PRODUCTION OF FORMALDEHYDE BY DEHYDROGENATION OF METHANOL

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Background:

Formaldehyde (HCHO, IUPAC Name: Methanal, CAS Number: 50-00-0) is a naturally-occurring organic compound and is the simplest aldehyde. It is a pungent, colorless gas that is stored as an aqueous solution to prevent its spontaneous polymerization into paraformaldehyde. Its large-scale end uses include the manufacture of phenolic, urea, and melamine resins, pentaerythritol, 1,4-butandiol, methylenediisocyanate, etc. *(Weissermel and Arpe)*.

Formaldehyde has the following pertinent properties *(Rao and Sittig)*:

Property	Value
Mol.wt.	30.03
M.P.	-118^0C
B.P.	-19^0C
Toxicity Limits	10 ppm
Lower Explosive Limit (LEL)	7 vol% in air
Upper Explosive Limit(UEL)	73 vol% in air

Description:

The following reactions take place within the conversion reactor *(Rao and Sittig)*:

1. Oxidation:
   $CH_3OH + 1/2\ O_2 \rightarrow HCHO + H_2O; \qquad \Delta H = -37\ Kcal$
2. Pyrolysis- Dehydrogenation:
   $CH_3OH \rightarrow HCHO + H_2; \qquad \Delta H = +19.8\ Kcal$
3. Side reaction- complete combustion:
   $CH_3OH + 3/2\ O_2 \rightarrow 2H_2O + CO_2; \qquad \Delta H = -162\ Kcal$

Pure methanol stream mixes with the recycle methanol vapor stream in the feed mixer to for the material stream 1, which is then pumped by the feed pump and heated in the feed heater to vaporize the methanol. Stream 3 is at a temperature of 423.15 K and 318.7 kPa. The air stream is a mixture of oxygen (21 mol%) and nitrogen (79 mol%) at 298 K and 101.325 kPa. The air stream is compressed to 300.025 kPa by the air compressor and heated to 473.15 K by the air heater. The resulting stream 5 is mixed with stream 3 in the feed-air mixer to give stream 6 which will be the inlet stream to the reactor. Reactions (1), (2), and (3) discussed above take place in the conversion reactor with a conversion of 80%, 85%, and 10% respectively. The reactor outlet stream 7 is mixed with water in mixer 004 and then sent to a compound separator, from where the vent gases are removed. The other outlet stream of the separator is fed to a distillation column for separating methanol from the reaction mixture. In the distillation column, water is the heavy key (HK) compound and methanol is the light key (LK) compound.

Formaldehyde will be obtained with water as an aqueous solution. The top product (distillate) from the column is pumped through the distillate pump and fed back to the feed mixer as the recycle methanol vapor stream. The bottom product is pumped by the bottoms pump and gives us the desired product stream: FORMALDEHYDE. The stream has around 31 mol% of HCHO.

Flowsheet:

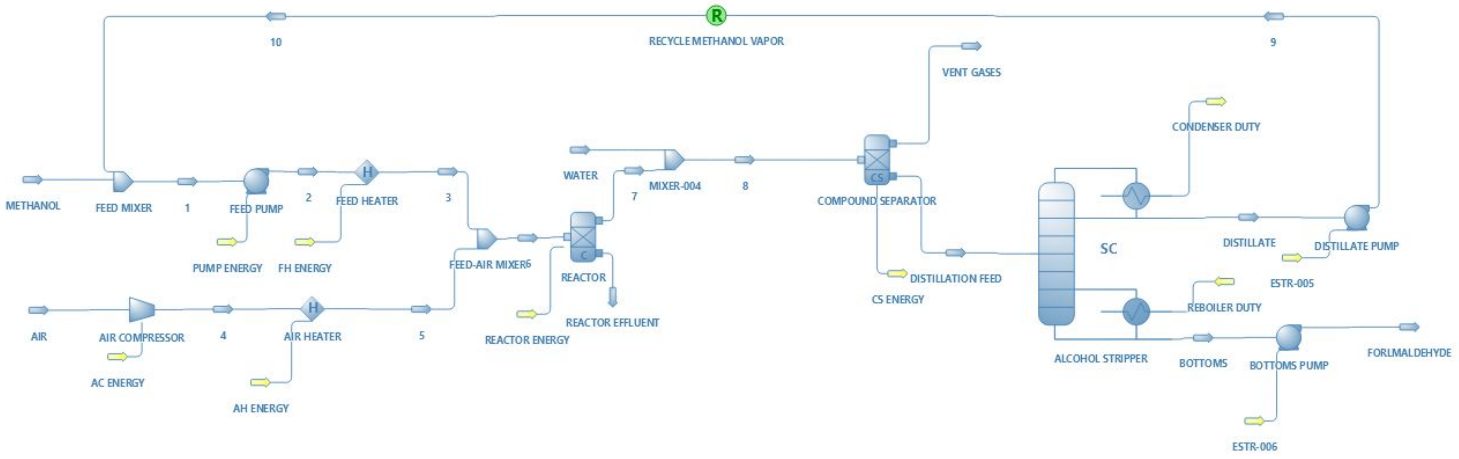

FIG.: FORMALDEHYDE FROM METHANOL

Results:

Master Property Table					
Object	**VENT GASES**	**METHANOL**	**FORLMALDEHYDE**	**AIR**	
Temperature	750.595	303.15	298.288	298	**K**
Pressure	229681	120000	350000	101325	**Pa**
Mass Flow	3.99333	0.48063	1.04279	4.17742	**kg/s**
Molar Flow	140.719	15	45.3374	144.794	**mol/s**
Volumetric Flow	3.82333	0.000612915	0.00118805	3.54046	**m3/s**
Molar Fraction (Mixture) / Formaldehyde	0	0	0.307624	0	
Molar Fraction (Mixture) / Oxygen	0.158612	0	0	0.21	
Molar Fraction (Mixture) / Methanol	0	1	0.092	0	
Molar Fraction (Mixture) / Water	0	0	0.600395	0	

References

Rao, M. Gopala, and Marshall Sittig. *Dryden's Outlines of Chemical Technology*. 3rd ed., EAST-WEST PRESS, 1997.

Weissermel, Klauss, and Hans Jurgen Arpe. *Industrial Organic Chemistry*. Wiley, 1993.