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# Heat Transfer Enhancement Using Spiral Fin in Heat Exchanger with Nano Fluids

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## ABSTRACT

In the present study, an attempt has been made to summarize and analyze the results of an examination of the waterside performance of spiral (or helical) fin and tube heat exchangers. Currently, the spiral fin and tube heat exchanger is a favored type of heat exchanger for the waste heat recovery unit (WHRU), a kind of economizer system.

The present paper we are using the Spiral fin copper as material along with the Nano fluids like $Al_2O_3$ mixed with base fluid water. Fins are installed on the outer surface of hot water tube. Experiment is conducted in parallel flow and counter flow and parallel flow the effectiveness of the system will increase by using Nano fluid with spiral fin heat exchanger system

## 1. INTRODUCTION

### 1.1. Heat Exchangers

The heat exchangers are found to have a wide range of applications ranging from the house-hold purposes to refineries and cryogenic operations. These heat exchangers had become the essential requirement of the current society as they do not cause any harmful effects to the environments. The cost involved in this energy extraction is also very less and economical. One of the concerns regarding these heat exchangers is to enhance the heat transfer and improve their efficiency. The survey and researches had been carried out in a large manner to improve the heat transfer enhancements. In this context, an objective is set to review the literature related to heat exchangers under the following categories: general study of heat exchangers, various configurations of heat exchangers, the compact heat exchangers and the effects of Nano fluid in the heat transfer enhancements.

Several scientific explanations have been done on the field of heat. Several laws of physics have been proved and accepted for conventional use in general application purposes. Such laws of physics suggest that heat has the ability to move from a body with higher temperatures into a body with lower temperatures. It therefore means that for heat transfer to take place there must be temperature difference between the two bodies.

However, heat transfer from one body to the other takes place through various methods. Such methods include radiation, conduction and convection. Depending on the nature of matter involved, a specific method of heat transfer is always involved. Radiation normally involves energy transfer in form of electromagnetic radiations. The transfer of heat from sun to the earth is through the process of radiation.

Heat transfer within solids takes place through conduction. It involves the transfer of heat by movement of atoms or molecules from one place to another. Convection however is the transfer of heat by mixing of one part of a medium with another. Convection is a common means of heat transfer between fluids.

Heat exchangers, therefore performs their work through such principles of heat. In a typical plate type heat exchanger, the heat penetrates the surface that separates the cold and the hot medium easily. Therefore, with the use of heat exchanger, it is possible to heat or cool fluids that have minimal energy levels.

Heat exchanger is a device, such as an automobile radiator, used to transfer heat from a fluid on one side of a barrier to a fluid on the other side without bringing the fluid into direct contact (Fogiel, 1999). Usually, this barrier is made from metal which has good thermal conductivity in order to transfer heat effectively from one fluid to another fluid. Besides that, heat exchanger can be defined as any of several devices that transfer heat from a hot to a cold fluid. In engineering practical, generally, the hot fluid is needed to cool by the cold fluid. For example, the hot vapor is needed to be cool by water in condenser practical. Moreover, heat exchanger is defined as a device used to exchange heat from one medium to another often through metal walls, usually to extract heat from a medium flowing between two surfaces. In automotive practice, radiator is used as heat exchanger to cool hot water from engine by air surrounding same like intercooler which used as heat exchanger to cool hot air for engine intake manifold by 4 air surrounding.

### 1.1.1. Function of Heat Exchanger

Heat exchanger is a special equipment type because when heat exchanger is directly fired by a combustion process, it becomes furnace, boiler, heater, tube-still heater and engine. Vice versa, when heat exchanger make a change in phase in one of flowing fluid such as condensation of steam to water, it becomes a chiller, evaporator, sublimate, distillation-column reboiler, still, condenser or cooler-condenser. Heat exchanger may be designed for chemical reactions or energy-generation processes which become an integral part of reaction system such as a nuclear reactor, catalytic reactor or polymer (Fogiel, 1999). Normally, heat exchanger is used only for the transfer and useful elimination or recovery of heat without changed in phase. The fluids on either side of the barrier usually liquids but they can be gasses such as steam, air and hydrocarbon vapor or can be liquid metals such as sodium or mercury. In some application, heat exchanger fluids may use fused salts.

### 1.1.2. Classification of Heat Exchangers

Heat exchangers are broadly classified based on the following considerations.

1. **Classification based on heat Transfer Process**

Based on heat transfer process heat exchangers are classified as direct contact and indirect contact

a) Direct contact

In direct contact heat exchangers, heat transfer takes place between two immiscible fluids like a gas and a liquid coming into direct contact.

e.g.: Cooling towers, jet condensers for water vapor, and other vapors utilizing water spray.

b) Indirect contact

In indirect - contact type of heat exchangers the hot and cold fluids are separated by an impervious surface. There is no mixing of the two fluids and these heat exchangers are also known as surface heat exchangers.

e.g: Automobile radiators.

2. **Classification based on type of construction**

a. Tubular heat exchangers
b. Plate heat exchangers
c. Plate fin heat exchangers
d. Tube-fin heat exchangers
e. Regenerative heat exchangers

3. **Classification based on flow Arrangement**

a. Parallel-flow: In this heat exchanger, the hot and the cold fluids enter at the same end of the heat exchanger and flow through in the same direction and leave together at the other end.

b. Counter flow: In this heat exchanger hot and cold fluids enter in the opposite ends of the heat exchanger and flow in opposite directions.

c. Cross flow: In this heat exchanger, the two fluids flow at right angles to each other.

### 1.2. 1.2 Introduction to fins

Convection heat transfer between a hot solid surface and the surrounding colder fluid is governed by the Newton's cooling law which states that "the rate of convection heat transfer is directly proportion alto the temperature difference between the hot surface and the surrounding fluid and is also directly proportional to the area of contactor exposure between them". Newton's law of cooling can be expressed as

$Q_{conv} = h\ A\ (T_S - T_\infty)$ Where, h = convection heat transfer coefficient

$T_S$ = Hot surface temperature

$T_\infty$= Fluid temperature

A = area of contact or exposure

Therefore, convection heat transfer can be increased by either of the following ways-

- Increasing the temperature difference ($T_S$ - $T_\infty$) between the surface and the fluid.
- Increasing the convection heat transfer coefficient by enhancing the fluid flow or flow velocity over the body.
- Increasing the area of contact or exposure between the surface and the fluid.

Most of the times to control the temperature difference is not feasible and increase of heattransfercoefficientmayrequireinstallationofapumporafanorreplacingthe existing one with a new one having higher capacity, the alternative is to increase the effective surface area by extended surfaces or fins.

**Fins** are the extended surface protruding from a surface or body and they are meant for increasing the heat transfer rate between the surface and the surrounding fluid by increasing heat transfer area.

2. **Example of surfaces where fins areused**

- Air cooled I.C. Engines
- Refrigeration condenser tubes
- Electric transformers
- Reciprocating air compressors
- Semi conductor devices
- Automobile radiator

**EXPERIMENTAL SET UP**

**Fig.**1. EXPERIMENTAL SET UP

The experimental setup consists of two concentric tubes in which fluids pass. The hot fluid is hot water, which is obtained from an electric geyser. Hot water flows through the inner tube, in one direction. Cold fluid is cold water, which flows through the annulus. Control valves are provided so that direction of cold water can be kept parallel or opposite to that of hot water. Thus, the heat exchanger can be operated either as paralle1 or counter flow heat exchanger. The temperatures are measured with thermometer. Thus, the heat transfer rate, heat transfer coefficient, LMTD and effectiveness of heat exchanger can be calculated for both parallel and counter flow.

**Specifications:**

(1) Heat exchanger - (a) Inner tube - 12 mm
(b) Outer tube - 49 mm G. I. Pipe
(c) Length of Heat exchanger is 1 m

(2) Electric heater - 3 KW Capacity to supply hot water.
(3) Number of Valves for flow and direction control- 5
(4) Number of Thermometers to measure temperatures - 10 to 110°C is 4
(5) Measuring flask and stop clock for flow measurement.

Fabrication of heat exchanger involves different machining processes which are based on factors such Machining properties such turning, drilling, boring.

**EXPERIMENTAL WORKING PROCEDURE:**

1. The power supply is switched on the electric geyser ensuring that there is adequate water flow though geyser.
2. Check the valves are in proper condition for required flow mode.
3. Start the water supply.
4. Adjust the water supply on hot and cold sides.
5. Keep the valves V2 & V3 closed and V1 & V4 opened so that arrangement is parallel flow.
6. Switch ON the geyser. Temperature of water will start rising. After temperatures
become steady, note down the readings in the observation table.

7. Repeat the experiment by changing the flow. Now open the valves V2 & V3 and
then close the valves V1 & V4. The arrangement is now counter flow. Wait until
the steady state is reached and note down the readings.

## . CALCULATION AND DISCUSSIONS

### 2.1. SPIRAL FIN HEAT EXCHANGER WITHOUT NANO FLUID

**PARALLELFLOW**:

| S.NO | Hot water inlet temperature($T_1$) K | Cold water inlet temperature ($T_2$) K | Cold water outlet temperature ($T_3$) K | Hot water outlet temperature ($T_4$)K |
|---|---|---|---|---|
| 1 | 327 | 307 | 310 | 323 |
| 2 | 329 | 309 | 312 | 324 |
| 3 | 333 | 310 | 314 | 325 |

**Note:** After reaching the last reading s.no .3 we got steady state condition and the values are recorded at this position.

Mass flow rate of hot water ($M_h$) = 1/69 lit/sec

Mass flow rate of cold water ($M_c$) = 1/62 lit/sec

Heat transfer rate from hot water ($Q_h$) = $M_h C_{ph} \Delta T_h$

= 1000 * 0.001 / 69 * 4.187 * (8) = 0.4854 kW

Heat transfer rate from cold water ($Q_C$) = $M_C C_{Pc} \Delta T_c$

= 1000 * 0.001 / 62 * 4.187 * (4) = 0.2701kW

Average value of Heat transfer ($Q_t$) = ($Q_h$ + $Q_C$)/ 2 = (0.4854 +0.2701)/2= 0.377 kW

Logarithmic mean temperature difference (LMTD) = ($\Delta T_I – \Delta T_o$)/ ln($\Delta T_I / \Delta T_o$) =23 – 11/ ln(23 / 11)

= 16.26 K

Area of inner pipe ($A_i$) = ∏ * $d_i$ * $l_i$ = ∏ * 0.012(m) *1.08(m) = 0.0407 $m^2$

Area of outer pipe ($A_o$) =∏ * $d_o$* $l_o$ = ∏ * 0.049(m) * 1(m)= 0.15 $m^2$

Over all heat transfer coefficient ($U_{ri}$)= = 0.377 / 0.0407* (16.23)= 0.570 kW /$m^2$ k

Over all heat transfer coefficient ($U_{ro}$) = = 0.377/ 0.15 * (16.23)= 0.154 kW/$m^2$ k

Effectiveness(ε) = 0.1739

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## 2.2. SPIRAL TUBE HEAT EXCHANGER WITHOUT NANO FLUID

**COUNTER FLOW**:

| S.NO | Hot water inlet temperature($T_1$) K | Cold water inlet temperature ($T_2$) K | Cold water outlet temperature ($T_3$) K | Hot water outlet temperature ($T_4$)K |
|---|---|---|---|---|
| 1 | 327 | 309 | 311 | 321 |
| 2 | 333 | 311 | 313 | 325 |
| 3 | 337 | 311 | 316 | 328 |

**Note:** After reaching the last reading s.no .3 we got steady state condition and the values are recorded at this position

Mass flow rate of hot water ($M_h$) = 1/64 lit/sec

Mass flow rate of cold water ($M_c$) = 1/60 lit/sec

Heat transfer rate from hot water ($Q_h$) = $M_h C_{ph} \Delta T_h$

= 1000 * 0.001/64*4.187*(9) = 0.588 kW

Heat transfer rate from cold water ($Q_C$)

= $M_C C_{Pc} \Delta T_c$= 1000*0.001/60*4.187*(5) = 0.3489 kW

Average value of Heat transfer ($Q_t$)

= ( $Q_h$ + $Q_C$)/ 2= (0.588+0.3489 )/2= 0.46845 kW

Logarithmic mean temperature difference (LMTD) = $(\Delta T_I – \Delta T_o)/ \ln (\Delta T_I / \Delta T_o)$

=26 – 12 / ln(26 / 12)= 18.106 K

Area of inner pipe ($A_i$) = $\prod * d_i * l_i$ = $\prod$ * 0.012(m) *1.08(m)

= 0.0407 $m^2$

Area of outer pipe ($A_o$) = $\prod * d_o * l_o$= $\prod$ * 0.049(m) *1(m) = 0.15 $m^2$

Over all heat transfer coefficient ($U_{ri}$) = = 0.46845 / 0.0407 * (18.10)= 0.79818 kW /$m^2$ k

Over all heat transfer coefficient ($U_{ro}$) = = 0.46845/ 0.153 * (18.10) = 0.169 kW /$m^2$ k

Effectiveness ($\varepsilon$) = 0.192

## 2.3. SPIRAL FIN HEAT EXCHANGER WITH NANO FLUID

**PARALLEL FLOW**:

| S.NO | Hot water inlet temperature($T_1$) K | Cold water inlet temperature ($T_2$) K | Cold water outlet temperature ($T_3$) K | Hot water outlet temperature ($T_4$)K |
|---|---|---|---|---|
| 1 | 314 | 309 | 308 | 323 |
| 2 | 332 | 310 | 317 | 326 |
| 3 | 336 | 311 | 318 | 327 |

**Note:** After reaching the last reading s.no .3 we got steady state condition and the values are recorded at this position

Mass flow rate of hot water ($M_h$) = 1/62 lit/sec

Mass flow rate of cold water ($M_c$) = 1/58lit/sec

Heat transfer rate from hot water ($Q_h$) = $M_h$ $C_{ph}$ $\Delta$ $T_h$= 1000*0.001/62*4.187*(9)= 0.6077kW

Heat transfer rate from cold water ($Q_C$)= $M_C C_{Pc}$ $\Delta$ $T_c$= 1000*0.001/58*4.187 * (7)= 0.50532 kW

Average value of Heat transfer ($Q_t$ ) = ( $Q_h$ + $Q_C$)/ 2= (0.6077+0.50532)/2 = 0.556 kW

Logarithmic mean temperature difference (LMTD) = ($\Delta T_I$–$\Delta T_o$)/ ln ($\Delta$ $T_I$/$\Delta T_o$)

= 22 – 9/ ln(22 / 9)= 14.544K

Area of inner pipe ($A_i$) = ∏ * $d_i$ * $l_i$ = ∏ * 0.012(m) *1.08(m) = 0.0407 $m^2$

Area of outer pipe ($A_o$) = ∏ * $d_o$* $l_o$= ∏ * 0.049(m) * 1(m)= 0.15 $m^2$

Over all heat transfer coefficient ($U_{ri}$) = = 0.556/0.0407 * (14.54)= 0.9395kW /$m^2$ k

Over all heat transfer coefficient ($U_{ro}$) = = 0.556 / 0.15 * (14.54)= 0.2499 kW /$m^2$ k

Effectiveness (ε) = 0.318

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## 2.4.SPIRAL FIN HEAT EXCHANGER WITH NANO FLUID

**COUNTERFLOW**:

| `S.NO | Hot water inlet temperature($T_1$) K | Cold water inlet temperature ($T_2$) K | Cold water outlet temperature ($T_3$) K | Hot water outlet temperature ($T_4$)K |
|---|---|---|---|---|
| 1 | 332 | 303 | 317 | 323 |
| 2 | 333 | 308 | 318 | 327 |
| 3 | 337 | 312 | 322 | 329 |

**Note:** After reaching the last reading s.no .3 we got steady state condition and the values are recorded at this position

Mass flow rate of hot water ($M_h$) = 1/59lit/sec

Mass flow rate of cold water ($M_c$) = 1/55 lit/sec

Heat transfer rate from hot water ($Q_h$) = $M_h$ $C_{ph}$ $\Delta$ $T_h$= 1000 * 0.001/9*4.187 * (8)= 0.5677 kW

Heat transfer rate from cold water ($Q_C$) =$M_C C_{Pc} \Delta T_c$=1000 *0.001/ 55*4.187 * (10) = 0.7612 kW

Average value of Heat transfer ($Q_t$ ) Logarithmic mean temperature difference (LMTD) = ($\Delta T_I$–$\Delta T_o$)/ ln ($\Delta$ $T_{I}$ /$\Delta T_o$)= 25 – 9 / ln(25 / 9) = 15.66K

Area of inner pipe ($A_i$) = ∏ * $d_i$ * $l_i$ = ∏ * 0.012(m) *1.08(m) = 0.0407 $m^2$

Area of outer pipe ($A_o$) = ∏ * $d_o$* $l_o$ = ∏ * 0.049(m)* 1(m) = 0.15 $m^2$

Over all heat transfer coefficient ($U_{ri}$) = 0.66445 / 0.0407 * (15.66) =1.042 kW /$m^2$ k

Over all heat transfer coefficient ($U_{ro}$) = 0.66445/ 0.15* (15.66) = 0.2772 kW /$m^2$ k

Effectiveness ($\varepsilon$)= = 0.40

## 2.5. EMPTY TYPE HEAT EXCHANGER WITH OUT NANO FLUID

**PARALLEL FLOW**:

| ` S.NO | Hot water inlet temperature($T_1$) K | Cold water inlet temperature ($T_2$) K | Cold water outlet temperature ($T_3$) K | Hot water outlet temperature ($T_4$)K |
|---|---|---|---|---|
| 1 | 313 | 311 | 301 | 308 |
| 2 | 321 | 303 | 307 | 315 |
| 3 | 323 | 304 | 307 | 315 |

**Note:** After reaching the last reading s.no .3 we got steady state condition and the values are recorded at this position

Mass flow rate of hot water ($M_h$) = 1/150 lit /sec

Mass flow rate of cold water ($M_c$) = 1/90 lit /sec

Heat transfer rate from hot water ($Q_h$) =$M_h$ $C_{ph}$ Δ $T_h$= 1000*0.001/150 * 4.187 * (8 )= 0.1226 kW

Heat transfer rate from cold water ($Q_C$) = $M_C C_{Pc}$ Δ $T_c$= 1000 0.001/90 * 4.187*(3)= .13956 kW

Average value of Heat transfer ($Q_t$ )=$Q_h$ + $Q_C$)/ 2= (0.1226 +0.13956 )/2= 0.13108 kW

Logarithmic mean temperature difference (LMTD) = ($\Delta T_I$–$\Delta T_o$)/ ln (Δ $T_I$ /$\Delta T_o$)= 19 – 8 / ln(19 / 8) = 12.71 K

Area of inner pipe ($A_i$) = ∏ * $d_i$ * $l_i$ = ∏ * 0.012(m) *1.08(m) = 0.0407 $m^2$

Area of outer pipe ($A_o$)= ∏ * $d_o$* $l_o$= ∏ * 0.049(m) * 1(m) = 0.15 $m^2$

Over all heat transfer coefficient ($U_{ri}$) =0.13108 / 0.04072 * (12.71)= 0.2533 kW /$m^2$ k

Over all heat transfer coefficient ($U_{ro}$) =0.13108/0.15*(12.7) 0.06740kW /$m^2$ k

Effeciveness (ε) = 0.157

## 2.6. EMPTY TYPE HEAT EXCHANGER WITH OUT NANO FLUID

**COUNTER FLOW**:

| ` S.NO | Hot water inlet temperature($T_1$) K | Cold water inlet temperature ($T_2$) K | Cold water outlet temperature ($T_3$) K | Hot water outlet temperature ($T_4$)K |
|---|---|---|---|---|
| 1 | 308 | 307 | 310 | 303 |
| 2 | 322 | 309 | 312 | 318 |
| 3 | 326 | 310 | 313 | 323 |

**Note:** After reaching the last reading s.no .3 we got steady state condition and the values are recorded at this position

Mass flow rate of hot water ($M_h$) = 1/120 lit /sec

Mass flow rate of cold water ($M_c$)= 1/69 lit /sec

Heat transfer rate from hot water ($Q_h$)= $M_h\, C_{ph}\, \Delta\, T_h$= 1000*0.001/120*4.187*(3)=0.1046 kW

Heat transfer rate from cold water ($Q_C$)= $M_C C_{Pc}\, \Delta\, T_c$= 1000*0.001/69*4.187*(3)=0.1820 kW

Average value of Heat transfer($Q_t$ )= ($Q_h$ + $Q_C$)/ 2 = (0.1046+0.182)/2= 0.1433 kW

Logarithmic mean temperature difference (LMTD)=($\Delta T_I$–$\Delta T_o$)/ln ($\Delta\, T_{I\,/}\Delta T_o$)=16-10 ln (16 / 10) = 12.76K

Area of inner pipe ($A_i$) = ∏ * $d_i$ * $l_i$ = ∏ * 0.012(m) *1.08(m) = 0.0407 $m^2$

Area of outer pipe ($A_o$) = ∏ * $d_o$* $l_o$ = ∏ * 0.049(m) * 1(m) = 0.15 $m^2$

Over all heat transfer coefficient ($U_{ri}$) = = 0.1433 / 0.0407 * (12.76) = 0.275 kW /$m^2$ k

Over all heat transfer coefficient ($U_{ro}$) = = 0.1433 / 0.15 * (12.76) = 0.07340 kW/$m^2$ k

Effectiveness (ε) = = = 0.1875

## 2.7. EMPTY TYPE HEAT EXCHANGER WITH NANO FLUID

**PARALLEL FLOW**

| ` S.NO | Hot water inlet temperature($T_1$) K | Cold water inlet temperature ($T_2$) K | Cold water outlet temperature ($T_3$) K | Hot water outlet temperature ($T_4$)K |
|---|---|---|---|---|
| 1 | 330 | 308 | 313 | 321 |
| 2 | 326 | 310 | 313 | 323 |
| 3 | 325 | 309 | 315 | 323 |

**Note:** After reaching the last reading s.no.1 we got steady state condition and the values are recorded at this position

Mass flow rate of hot water ($M_h$) = 1/130 lit /sec

Mass flow rate of cold water ($M_c$) = 1/70 lit /sec

Heat transfer rate from hot water ($Q_h$) = $M_h C_{ph} \Delta T_h$=1000*.001 / 120 * 4.187 * (9) = 0.289kW

Heat transfer rate from cold water ($Q_C$ )= $M_C C_{Pc} \Delta T_c$= 1000*0.001/130*4.187*(9)= 0.5383 kW

Average value of Heat transfer ($Q_t$ ) = ($Q_h$ + $Q_C$)/ 2= (0.289+0.5383)/2= 0.4136 kW

Logarithmic mean temperature difference (LMTD) =($\Delta T_I$–$\Delta T_o$)/ ln ($\Delta T_I$ /$\Delta T_o$)22-8/ ln (22 /8) = 13.839 K

Area of inner pipe ($A_i$) = ∏ * $d_i$ * $l_i$ = ∏ * 0.012(m) *1.08(m)= 0.0407 $m^2$

Area of outer pipe ($A_o$) = ∏ * $d_o$* $l_o$= ∏ * 0.049(m) * 1(m) = 0.15 $m^2$

Over all heat transfer coefficient ($U_{ri}$) = = 0.4136 / 0.0407* (13.839)= 0.7343 kW /$m^2$ k

Over all heat transfer coefficient ($U_{ro}$) = = 0.4136 /0.15 * (13.839)= 0.19536 kW /$m^2$ k

Effectiveness(ε) = = = 0.

## 2.8. HEAT EXCHANGER WITHOUT FIN WITH NANO FLUID

**COUNTER FLOW**:

| ` S.NO | Hot water inlet temperature($T_1$) K | Cold water inlet temperature ($T_2$) K | Cold water outlet temperature ($T_3$) K | Hot water outlet temperature ($T_4$)K |
|---|---|---|---|---|
| 1 | 327 | 303 | 308 | 316 |
| 2 | 328 | 306 | 311 | 316 |
| 3 | 329 | 309 | 313 | 318 |

**Note:** After reaching the last reading s.no.3 we got steady state condition and the values are recorded at this position

Mass flow rate of hot water ($M_h$) = 1/120 lit /sec

Mass flow rate of cold water ($M_c$) = 1/60lit /sec

Heat transfer rate from hot water ($Q_h$)= $M_h C_{ph} \Delta T_h$= 1000*0.001/120*4.187*(11)= 0.383kW

Heat transfer rate from cold water ($Q_C$)=$M_C C_{Pc} \Delta T_c$=1000*0.001/60*4.187*(5)= 0.34891kW

Average value of Heat transfer ($Q_t$ ) = ($Q_h$ + $Q_C$)/ 2 = (0.383+0.34891)/2= 0.3659 kW

Logarithmic mean temperature difference (LMTD) = ($\Delta T_I$–$\Delta T_o$)/ ln ($\Delta T_I/\Delta T_o$) =24 - 9 / ln (24 / 9) = 15.29K

Area of inner pipe ($A_i$) = ∏ * $d_i$ * $l_i$ = ∏ * 0.012(m) *1.08(m) = 0.0407 $m^2$

Area of outer pipe ($A_o$) = ∏ * $d_o$* $l_o$= ∏ * 0.049(m)* 1(m) = 0.15$m^2$

Over all heat transfer coefficient ($U_{ri}$) = = 0.3659/0.0407 * (15.29) 0.5879 kW /$m^2$ k

Over all heat transfer coefficient ($U_{ro}$) = = 0.3659 / 0.15 * (15.29)= 0.1564 kW /$m^2$ k

Effectiveness ($\varepsilon$) = 0.287

## ADVANTAGES

- Very simple to construct
- Very easy of operation
- U-type or hairpin constructions handle differential thermal expansions.
- It has larger surface area and compact volume as compared to straight tube heat exchanger.
- It eliminates the dead-zones that are common drawbacks in the shell and tube type heat exchangers because the whole surface area of the curved pipe is exposed to the moving fluid.
- They give improved heat transfer characteristics because of small wall resistance.
- More turbulence is created inside the coil tube so fouling is less.

## DISADVANTAGES

The use of two single flow areas leads to relatively low flow rates and moderate temperature differences.

size, it can be used in applications where space limitation is present such as marine

## APPLICATIONS

1. Because of compactcooling systems, cooling of lubrication oil, central cooling and industrial applications.
2. In HVACs due to their compact structure and greater heat transfer rate.
3. Used in chemical reactors because of high heat transfer capacity.
4. In cryogenic applications for liquefaction of gases.
5. Used in hydro carbon processing for the recovery of CO2, cooling of liquid hydrocarbons, also used in polymer industries for cooling purpose**3.**

## RESULTS & CONCLUSION

| S.No | | | LMTD | Effectiveness |
|---|---|---|---|---|
| 1 | Spiral fin heat exchanger without Nano fluid | Parallel Flow | 16.23 | 0.17 |
| | | Counter Flow | 18.106 | 0.19 |
| 2 | Spiral fin heat exchanger with Nano fluid | Parallel Flow | 14.544 | 0.31 |
| | | Counter Flow | 15.66 | 0.4 |
| 3 | Empty heat exchanger without Nano fluid | Parallel Flow | 12.71 | 0.15 |
| | | Counter Flow | 12.76 | 0.18 |
| 4 | Empty heat exchanger with Nano fluid | Parallel Flow | 13.89 | 0.22 |
| | | Counter Flow | 15.29 | 0.287 |

## CONCLUSION:-

The effectiveness of the heat exchanger without Nano fluid and with Nano fluid($Al_2o_3$ ) is conducted with the observation of results the heat exchanger is effective with Nano fluid by 46.67% parallel flow in counter flow 59% when compared with Heat exchanger without Nano fluid.When we are using Nano fluids with spiral fins to the effectiveness will increased when compared with without spiral fin and Nano fluid is observed and the effectiveness increased by 106% in parallel flow and 122% in counter flow Heat exchanger.

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