The University of Jordan

Faculty of Engineering and Technology

Chemical Engineering Department

Chemical Engineering Laboratory2

Experiment (4)

Title Of The Experiment:

CONCENTRIC TUBE HEAT EXCHANGER

Done by:

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Report Type: short Report

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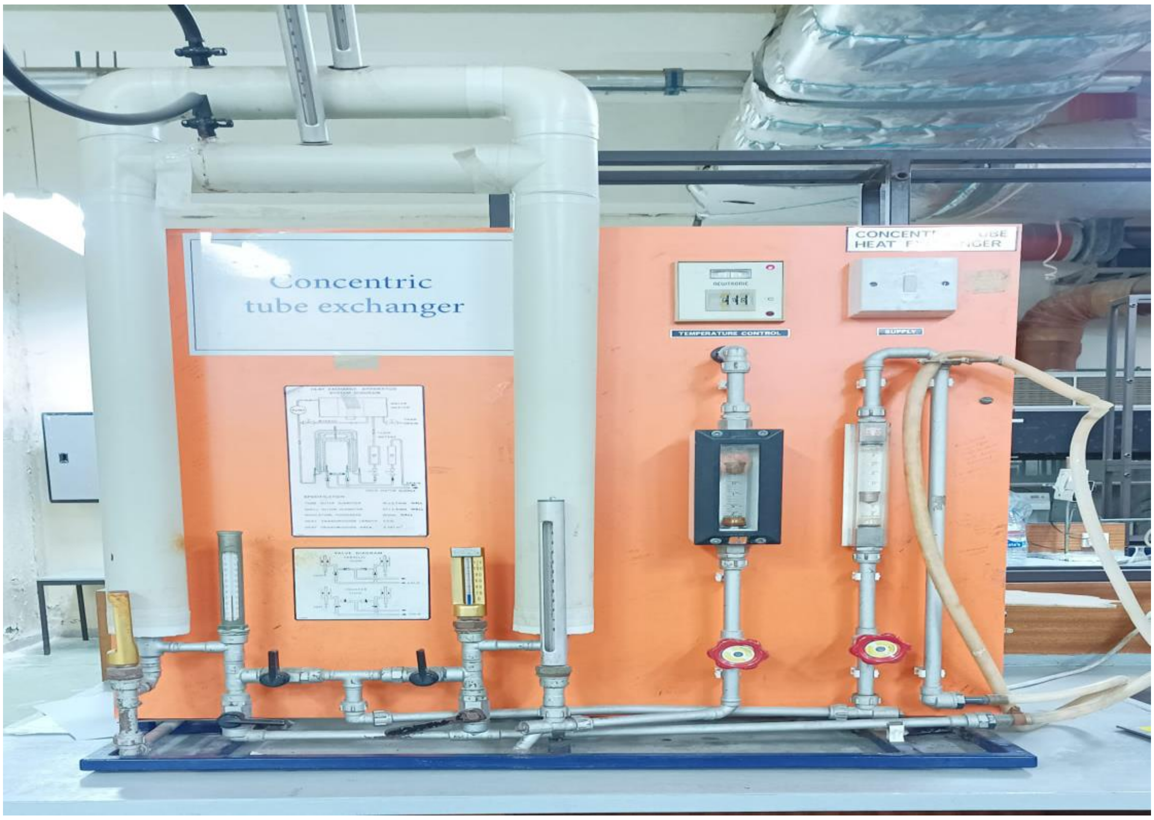
Abstract:

In this experiment the temperature distribution for steady state energy conduction across a uniform cross-section will be measured and illustrated and the effect of a change in heat input in this experiment will be demonstrated. Also, brass's thermal conductivity (k) could be determined and compared with the theoretical value. Finally, graph shows the relationship between heat inputs and temperature will be drawn.



Contents

Result :

heat transfer area(m2)	0.067
heat transfer length(m)	1.5
cold water flow rate (cm^3/min)	1200
cold water flow rate (m^3/s)	0.00002

co-current flow							
hot water flow rate (cm^3/min)	hot water flow rate (m^3/sec)	T(hot in) C	T(hot out)	T(cold in)	T(cold out)	ΔT hot	ΔTcold
1000	1.67E-05	64	48	14	38	16	24
1500	2.50E-05	64	52	13	32	12	19
2000	3.33E-05	66	54	14	34	12	20
2500	4.17E-05	66	56	13	37	10	24

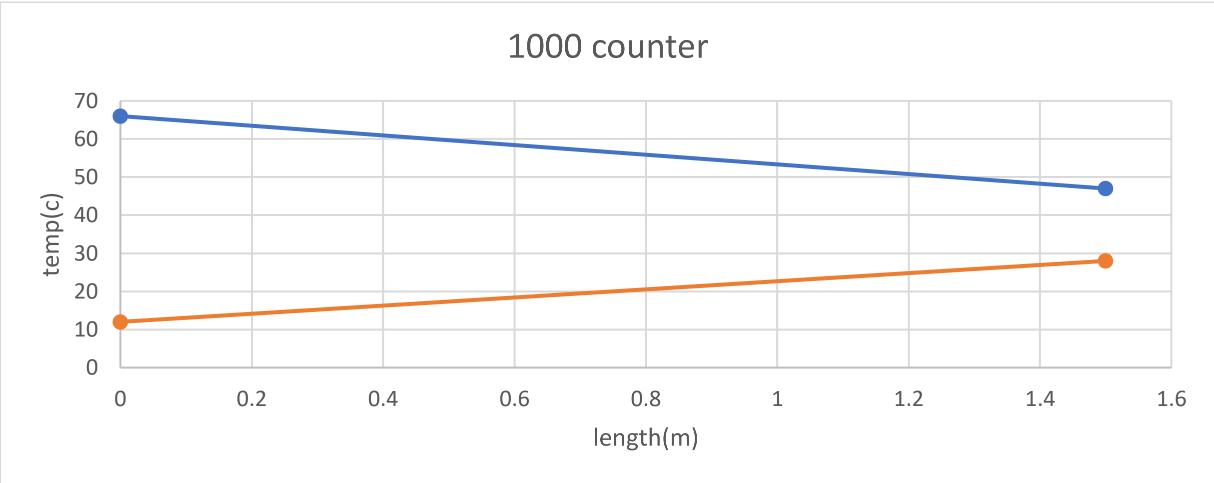
Q absorbed	Qemitted	ΔT 1 (°C)	ΔT 2 (°C)	ΔT lmtd	U	Ŋ overall	Ŋ cold
1999.9595	1098.9801	50	10	24.85339738	1201.048721	181.9832326	0.48
1584.6831	1235.1855	51	20	33.116355	714.2086507	128.2951522	0.37254902
1667.4856	1645.2074	52	20	33.48991806	743.1443914	101.3541294	0.384615385
2000.4811	1712.8688	53	19	33.14315226	900.8777116	116.791265	0.452830189

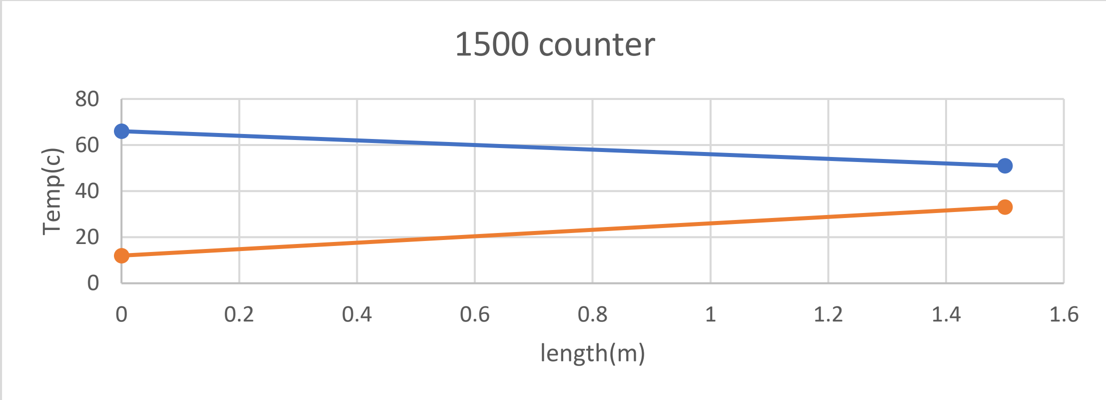
Ŋ hot	Cold Stream Avg.Temp (K)	Hot Stream Avg.Temp (K)	density Hot [kg/m^3)	density cold [kg/m^3	mass cold	mass hot	CP hot (j/(kg.k))	CP cold (j/(kg.k))	Efficiency of exchanger %
0.32	299.13	329.13	985.22	996.79	0.019936	1.64E-02	4183	4180	40
0.23529412	295.63	331	984.29	997.66	0.019953	2.46E-02	4183	4180	30.39216
0.23076923	297.13	333	983.27	997.3	0.019946	3.28E-02	4183	4180	30.76923
0.18867925	298.13	334	982.76	997.05	0.019941	4.09E-02	4183	4180	32.07547

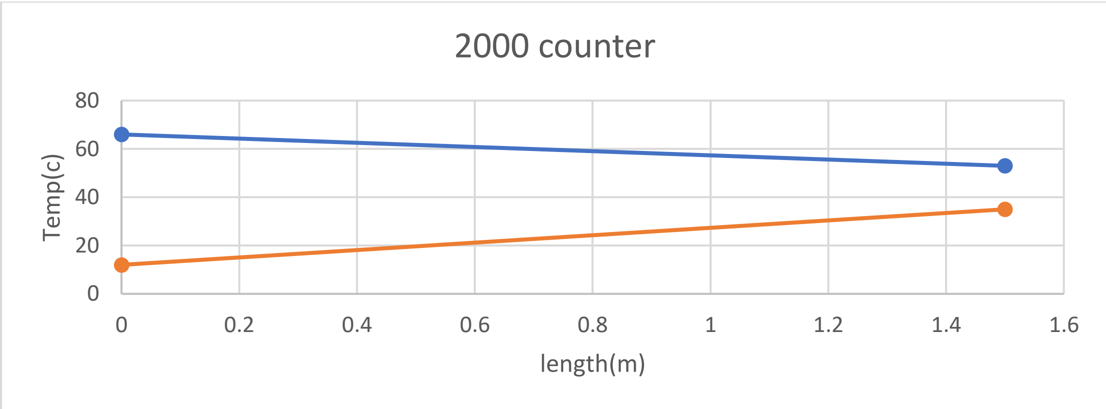
counter-current flow							
hot water flow rate (cm^3/min)	hot water flow rate (m^3/sec)	T(hot in) C	T(hot out)	T(cold in)	T(cold out)	ΔT hot	ΔT cold
1000	1.67E-05	66	47	12	28	19	16
1500	2.50E-05	66	51	12	33	15	21
2000	3.33E-05	66	53	12	35	13	23
2500	4.17E-05	66	54	13	36	12	23

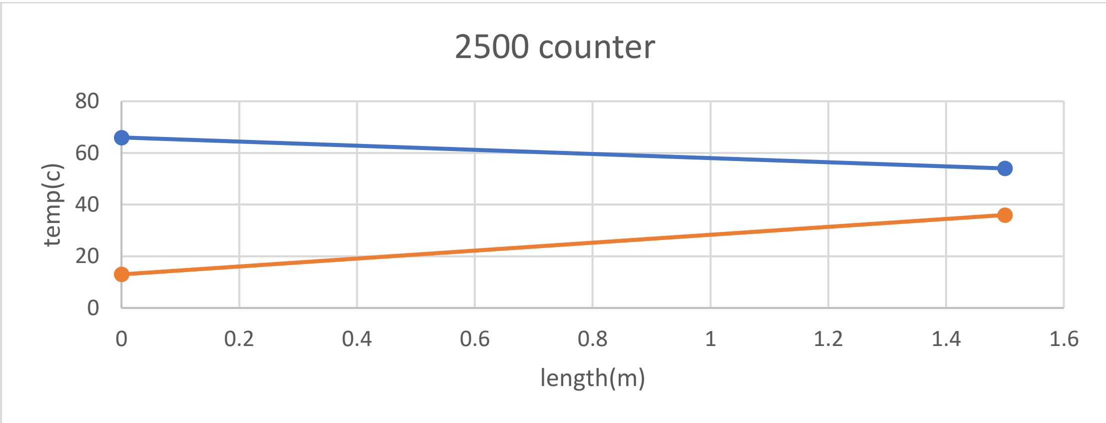
Q absorbed	Qemitted	ΔT 1 (°C)	ΔT 2 (°C)	ΔT lmtd	U	Ƞ overall	Ƞ cold
1335.2057	1304.7077	54	19	33.50741016	594.7473449	102.3375365	29.62962963
1751.4919	1543.4799	54	18	32.76861216	797.7655557	113.4768162	38.88888889
1917.8392	1782.9787	54	18	32.76861216	873.5330375	107.5637767	42.59259259
1917.4354	2055.8399	53	18	32.40980346	883.0179628	93.26773766	43.39622642

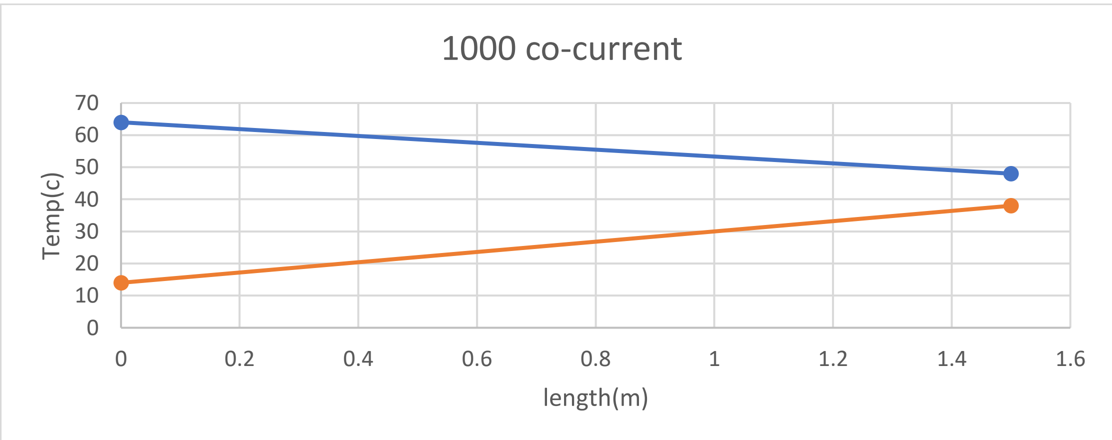
Ƞ hot	Cold Stream Avg.Temp (K)	Hot Stream Avg.Temp (K)	density Hot [kg/m^3)	density cold [kg/m^3	mass cold	mass hot	CP hot (j/(kg.k))	CP cold (j/(kg.k))	Efficiency of exchanger %
0.35185185	293.13	329.63	984.97	998.21	0.019964	1.64E-02	4183	4180	32.40741
0.27777778	295.63	331.63	983.97	997.66	0.019953	2.46E-02	4183	4180	33.33333
0.24074074	296.63	332.63	983.64	997.42	0.019948	3.28E-02	4183	4180	33.33333
0.22641509	297.63	333.13	982.95	997.21	0.019944	4.10E-02	4183	4180	33.01887

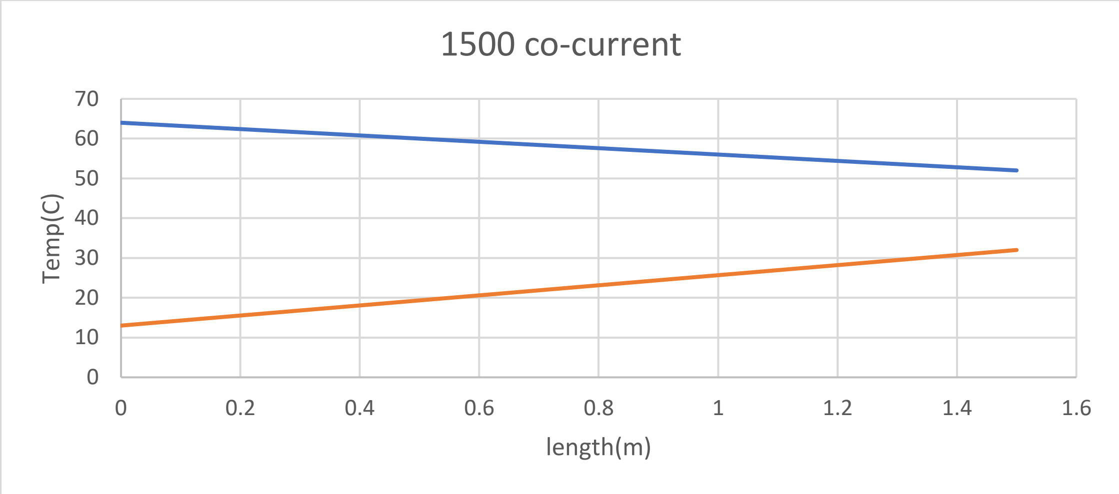



1500 counter
80
60
40
20
0
Temp(c)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
length(m)


2000 counter
80
60
40
20
0
Temp(c)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
length(m)


2500 counter
80
60
40
20
0
temp(c)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
length(m)


1000 co-current
70
60
50
40
30
20
10
0
Temp(c)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
length(m)


1500 co-current
70
60
50
40
30
20
10
0
Temp(C)
0
0.2
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0.8
1
1.2
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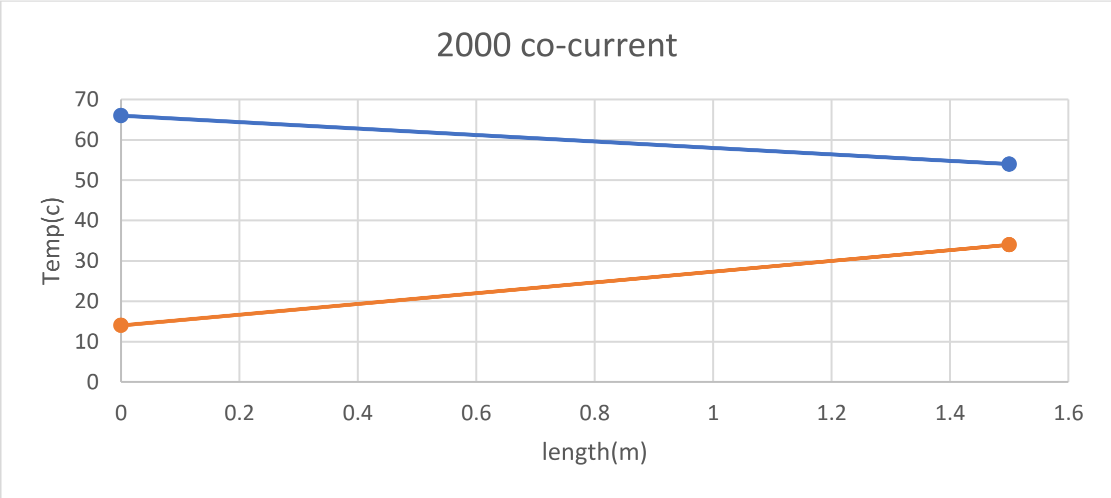
1.6
length(m)


2000 co-current
70
60
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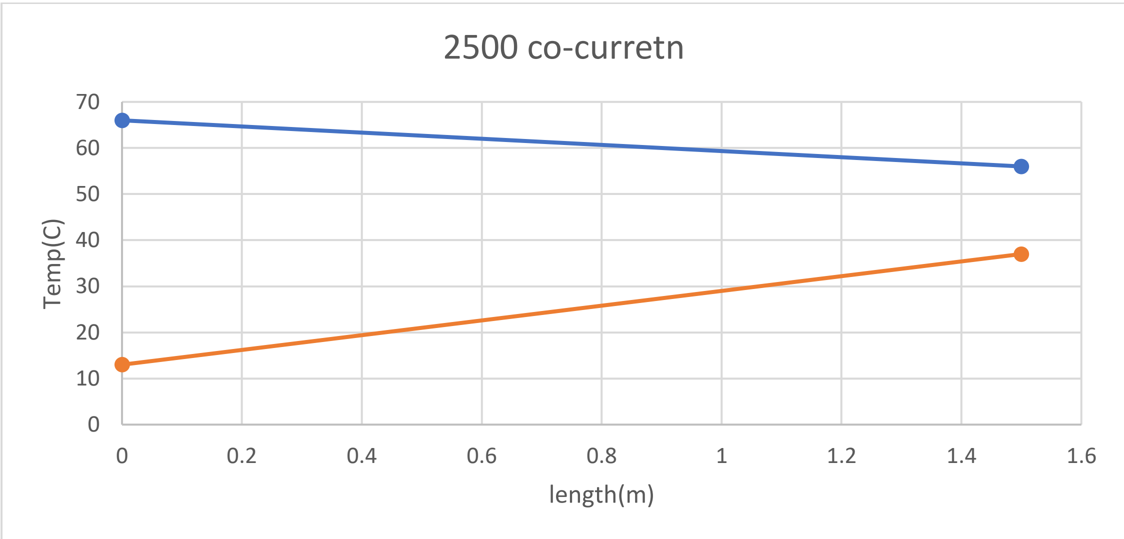
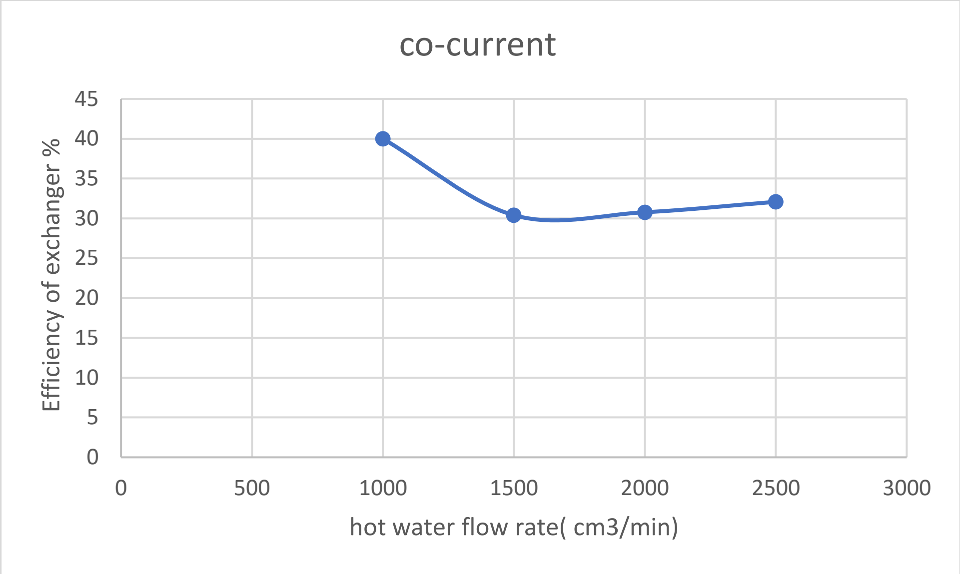
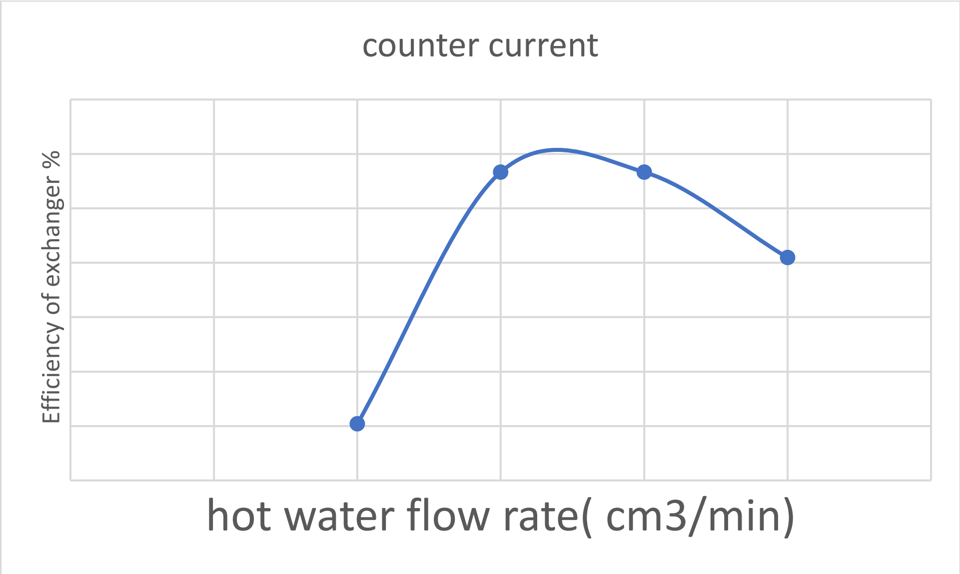
0
Temp(c)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
length(m)


2500 co-curretn
70
60
50
40
30
20
10
0
Temp(C)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
length(m)





Discussion:

Objective

1. To show the principles of operation of a concentric tube heat exchanger with co- and counter-flow arrangements.

2. To show how the performance characteristics of a concentric tube heat exchanger are affected by variations in hot water temperature and flow rate.

In this experiment, we will study the heat transfer between hot water (approximately at 70degrees Celsius) and cold water (at room temperature) and note the relationship with the flow rate change of hot water and how it affects the efficiency of the process.

As we know, heat will be transferred from hot water to cold water.

Hot water is pumped through the pump, two tubes come out of the pump, one of which transfers hot water to the system and the other is there for two purposes, the first to protect the pump from damage if the system failure and the second to maintain the level of liquid inside the tank.

We will control the amount of cold-water flow by opening the tap.

There will be an inner tube through which the hot water will pass and an outer tube surrounding it through which the cold water will pass through and thus the cold water surrounds the walls of the hot water pipe from all sides and it is perpendicular and heat transfer occurs As for reaching the horizontal pipes, the hot water is separated from the cold water by two separate pipes, and not one of them is inside the other(Because in the case of horizontal pipes, the cold water will not be surrounding the hot water pipe from all sides, but only from the bottom, and this is due to gravity, and therefore we will not care about the transfer of heat in this case)

We will repeat this process with different flow values of hot water and note the amount of heat transferred by measuring the temperature of hot and cold water entering and leaving the system using a thermometer.

There may be a slight error because of some heat loss to the surroundings, personal errors in taking the reading, or an error from the device itself.

Conclusion :

- The value of thermal conductivity for the solid-phase material is greater than its value in liquid-phase material, and both are higher than its value in the gas phase material.
- In this experiment the conduction heat transfer occurs in linear form from the top to the bottom of the cylinder, not in the radial direction.
- From this experiment It's noticed that the thermal conductivity value is affected direct proportional with temperature and heat transfer, but inverse proportional with the length.
- Thermal conductivity value is also affected by the type of material.
- It's noticed that when the temperature Difference is increased , the input power will decrease.
- Temperature variation increase when the voltage value increase.
- Conductivity increases as heat transfer coefficient increases.

References:

- https://antoine.frostburg.edu/chem/senese/javascript/water-density.html

- Coulson & Richardson, "Chemical Engineerning ", Vol. 1.1980

- D.Q. kern, "Process Heat Trancfer ". McGraw Hill, 1982

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Appendices:

Sample of calculations

In a counter current flow for 1500Cm^3/min hot streams as a sample:

Mass flow rate =1500$\frac{cm^3}{min}$*$\frac{1\ min}{60\ sec}$*$\frac{1\ m^3}{100^3 cm^3}$*$\frac{983.97\ Kg}{m^3}$= 0.0246 $\frac{Kg}{sec}$

$$Qe = m_h . c_{ph}\ (T_{in\ hot}\ - T_{out\ hot})$$

Qe = 0.0246 *4183*(66-51) = 1543.53 J/kg. min.

Qa=$m_c . c_{pc}\ (T_{iout\ cold}\ - T_{in\ cold})$

Qa=0.019953*4180*(33-12)=1751.47 J/kg. min.

$\eta_{hot} = \frac{\Delta T\ hot}{\Delta T\ max}$, η_{hot} =$\frac{T\ hotin - Thot\ out}{Thot\ in - Tcold\ in}$*100%=$\frac{66-51}{66-12} * 100\%$ =27.78%

$\eta_{cold} = \frac{\Delta T\ cold}{\Delta T\ max}$, η_{cold} =$\frac{T\ cold\ out - Tcold\ in}{Thot\ in - Tcold\ in}$*100%=$\frac{33-12}{66-12} * 100\% = 38.89\%$

$\eta_{overall} = \frac{Qa}{Qe} = \frac{1751.47}{1543.53} * 100\%$=113.47%

efficiency of exchanger = (27.78%+38.89%)/2 = 33.33%

LMTD = (ΔT_1 – ΔT_2) / (ln (ΔT_1/ ΔT_2)).

ΔT_1 = T $_{Hot\ inlet}$ – T $_{Cold\ inlet.}$ = 66-12= 54 C

ΔT_2 = T $_{Hot\ outlet}$ – T $_{Cold\ outlet}$ = 51-33= 18 C

So LMTD = (54-18)/ ln (54/18) = 32.77C.

U = Qe/ (LMTD *Area).

U = 1534.53/ (32.77*0.067) = 703.01 J/min.C.m^2