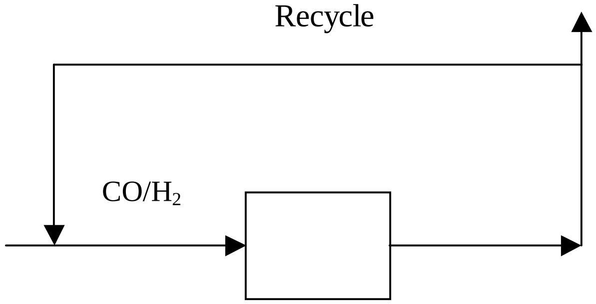
MATERIAL BALANCE

Reactor :



Basis: 100 tonnes of product**---**methanol

Production per hour=130.045 kmoles/hr

Accounting for the 5% fraction of methanol that decomposes to dimethyl ether , total methanol that has to be produced is = 136.9 kmoles/hr.(rxn. C)

CO Balance: CO required to produce methanol is same as the methanol qty. produced.(rxn. A)

But selectivity of this rxn.=87.5%[6]

Selectivity = amt. of desired product / amt. of undesired product

Therefore, total CO required = 136.9/.875 = 156.681 kmoles/hr out of which (156.681- 136.9) = 19.591 kmoles/hr is utilized for side rxn.s b (methanation)

Now, 25% of CO is consumed in first rxn, & rest in second.

CO consumed here = (4.897 + 14.693) = 19.591 kmoles/hr

Ether Balance: Ether produced by decomposition of methanol = (136.9-130.045)/2 = 3.4225 kmoles/hr.

Methane Balance: Methane produced in 2 side rxn.s = (4.897 + 14.693)= 12.2435 kmoles/hr

Water Balance: Water produced = (4.897 + 6.845/2) = 8.3195 kmoles/hr

Carbon dioxide: CO_2 produced = 7.3465 kmoles/hr

Hydrogen Balance: Hydrogen required = 136.92 x 2 + 4.817 x 3 + 14.693 = 303.564 kmoles/hr

But synthesis gas contains CO & H2 in the ratio 1:4 [5]. Hence hydrogen present in feed gas = 626.724 kmoles/hr.
Excess hydrogen in rxn. = 323.16 kmoles/hr

Conversion per pass: In one pass only about 50% of synthesis gas is converted because thermodynamic equilibrium is reached[3,4]

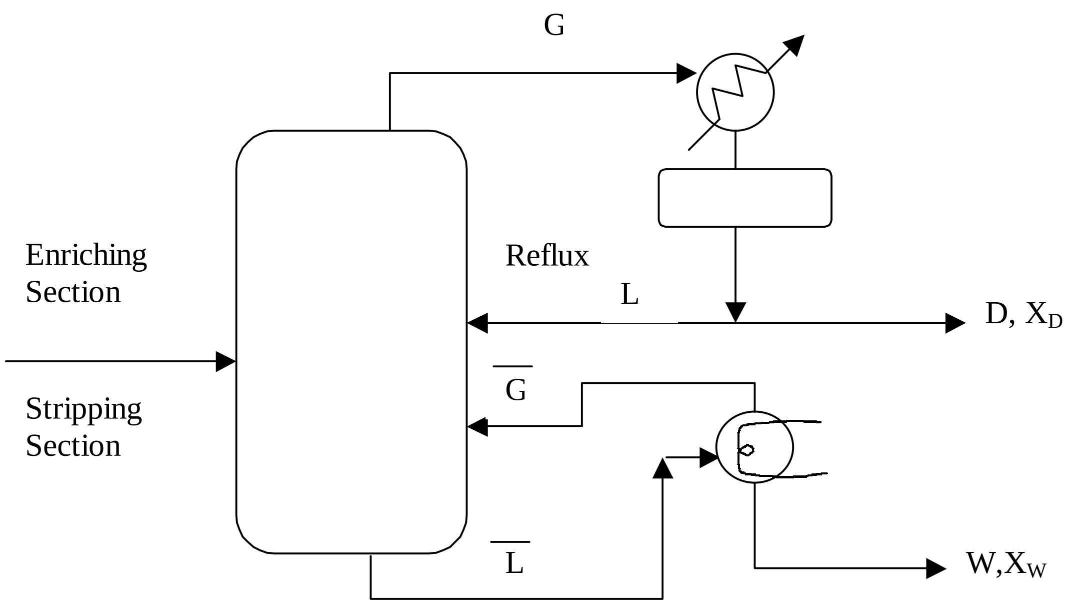
A part of the product steam is purged & rest is recycled .Since CO is the limiting reactant , we find recycle gas amount w.r.t. CO.
Unreacted CO = Purged CO + Recycled CO
0.5(CO + X) = 0.05 x 0.5 x (CO + X) + X
CO converted to methanol is found to be 130.045 kmoles/hr
From here we find the recycled amount of CO to be = 125.0855 kmoles/hr

Distillation column 1[Light Ends Coloumn]: Since we have ignored all other side rxn.s,only ether is distilled in the coloumn.

Since we have ignored all other side reactions,only ether is distilled in column. We assume that x_D = 0.998 & x_W = 0.005
Feed F = methanol + water + ether
= 130.045 + 8.315 + 3.4225
= 141.7865 kmoles/hr
x_F = 0.02414
D = 2.256 kmoles/hr

W =138.369 kmoles/hr

Distillation column 2[Purification column] : Since we have ignored higher alcohol formation reactions, only methanol & water enter this column.We also ignore the very small amount of ether that may be present.Hence, feed to this tower is just the binary mixture of methanol & water.



Feed to the tower is saturated liquid. A total condensor is used & reflux returns to the column at its bubble point.

Total moles of feed = 138.36 kmoles/hr.This contains 130.045 kmoles/hr of methanol.

Hence xF = 130.045/138.36 = 0.939

Specific grade A methanol is 99.85 wt%[1,3]

Then xD = (99.85/32.04)/(1-0.9985)/18 + 0.9985/32)

We assume a xW of 0.01

Using relations F = D + F & FxF = DxD + WxW,

We obtain D,distillate(methanol) = 130.189 kmoles/hr

W,residue(water) = 8.171 kmoles/hr\