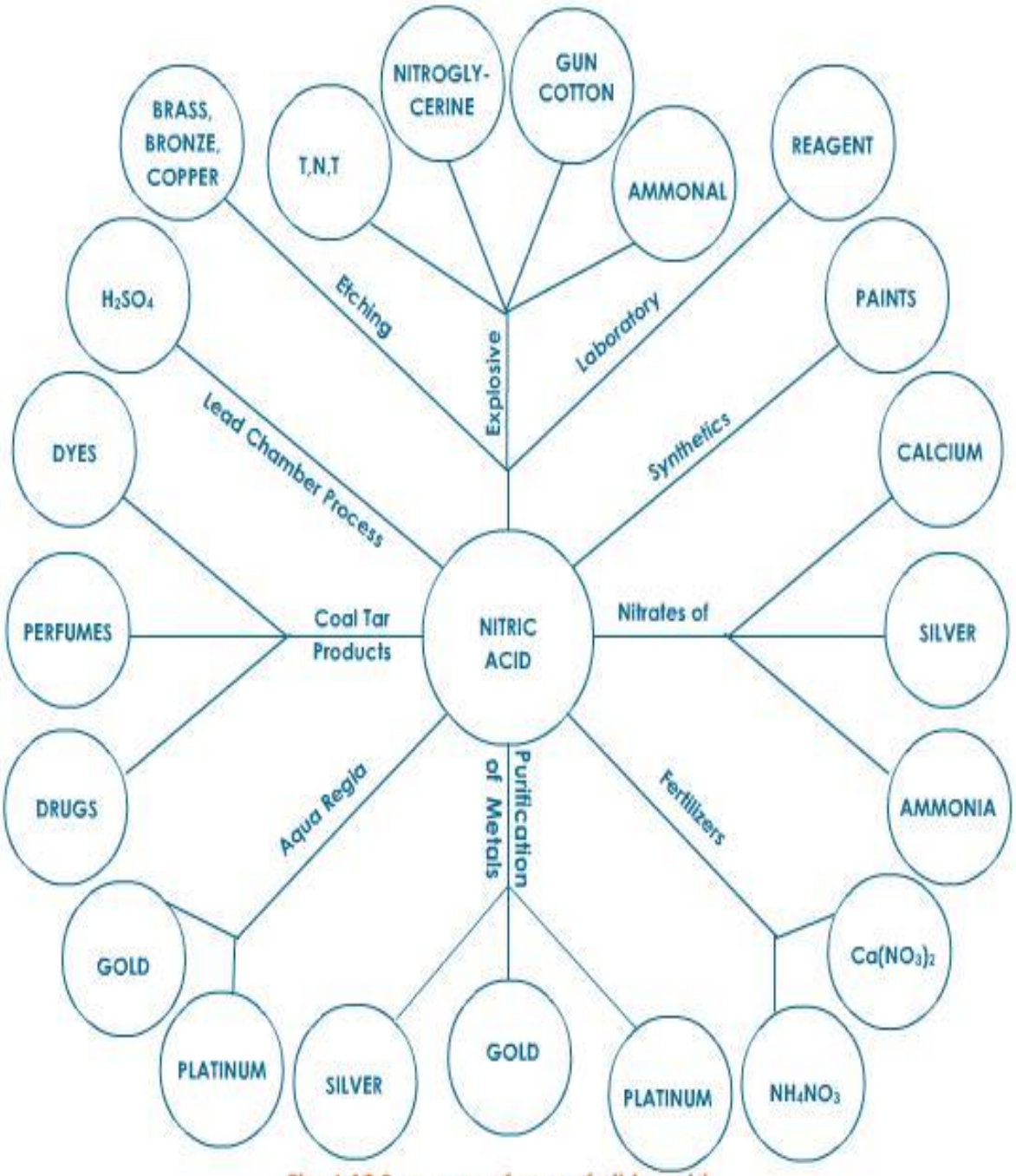


Fig. 6.18 Summary of uses of nitric acid