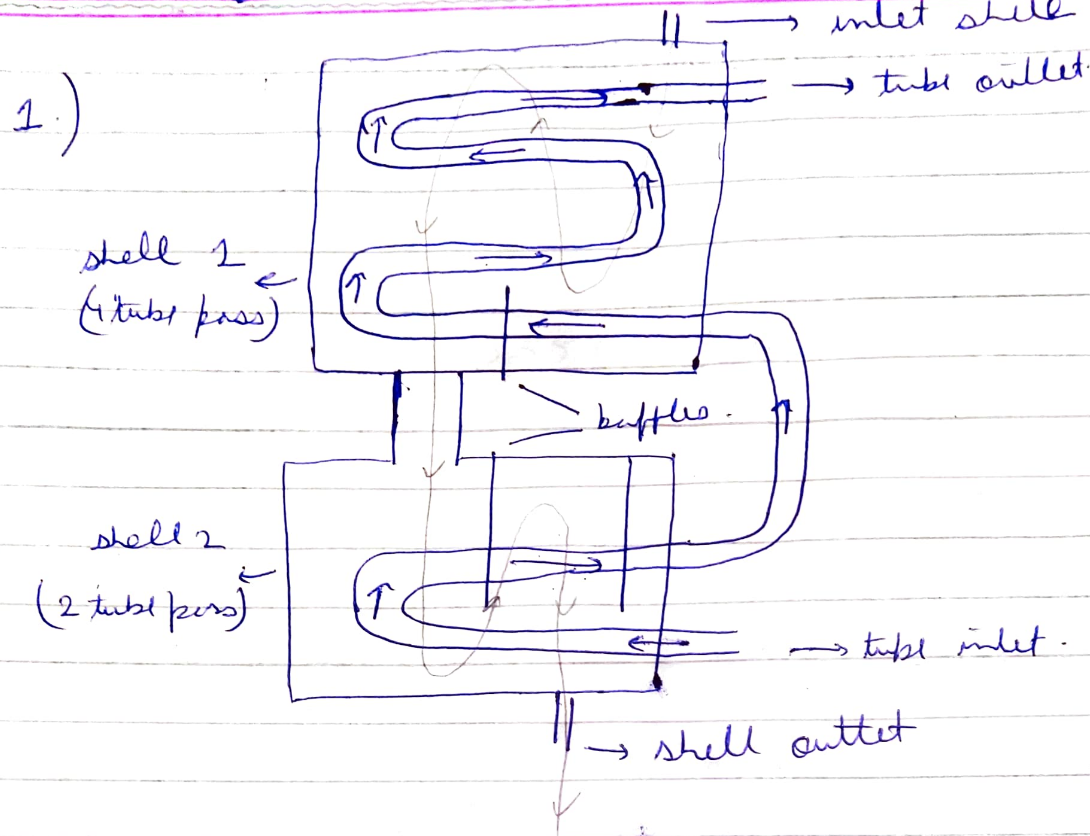
SHUBHAM GUPTA 180749

CHE-312, ASSIGNMENT-6

1.)



2.) log mean temperature diff. (LMTD)

$$\Delta T_{lm} = \frac{\Delta T_1 - \Delta T_2}{\ln(\Delta T_1 / \Delta T_2)}$$

average mean temperature diff (AMTD)

$$\Delta T_{AM} = \frac{\Delta T_1 + \Delta T_2}{2}$$

ΔT_1 is temp difference b/w hot & cold fluid at inlet
ΔT_2 is temp ——— " ——— at outlet

if $\Delta T_1 \doteq \Delta T_2$, $\boxed{AMTD = \Delta T_1 = \Delta T_2}$

now, we write $\ln(\Delta T_1/\Delta T_2)$ as $\ln\left(1 + \frac{\Delta T_1}{\Delta T_2} - 1\right)$

using taylor series expansion,
$\ln(\Delta T_1/\Delta T_2) = (\Delta T_1/\Delta T_2 - 1)$
since $\ln(1+x) \simeq x$

$$\boxed{LMTD = \frac{(\Delta T_1 - \Delta T_2)\,\Delta T_2}{(\Delta T_1 - \Delta T_2)} = \Delta T_1 = \Delta T_2}$$

AMTD = LMTD if temp. diff. b/w hot & cold fluid is constant throughout the length of heat exchange.

also, $\Delta T_1 = \Delta T_2$ when $C_c \simeq C_h$

This is also applicable when diff. b/w ΔT_1 & ΔT_2 is not very large compared to values of ΔT_1 & ΔT_2

When ΔT_1 differs from ΔT_2 by not more than 40%. then error in using AMTD is less than 1% compared to LMTD.

3) Given :

C_p water = 4180 J/kg K
C_p geo water = 4310 J/kg K.
$\dot{m}$ water = 0.2 kg/s.
$\dot{m}$ geowater = 0.3 kg/s
U = 550 W/m²k.
D = 0.8 cm = 8×10^{-3} m

rate of heat transfer in heat exchanger.
$\dot{Q} = [\dot{m}\, C_p\, (T_{out} - T_{in})]$ water.

$$\boxed{\dot{Q} = 29.26 \text{ kW}}$$

the outlet temp of geothermal water :
$\dot{Q} = [\dot{m}\, C_p\, (T_{in} - T_{out})]_{geo}$

$$\boxed{T_{out} = 117.4°C}$$

now we will calculate ΔT_{lm}
$$\Delta T_{lm} = \frac{\Delta T_1 - \Delta T_2}{\ln(\Delta T_1 / \Delta T_2)}$$
$\Delta T_1 = 140 - 25 = 115°C$
$\Delta T_2 = 117.4 - 60 = 57.4°C$

$$\therefore \boxed{\Delta T_{lm} = 82.9°C}$$

for surface area of heat exchanger.
$\dot{Q} = U A_s \Delta T_{lm}$
solving for A_s, $\boxed{A_s = 0.642 \text{ m}^2}$

$\therefore$ length of tube = $\dfrac{A_s}{\pi D}$ $\Rightarrow$ $\boxed{L = 25.5 \text{ m}}$

(Ans)

4.) modifying the parallel flow heat exchanger to counter flow heat exchanger

$\Delta T_1 = 140 - 60 = 80°C$
$\Delta T_2 = 117.37 - 25 = 92.37°C$

$\boxed{\Delta T_{em} = 86.04°C}$

$\dot{Q} = U A_s (\Delta T_{em})$
solving for A_s, $\boxed{A_s = 0.62}$

$A_s = \pi D L$
$\therefore \boxed{L = 24.6\ m}$

$\therefore$ the modification, i.e, change parallel flow heat exchanger to a counter flow heat exchanger is good.

5). given :

$T_{in\,H} = 95°C$

~~Tout...~~

$T_{in\,c} = 20°C$

$T_{out\,H} - T_{in\,c} = 15°C$

$\dot{m}_H = 1.5\,\dot{m}_c$

$UA = 1400\,W/K$

$C_p = 4180\,J/kg\,W.$

a)

$C_h = \dot{m}_h C_{ph} = 1.5\,\dot{m}_c\,(4.18) = 6.27\,\dot{m}_c$

$C_c = 4.18\,\dot{m}_c$

$C_{min} = C_c = 4.18\,\dot{m}_c$

$C = \dfrac{C_{min}}{C_{max}} = \dfrac{4.18\,\dot{m}_c}{6.27\,\dot{m}_c}$

$\boxed{C = 0.667}$

now the rate of heat transfer

$\dot{Q} = C_c\,(T_{c\,out} - C_{in\,c})$

$\dot{Q} = 4.18\,\dot{m}\,(T_{c\,out} - 20)$ --- (1)

also

$\dot{Q} = C_h\,(T_{h\,in} - T_{h\,out})$

$\dot{Q} = 6.27\,\dot{m}\,(95 - (T_{c\,out} + 15))$ --- (2)

solving (1) & (2) to get $T_{c\,out}$

$\boxed{T_{c\,out} = 56°C}$

b.) effectiveness of heat exchanger

$\varepsilon = \dfrac{\dot{Q}}{\dot{Q}_{max}} = \dfrac{C_c\,(T_{c\,out} - T_{c\,in})}{C_c\,(T_{h\,in} - T_{c\,in})}.$

$\boxed{\varepsilon = 0.48}$

c) NTU of heat exchanger

$$NTU = \frac{1}{C-1} \ln\left(\frac{\varepsilon - 1}{\varepsilon C - 1}\right)$$

$NTU = 0.805$

we will obtain $\dot{m}_c$ from NTU definition

$$NTU = \frac{UA_s}{C_{min}} = \frac{1.400\ kW/^\circ C}{4.18\ \dot{m}_c}$$

$\therefore \boxed{\dot{m}_c = 0.416\ kg/s}$

d.) rate of heat transfer

$\dot{Q} = \dot{m}_c C_{pc} (T_{c\,out} - T_{c\,in})$

$\boxed{\dot{Q} = 62.6\ kW}$

(Ans)