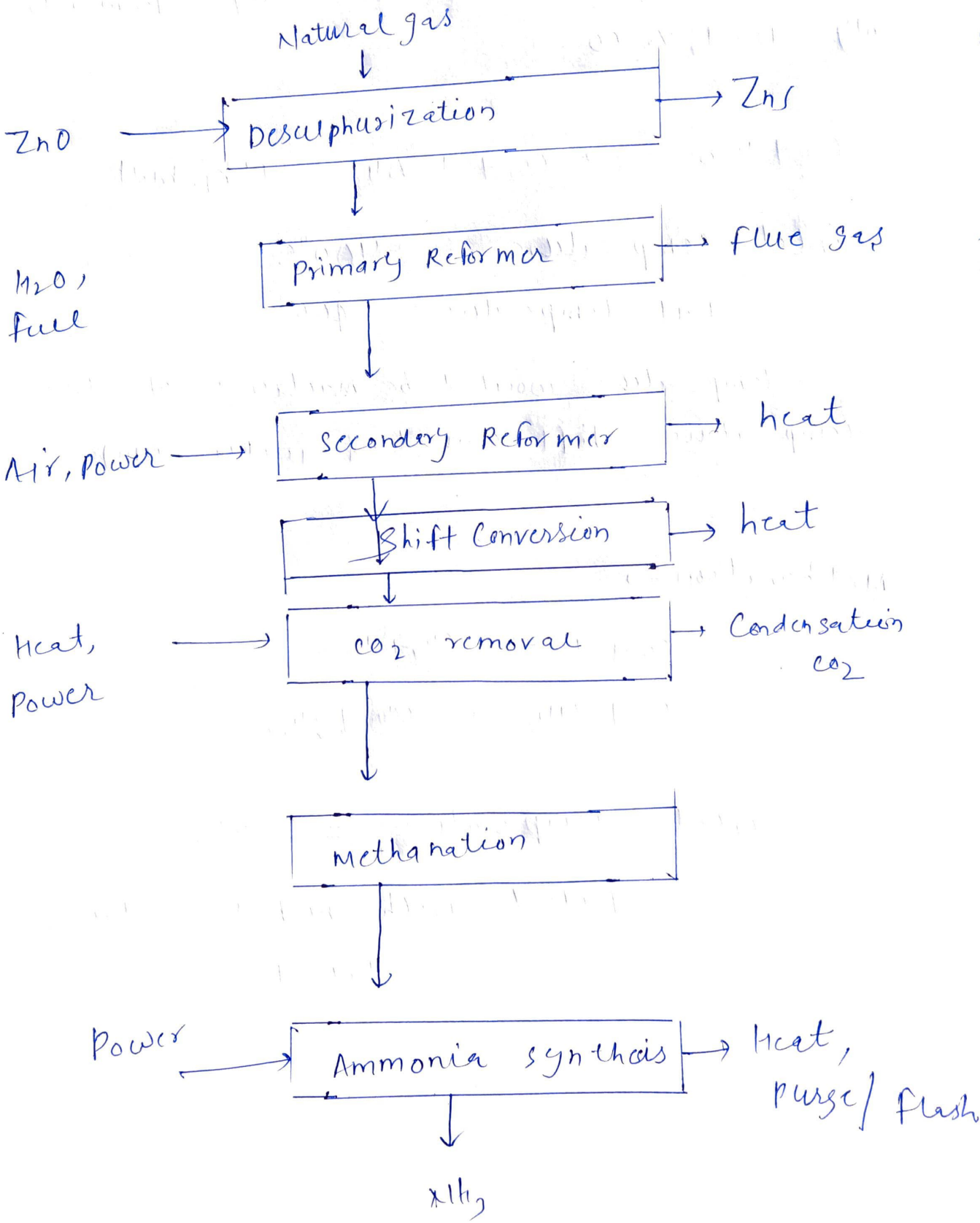
Question - 1 CL371 Remajor Sanjeev

Flow chart of Ammonia Synthesis



Question-2 Sources :- owlnet.rice.edu/~ceng403

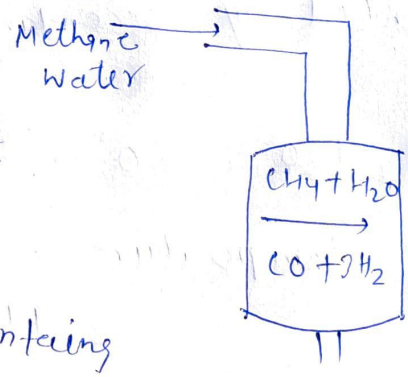
operation conditions and efficiencies for each input operations in the product of ammonia.

Overall rxn →

$$0.88CH_4 + 1.26Air + 1.24H_2O \longrightarrow 0.88CO_2 + N_2 + 3H_2$$

it normally takes place at 25-35 atm pressure

→ Primary Reforming →



the steam/gas mixture is heat further at 500-600°C.

the reformer consists Iron-Containing reforming catalyst.

Highly endothermic and additional heat required to raise temp to 780° – 830°C at outlet.

Pressure : 35.29 bar air stream

Conversion →

let ~~pp~~ CH_4 entered = 1250 unit

CH_4 at exit = 489.042 unit

so Conversion of methane = 35 % (Appx)

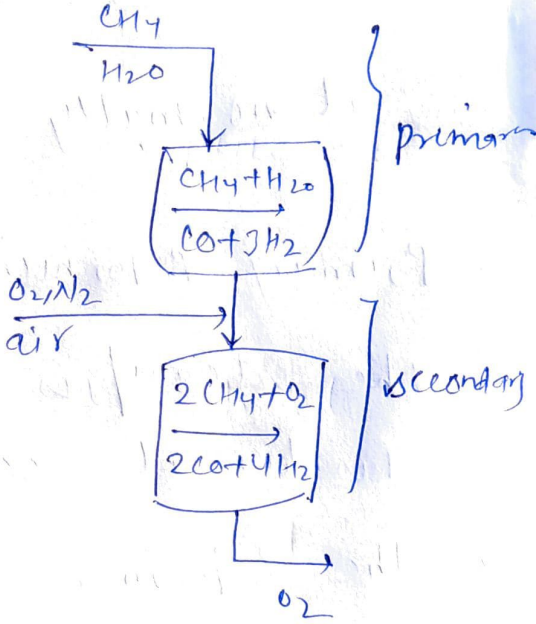
Heat of rxn = 50 MMkcal/hr

Secondary Reforming →

- Only 30-40% of the hydro carbon react.
- Addition of air to convert the methane molecule that did not react during primary reforming.

Inlet temperature :- Temperature of primary reforming exit will be inlet of secondary reforming.

780 - 830°C.



Exit temperature →

995.8 °C

operating pressure = 35.29 bar throughout the reformer

conversion of Methane →

let inlet CH_4 = 489.042

exit CH_4 = 21.281

so it only converts 4.29% methane

Conversion of H_2O →

~~inlet~~ = 99% water converts

conversion of O_2 → 100%.

Shift Conversion →

The process gas from the secondary reformer is only 12 - 15% CO

$$CO + H_2O \longleftrightarrow CO_2 + H_2 \quad \Delta H = -41\ kj.\ mol$$

inlet temperature = 400°C

Exit temperature = 400°C

temperature would be maintained b/c low temperature shift convertor (equilibrium)

Methanation :→

$$CO + 3H_2 \longrightarrow CH_4 + H_2O$$

$$CO_2 + 4H_2 \longrightarrow CH_4 + 2H_2O$$

inlet temperature = 300°C

filled with nickel containing catalyst

Que 3.

1. Reactions involved in production of Ammonia -

$$CH_4 + H_2O \longrightarrow CO + 3H_2 \quad (1)$$

$$CO + H_2O \longrightarrow CO + H_2 \quad (2)$$

$$CO_2 + 4H_2 \longrightarrow CH_4 + 2H_2O \quad (3)$$

$$3H_2 + N_2 \longrightarrow NH_3 \quad (4)$$

First we do the partial oxidation of heavy oils. The partial oxidation is used for the gasification of heavy feed stocks, such as oil and coal. Extremely viscous hydrocarbon and plastic wastes may also be used as fractions for the feed. The partial oxidation process offers an alternative for future utilization of such waste.

An air seperation unit is required for production of oxygen for partial oxidation step.

The nitrogen is added in liquid nitrogen wash to remove impurities from synthasis gas.

The partial oxidation gasification is a non-catalyc process taking place at high pressure (More than 50 bars) and temperature around (1400°C). Some steam is added for temperature modration.

Simplified reaction pattern :-

$$-CH_n- + 0.5O_2 \longrightarrow CO + \frac{n}{2} H_2$$

Steam Reforming process :- The theoritical process conversions, based on methane feedstock, are given in the following appx. formulae -

$$0.88\,CH_4 + 1.26\,Air + 1.24\,H_2O \rightarrow 0.88\,CO_2 + N_2 + 3H_2$$

$$N_2 + 3H_2 \longrightarrow 2NH_3$$

The synthesis gas production and purification normally take place at 25-35 bar pressure.

The ammonia synthesis pressure is usually in the range 100-250 bar.

Q13 (b)

Given → Amount of ammonia production = 100000 kg/year
@ temp = 200°C
@ pressure = 200 atm

H_2 and N_2 required for given ammonia production

total MW = 34

$$H_2 = \frac{6}{34} \times 100000 = 17647.05 \text{ kg/year}$$

$$N_2 = \frac{(14 \times 2)}{34} \times 100000 = 82352.94 \text{ kg/year}$$

Amount of N_2 and H_2 after methanation at efficiency of 30%. say

$$N_2 = \frac{10\cancel{0}}{9\cancel{0}} \times 82352.94 = 27450.98 \text{ kg/yr}$$

$$H_2 = \frac{10\cancel{0}}{3\cancel{0}} \times 17647.05 = 58823.33 \text{ kg/yr.}$$

→ Amount of H_2 convert into product in methanation process →

Let suppose 90% of H_2 doesn't react

$$= \frac{9\cancel{0}}{10\cancel{0}} \times 58823.33$$

$$= 52941 \text{ kg/yr}$$

Convert H_2 ⇒ 58823.33 − 52941

$$= 5882.3 \text{ kg/yr}$$

let H_2 released in 2nd rxn → g kg/hr

for 90% conversion →

CO converted = 14 g kg/hr

CO feeded = $\frac{14g \times 10}{9} = \frac{140g}{9}$ kg/hr

→ from reaction 1

CO formed = $\frac{140g}{9}$

H_2 formed = $\frac{6}{28} \times \frac{140g}{9} = \frac{10g}{3}$ kg/hr

H_2 reacted + formed = $\frac{10g}{3} + g$

= 52.941 kg/hr

= 7.5 kg/hr

$10g + 3g = 22.5$

$13g = 22.5$

$g = 1.8$

H_2 formed = $\frac{10 \times 1.8}{3} = 6$ kg/hr
rxn (1)

Chy reacted = $\frac{20}{6} \times 6 = 20$ kg/hr
rxn (1)