

## ENERGY BALANCE

### Energy balance around the Extractor

Since the extractor does not contain any heating equipment the energy balance around the extractor is not required.

### Energy balance around the I<sup>st</sup> condenser

The stream coming out of the stripping section is saturated diethylene glycol.

Therefore latent heat of vaporisation of diethylene glycol at 244°C is

$$\lambda = 633 \text{ KJ/Kg}$$

Therefore total heat load on the condenser is given by;

$$Q = m \times \lambda$$

Where,  $m$  – mass flow rate of feed in kg/s

$$\therefore Q = 86.34 \times 633$$

$$= \mathbf{54653 \text{ KW}}$$

### Energy balance around the II condenser

The side stream coming out of solvent stripper, i.e, enriched with aromatics is at saturated vapour condition.  $\therefore$  the temperature is approximated as 130°C

$\therefore$  at 130°C

$$(\lambda)_B = 348.56 \text{ kJ/kg}$$

$$(\lambda)_T = 353.26 \text{ kJ/kg}$$

$$(\lambda)_X = 353.77 \text{ kJ/kg}$$

$\therefore$  The heat load on the condenser is given as

$$Q = (\sum x_i * \lambda_i) \times m$$

$$= (0.1568 \times 348.56 + 0.4252 \times 353.26 + 0.4156 \times 353.77) \times 6.7979$$

$$= \mathbf{2392.09 \text{ KW}}$$

Since the Claytreater and separator does not contain any heating equipment, the energy balance around these equipments is not required.

### Energy balance around the Benzene Column:

Since water is added as washing liquid to the extracted aromatic stream, there will be a considerable temperature drop in the system and further more the energy losses in clay treater and separator also contributes to the temperature drop. ∴ Assume the feed temperature to the Benzene column = 98°C and the reference temperature is taken as =0°C

$$\therefore (Cp)_B = 1.856 \text{ kJ/kg.K}$$

$$(Cp)_T = 1.809 \text{ kJ/kg.K}$$

$$(Cp)_X = 1.841 \text{ kJ/kg.K}$$

$$\begin{aligned} \therefore (Cp)_{\text{avg.}} &= \sum (x_i \times Cp_i) \\ &= 1.825 \text{ kJ/kg.K} \end{aligned}$$

and,

$$(\lambda)_B = 389.5 \text{ kJ/kg}$$

$$(\lambda)_T = 391.3 \text{ kJ/kg}$$

$$(\lambda)_X = 396.2 \text{ kJ/kg}$$

Now assuming the Reflux Ratio as;

$$R = 1.2$$

$$\begin{aligned} \therefore \text{The flow rate to the condenser} &= (R + 1) D \\ &= (1.2 + 1) 1.014 \\ &= 2.2308 \text{ kg/s} \end{aligned}$$

∴ The heat load on the condenser;

$$\begin{aligned} Q_c &= m \times \lambda \\ &= \mathbf{868.89 \text{ KW}} \end{aligned}$$

To find  $Q_b$ ,

Assume that heat loss in the distillation column is negligible.

∴ The heat balance around the benzene column;

$$F \times h_F + Q_b = D \times h_D + W \times h_W + Q_c$$

i.e,  $6.7979 \times (C_p)_{\text{avg}} \times T + Q_b = 1.014 \times 1.856 \times 60 + 5.78 \times 1.831 \times 60 + 868.89$

$$\Rightarrow Q_b = \mathbf{872.42 \text{ KW}}$$

**Energy balance around the Toluene Column:**

The feed to the column is saturated.

∴ the temperature = 123.5 °C

And the heat load on the condenser,  $Q_c = 2829.09 \text{ KW}$

For  $Q_b$ , overall heat balance;

$$F \times h_F + Q_b = D \times h_D + W \times h_W + Q_c$$

$$\Rightarrow Q_b = \mathbf{2860.05 \text{ KW}}$$