CHAPTER-5

ENERGY BALANCE:

Let, Reference Temperature = 30°C

Heater 1 (To heat Propylene): to 100°C

$Q = m\ C_p\ \Delta t$

$$m = 146.564\ \frac{\text{k - moles}}{\text{hr}} = \frac{146.564}{3600}\quad \frac{\text{K - moles}}{\text{S}}$$

C_p=70 x 10^3 J/K-mole (K)

Δt = 100-30 = 70°C

$$\therefore Q = \frac{146.564}{3600} \times 70 \times 10^3 \times (100 - 30) = 199.49\ \text{KW}$$

i.e., 199.49 KW of heat has to be supplied

Heater 2 (To heat synthesis gas): to 100°C

$Q=m\ C_p\ \Delta t$

$$m = 293.13\ \frac{\text{K - moles}}{\text{hr}} = \frac{293.13}{3600}\quad \frac{\text{K - moles}}{S}$$

C_p=30 x 10^3 J/K-mole(K)

Δt = 100-30 = 70°C

$$Q = \frac{293.13}{3600} \times 30 \times 10^3 \times 70) = 170.99\ \text{KW}$$

i.e., 170.89 KW of heat has to be supplied

Oxo Reactor: Reaction temperature (T_p) = 130°C

ΔH_R, at 298°C = -136.7 KJ/mole =$-136.7\text{x}10^3$ J/mole
=$-136.7\text{x}10^6$ J/K mole

heat in	+	heat Generation	=	heat Out	+	heat accumulation

Let the reference temperature (T_R) be equal to the feed temperature (T_f)

i.e $T_R = T_f = 100°C$

$\therefore$ heat in term $\rightarrow$ vanishes

Consider, steady state i.e. heat Accumulation $\rightarrow$ vanishes

$m_{propylene} \times \Delta H_R = m\, C_{p(avg),gas}\,(T_P - T_R) - m_w\, C_{pw}(T_O - T_P)$

$$\frac{0.98 \times 146.564}{3600}(-136.7 \times 10^6) = \frac{143.633}{3600}(125 \times 10^3)(130 - 100)$$

$$+ \frac{146.564}{3600}(30 \times 10^3)(130 - 100) - M_w (74.7 \times 10^3)(45 - 30)$$

$-5.454 \times 10^6 = 149.61771 \times 10^3 + 36.641 \times 10^3 - 1.1205 \times 10^6\, m_w$

m_w=5.0338 K-moles/s

m_w=90.61 Kg/s

ie. 90.61 kg/s of water has to be circulated

Cooler : (130°C – 72.55°C)

$Q = m\, C_p\, \Delta T$

$$m = \frac{135.594}{3600} \quad \frac{\text{K - moles}}{S}$$

C_p=120x10^3 J/K-moles/K

Δt=130-72.55 = 57.45°C

$$Q = \frac{135.594}{3600} \times 120 \times 10^3 \times 57.45 = 259.66 \text{ KW}$$

i.e. 259.66 KW of heat has to be removed

Overhead condenser :

Q=mλ

$$m = \frac{26.564}{3600} \text{ K-moles/s}$$

λ=3.2 x 10^7 J/K-moles

$$Q = \frac{26.564}{3600} \times 3.2 \times 10^7 = 236.12 \text{ KW}$$

i.e. 236.12 KW of heat has to be removed

Reboiler:

Q=mλ

λ=3.2 x 10^7 J/K-mole

$$m = \frac{109.03}{3600} \text{ k - moles/S}$$

$$Q = \frac{109.03}{3600} \times 3.2 \times 10^7 = 969.16 \text{ KW}$$

i.e., 969.16 Kw of heat has to be supplied.