ENERGY BALANCE

BASIS : 1 Hr of operation

Reference temperature $=25^0C$

Balance around naphthalene tower

Enthalpy of feed stream at 231.67^0C

Assume feed is binary mixture

Feed is saturated liquid

$H_F = F \{X_{NF} C_{pl} (231.67-25) + X_{DF} C_{pl} (231.67-25)\}$

$= 1235.16 \{0.6 \times 226.1 \times (231.67 - 25) + 0.3988 \times 240 \times (231.67 - 25)\}$

$= 61107677.49$ KJ\hr

Enthalpy of bottom stream at 245^0C

$H_D = D\{X_{ND} C_{pl} (245-25) + X_{DD} C_{pl} (245-25)\}$

$=703.046 \{0.3010 \times 228.1 \times (245 - 25) + 0.6959 \times 240 \times (245 - 25)\}$

$= 38893781.45$ KJ\hr

Enthalpy of at top stream at 218.33^0C

$H_P = P\{X_{NP} C_{pl} (218.33-25) + X_{DP} C_{pl} (218.33-25)\}$

$=532.312 \{0.9911 \times 220.1 \times (218.33 - 25) + 6.56 \times 10^{-3} \times 234 \times (218.33 - 25)\}$

$= 22608196.13$ KJ\hr

Condenser load

$Q_C = 12539255.76$ KJ\hr

$Q_B = H_P + H_D - H_F + Q_C$

$Q_B = 12933556.03$ KJ\hr

Balance around tower 1st

At $=160^0C$

$H_{F1} = F_1\{X_{NF1} C_{pl} (160-25) + X_{DF1} C_{pl} (160-25) + X_{TF1} C_{pl} (160-25)\}$

$=1980.25 \{0.5927 \times 160 \times (160 - 25) + 0.2227 \times 180 \times (160 - 25)$

$+ 0.1638 \times 110 (160-25)\}$

$= 41241761.83$KJ\hr

$H_{F2} = F_2\{X_{NF2} C_{pl} (230.6 - 25) + X_{DF2} C_{pl} (230.6-25) + X_{TF2} C_{pl} (230.6-25)\}$

$=1653.92 \{0.69 \times 230 \times (230.6-25) + 0.275 \times 240 \times (230.6 - 25)$

$+ 0.0008 \times 180 \times (230.6 - 25)\}$

= 76457292.03 KJ\hr

similarly at top at 112^0C

H_T =2849976.605 KJ\hr

condenser load

Q_C =m ç

=(0.9911 x92 + 0.01 x128) x326.31 x 295.2

= 8896735.12 KJ\hr

Q_B = 46962241.93 KJ\hr

Balance around tower 2

H_{F2} =76457292.03 KJ\hr

H_F = 61107677.44 KJ\hr

H_{F3} at 259^0C

H_{F3} =419.071{ 230 x 0.1 x 234 +240 x0.7646 x234}

=0322.04 KJ\hr 2025

Q_C =m ç

= 4910707.45 KJ\hr

Q_B = 4910707.45 KJ\hr

Balance around column 3

H_{F3} =61107677.44 KJ\hr

H_H = 53.8{0.5081(276.15 –25) x240 + 0.4911 x230 (276.15 –25)}

= 3173897.72 KJ\hr

H_R = 365.271{0.1147(256-25) +0.8028x240(256 – 25)}

= 18483122.12 KJ\hr

Q_C =m ç

= 365.271 x0.142 x 338.2

= 18948618.41 KJ\hr

Balance around cooler at 238^0C

Q = D{ X_{2D} Cp(238 –159.2) + X_{3D} Cp (238 –159.2)}

= 703.046 { 0.3040 x190 x78.8 + 0.6960 x 200 x 78.8}

= 10911523.07 KJ\hr

Balance around heater feed stream entering

Let feed temperature is 105^0C

H_{F1} =911.93 { 0.3558 x(105-25)x93 +0.1536 x130 (105 –25)

+ 0.4617 x159.12 (105 –25) }

= 9230477.86 KJ\hr

heat added in heater to heat the feed to 256.43^0C

= 911.93{ 0.3558 x 170.2 x(256.43-105) +0.1535 x200 (256.43 –105)

+ 0.4617x240 (256.43 –105)}

= 27904079.28 KJ\hr

$H_{F2} = H_{F1} + H_{FQ}$

= 37134557.08 KJ\hr

Balance around reactor

heat of reaction = -82920 KJ\kmole

total heat produced by reaction

= 82920 x 390.71

= 32397673.2 KJ\hr

Balance around J_1

$F_{DD} = F_{DD1} + H_D$

= 55617681.2 KJ\hr

Balance around junction J_2

$H_L = H_{F1} + H_{R1}$

= 18948618.41

balance around separator

H_G = 3658.75{ 0.89 x 30 x(160 –25) +0.11 x 85.34(160 - 25)

= 17821044.4 KJ\hr

$H_c = H_L + H_G$

= 36769662.81 KJ\hr

balance around H_2 gas heater

$Q = H_2$ x Cp (700 –25)

= 3658.75 x 30 (700 –25)

= 74049187.5 KJ\hr