HEAT TRANSFER ANALYSIS OF HELICAL TUBE HEAT-EXCHANGER.

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Submitted to the Department of Mechanical Engineering,
Sonargaon University (SU)
In partial fulfillment of the requirements for the award of the degree
of
Bachelor of Science in Mechanical Engineering

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Heat transfer Heat transfer analysis of Helical tube heat exchanger

A Project

by

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DECLARATION

HEAT TRANSFER ANALYSIS OF HELICAL TUBE HEAT-EXCHANGER
Submitted to the Sonargaon University, recorded of an original work done by us under the guidance of NURUZZAMAN RAKIB, Lecturer of Sonargaon University**.**

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Gratitude takes three forms a felling from heart, an expression in words and giving a return. we take this opportunity to express our heartfelt feelings.

This satisfaction and euphoria that accompany a successful competition of any task would be without the mention of the people incomplete without the mention of the people who made it possible, with whose constant guidance and encouragement crowned our efforts with success.

We consider it as our privilege to express our gratitude and respect to all those who guided and inspired in the completion of this project.

Our sincere thanks to **NURUZZAMAN RAKIB** who was with us at every stage till the completion of our project in spite of his busy schedule. His vision discourages and energy propelled us when the going seemed through, we are gently indebted for his valuable , constructive and critical guidance during this project.

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ABSTRACT

Helical tube heat exchangers are one of the most common equipment found in many industrial applications. Helical tube heat exchanger is one of the devices which are used for the recovery system. The helical tube heat exchangers can be made in the form of a shell and tube heat exchangers and can be used for industrial applications such as power generation, nuclear industry, process plants, heat recovery systems, refrigeration, food industry etc. In our work we had designed, fabricated and experimentally analyzed a helical tube heat exchanger. From the observations and calculations, the results of the helical tube heat exchanger. From our obtained results, the helical tube heat exchanger showed increase in the heat transfer rate, effectiveness and overall heat transfer coefficient over the straight tube heat exchanger on all mass flow rates and operating conditions. The centrifugal force due to the curvature of the tube results in the secondary flow development which enhances the heat transfer rate.

CHAPTER -1

INTRODUCTION

1.1 INTRODUCTION

Helical coil heat exchangers are one of the most common equipment found in many industrial applications ranging from chemical and food industries, power production, electronics, environmental engineering, manufacturing industry, air-conditioning, waste heat recovery, cryogenic processes, and space applications. Helical coils are extensively used as heat exchangers and reactors due to higher heat and mass transfer coefficients, narrow residence time distributions and compact structure. The modification of the flow in the helically coiled tubes is due to the centrifugal forces. The curvature of the tube produces a secondary flow field with a circulatory motion, which causes the fluid particles to move toward the core region of the tube. The secondary flow enhances heat transfer rates as it reduces the temperature gradient across the cross-section of the tube. Thus there is an additional convective heat transfer mechanism, perpendicular to the main flow, which does not exist in conventional heat exchangers. An extensive review of fluid flow and heat transfer in helical pipes has been presented in the literature

1.2 OBJECTIVE

1. To recognize what is helical tube heat exchanger.
2. To know production & operation process of helical tube heat exchanger
3. To know about helical tube heat exchanger and heat analysis rate.

Chapter 2

History & Literature

2.1 The historical development of heat exchanger

The historical development of heat exchangers can be traced back to the last century. The following is the historical development process of the heat exchanger.

The heat exchanger can be a separate device, such as a heater, cooler and condenser, etc.; it can also be a component of a process equipment, such as a heat exchanger in an ammonia synthesis tower.

Due to the limitation of manufacturing technology and scientific level, the early heat exchangers could only adopt simple structures, and the heat transfer area was small and the volume was large, such as the serpentine heat exchangers. With the development of the manufacturing process, a shell-and-tube heat exchanger is gradually formed, which not only has a larger heat transfer area, but also has a better heat transfer effect. It has become a typical heat exchanger in industrial production for a long time.

Plate heat exchangers appeared in the 1920s and were used in the food industry. The heat exchanger made of plate instead of tube has compact structure and good heat transfer effect, so it has been developed into various forms one after another.

In the early 1930s, Sweden made the spiral plate heat exchanger for the first time. Then the British used brazing to produce a plate-fin heat exchanger made of copper and its alloy materials for the heat dissipation of aircraft engines.

At the end of the 1930s, Sweden produced the first plate and shell heat exchanger for use in pulp mills. During this period, in order to solve the heat exchange problem of strong corrosive media, people began to pay attention to heat exchangers made of new materials.

Around the 1960s, due to the rapid development of space technology and cutting-edge science, various high-efficiency and compact heat exchangers were urgently needed. Coupled with the development of stamping, brazing and sealing technologies, the heat exchanger manufacturing process has been further improved, which has promoted the vigorous development and wide application of compact plate surface heat exchangers.

In addition, since the 1960s, in order to meet the needs of heat exchange and energy saving under high temperature and high pressure conditions, typical shell-and-tube heat exchangers have also been further developed.

In the mid-1970s, in order to strengthen heat transfer, heat pipe heat exchangers were created on the basis of research and development of heat pipes.

After the 1980s, a new trend of independent development of heat transfer technology appeared in China, and a large number of enhanced heat transfer elements were introduced to the market. Representative works during the climax of domestic heat transfer technology include baffle rod heat exchangers, new structure high-efficiency heat exchangers, high-efficiency reboilers, high-efficiency coolers, double-pass heat exchangers, plate heat exchangers, surface-based air coolers, etc.

After entering the 21st century, a large number of enhanced heat transfer technologies have been applied to industrial installations, and China's heat exchanger industry has achieved rapid improvement in the technical level, and plate heat exchangers have gradually risen. In recent years, China has also made major breakthroughs in large-scale shell-and-tube heat exchangers, large-diameter threaded locking ring high-pressure heat exchangers, high-efficiency and energy-saving plate heat exchangers, and large-scale plate air preheaters.

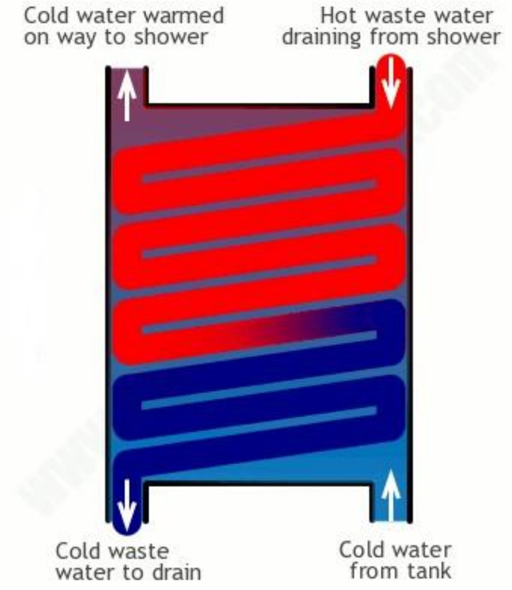

Figure1.1:- Concept Of Heat-exchanger.

2.2 Definition of heat exchanger.

A heat exchanger is a device which allows for fast and efficient transfer of heat from one medium to another. It is used to heat or cool a particular medium using another in the vicinity. The process works based upon the basic science of flow of heat; from hot to cool medium. While anybody can decrease or increase the temperature of a medium; using physical contact or intermixing with another medium. A heat exchanger allows for the transfer of heat without actual contact in between.

It basically consists of segregated elements with high thermal conductivity to act as an element for heat transfer. They keep the two fluids separated from each other; while allowing efficient transfer of heat. Irrespective of the and shape of the exchanger; the actual heat transfer happen in response to the relative flow of liquid in these segregated elements.

2.3 Different types flow of heat exchanger.

Mainly heat exchanger transfer of heat depend upon the three ways
1 Parallel flow
2 Counter flow
3 Cross flow

1. Parallel Flow:

In a parallel-flow heat exchanger fluids flow in the same direction. If the specific heat capacity of fluids are constant, it can be shown that .

2.Counter Flow:

In a counter-flow heat exchanger fluids flow in the opposite direction. If the specific heat capacity of fluids are constant.

3.Cross Flow:

In a cross-flow heat exchanger the direction of fluids are perpendicular to each other. The required surface area, across for this heat exchanger is usually calculated by using tables. It is between the required surface areas for counter-flow.

Chapter – 3

Project Overview & Design Methodology

3.1 Project Overview

Heat transfer performance of heat exchanger which is mostly used in corrosive environment was the main objective of this project. The space limitation is overcome by the use of helical configuration. It has greater corrosion resistance & zero fouling factors. So, I have designed& develop the helical coil tube in tube heat exchanger of copper material for the purpose, to know performance and utility. performance of helical copper tube heat exchanger, it is necessary to develop the system containing helical copper tube heat exchanger along with other accessories & measuring instruments required for measuring the required parameters to determine performance characteristics of heat exchanger.

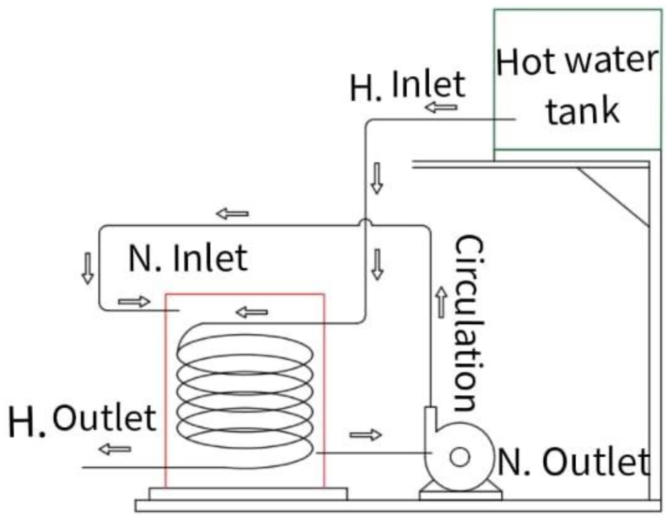

Figure 3.1: project overview design

DESIGN METHODOLOGY

3.2 Fabrication Of Tank:

In the first case we collect sheet metal from local market after that according to our design we bend the sheet metal and round it. Than riveting to shape tank and putty to prevent leakage.

Tank data sheet:

For Tank 1

- Diameter of tank = 0.406 m
- Height of tank = 0.3 m
- Volume V = $\pi r^2 l$

Now r = $\frac{d}{2}$
= 0.406/2
= 0.203
Volume= ∏*0.203^2*0.3
= 0.039 m^3

Figure3.2:- Tank 1

For Tank 2

- Diameter of tank = 0.25 mm
- Height of tank = 0.25 mm
- Volume V = $\pi r^2 l$

Now r = $\frac{d}{2}$
= 250/2
= 125
Volume= ∏*0.125^2*0.250
= 0.012 m^3

Figure 3.3: Tank 2

3.3 Fabrication of coil:

The heat exchangers coil is manufactured from copper material. The inner tube having dia. 6.4 mm and outer tube of dia. 12.5 mm. Pitch is of 30 mm. The curvature radius of the coil is 62.5 mm and the stretched length of the coil is 4800 mm. While the bending of tubes very fine sand filled in tube to maintain smoothness on inner surface and this washed with compressed air. The care is taken to preserve the circular cross section of the coil during the bending process. The end connections soldered at tube ends and two ends drawn from coiled tube at one position

Figure 3.4: Fabrication of helical tube coil

3.4 Required fittings

1. **Copper Tube connector**
2. **Teflon Tape**
3. **Ball valve**
4. **Tube Connector**
5. **Whose clump**
6. **Socket**
7. **Tank joint fittings**
8. **Measuring Flux**

Copper Tube connector:-

Its use to joint copper tube, each other**.**

Figure 3.5: Copper Tube connector.

Teflon Tape

Its commonly used in plumbing for sealing pipe threads.

Figure3.6: Teflon Tape

Ball valve

It is used to control flow of water

Valve size = 12.7 mm.

Figure 3.7 : Ball valve

Gas Tube Connector

It is used to connect whose pipe connect .

Connector size :- 12.7 mm / 8 mm

Figure 3.8 : Gas Tube Connector

Hose clump

Hose clump use to join hose pipe with tube connector joint.

Figure 3.9: Hose Clump

Socket

Its use to joint pipe & other fittings

Figure 3.10 : Socket

Tank Joint Fittings:

We use tank joint fittings at normal water tank create circulation line.

Figure 3.11: Tank joint fittings

Hose pipe
It is used to create normal water circulation line

Figure 3.12 : Hose pipe

Required Electric Instrument

1. **Dc pump**
2. **Adapter**

Dc pump

Dc pump used to circulate cold water.

Figure 3.13:Dc Pump

Adapter

Adapter use to run Dc pump.

Figure 3.14: Adapter

Required Measuring Instrument

1. **Thermometer**
2. **Measuring Flux**

Thermometer

Thermometer use to measure temperature.

Figure 3.15: Thermometer

Measuring flux

Its use to measure water.

Size : 1000 ml

Figure 3.16 : Measuring Flux

3.7 Experiment set up

We fitted the helical tube transversely in tank-1(heat exchanger) as per as design. we fitted a tube at Tank -2 (Hot water Tank) ,we used it as a delivery line on tank-2.we connected hot water tank delivery line and helical tube suction line via connector. To circulate cold water we installed a centrifugal pump transversely at Tank -1.

Figure 3.17: Experimental Setup of Helical Tube Heat exchanger

CHAPTER-4

PROCUDURE OF TESTING & EXPERIMENT

4.1Procedure For Testing In counter Flow Configuration :-

1. we closed tank-2 valve and reserve hot water.

2. we reserve cold water at Tank -1.

3. Start flow of hot water in downward direction.

4. Start cooling water pump, and send water top to bottom.

5. Take mass flow readings for hot water: Collect the Hot water in measuring flask up to desired level and note down the time required to fill the hot water up to desired level. It will give you the reading ml/Sec.

6. Also note down the temperature of Hot water at Inlet and Outlet

7. Take mass flow readings for cold water: Collect the Water in measuring flask up to desired level and note down the time required to fill the hot oil up to desired level. It will give you the reading in ml/Sec. Convert that reading into Kg/Hr

8. Also Note down the Temperature Of water at Inlet and Outlet.

4.2 Temperature reading & Calculate data

Observation table for heat exchanger counter flow & temperature data.
For 30 sec cycle. **(Table -4.1)**

Sr. No.	Initial temp (Hot water) ^{0}C **(TH_{Inlet})**	Final Temp (Hot water) ^{0}C **(TH_{outlet})**	Initial temp (cold water) ^{0}C **(TC_{Inlet})**	Final Temp (cold water) ^{0}C **(TC_{outlet})**	**($\Delta T_1 = TH_I - TC_O$) ^{0}C**	**($\Delta T_1 = TH_O - TC_I$) ^{0}C**	**ΔTM ^{0}C**	Volume of hot water.(mL)
1	50	40	32	32.5	17.5	8	12.13	620
2	49	39	32	32.9	16.1	7	11.40	550
3	49	37	33	33.7	15.3	4	8.42	630
4	45	36	33	34.5	10.5	3	5.98	650
5	47	38	32	32.5	14.5	6	9.83	680

Here
As per the definition and equation for Log Mean Temperature Difference (LMTD)

$$LMTD = \frac{\Delta T_1 - \Delta T_2}{\ln\left(\frac{T_1}{T_2}\right)}$$

$\Delta T_1 \longrightarrow$ the temperature difference between hot and cold fluids at one end of the heat exchanger

$\Delta T_2 \longrightarrow$ the temperature difference between hot and cold fluids at the other end of the heat exchanger.
For counter current heat exchanger,

<u>For reading no 1</u>

ΔT_1 = TH1 - TC2 = 50– 32.5= 17.5 ^{0}C

ΔT_2 = TH2 - TC1 = 40 – 32 = 8 ^{0}C

Definition given above,

$\triangle$T LMTD for counter current flow = (17.5- 8) / ln (17.5/8) = 9.5 / 0.783 = 12.13^{0}C

For reading no 2

ΔT_1 = TH1 - TC2 = 49– 32.9= 16.1 ^{0}C

ΔT_2 = TH2 - TC1 = 39 – 32 = 7 ^{0}C

Definition given above,

$\triangle$T LMTD for counter current flow = (16.1- 7) / ln (16.1/7) = 9.5 / 0.86 = 11.40^{0}C

For reading no 3

ΔT_1 = TH1 - TC2 = 49– 33.7= 15.3 ^{0}C

ΔT_2 = TH2 - TC1 = 37 – 33 = 4 ^{0}C

Definition given above,

$\triangle$T LMTD for counter current flow = (15.3 - 4) / ln (15.3/4) = 11.3 / 1.34= 8.42^{0}C

For reading no 4

ΔT_1 = TH1 - TC2 = 45– 34.5= 10.5 ^{0}C

ΔT_2 = TH2 - TC1 = 36 – 33 = 3 ^{0}C

Definition given above,

$\triangle$T LMTD for counter current flow = (10.5 - 3) / ln (10.5/3) = 7.5 / 1.34= 5.98^{0}C

For reading no 5

ΔT_1 = TH1 - TC2 = 47– 32.5= 14.5 ^{0}C

ΔT_2 = TH2 - TC1 = 38 – 32 = 6 ^{0}C

Definition given above,

$\triangle$T LMTD for counter current flow = (14.5 - 6) / ln (14.5/6) = 8.5 / 0.88= 9.63^{0}C

Now $\triangle TM_{average} = \sum \triangle TM$/No of $\triangle$TM
=(12.13+11.40+8.42+5.98+9.83)/5
=9.55 k (Because temp difference equal temperature & kelvin)
Now Tube length = 4800 mm
=4.8m
Tube diameter d= 12.7mm
=0.0127m

Surface area $A_s = \pi dl$

$= (3.1416 \times 0.0127 \times 4.88)$

$= 0.1947\ m^2$

The Overall heat transfer co-efficient heat transfer water to water (850 to 1700) W/m^2k. *[From book:- Heat and mass transfer Fundamentals & application ; by yunus A.cengel and Afshin J. Ghajar]*

We assumed,

Overall heat transfer co-efficient $U = 1200\ W/m^2k$

Heat transfer $Q = UA_s \triangle Tm_{avg}$

$= (1200 \times 0.1947 \times 9.55)$

$= 2231.262$ Joule

Heat transfer rate $Q^0 = Q/T$[Here T= 30 sec]

$= 2231.262/30$

$= 74.3754$ Watt

Observation table for heat exchanger flow & temperature data.

For 35 sec cycle **(Table -4.2)**

Sr. No.	Initial temp (Hot water) ^{0}C **(TH_{Inlet})**	Final Temp (Hot water) ^{0}C **(TH_{outlet})**	Initial temp (cold water) ^{0}C **(TC_{Inlet})**	Final Temp (cold water) ^{0}C **(TC_{outlet})**	**($\Delta T_1 = TH_I - TC_O$) ^{0}C**	**($\Delta T_1 = TH_O - TC_I$) ^{0}C**	**ΔTM ^{0}C**	Volume of hot water.(mL)
1	60	39	34	35	25	5	12.42	650
2	58	39	33	34	24	6	12.98	570
3	55	39.5	33	34	21	6.5	12.37	660
4	55	38	33.5	35	20	4.5	10.39	690
5	54	38.5	33.5	34	20	5	10.82	700

Here
As per the definition and equation for Log Mean Temperature Difference (LMTD)

$$LMTD = \frac{\Delta T_1 - \Delta T_2}{\ln\left(\frac{T_1}{T_2}\right)}$$

$\Delta T_1 \longrightarrow$ the temperature difference between hot and cold fluids at one end of the heat exchanger

$\Delta T_2 \longrightarrow$ the temperature difference between hot and cold fluids at the other end of the heat exchanger.
For counter current heat exchanger,

<u>For reading no 1</u>

ΔT_1 = TH1 - TC2 = 60– 35= 25 ^{0}C

ΔT_2 = TH2 - TC1 = 39 – 34 = 5 ^{0}C

Definition given above,

$\triangle$T LMTD for counter current flow = (25-5) / ln (25/5) = 20 / 1.609 = 12.42^{0}C

<u>For reading no 2</u>

ΔT_1 = TH1 - TC2 = 58– 34= 24 ^{0}C

ΔT_2 = TH2 - TC1 = 39 – 33 = 6 ^{0}C

Definition given above,
$\triangle$T LMTD for counter current flow = (24- 6) / ln (24/6) = 18 / 1.38= 12.98^{0}C

For reading no 3

ΔT_1 = TH1 - TC2 = 55– 34= 21 ^{0}C

ΔT_2 = TH2 - TC1 = 39.5 – 33 = 6.5 ^{0}C

Definition given above,

△T LMTD for counter current flow = (21 – 6.5) / ln (21/6.5) = 14.5 / 1.17= 12.37^{0}C

For reading no 4

ΔT_1 = TH1 - TC2 =55– 35= 20 ^{0}C

ΔT_2 = TH2 - TC1 = 38 – 33.5 = 4.5 ^{0}C

Definition given above,

△T LMTD for counter current flow = (20 – 4.5) / ln (20/4.5) = 15.5 / 1.49= 10.39^{0}C

For reading no 5

ΔT_1 = TH1 - TC2 = 54– 34= 20 ^{0}C

ΔT_2 = TH2 - TC1 = 38.5 – 33.5 = 5 ^{0}C

Definition given above,

△T LMTD for counter current flow = (20 - 5) / ln (20/5) = 15 / 1.39= 10.82^{0}C

Now △TM $_{average}$=∑△TM/No of △TM
=(12.42+12.98+12.37+10.39+10.82)/5
=11.796 k (Because temp difference equal temperature & kelvin)

Now Tube length = 4800 mm
=4.8m

Tube diameter d= 12.7mm
=0.0127m

Surface area A_s= πdl
=(3.1416×0.0127×4.88)
= 0.1947 m^2

The Overall heat transfer co-efficient heat transfer water to water (850 to 1700) W/m^2k. *[From Heat and mass transfer book Fundamentals & application ; by yunus A.cengel and Afshin J. Ghajar]*

We assumed,
Overall heat transfer co-efficient U= 1200 W/m^2k

Heat transfer Q = $UA_s\triangle Tm_{avg}$
=(1200×0.1947×11.796)
=2746.109 Joule

Heat transfer rate Q^0=Q/T {here T= 35 sec}
=2746.1088/35
=78.46 Watt

Observation table for heat exchanger flow & temperature data.

For 40 sec cycle **(Table -4.3)**

Sr. No.	Initial temp (Hot water) ^{0}C (**TH $_{Inlet}$**)	Final Temp (Hot water) ^{0}C (**TH $_{outlet}$**)	Initial temp (cold water) ^{0}C (**TC $_{Inlet}$**)	Final Temp (cold water) ^{0}C (**TC $_{outlet}$**)	**($\Delta T_1 = TH_I - TC_O$) ^{0}C**	**($\Delta T_1 = TH_O - TC_I$) ^{0}C**	**ΔTM ^{0}C**	Volume of hot water.(mL)
1	55	41	38	39	16	3	7.76	1400
2	55	41.5	38	39	16	3.5	8.22	1430
3	54	42	39	39.5	14.5	3	7.40	1350
4	54	42	39	39.5	14.5	3	7.40	1410
5	52	40.5	40	40	12	0.5	3.62	1400

Here

As per the definition and equation for Log Mean Temperature Difference (LMTD)

$$LMTD = \frac{\Delta T_1 - \Delta T_2}{\ln\left(\frac{T_1}{T_2}\right)}$$

$\Delta T_1 \rightarrow$ the temperature difference between hot and cold fluids at one end of the heat exchanger

$\Delta T_2 \rightarrow$ the temperature difference between hot and cold fluids at the other end of the heat exchanger.

For counter current heat exchanger,

<u>For reading no 1</u>

ΔT_1 = TH1 - TC2 = 55– 39= 16 ^{0}C

ΔT_2 = TH2 - TC1 = 41 – 38 = 3 ^{0}C

Definition given above,

$\triangle$T LMTD for counter current flow = (16-3) / ln (16/3) = 13 / 1.609 = 7.76^{0}C

<u>For reading no 2</u>

ΔT_1 = TH1 - TC2 = 55– 39= 16 ^{0}C

ΔT_2 = TH2 - TC1 = 41.5 – 38 = 3.5 ^{0}C

Definition given above,

$\triangle$T LMTD for counter current flow = (16- 3.5) / ln (16/3.5) = 12.5 / 1.51= 8.22^{0}C

For reading no 3

ΔT_1 = TH1 - TC2 = 54– 39.5= 14.5 ^{0}C

ΔT_2 = TH2 - TC1 = 42 – 39 = 3 ^{0}C

Definition given above,

$\triangle$T LMTD for counter current flow = (14.5 – 3) / ln (14.5/3) = 11.5 / 1.58= 7.30^{0}C

For reading no 4

ΔT_1 = TH1 - TC2 = 54– 39.5= 14.5 ^{0}C

ΔT_2 = TH2 - TC1 = 42 – 39 = 3 ^{0}C

Definition given above,

$\triangle$T LMTD for counter current flow = (14.5 – 3) / ln (14.5/3) = 11.5 / 1.58= 7.30^{0}C

For reading no 5

ΔT_1 = TH1 - TC2 = 52– 40= 12 ^{0}C

ΔT_2 = TH2 - TC1 = 40.5 – 40 = 0.5 ^{0}C

Definition given above,

$\triangle$T LMTD for counter current flow = (12 – 0.5) / ln (12/0.5) = 11.5 / 3.178= 3.62^{0}C

Now $\triangle TM_{average} = \sum \triangle TM / \text{No of } \triangle TM$
=(7.76+8.22+7.30+7.30+3.62)/5
=5.38 k (Because temp difference equal temperature & kelvin)

Now Tube length = 4800 mm
=4.8m
Tube diameter d= 12.7mm
=0.0127m

Surface area $A_s = \pi dl$
=(3.1416×0.0127×4.88)
= 0.1947 m^2

The Overall heat transfer co-efficient heat transfer water to water (850 to 1700) W/m^2k. *[From book:- Heat and mass transfer Fundamentals & application ; by yunus A.cengel and Afshin J. Ghajar]*

We assumed,

Overall heat transfer coefficient U= 1200 W/m^2k

Heat transfer $Q = UA_s\triangle Tm_{avg}$

$=(1200\times0.1947\times5.38)$

$=1252.46$ Joule

Heat transfer rate $Q^0=Q/T$ {here T= 40 sec}

$=1252.46 /40$

$=31.13$Watt.

Observation table for heat exchanger flow & temperature data.

For 45 sec cycles **(Table -4.4)**

Sr. No.	Initial temp (Hot water) ^{0}C **(TH $_{Inlet}$)**	Final Temp (Hot water) ^{0}C **(TH $_{outlet}$)**	Initial temp (cold water) ^{0}C **(TC $_{Inlet}$)**	Final Temp (cold water) ^{0}C **(TC $_{outlet}$)**	**(ΔT_1 =TH$_I$-TC$_O$) ^{0}C**	**(ΔT_1 =TH$_O$-TC$_I$) ^{0}C**	**ΔTM ^{0}C**	Volume of hot water.(mL)
1	54	42.5	37	37.5	16.5	5.5	10.01	1500
2	53	42	37	38	15	5	9.10	1520
3	51	39.5	38	38.5	12.5	1.5	5.19	1480
4	51	40	38	38.7	12.3	2	5.67	1510
5	52	40.5	38.5	39	12	2	5.81	1550

Here

As per the definition and equation for Log Mean Temperature Difference (LMTD)

$$LMTD = \frac{\Delta T_1 - \Delta T_2}{\ln\left(\frac{T_1}{T_2}\right)}$$

$\Delta T_1 \rightarrow$ the temperature difference between hot and cold fluids at one end of the heat exchanger

$\Delta T_2 \rightarrow$ the temperature difference between hot and cold fluids at the other end of the heat exchanger.

For counter current heat exchanger,

For reading no 1

ΔT_1 = TH1 - TC2 = 54– 37.5= 16.5 ^{0}C

ΔT_2 = TH2 - TC1 = 42.5 – 37 = 5.5 ^{0}C

Definition given above,

$\triangle$T LMTD for counter current flow = (16.5-5.5) / ln (16.5/5.5) = 11/ 1.09 = 10.01^{0}C

For reading no 2

ΔT_1 = TH1 - TC2 = 53– 38= 15^{0}C

ΔT_2 = TH2 - TC1 = 42 – 37 = 5 ^{0}C

Definition given above,

$\triangle$T LMTD for counter current flow = (15- 5) / ln (15/5) = 10 / 1.09= 9.10^{0}C

For reading no 3

ΔT_1 = TH1 - TC2 = 51– 38.5= 12.5 ^{0}C

ΔT_2 = TH2 - TC1 = 39.5 – 38 = 1.5 ^{0}C

Definition given above,
$\triangle$T LMTD for counter current flow = (12.5 – 1.5) / ln (12.5/1.5) = 11 / 2.12= 5.19^{0}C

For reading no 4

ΔT_1 = TH1 - TC2 = 51– 38.7= 12.3 ^{0}C

ΔT_2 = TH2 - TC1 = 40 – 38 = 2 ^{0}C

Definition given above,

$\triangle$T LMTD for counter current flow = (12.3 – 2) / ln (12.3/2) = 10.3 / 1.81= 5.67^{0}C

For reading no 5

ΔT_1 = TH1 - TC2 = 52– 39= 12 ^{0}C

ΔT_2 = TH2 - TC1 = 40.5 – 38.5 = 2 ^{0}C

Definition given above,

$\triangle$T LMTD for counter current flow = (12 – 2) / ln (12/2) = 10 / 1.79= 5.81^{0}C

Now $\triangle TM_{average} = \sum \triangle TM / \text{No of } \triangle TM$
=(10.01+9.10+5.19+5.67+5.81)/5
=7.156 k (Because temp difference equal temperature & kelvin)

Now Tube length = 4800 mm
=4.8m

Tube diameter d= 12.7mm
=0.0127m

Surface area A_s= πdl
=(3.1416×0.0127×4.88)
= 0.1947 m^2

The Overall heat transfer co-efficient heat transfer water to water (850 to 1700) W/m^2k. . *[From book:- Heat and mass transfer Fundamentals & application ; by yunus A.cengel and Afshin J. Ghajar]*

We assumed,
Overall heat transfer coefficient U= 1200 W/m^2k

Heat transfer Q = $UA_s\triangle Tm_{avg}$
=(1200×0.1947×7.156)
=1671.93 Joule

Heat transfer rate Q^0=Q/T {here T= 45sec}
=1671.93 /45
=37.15Watt.

4.5 Result summary

Sl. no	Cycle Time	△TM average	Heat transfer Q	Heat transfer rate Q^0
01	**30 Sec**	**9.55**	**2231.46**	**74.37**
02	**35 Sec**	**11.796**	**2746**	**78.46**
03	**40 Sec**	**5.18**	**1252.46**	**37.15**
04	**45 Sec**	**7.156**	**1671.93**	**37.15**

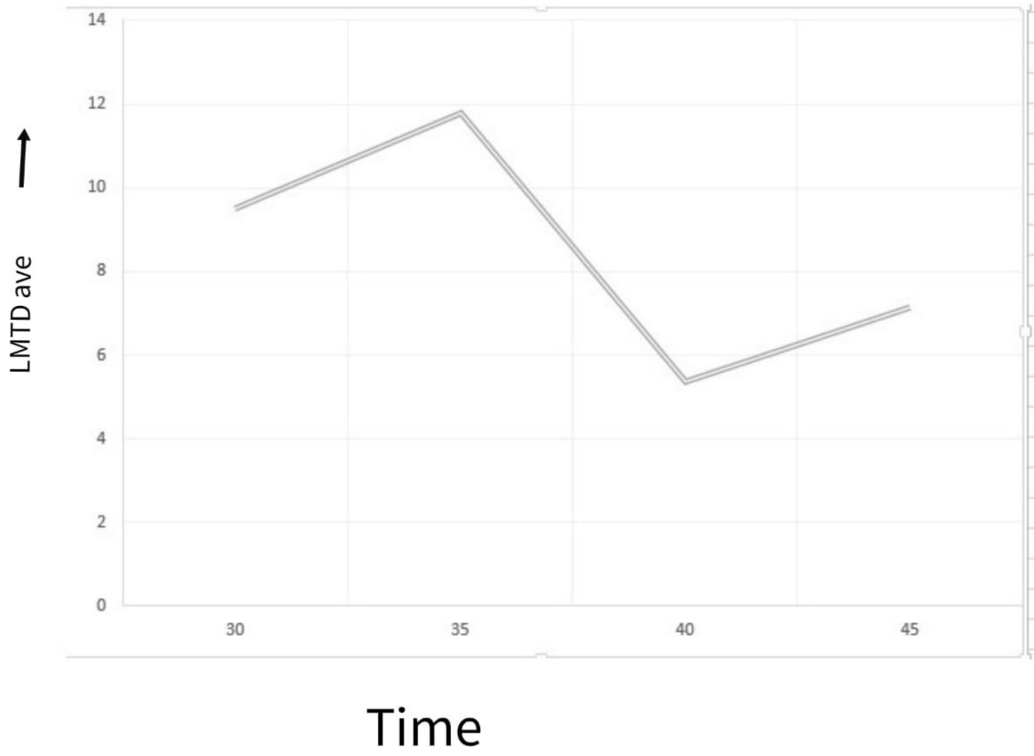

Figure 4.1 : LMTD vs TIME graph.

CHAPTER -5

SCOPE & APPLICATION

5.1Application of the helical tube heat exchanger

A helical tube heat exchanger is generally applied in industrial applications due to its compact structure, larger heat transfer area and higher heat transfer capability etc. The importance of compact heat exchangers has been recognized in many industrial applications ranging from chemical and food industries, power production, electronics, environmental engineering, manufacturing industry, air conditioning, waste heat recovery, cryogenic processes and space applications for the last six decades. However, flow and helical coils are extensively used as heat exchangers and reactors due to higher heat and mass transfer coefficients, narrow residence time distributions and compact structure.

5.2 Advantage of helical tube heat exchanger

- Helical tube give better heat transfer characteristic, since they have lower resistance & high process side efficient
- The whole surface area of the curved pipe is exposed to the moving fluid , which eliminates the dead zone that are common drawback of in the tube type heat exchanger .
- A helical coil offer a larger surface area in a relatively smaller reactor volume and lesser floor area.
- Helical tube heat exchanger eliminates thermal expansion and thermal shock problem.

5.3 Disadvantage of helical tube heat exchanger

- For highly reactive fluids or highly corrosive fluid coils cannot be used , instead are used.
- Cleaning of vessels with coil tube is more difficult.
- The design of the helical tube type heat exchanger is also bit a difficult.

CHAPTER-6

CONCLUSION & REFERENCES

5.1 CONCLUSION

The effectiveness of heat exchanger greatly affected by hot water mass flow rate and cold water mass flow rate. When cold water mass flow rate is constant and hot water mass flow rate increased by the effectiveness decreases. increase in cold water mass flow rate for constant in effectiveness. For helical coil heat exchanger with counter flow is obtained. Helical coil counter flow is most effective in all these condition.

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