Ammonia production continued….

- **Steam reforming**
- **$CH_4+H_2O \rightarrow CO+3H_2$ Endothermic reaction**
- **$CO+H_2O \leftrightarrow CO_2+H_2$ Exothermic reaction**
- **If carbon and sulphur are together eg CS_2 we go for hydrotreating**
- **If we use naptha instead of natural gas, CO to H_2 ratio will be different with more CO forming**
- **This sulphur removal is referred to as gas cleaning.**
- **Next is steam reforming**
- **At the end of primary reforming we have CO_2, CO, H_20, H_2**
- **To prevent the formation of CO_2 we keep the temperature as high as possible.**
- **In the secondary reformer, we have a combustion zone and reforming zone**
- **In combustion zone H_2 is combusted to H_2O**
- **The air that we supply depends on end products(required N_2 to H_2 ratio) and the temperature we want to achieve.**
- **At the end we are left with CO and H_2 but CO can poison the N_2 H_2 reaction catalyst**
- **We use shift reaction to convert CO to CO_2 since direct removal of CO is not feasible**
- **CO_2 is removed and we are left with N_2 and H_2.**
- **Since few traces of CO and CO_2 we use METHANATION**
- **$CO+3H_2 \leftrightarrow CH_4+H_2O$**
- **Since Ammonia synthesis is exothermic and equilibrium limited reaction**
- **It requires multiple bed reactor**

- **But it is different from that of sulphur.**
- **In this reactor cold H_2 and N_2 are passed to the reactor at each bed so that temperature would come down**
- **Such reactors are called Quench Reactors**
- **One disadvantage of this reactor is that requirement of catalyst will go up**
- **But since we are introducing N_2 and H_2 at various stages that N_2 and H_2 will have only one bed worth of catalyst**
- **Improvements**
- **Natural gas as feedstock**
- **Initially syn-gas was produced at a lower pressure but from 1950's syn-gas is produced at high pressure :- compression cost reduces**
- **Low temperature shift and methanation catalyst**
- **Improvement in compression equipment-> centrifugal compressor**

METHANOL

- Almost similar process for methanol i.e. requires high pressure
- $CO+2H_2$ (syngas) $\leftrightarrow CH_3OH$ exothermic
- $CO_2+3H_2 \leftrightarrow CH_3OH+H_2O$ exothermic
- On subtracting these two we get shift reaction
- We want our catalyst to be highly selectivity for methanol to get rid of other side reaction
- Since we get 1:3 ratio CO H_2 we can introduce CO_2 for excess H_2 produced
- First step is syn gas production (from steam reforming)
- Here also reactor is quench reactor
- After we separate three kinds of product

- Light components, methanol, heavier components
- Sulphur is a problem here too
- Cu is used as a catalyst
- It shifted classical process to modern process
- Now we have a three phase reactor
- Here the catalyst is suspended in an inert liquid
- Heat removal is efficient
- It prevents runaway reactions (when heat removal is not efficient)