

MANUFACTURING PROCESSES

The synthesis gas for manufacture of Ammonia is produced by steam reforming or partial oxidation of Hydrocarbon feed. In most industries steam reforming is the norm. A flow sheet describing the various operations in a typical single train ammonia plant is shown. The various processes used commercially in industries for production of Ammonia are

1. Braun Purifier process
2. Foster Wheeler AM2 process
3. ICI process

Braun Purifier process

In the secondary reformer 1.5 times the stoichiometric quantity of air is used. This increases the heat load and reduces the radiant duty of the primary reformer to less than two thirds its usual duty. Excess nitrogen is removed by a cryogenic purification unit after methanation occurs. Large air compressors used are driven by gas turbines. Owing to the high purity of synthesis gases, lower recycle gas flow, lower refrigeration duty and lower purge duty will suffice.

Foster Wheeler AM2 process

In the secondary reformer excess air is used as in the previous case. Instead of treating the whole feed in primary reformer, some bypass is fed to the secondary reformer. Partial reaction in primary reformer will allow for a lower steam to carbon ratio. Excess air used is much higher than in the case of Braun purifier process. A cryogenic unit removes nitrogen from the exit gases leaving the methanator. CO_2 is removed using physical solvents. Absorption system provides refrigeration for ammonia recovery.

ICI process

Hydrocarbon feed is subjected to steam reforming in two stages to form oxides of Carbon, methane and hydrogen. In the secondary reformer air is mixed with the gases to get a $N_2 : H_2$ ratio of 1:3. Carbon monoxide is removed by shift conversion. Carbon dioxide is removed by absorption into MEA or Potassium Carbonate solution. Traces of CO and CO_2 are removed by conversion into methane. Synthesis gas is used to produce ammonia.

Advantages of this process are

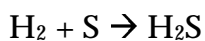
1. Intensive heat recovery
2. Generation of steam which can be imported.
3. Less dependency on electricity
4. Capital cost is least.

Process Description

The hydrocarbon used is Naphtha. Naphtha used contains sulfur which is a catalytic poison in the ammonia synthesis process. It must be removed before the feed can be used for producing hydrogen.

Desulfurizer

The sulfur in the naphtha feed stock is converted to hydrogen sulfide in the presence of Cobalt - Molybdenum catalyst at a temperature of about 673 K



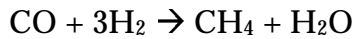
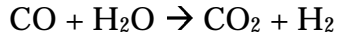
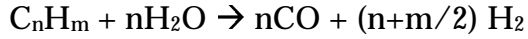
The sulfur content is reduced to less than 5ppm

Reforming

The reformation process is carried out in two stages.

Primary Reformer

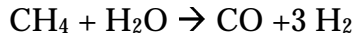
In the first stage desulfurized naphtha is mixed with steam in a tubular reforming furnace. The reformation reactions occur at a temperature of about 673 K. Steam to carbon ration must be maintained between 3.5 and 4.5 to ensure that Carbon deposition does not occur.



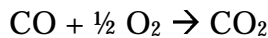
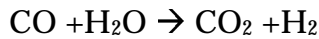
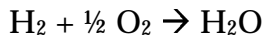
The overall reaction is highly exothermic and the outlet temperature is about 1093 K. The primary reforming process is characterized by a low pressure.

Secondary Reformer

The gases from the primary reformer are mixed with air and steam at the outlet temperature of the primary reformer. The remaining hydrocarbon like methane are further subjected to reformation and the overall yield of hydrogen is increased. Air is mixed to form a mixture of H₂ and N₂ for the synthesis process.



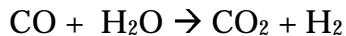
Other side reactions occurring are



Initially the carbon monoxide burns in air to produce carbon dioxide and the temperature increases to about 1200 °C. Then adiabatic reaction of methane with steam occurs and the outlet temperature decreases to about 1000 °C at the outlet.

Carbon monoxide Conversion

Concentration of CO is reduced to about 0.1 – 0.3 % by volume in two stage converter.



HTSC

CO concentration is reduced to about 3% by volume by means of water gas shift reaction at a temperature of about 593 to 693 K. The reaction being exothermic the exit gases are at a higher temperature. They are cooled before being sent to the secondary reformer.

LTSC

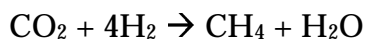
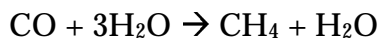
The reaction occurs at a temperature of about 523 K. Concentration of CO in the exit gas is reduced to about 0.3 % by volume.

CO₂ Absorption

Monoethanolamine solution is used as the absorbing medium. The absorption operates at atmospheric pressure and a temperature of about 100 °C. The tower is usually a packed tower. Counter current absorption is practised. The spent MEA solution is regenerated in a regenerating column by steam stripping.

Methanation

Even trace quantities of Carbon monoxide and Carbon dioxide will act as catalyst poisons in the synthesis loop. Hence they must be removed by conversion into methane. Methane though not an inert gas is nevertheless inert in the ammonia synthesis process. The reaction in the methanator occurs at a temperature of about 573 to 673 K. The exit gases containing steam are condensed and cooled before being stored for the synthesis loop.



Ammonia Synthesis

Synthesis gas is compressed to about 50 MPa and heated to about 673 K before passing through the catalyst beds.

The reaction being a reversible one high pressure favours the forward phase. As the concentration of ammonia in the exit gas is low, recycling of gas is necessary.

The converter used is a vertical type of converter.

Catalyst activity increases with increase in temperature, hence ideal temperature profile is one in which rate of ammonia production is a maximum at all parts of the bed. In the upper part of the converter the concentration of ammonia being low the temperature is high ensuring high reaction rates. In the lower parts temperature must be low due to increasing influence of equilibrium concentration.