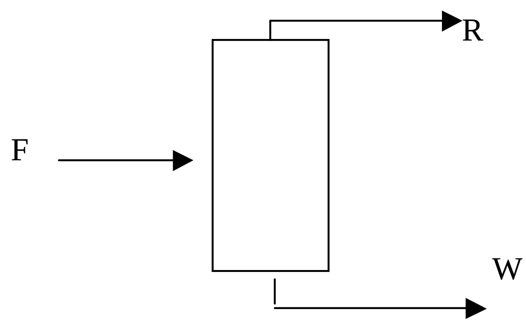
ENERGY BALANCE

<u>HEAT BALANCE ACROSS FRACTIONATOR 4</u>



Feed, F = 13883.73 kg / hr.

Wt%: $X_{EB} = 0.173$

$X_{MX} = 0.218$

$X_{PX} = 0.176$

$X_{OX} = 0.433$

Recycle, K = 9450.46 kg / hr.

$X_{EB} = 0.108$

$X_{PX} = 0.216$

$X_{MX} = 0.13$

$X_{OX} = 0.36$

Stream, R = 13661.59 kg / hr.

$X_{EB} = 0.246$

$X_{PX} = 0.292$

$X_{OX} = 0.1476$

$X_{MX} = 0.292$

Stream, W = 9673.39 kg / hr.

Wt% $X_{ox} = 0.7$

$X_{TMB} = 0.3$

Assume fresh feed enters at 30°C.

Let the base (reference) temperature be 273 K

Cp_{EB} at 303 K = 1.7673 *10^3 J / kg°K

Cp_{PX} at 303 K = 1.117 *10^3 J / kg°K

Cp_{MX} at 303 K = 1.7432 *10^3 J / kg°K

Cp_{OX} at 303 K = 1.7828 *10^3 J / kg°K

Cp_{TMB} at 303 K= 1.8195 *10^3 J / kg°K

∴ Enthalpy of F, h_F = (0.173*1.7673 + 0.176*1.117 + 0.433*1.7828) *

1000*17384.33*(303-273)

∴ h_F = 689*10^6 J / hr.

Enthalpy of stream K: Assume K enters at its bubble point.

h_R = (0.108*2.064 + 0.113*2.223 + 0.216*2.107 + 0.36*2.08 + 0.189*2.183)*1000* (413 – 273)*9450.46

∴ h_R = 2.816*10^9 J / hr.

∴ h_{feed} = h_R + h_F = 6.89*10^8 + 2.816*10^9

∴ $H_{(R+F)}$ = 2.823*10^9 J / hr.

F + R stream = Flow rate = 23334.19 kg / hr.

$X_{EB} = 0.1405$

$X_{PX} = 0.196$

$X_{MX} = 0.174$

$X_{OX} = 0.396$

$X_{TMB} = 0.0945$

A heat balance determines temperature of feed, T.

= (0.1405*2.064 + 0.174* 2.223 + 0.196*2.107 + 0.396* 2.08 +

0.0945* 2.183)* 1000* (T- 273)* 23334.19

= $h_e + h_F = 2.823*10^9$ J / hr.

∴ T = 83.2 ^{0}C

Specific heat capacities in the above calculation were determined at

(140 + 30) / 2 = 85° C

Hence error in temperature is very small.

Enthalpy of stream R

R is a liquid stream emerging from the condenser at bubble pt.

$T^{sat} = T_{bp} = 140^0C$

h_R= (0.246*2.064+0.292*2.223+0.292*2.107+0.1476*2.08)*1000*13661.59*(413-273)

= $3.976*10^9$ J / hr.

h_W = (0.7*2.08+0.3*2.183)*1000*9673.39*(423-273)

= $3.063*10^9$ J / hr.

Latent heats:

$\lambda_{EB} = 3.3725 \times 10^5$ J / kg

$\lambda_{PX} = 3.3819 \times 10^5$ J / kg

$\lambda_{MX} = 3.412 \times 10^5$ J / kg

$\lambda_{OX} = 3.4514 \times 10^5$ J / kg

Assume Reflux ratio equal to 2.0

Condenser Load:

Q_c= (0.246*3.3725+0.292*3.3819+0.292*3.412+0.1476*3.4514)*100000 *13661.59

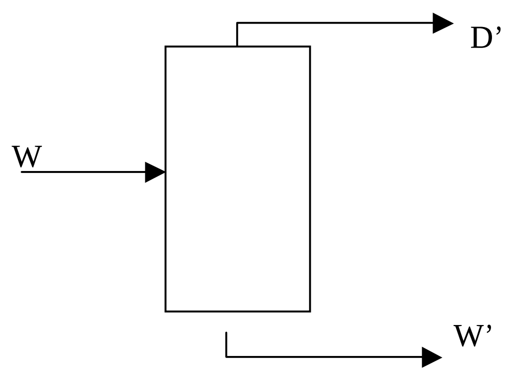
$Q_c = 4.54*10^9$ J / hr.

Reboiler Load:

$Q_B = Q_c + h_{F1} + h_{F2} - h_F$

$Q_B = 1.089*10^{10}$ J / hr.

HEAT BALANCE ACROSS FRACTIONATOR 5



W =9673.39 kg / hr

Molecular Weight, Mw =110.5 kg / kgmol

Hence, W =87.54 kgmol / hr

Mole fractions X_{OX} =0.727, X_{TMP} =0.2746

$h_w = 3.063*10^9$ J / hr

D =4421 kg / hr

M_w =106.1 kg / kgmol

D = 41.67 kmol / hr

Wt. % X_{OX} =0.99, X_{TMB} =0.01

Mole fractions: X_{OX} =0.99, X_{TMB} =0.01

W = 5252.38 kg / hr

M_w = 119.3 => W = 44.02 kmol / hr

Mole fractions: X_{OX} = 0.05, X_{TMP} =0.95

Wt. %: X_{OX} = 0.05, X_{TMB} = 0.95

T_W^{sat} =150^{0}C

$T_{D'}^{sat}$ =144^{0}C (From T-x-y plot)

$T_{W'}^{sat}$ = 164^{0}C (From T-x-y plot)

$H_{D'}$ = (0.99*2.099+0.01*2.205)*1000*4421*(417-273)

$H_{D'}$ = 1.346*10^9 J/hr.

$H_{w'}$= (0.05*2.175+0.95*2.292)*1000*5252.38*(437-273)

$H_{W'}$ =1.969*10^9 J/hr.

Minimum Reflux Ratio, Rm =3.213 (From design of column)

R = 1.5R_m =4.01625

V = 22396.05 kg/hr

And L = 30234.325- 5252.38

= 24981.945 kg/hr (assuming a total vaporizer)

Latent Heat of TMB = 3.25*10^5 J/hr

Condenser Load

Q_c = (0.99*3.4514+0.01*3.25)*100000*22396.05

= 7.72*10^9 J/hr

Reboiler load,

Q_w = (0.95*3.25+0.05*3.4514)*100000*24981.945

= 8.114*10^9 J/hr

It is assumed that the Parex separator works under Isothermal condition. Hence, there will be no heat input or heat output from the system.

REACTOR HEAT BALANCE

The following assumptions are made

The Reaction is an isomerisation reaction

The heat of reaction is neglected.

Therefore heat entering, h_R=heat leaving

Preheater before reactor

K= 9450.46 kg / hr at 60 ^{0}C .

Therefore h_K= $(4.859*10^9*9450.46) / 11556.025$

$= 3.97*10^9$ J / hr.

Steam at 1 atm pressure is used as a heating medium.

2243*1000*M=9450.46(0.1384*1.54+0.1674*1.224+0.1193*1.331
+0.6349*1.587)*1000(373-60)

M = 2090.127 kg / hr.

Condenser after reactor

Cooling water at 25^{0}C, heated to 45^{0}C.

$M*(45-25)*4.18*10^9$=9450.46*(0.108*1.574+0.216*1.224+0.13*1.587
+0.36*1.331)*1000*(373-141) +9450.46(0.108*3.37
+0.216*3.3819+0.13*3.412+0.36*3.4514)*100000

=> M=60927.75 kg / hr.