

HEAT BALANCE

Heat Balance across the Reactor – G-L Separator Envelope:

The raw materials enter at a temperature of 30°C into the reactor. The reactor is maintained at a temperature of 200° and a pressure of 1500 KPa. The product leaving the reactor is at the same temperature as that of the reactor. The heat of reaction is maintained by refluxing the liquid in the reactor. The Vapors leave the reactor and get condensed in the condenser and then moves to the G-L Separator where the air and other uncondensed gases are let of to the stack.

$$\text{Heat of Reaction} = 217.762 \text{ Kcal/mole}$$

$$\begin{aligned} \text{Enthalpy of feed} &= 20.79 \times 10^3 \times 0.397 \times 30 + 1562 \times 0.52 \times 30 + 2.23 \times 10^6 \times 0.24 \times 30 \\ &= 16.33 \times 10^6 \text{ Kcal/hr} \end{aligned}$$

$$\begin{aligned} \text{Enthalpy of the liquid leaving out} &= 1039.58 \times 0.397 \times 200 + 30937.5 \times 0.287 \times 200 \\ &\quad + 6709.17 \times 200 + 1562.5 \times 0.52 \times 200 \\ &= 3.362 \times 10^6 \text{ Kcal/hr} \end{aligned}$$

$$\begin{aligned} \text{Enthalpy of air leaving from the G-L separator} &= 75.01 \times 10^3 \times 0.24 \times 200 \\ &= 3.6 \times 10^6 \text{ Kcal/hr} \end{aligned}$$

$$\begin{aligned} \text{Heat of reaction} &= 217.76 \times 186.35 \times 10^6 \\ &= 40.57 \times 10^6 \text{ Kcal/hr} \end{aligned}$$

$$\begin{aligned} \text{Enthalpy of feed} + \text{Heat of Reaction} &= \text{Enthalpy of Liquid out} + \text{Enthalpy of air leaving} \\ &\quad + \text{Heat lost in the Condenser} \end{aligned}$$

$$16.33 \times 10^6 + 40.57 \times 10^6 = 3.362 \times 10^6 + 3.6 \times 10^6 + Q$$

$$\begin{aligned} \text{Heat Load on the Condenser} = Q &= 49.938 \times 10^6 \text{ Kcal/hr} \\ &= 58039.04 \text{ KW} \end{aligned}$$

Heat Balance Across the Surge Vessel:

The Liquid outlet from the reactor is fed to the surge vessel operating at atmospheric pressure and a temperature of 90 °C. The liquid stream is cooled by passing water around the jacket.

$$\begin{aligned}\text{Enthalpy of the liquid Entering} &= 1039.58 \times 0.397 \times 200 + 30937.5 \times 0.287 \times 200 \\ &\quad + 6709.17 \times 200 + 1562.5 \times 0.52 \times 200 \\ &= 3.362 \times 10^6 \text{ Kcal/hr}\end{aligned}$$

$$\begin{aligned}\text{Enthalpy of the liquid leaving out} &= 1039.58 \times 0.397 \times 80 + 30937.5 \times 0.287 \times 80 \\ &\quad + 6709.17 \times 80 + 1562.5 \times 0.52 \times 80 \\ &= 1.3448 \times 10^6 \text{ Kcal/hr}\end{aligned}$$

Enthalpy of Liquid Entering = Enthalpy of liquid leaving + Heat Lost

$$\begin{aligned}\text{Heat Lost} &= 3.362 \times 10^6 - 1.3448 \times 10^6 \\ &= 2.0172 \times 10^6 \text{ Kcal/hr} \\ &= 2344.43 \text{ KW}\end{aligned}$$

Heat Balance Across the Drier:

The Solid enters the drier at a temperature of 176 °F and leaves the drier at a temperature of 251.5 °F. The air is entering the drier at a temperature of 313 °C and leaves the drier at a temperature of 190 °C.

$$\begin{aligned}\text{Enthalpy of feed} &= 68205.51 \times 0.2871 \times 176 + 1722.38 \times 176 \\ &= 3.749 \times 10^6 \text{ Btu/hr}\end{aligned}$$

$$\begin{aligned}\text{Enthalpy of the product} &= 68205.51 \times 0.2871 \times 251.5 + 1722.38 \times 251.5 \\ &= 5.098 \times 10^6 \text{ Btu/hr}\end{aligned}$$

$$\begin{aligned}\text{Enthalpy of air entering} &= 71000 \times 0.2485 \times 313 \\ &= 5.098 \times 10^6 \text{ Btu/hr}\end{aligned}$$

$$\begin{aligned}\text{Enthalpy of air out} &= 71000 \times 0.265 \times 190 \\ &= 3.57 \times 10^6 \text{ Btu/hr}\end{aligned}$$

$$\begin{aligned}\text{Enthalpy of feed} + \text{Enthalpy of air entering} &= \text{Enthalpy of product} + \text{Enthalpy of air out} \\ &\quad + \text{Losses}\end{aligned}$$

$$\begin{aligned}
\text{Losses} &= 3.749 \times 10^6 + 5.52 \times 10^6 - 5.098 \times 10^6 - 3.57 \times 10^6 \\
&= 3.31 \times 10^5 \text{ Btu/hr} \\
&= 97.006 \text{ KW}
\end{aligned}$$

Heat Balance Across the Residue Still:

The outlet from the centrifuge is fed to the residue still the feed is at a temperature of 80°C and the tower is maintained at a temperature of 101.4 °C which is the saturation temperature of the mixture. Reflux of the still is assumed as 0.6

$$\begin{aligned}
\text{Enthalpy of the feed} &= 1039.58 \times 0.397 \times 80 + 1562.5 \times 0.52 \times 80 + 5929.17 \times 80 \\
&= 5.724 \times 10^5 \text{ Kcal/hr}
\end{aligned}$$

$$\begin{aligned}
\text{Enthalpy of the distillate} &= 1486.7 \times 0.52 \times 101.4 + 5333.3 \times 101.4 \\
&= 6.192 \times 10^5 \text{ Kcal/hr}
\end{aligned}$$

$$\begin{aligned}
\text{Enthalpy of the residue} &= 1039.58 \times 0.397 \times 101.4 + 75.8 \times 0.52 \times 101.4 + 595.87 \times 101.4 \\
&= 1.063 \times 10^5 \text{ Kcal/hr}
\end{aligned}$$

$$\begin{aligned}
\text{Heat Removed by the condenser} &= 10912.08 \times 478.34 \\
&= 5.219 \times 10^6 \text{ Kcal/hr}
\end{aligned}$$

$$\begin{aligned}
\text{Heat Supplied by the reboiler} &= \text{Enthalpy of distillate} + \text{Enthalpy of residue} \\
&\quad + \text{Heat removed by condenser} - \text{Enthalpy of feed} \\
&= 6.192 \times 10^5 + 1.063 \times 10^5 + 5.219 \times 10^6 - 5.724 \times 10^5 \\
&= 5.3721 \times 10^6 \text{ Kcal/hr} \\
&= 6243.57 \text{ KW}
\end{aligned}$$

Heat Balance across the dehydration Tower:

The product from the residue still essentially has water associated with acetic acid. The dehydration tower is operated at 101.4°C. and feed enters the tower at the same temperature. The reflux ratio is assumed to be 0.6

$$\begin{aligned}
\text{Enthalpy of feed} &= 1486.7 \times 0.52 \times 101.4 + 5333.3 \times 101.4 \\
&= 6.192 \times 10^5 \text{ Kcal/hr}
\end{aligned}$$

$$\begin{aligned}
\text{Enthalpy of Distillate} &= 5397.588 \times 101.4 \\
&= 5.4732 \times 10^5 \text{ Kcal/hr}
\end{aligned}$$

$$\begin{aligned}\text{Enthalpy of residue} &= 1328.04 \times 0.397 \times 101.4 \\ &= 5.3461 \times 10^4 \text{ Kcal/hr}\end{aligned}$$

$$\begin{aligned}\text{Heat removed by the condenser} &= 8636.14 \times 538.3 \\ &= 4.649 \times 10^6 \text{ Kcal/hr}\end{aligned}$$

$$\begin{aligned}\text{Heat Supplied by the reboiler} &= \text{Enthalpy of distillate} + \text{Enthalpy of residue} \\ &\quad + \text{Heat removed by condenser} - \text{Enthalpy of feed} \\ &= 5.4732 \times 10^5 + 5.3461 \times 10^4 + 4.649 \times 10^6 - 6.192 \times 10^5 \\ &= 4.6306 \times 10^6 \text{ Kcal/hr} \\ &= 5381.76 \text{ KW}\end{aligned}$$