

ENERGY BALANCE:

1) EVAPORATOR:

Heat supplied by steam =(heat required to boil spent lye) + (Heat required to vaporize glycerin)

Therefore, $W_s \lambda_s = m c_p \Delta t_1 + m_1 \lambda$

λ_s -latent heat of inlet steam to the first effect = 2257.86 KJ/ kg

W_s -mass flow rate of inlet steam

m -mass flow rate of feed to the first effect = 55774 .3 kg/hr

c_p -specific heat of lye = 2.41 KJ/kg°C

m_1 -mass flow rate of glycerin = 3904.17 kg/hr

λ -latent heat of glycerin solution = 6987.46 KJ/kg

$W_s \times 2257.86 = [55774.3 \times 2.41 \times (21.54)] + (3904.17 \times 6987.46)$

$W_s = 5.153$ Kg/sec

Thus amount of steam required = 5.153 Kg/sec

2) BAROMETRIC CONDENSER:

Vapor entering the condenser $m = 55774.3$ Kg/hr

Inlet temperature of cold water =30°C

Outlet temperature of water =50°C

$m_w c_p \Delta t = m \lambda$

m_w -mass flow rate of water

c_p -specific heat of water =4.187 KJ/kg°C

λ -latent heat of glycerin vapour=6987.46 KJ/kg

$m_w \times 4.187 \times (50-30) = 55774.3 \times 6987.46$

$m_w = 4653.937$ Kg/hr

Therefore amount of cold water required = 4653.937 Kg/hr

3) STILL:

Amount of glycerin = 93700 Kg/day

= 7808.3 Kg/hr

Latent heat of glycerin $\lambda = 6987.46$ KJ/kg

Heat required to vaporize glycerin = $m \lambda$

= 7808.3 × 6987.46

$$= 5456.0183 \times 10^4 \text{ KJ/hr}$$

$$\text{Amount of water} = 23425 \text{ Kg/day}$$

$$= 1952 \text{ Kg/hr}$$

$$\text{Latent heat of water } \lambda = 1965 \text{ KJ/kg}$$

$$\text{Heat require to vaporize water} = m\lambda$$

$$= 1952 \times 1965$$

$$= 3835.680 \times 10^3 \text{ KJ/hr}$$

$$\text{Therefore total heat required} = 5839.5863 \times 10^4 \text{ KJ/hr}$$

Now taking superheated steam at 200°C

$$\text{Latent heat of steam at } 200^\circ\text{C } \lambda = 1938.4 \text{ KJ/kg}$$

$$\text{Now } Q = m_s \lambda$$

m_s -mass flow rate of steam

$$\text{Thus } 5839.5863 \times 10^4 = 1938.4 \times m_s$$

$$m_s = 30125.9 \text{ kg/hr}$$

$$= 7230216 \text{ Kg/day}$$

4) MAIN CONDENSER:

$$\text{Heat of vaporization of glycerin } \lambda = 18170 \text{ cal./mole}$$

$$= 18170 \times 4.18 \times 92 \text{ J/Kg}$$

$$= 6987.46 \text{ KJ/Kg}$$

$$\text{Amount of heat removed from the vapor } Q = m \times \lambda$$

$$= (7652/3600) \times 6987.46 \times 1000$$

$$= 14852.23 \text{ KJ/sec}$$

$$(m)_w \times C_p \times \Delta t = (m)_G \times \lambda$$

$$(m)_w \times 4.187 \times (35-20) = 14852.23 \text{ KW}$$

$$(m)_w = (14852.23 \times 1000) / (4.187 \times 15)$$

$$(m)_w = 236.48 \text{ Kg/Sec}$$

$$\text{Amount of water required} = 236.48 \text{ Kg/sec}$$