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# CH4010 ASSIGNMENT - 1

CH18B025

## 2. AREA TARGETTING contd.

First, let's start from finding out area requirement of cooler.

Assume that the average heat transfer coefficient, $U = 0.001$ ~~kW/K m²~~ $MW/Km^2$

$= 1\ kW/m^2$

$$Q = AU\,LMTD$$

$$\Rightarrow A = \frac{Q}{U \times LMTD}$$

**part - 1:** Given that ~~Assume~~ the cooling water heats up from a temperature of 15°C to 30°; $T_{hot,entry} = T_{hot,exit} + \frac{Q_c}{F_q}$ $= 40 + \frac{168}{6.1} = 67.54$

$T = 67.541^\circ$ → $40^\circ$ Hot stream ($H_1 + H_2$) ($F_q = 2.1 + 4 = 6.1\ kW/K$)

6.1 kW/K

$30^\circ$ ← $15^\circ$ Water

$$A_1 = \frac{Q_c}{10^3 \times 0.001 \times LMTD}$$

$$LMTD = \frac{(67.541 - 30) - (40 - 15)}{\ln\left(\frac{67.541 - 30}{40 - 15}\right)}$$

$$\Rightarrow LMTD = 30.8468^\circ$$

$$\therefore A_1 = \frac{168}{0.001 \times 10^3 \times 30.8468} = \boxed{5.446\ m^2}$$

**Part - 2:** → from previous step

$T = 80.3279°C$ → 67.541°C, 6.1 kW/K, $FCp = 6.1\ kW/K$

From heat balance

60°C ← 30°C, 2.6 kW/K, $FCp = 2.6\ kW/K$ ($C_1$)

From graph

Heat balance.

$$(T - 67.541)6.1 = (60 - 30)(2.6)$$

$$\Rightarrow T = 80.3279^\circ C$$

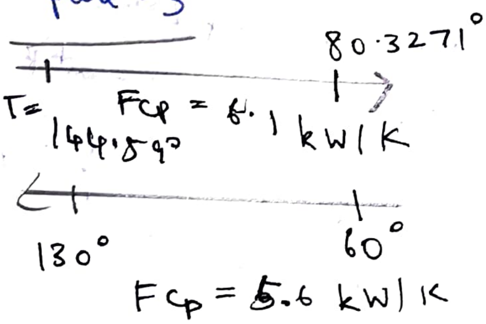
$$Q_1 = 2.6(60-30) = \underline{78\ \text{kW}}$$

$$LMTD = \frac{(80.328-60)-(67.541-30)}{\ln\left(\frac{80.328-60}{67.541-30}\right)}$$

$$= \underline{28.06\,^\circ C}$$

$$A_2 = \frac{78}{0.001\times10^3 \times 28.06} = \boxed{2.78\ m^2}$$

Part-3




$$Q_2 = 5.6(130-60)$$
$$= \underline{392\ \text{kW}}$$

Heat balance:

$$6.1(T - 80.3271) = 392$$

$$\Rightarrow T = 144.589\,^\circ C$$

$$LMTD = \frac{(144.59-130)-(80.3271-60)}{\ln\left(\frac{144.59-130}{80.3271-60}\right)}$$

$$= \underline{17.3\,^\circ C}$$

$$A_3 = \frac{Q_2}{U\times LMTD} = \frac{392}{0.001\times10^3 \times 17.3} = \boxed{22.658\ m^2}$$

## part-4

$150^\circ \longrightarrow 144.59^\circ$, $FCp = 6.1\ kW/K$

$T = 141^\circ \longleftarrow 130^\circ$, $FCp = 3\ \cancel{2.6}\ kW/K$

$$Q_3 = \cancel{2.6}\ 6.1\,(150 - 144.59)$$
$$= \underline{33\ kW}$$

Heat Balance,

$$\cancel{2.6}\,3\,(T - 130) = 6.1\,(150 - 144.59).$$

$$\Rightarrow T = 141^\circ C$$

$$LMTD = \frac{(150 - 141) - (144.59 - 130)}{\ln\left(\frac{150 - 141}{144.59 - 130}\right)} = \underline{11.571^\circ}$$

$$A_4 = \frac{33}{0.001 \times 10^3 \times 11.571^\circ} = \boxed{2.852\ m^2}$$

## part-5

$150^\circ \longrightarrow 180^\circ$, $FCp = 2.1\ kW/K$

$T = 162^\circ \longleftarrow 141^\circ$, $FCp = \cancel{2.6}\ 3 kW/K$

$$Q_4 = 2.1\,(180 - 150)$$
$$= \underline{63\ kW}$$

Heat balance,

$$(\cancel{2.6}\,3)(T - 141) = 2.1\,(180 - 150)$$

$$\Rightarrow T = 162^\circ$$

$$LMTD = \frac{(180 - 141) - (162 - 150)}{\ln\left(\frac{180 - 141}{162 - 150}\right)} = \underline{12.984^\circ C}$$

$$A_5 = \frac{63}{1 \times 12.984} = \boxed{4.852\ m^2}$$

part - 6

We ~~can~~ are ~~assume~~ given that the ~~the~~ heating utility is steam and that it ~~rono~~ condenses at 300°C (only latent heat)

$\dot{Q}_h$ = 54 kW ; cold stream heated from 162° - 180°

$$LMTD = \frac{(180-300) - (162-300)}{\ln\left(\frac{300-180}{300-162}\right)} = \underline{128.79°}$$

$$\therefore A_6 = \frac{54}{128.79} = 0.4193$$

$$\approx \boxed{0.42 \ m^2}$$

$$\text{Total Area} = \sum_{k=1}^{6} A_k$$

= 5.454 2.78 + 22.66 + 2.85 + 4.85 + 0.42

= 39.0073 $m^2$

Area target = $\boxed{39.01 \ m^2}$

3) Above pinch, S = 1 hot + 1 cold + 1 utility
= 3.

∴ No of hexchangers = ~~3A~~ 1 S - 1
= 2 exchangers

Below pinch,

no of streams, $S$ = 2 hot + 2 cold + 1 utility ~~4~~

= ~~4~~ 5 streams

No of exchangers = ~~S~~ − 1 = 5 − 1

= 4 exchangers

~~Total Minimum num~~

Minimum number of heat exchangers = 2 above + 4 below

$\Rightarrow$ Min no. of units = $\boxed{6}$ heat exchangers

4. Cost Target

Steam cost = ₹ 12000 × $Q_h$ = 120000 × $54 \times 10^{-3}$

= 6480 rupees/year

Water cost = 10000 × $Q_c$ = $10^4 \times 168 \times 10^{-3}$

= 1680 rupees/year.

Capital cost = $6 \times \left(40000 + 500 \frac{\text{target area}}{6}\right)$

$= 6 \times \left(40000 + 800 \times \frac{39.0073}{6}\right)$

= ₹ 259503.7

Annualisation factor = 0.25

Total cost = Annualization factor × Capital cost

+ Utility costs

(i.e. steam heating + cooling costs)

$= 0.25 \times (259803.7)$

$+ 1680 + 6480$

$= \boxed{₹\ 73035.917\ /\text{year}}$

$= \boxed{₹\ 73{,}036\ /\text{year}}$