PLNL
Point Lisas Nitrogen Limited

Production of Anhydrous Ammonia

A typical modern ammonia-producing plant first converts natural gas (i.e., methane) into gaseous hydrogen. The method for producing hydrogen from hydrocarbons is known as steam reforming.[2] The hydrogen is then combined with nitrogen to produce ammonia via the Haber-Bosch process.

Starting with a natural gas feedstock, the processes used in producing the hydrogen are:

- The first step is to remove sulphur compounds from the feedstock because sulphur deactivates the catalysts used in subsequent steps. Sulphur removal requires catalytic hydrogenation to convert sulphur compounds in the feedstocks to gaseous hydrogen sulphide:
    - $H_2 + RSH \rightarrow RH + H_2S(gas)$

    - The gaseous hydrogen sulphide is then adsorbed and removed by passing it through beds of zinc oxide where it is converted to solid zinc sulphide:
        - $2S + ZnO \rightarrow ZnS + H_2O$

    - Catalytic steam reforming of the sulphur-free feedstock is then used to form hydrogen plus carbon monoxide:
        - $CH_4 + H_2O \rightarrow CO + 3H_2$

- The next step then uses catalytic shift conversion to convert the carbon monoxide to carbon dioxide and more hydrogen:
    - $CO + H_2O \rightarrow CO_2 + H_2$

    - The carbon dioxide is then removed by potassium carbonate solution.

- The final step in process gas clean up prior to introduction to the synthesis loop is to use catalytic methanation to remove any small residual amounts of carbon monoxide or carbon dioxide from the hydrogen:
    - $CO + 3H_2 \rightarrow CH_4 + H_2O$
    - $CO_2 + 4H_2 \rightarrow CH_4 + 2H_2O$

To produce the desired end-product ammonia, the hydrogen is then catalytically reacted with nitrogen (derived from process air) to form anhydrous ammonia. This step is known as the ammonia synthesis (also referred to as the Haber-Bosch process):

$3H_2 + N_2 \rightarrow 2NH_3$

Production of Anhydrous Ammonia cont'd

Due to the nature of the Ruthenium based catalyst used in the ammonia synthesis reaction, only very low levels of oxygen-containing compounds (especially CO, CO2 and H2O) can be tolerated in the synthesis gas mixture of hydrogen and nitrogen.

Because of relatively low single pass conversion rates (typically less than 20%), a large recycle stream is required. This can lead to the accumulation of inerts in the synthesis loop gas.

The steam reforming, shift conversion, carbon dioxide removal and methanation steps each operate at absolute pressures of about 350 to 550 psi, and the ammonia synthesis loop operates at absolute pressures ranging from 900 – 2600 psi depending upon which proprietary design is used.

[See Diagram below]

