ENERGY BALANCE

The datum temperature is taken as 30ºc.

1) ENERGY BALANCE AROUND THE REACTOR

Feed of ethylene oxide and ethyl alcohol can be assumed at room temp (30ºc).

1 hour of operation is taken as the basis.

Heat input + generation rate

= heat output - heat supplied externally

a. **Heat input** = $(mc_p\Delta t)_{alcohol} + (mc_p\Delta t)_{EtO}$

= 0 + 0 ,($t_{reference} = t_{feed}$)

= 0

b. **Generation rate**

The heat of reaction is 23kcal/gmol of EtO reacted.

Generation rate = $\Delta H_R \times$feed rate×conversion

= $23\times4180\times10^3\times152.30\times0.95$

= 13.9100159×10^9J/hr

c. **Heat output**

= $(mc_p\Delta t)_{alcohol} + (mc_p\Delta t)_{mge} + (mc_p\Delta t)_{carbitol} + (mc_p\Delta t)_{tge} + (mc_p\Delta t)_{EtO}$

The product outlet temperature is taken as that of reaction temp,200ºc.

$(mc_p\Delta t)_{alcohol}$ = 789.77×175×170kJ/hr

$(mc_p\Delta t)_{mge}$ = 114.97×210×170 kJ/hr

$(mc_p\Delta t)_{EtO}$ = 7.614×115×170 kJ/hr

$(mc_p\Delta t)_{carbitol}$ = 9.0825×481.4×170 kJ/hr

$(mc_p\Delta t)_{tge}$ = 439.614×3.85125×170 kJ/hr

Therefore heat output = 28.780×10^6 kJ/hr

d. **Heat supplied externally** = $(28.780 - 13.910)\times10^6$ kJ/hr

= 14.8700×10^9 J/hr

= 4130.5kW.

2) ENERGY BALANCE AROUND THE ALCOHOL RECOVERY TOWER

Heat input + Reboiler load

= heat output + heat load of condenser

a. Heat input

output from the reactor is feed for the tower hence,

heat input = 28.780×10^9 J/hr.

b. Heat output

The products of the tower are at 100ºc.

The output of the tower are distillate and residue.

heat out with distillate = $(mc_p\Delta t)_{alcohol}$

= $789.27\times150\times70$ kJ/hr.

heat out with residue = $(mc_p\Delta t)_{carbitol} + (mc_p\Delta t)_{mge} + (mc_p\Delta t)_{tge}$

= $9.0825\times343.25\times70 + 114.97\times105\times70$

+ $3.8512\times376.75\times70$

= 1.16718kJ/hr

The total heat output = 9.453×10^6 kJ/hr

c. Condenser load- Reboiler load = $(28.780-9.453)\times10^9$

= 19.327×10^9 J/hr.

3) ENERGY BALANCE AROUND TOWER 1 (MGE-SEPARATION)

Heat input + Reboiler load

= heat output + heat load of condenser

a. Heat input

output from the alcohol recovery tower is feed for the tower hence,

heat input = 1.1671×10^9 J/hr.

b. Heat output

The products of the tower are at 150ºc.

The output of the tower are distillate and residue.

heat out with distillate = $(mc_p\Delta t)_{mge}$

$= 114.97 \times 205 \times 120$ kJ/hr.

heat out with residue $= (mc_p\Delta t)_{carbitol} + (mc_p\Delta t)_{tge}$

$= 9.0825 \times 418.99 \times 120 + 3.8512 \times 457.52 \times 120$

$= 0.667 \times 10^6$ kJ/hr

The total heat output $= 3.4952 \times 10^6$ kJ/hr

c. Reboiler load - Condenser load $= (3.4952 - 1.1671) \times 10^9$

$= 2.3281 \times 10^9$ J/hr.

4) <u>ENERGY BALANCE AROUND TOWER 2 (PRODUCT TOWER).</u>

Heat input + Reboiler load

= heat output + heat load of condenser

a. Heat input

output from tower 1 is feed for the tower hence,

heat input = 0.667×10^9 J/hr.

b. Heat output

The products of the tower are at 202^{o}c.

The output of the tower are distillate and residue.

heat out with distillate $= (mc_p\Delta t)_{carbitol}$

$= 9.0825 \times 481.6 \times 172$ kJ/hr.

heat out with residue $= (mc_p\Delta t)_{tge}$

$= 3.8512 \times 505.6 \times 172$

$= 0.3349 \times 10^6$ kJ/hr

The total heat output $= 1.0872 \times 10^6$ kJ/hr

c. Reboiler load - Condenser load $= (1.0872 - 0.667) \times 10^9$

$= 0.4202 \times 10^9$ J/hr