

PERFORMANCE TEST OF HEAT EXCHANGER USING COPPER TUBES WITH FIN



Course Title: Project and Thesis
Course Code: ME-400

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Declaration

It is declared hereby that this thesis paper or any part of it has not been submitted to anywhere else for the award of any degree.

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Certification

This is to certify that this project entitled “**Performance Test of Heat Exchanger using Copper Tubes with Fin**” is done by the above students under my direct supervision.

This project work has been carried out by them in the laboratories of the Department of Mechanical Engineering under the Faculty of Engineering, Sonargaon University (SU) in partial fulfillment of the requirements for the degree of Bachelor of Science in Mechanical Engineering.

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ABSTRACT

Heat exchanger is an equipment used to transfer heat from one fluid to another. It has extensive domestic and industrial applications. Extensive technical literature is available on heat exchanger design, operation and maintenance, but it is widely scattered throughout the industrial bulletins, industrial design codes and standard, technical journals, etc. The purpose of this book is to consolidate into basic background and concepts design of heat exchangers, operation, cleaning and green technology maintenance on heat exchanger closely related to the industrial practices. An experiment was conducted with a fin-and-tube heat exchanger model. It uses empirical heat transfer and flow friction correlations identified in the literature. The heat transfer capacity with fin and without fin was investigated experimentally. Related calculations were done to compare the heat transfer performance of heat exchanger with fin and without fin. The model structure, its range of validity and accuracy are described in details.

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Mathematical Symbols

L= Length

A= Area

D= Diameter

Q= Total Heat

U= Over all co-efficient of Heat Transfer

m_c = Mass of Cold Water

m_h = Mass of Hot Water

T_h = Temperature of Hot Water

T_c = Temperature of Cold Water

ΔT = Temperature Difference

LMTD= Logarithmic Mean Temperature Difference

Chapter-1

INTRODUCTION

1.1 Introduction

Heat exchanger is the one of the most important processes in engineering which transfers the heat between flowing fluids, means a process to transfer heat from one fluid to another fluid. To transfer internal thermal energy between two or more fluids at different temperatures heat exchanger is used. Usually fluids are not mixed in most of the heat exchangers. Mostly heat exchangers are used in petroleum, power, refrigeration and air conditioning, alternate fuels and automobile fields and day to day its uses are increasing. In a transient manner, heat transfer between fluids takes place through a separating wall or into and out of a wall in a heat exchanger. Fluids are separated by a heat transfer surface in many heat exchangers, and ideally, they do not mix or leak. Sometimes it referred to as a sensible heat exchanger if there is no phase change occurs in any of the fluids in the exchanger.

1.2 General criteria for materials selection

A general procedure that could be used for identifying the most appropriate material for a specific heat exchanger application would consist of the following steps. –Define the heat exchanger requirements –Establish a strategy for evaluating candidate materials –Identify candidate materials –Evaluate materials in depth Special considerations which affect materials selection.

1.3 Physical Properties

High heat transfer coefficient (requiring high thermal conductivity for tube material) – Thermal expansion coefficient to be low and as compatible as possible with those of the materials used for tube sheet, tube support and shell to provide resistance to thermal cycling.

1.4 Mechanical Properties

Good tensile and creep properties are required. High creep rupture strength at the highest temperature of operation and adequate creep ductility to accommodate localized strain at notches are important. Good fatigue, corrosion fatigue and creep-fatigue behavior and high fracture toughness and impact strength to avoid fast fracture are required.

1.5 Objective:

Main objectives of this research work are given bellow:

- 1.5.1 To know about heat exchanger types.
- 1.5.2 To analyze the performance of copper tube heat exchanger with fin.
- 1.5.3 Compare heat exchanger performance with and without fins.

1.6 Research purposes:

The purpose of writing contained in the theme of scientific writing this time aims as follows:

1. Analysis of the heat transfer process that occurs in the shell and tube heat exchanger,
2. calculating the comparison of the influence of various mass flow velocities on the temperature of the hot water outlet on the tube

1.7 Methodology of the Study:

- Creating an idea for design and construction of water heat exchanger and designing a block diagram and circuit diagram to know components requirements for construction of the unit
- Collecting all components and hardware device for constructing the system.
- Assembling of the whole block in a board and finally run the system and test the performance.

1.8 Classification of heat exchangers:

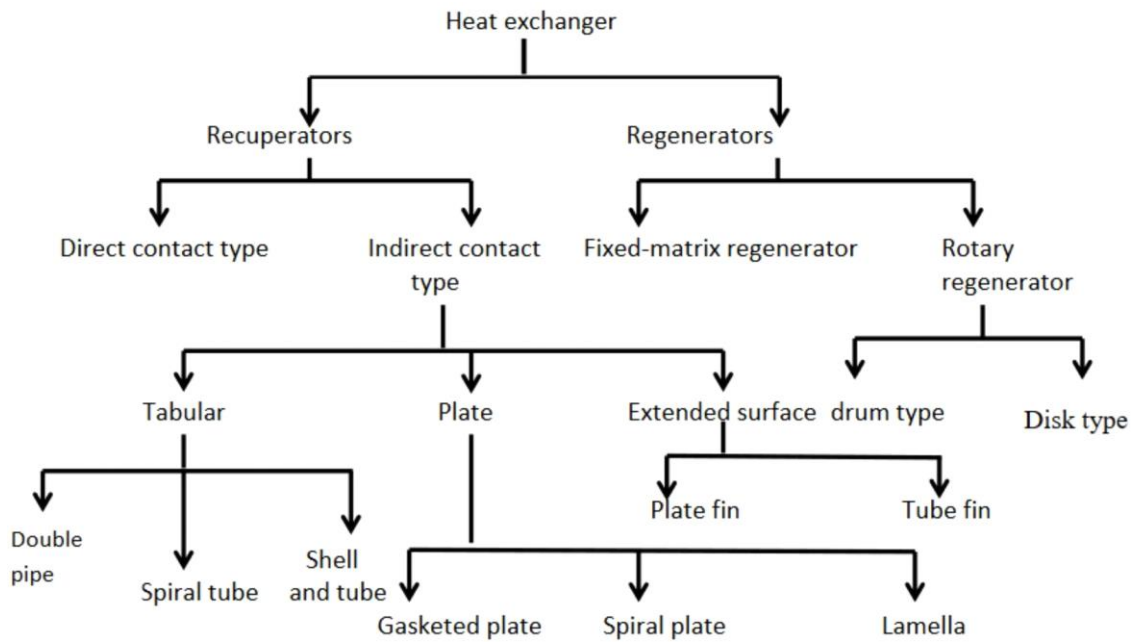


Figure 1.1: Classification of heat exchanger

1.8.1 Shell and Tube:

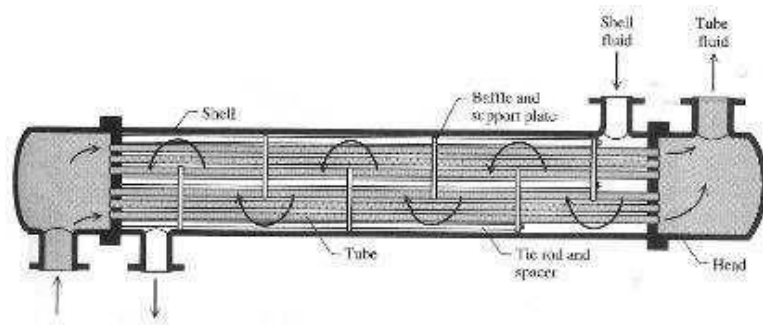


Figure 1.2: Shell and tube heat exchanger

This type of heat exchanger is normally built of a bundle of round tubes mounted in a cylindrical shell with the tube axis parallel to that of the shell. One of the streams flows along the tubes, while the other stream flows along the shell. The following components are used in a shell and tube heat exchanger:

Tubes: Round tubes of various shapes that are used as a means to flow by one of the streams. The tubes most commonly used in process and power industry exchangers are the tube bundles with straight and U-tubes. Nuclear exchangers on the other hand use more complicated shapes, such as sine-wave bend, J-shape and L-shape, because they allow for large thermal expansion of the tubes.

Shell: The shell is a cylindrical container with a circular cross section that allows for the flow of the second stream. The tubes are contained within the shell, and the heat exchange occurs between the tube stream and the shell stream.

Nozzles: The nozzles are the inlet and outlet for the streams in both the tubes and the shell. These are pipes of constant cross section that are used to distribute or collect the fluid uniformly on the shell and tube sides.

Front- and Rear-end heads: These are used as the entrance and exit by the tube fluid. The front-end is stationary, while the rear-end can either be stationary (does not allow for thermal expansion) or floating (allows for thermal expansion).

Baffles: Baffles are classified into two types: transverse, and longitudinal. Transversal baffles can be further classified into plate baffles and grid baffles. Plate baffles are used to support the tubes during assembly and to direct the fluid in the tube bundle at an angle of approximately 90° to achieve higher heat transfer coefficients. They also increase the turbulence of the shell fluid and minimize tube to tube temperature differences and thermal stresses due to cross flow. Likewise, grid baffles are also used to support the tubes and increase the turbulence of the shell fluid, but unlike in plate baffles, the flow is parallel to the tubes. Grid baffles support the tube in such a way that they virtually eliminate flow induced vibrations.

1.8.2 Concentric:

This type of heat exchanger (also called a double pipe heat exchanger) has a much simpler design, consisting of two concentric pipes wherein one stream flows through the inner pipe, and the other stream flows through the outer pipe. The flow can be either parallel (both streams flow along in the same direction) or counter flowing (the two streams flow in different directions), with the former being ideal for applications needing constant wall temperature and the latter being ideal for the highest performance for the given surface area. Double pipe heat exchangers are generally used for small capacity applications where the total heat transfer surface area is less than 50m² because the cost per unit area is much higher when compared to other types of heat exchangers.

This type of heat exchanger consists primarily of thin plates, which can either be smooth or corrugated. Plate heat exchangers can be classified as gasketed, welded, or brazed depending on the type of leak tightness required.

Gasketed exchangers consist of thin rectangular plates sealed around the edges by gaskets and held together in a frame (as shown in figure 3). The main advantage of this design is that the heat exchanger can be disassembled easily for maintenance and inspection purposes. One of the main applications of gasketed exchangers is that they can generate high heat transfer coefficients due to the breakup and formation of boundary layers, vortex flow generation, and small hydraulic diameter flow passes. Furthermore, high shear stresses, high turbulence and mixing due to plate corrugation patterns reduce fouling to about 10 to 25% of that of a shell and tube heat exchanger. Due to the high generation of heat transfer coefficients and low fouling, the surface area required for a plate heat exchanger is one half to one third that of a shell and tube heat exchanger, thus reducing the cost and overall volume of the heat exchanger. Gasketed plate heat exchangers also have high thermal capacity due to the high degree of counter flow that is achievable, and are unaffected by the flow induced vibrations, noise, thermal stresses, and entry impingement problems that are common in shell and tube heat exchangers.

However, gasketed exchangers also have disadvantages, one of them being that they are unable to handle high pressures (maximum possible being 3MPa). The gasket materials restrict their use in highly corrosive applications, and limit the maximum operating conditions to 260°C. Maintenance of this type of heat exchanger must also be regular as the gasket life is sometimes

limited and must be replaced. To overcome the limitations of gasketed exchangers, for example in corrosive applications, welded or brazed heat exchangers can be used instead.

Welded exchangers have plates that are welded together instead of being held together in a frame, but with a loss of the disassembling flexibility available in gasketed exchangers. They are also constructed to be much bigger than gasketed exchangers so as to reduce the welding costs. The main advantage of this type of plate heat exchanger is that it can withstand higher limits of operating temperatures and pressure (usually about 350°C and 4MPa).

1.9 Counter Flow:

In a counter flow heat exchanger, the two streams flow parallel to each other but in opposite directions. This is the flow arrangement with the highest efficiency as it produces the highest temperature change in each fluid when compared to other flow arrangements for given thermal conductance, fluid flow rates, and fluid inlet temperatures. The maximum temperature difference across the exchanger wall thickness (between the wall surfaces exposed to the hot and cold sides) produces minimal thermal stresses in the wall when compared to other flow arrangements.

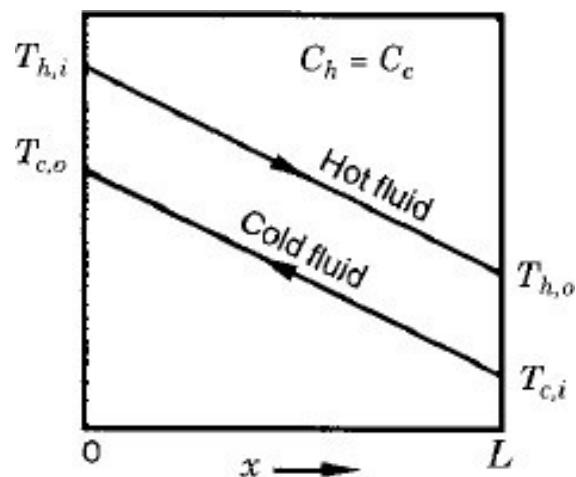


Figure 1.5: Counter flow heat exchanger

1.9.1 Fin Type

Finned tube heat exchangers are the type of heat exchangers in which fins are attached to the outer tube of the exchanger. Adding fins facilitates transfer the fluid heat easily outside the tube. It is for the transfer of water, air or another gas. In a finned tube heat exchanger, an overall flow pattern is often cross flow, but it can also be counter flow or parallel flow. A finned tube is very helpful as one of the fluids is water, air or any other gas in an air heat exchanger. There is a low air-side heat transfer coefficient, which increases the surface area of heat transfer

1.9.2 Without Fin Type

Heat exchangers without fins are simple, cost-effective devices suitable for applications where rapid heat transfer or maximum efficiency is not essential. Their uncomplicated design and lower cost make them an attractive option for various industries, as long as the heat transfer requirements of the specific application can be met with their design.

Chapter-2

Literature Review

In 1920s, there appeared plate heat exchanger that was invented by Dr Richard Seligman [3] and revolutionized methods of indirect heating and cooling of fluids. Dr Richard Seligman founded APV in 1910 as the Aluminum Plant and Vessel Company Limited, as specialist fabricating firm supplying welded vessels to the brewery and vegetable oil trades. The heat exchanger which is produced with plate pipe has compact structure and very good heat effect, subsequently it small by little developed into numerous forms. In the early 1930s, Sweden firstly made out spiral plate heat exchanger. Then Britain used the brazing approach to make out the plate fin heat exchanger which is developed from copper and alloy materials, and it was used for the cooling of aircraft engines.

In the late of 1930s, Sweden had produced the 1st shell heat exchanger, which is employed for the pulp plant. At the same time, in order to solve the heat exchanging issue of powerful corrosive medium, people began to be conscious of the heat exchanger are made of new materials. In about 1960s, on account of the rapid growth and development of space technology and advanced science, people are inside the urgent require for a range of high performance compact heat exchangers, and with the growth stamping, brazing and sealing technology, heat exchanger manufacturing procedure has been further improved, thereby promoting the compact plate heat exchanger rapid development and wide application. Moreover, since the 1960s, so as to adjust to the requirement of heat exchanging and energy saving underneath the high temperature and pressure conditions, the typical shell tube heat exchanger has as well been further developed.

At the middle of 1970s, in order to enhance heat transfer, based on researching and developing the heat pipe, folks have developed heat pipe heat exchanger. Though the first detailed study in two phase flow was carried out by Lockhart and Martinelli in the year 1949. Bes Y Reitzel (1993) determined the thermal performance using a dimensionless approach that gave better results as the number of spirals in the unit increases. A through description of the

exchanger geometry was published he provides the expressions to calculate spiral diameter, number of turns and length of the semicircles.

A wide range of researches are already done to study the flow characteristics and heat transfer in helical heat exchangers. The enhancement of the heat transfers in the helically coiled tubes is due to the centrifugal forces. A secondary flow field is produced due to the curvature of the tube with a circulatory motion, which causes the fluid particles to move towards the core region of the tube. The secondary flow enhances heat transfer rates by reducing the temperature gradient across the cross-section of the tube. Thus, there is an additional convective heat transfer mechanism occurs, perpendicular to the main flow, which does not exist in straight tube heat exchangers.

CHAPTER-3
EXPERIMENTAL DESIGN

3.1 Introduction of component:

SL.NO	Particulars	Specification	Qty.
1	Power Supply	12V	1
2	Pump Motor	12 Volt	1
3	Temperature Meter	0 to 100 Degree Celsius	3
4	Temperature Control Sensor	W 1209	1
5	Copper Tube		1
6	Boiler Pipe		1
7	Heater		1
8	Heat Sink Block		1
9	Cold Water Tank		1

Table 3.1: List of Components

3.2 Pump Motor:



Figure 3.2: Pump Motor

- **DC 12V Water Pump Motor 700L/H**
- Power:16.8W
- Max Flow Rate: 700L/H
- Max Water Head: 5M
- Circulating Water Temperature:60°C

Specification:

- Material: ABS (Acrylonitrile Butadiene Styrene) + Stainless Steel
- Overall Size: Approx. 80 x 48 x 63mm/3.15 x 1.89 x 2.48"
- Pump Inlet Diameter: 16mm (Outer), 12mm(Inner)
- Pump Outlet Diameter: 12mm (Outer), 6.9mm(Inner)
- Inlet/Outlet: 1/2" malethread
- Voltage: 6-12VDC
- Maximum Rated Current:1.2A
- Power:16.8W
- Max Flow Rate: 700L/H
- Max Water Head:5M
- Max Circulating Water Temperature:60°C

3.3 Temperature Meter:

A temperature meter is an instrument used to measure the temperature of beings or things. The most widely recognized temperature meter is a mercury thermometer used to measure the temperature of people.



Figure 3.3: Temperature Meter

- **Digital Temp Meter**

- Digital Display -50C to+110C.
- Modeling simple, elegant, LCD panels inline connections, moisture-resistant.
- Strong anti-interference, applies to refrigerated cabinets, display counters and other needs of temperature measurement and display of various equipment.
- Remote wired probe can read temperature up to 3 feet away.
- No need to wire to any permanent power source. Size:48 x 28 x 15mm.

3.4 Copper Tube:

Copper pipes are commonly used in the construction industry for water supply lines and refrigerant lines in HVAC (heating, cooling, and air-conditioning) systems. Copper pipes can be manufactured as soft or rigid copper and offer excellent corrosion resistance and reliable connections.



Figure 3.4: Copper Tube

3.5 Temperature Control Sensor W 1209:



Figure 3.5: Temperature Control Sensor

- Temperature Control Range: -50 ~ 110 C
- Resolution at -9.9 to 99.9: 0.1 C
- Resolution at all other temperatures: 1 C
- Measurement Accuracy: 0.1 C
- Control Accuracy: 0.1 C
- Refresh Rate: 0.5 Seconds
- Input Power (DC): 12V
- Measuring Inputs: NTC (10K 0.5%)
- Waterproof Sensor: 0.5M
- Output: 1 Channel Relay Output, Capacity: 10A

3.5.1 Project Image:



3.6 Block Diagram Heat Exchanger :

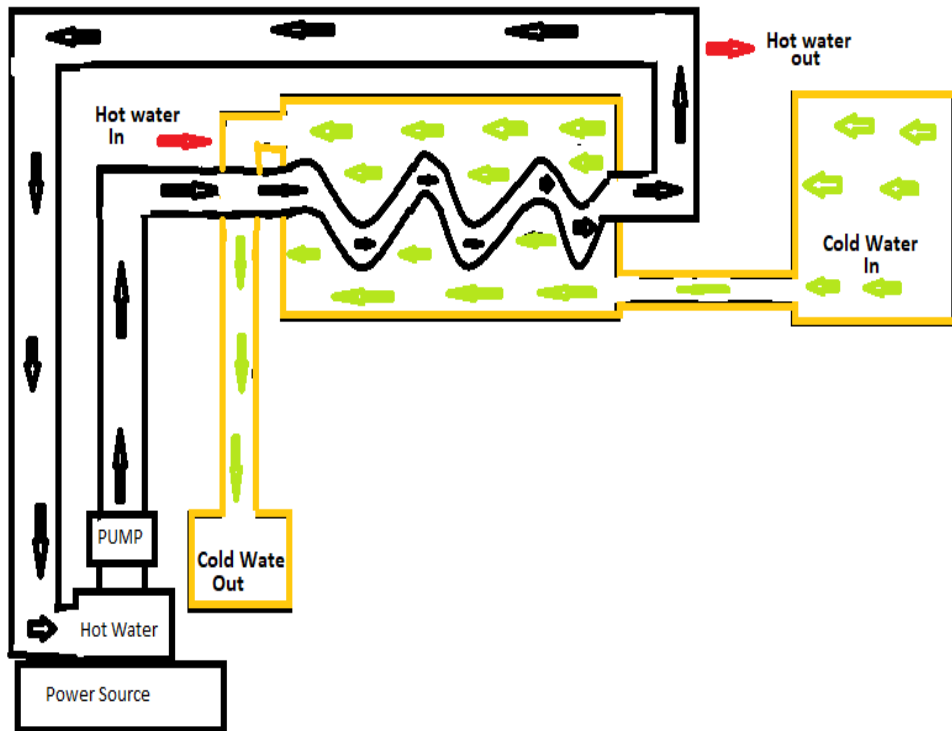


Figure 3.6: Block Diagram of Heat Exchanger

3.7 Working Principle:

The plan of this project is that there will be two water tank and one heater and all have temperature meters. From the heater, hot water will pass through the pump motor to copper pipe through the water cooling heat exchanger. To power up the Pump Motor SMPS Power Supply is used. Water after passing through the fin type and plain type copper tube return to the hot water tank and recycled and the cycle continues. Temperature Meters were set on Recycle Water Tank, so that the difference between the Hot water and Cold water can be measured.

CHAPTER-4
DATA ANALYSIS AND DISCUSSION

4.1 Data Table for Fin and without Fin type :

Copper Tube with Fin	Copper Tube without Fin
<u>Hot Water:</u> $T_{h \text{ in}} = 65.6^{\circ}\text{C}$ $T_{h \text{ out}} = 42.8^{\circ}\text{C}$	<u>Hot Water:</u> $T_{h \text{ in}} = 65.6^{\circ}\text{C}$ $T_{h \text{ out}} = 48.7^{\circ}\text{C}$
<u>Cold Water:</u> $T_{c \text{ in}} = 29.9^{\circ}\text{C}$ $T_{c \text{ out}} = 33.9^{\circ}\text{C}$	<u>Cold Water:</u> $T_{c \text{ in}} = 30.1^{\circ}\text{C}$ $T_{c \text{ out}} = 34.2^{\circ}\text{C}$

Table 4.1: Data Table of Counter Flow

4.2 With Fin:

$$L = 1.15 \text{ m}$$

$$D = 0.006 \text{ m}$$

$$m_c = 0.028 \text{ kg/sec}$$

$$m_h = 0.166 \text{ kg/sec}$$

$$T_{h \text{ in}} = 65.6^\circ\text{C}$$

$$T_{h \text{ out}} = 42.8^\circ\text{C}$$

$$T_{c \text{ in}} = 29.9^\circ\text{C}$$

$$T_{c \text{ out}} = 33.9^\circ\text{C}$$

$$A = \pi DL = \pi \times 0.006 \times 1.15 = 0.021 \text{ m}^2$$

$$Q = m_h \times c_p \times (T_{h \text{ in}} - T_{h \text{ out}}) \\ = 0.166 \times 4.2 \times 10^3 \times (65.6 - 42.8)$$

$$= 15896.16 \text{ Watt}$$

$$\Delta T_{\text{cn}} = \frac{(T_{h \text{ in}} - T_{c \text{ out}}) - (T_{h \text{ out}} - T_{c \text{ in}})}{\ln \frac{T_{h \text{ in}} - T_{c \text{ out}}}{T_{h \text{ out}} - T_{c \text{ in}}}}$$

$$= \frac{(65.6 - 33.9) - (42.8 - 29.9)}{\ln \frac{65.6 - 33.9}{42.8 - 29.9}}$$

$$= 20.01 \text{ }^\circ\text{C}$$

$$Q = UA(LMTD)$$

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

$$= \frac{15896.16}{0.021 \times 20.01}$$

$$U = 37829.1 \text{ Watt/m}^2\text{C}$$

4.3 Without Fins:

$$L = 1.15 \text{ m}$$

$$D = 0.006 \text{ m}$$

$$m_c = 0.028 \text{ kg/sec}$$

$$m_h = 0.166 \text{ kg/sec}$$

$$T_{h \text{ in}} = 65.6^\circ\text{C}$$

$$T_{h \text{ out}} = 48.7^\circ\text{C}$$

$$T_{c \text{ in}} = 30.1^\circ\text{C}$$

$$T_{c \text{ out}} = 34.2^\circ\text{C}$$

$$A = \pi DL = \pi \times 0.006 \times 1.15$$

$$= 0.021 \text{ m}^2$$

$$Q = m_h \times c_p \times (T_{h \text{ in}} - T_{h \text{ out}})$$

$$= 0.166 \times 4.2 \times 10^3 \times (65.6 - 48.7)$$

$$\Delta T_{\text{cn}} = \frac{(T_{h \text{ in}} - T_{c \text{ out}})(T_{h \text{ out}} - T_{c \text{ in}})}{\ln \left(\frac{T_{h \text{ in}} - T_{c \text{ out}}}{T_{h \text{ out}} - T_{c \text{ in}}} \right)}$$

$$\ln \left(\frac{T_{h \text{ in}} - T_{c \text{ out}}}{T_{h \text{ out}} - T_{c \text{ in}}} \right)$$

$$= 11782.68 \text{ Watt}$$

$$= \frac{(65.6 - 34.2) - (48.7 - 30.1)}{\ln \left(\frac{65.6 - 34.2}{48.7 - 30.1} \right)}$$

$$\ln \left(\frac{65.6 - 34.2}{48.7 - 30.1} \right)$$

$$= 24.44^\circ\text{C}$$

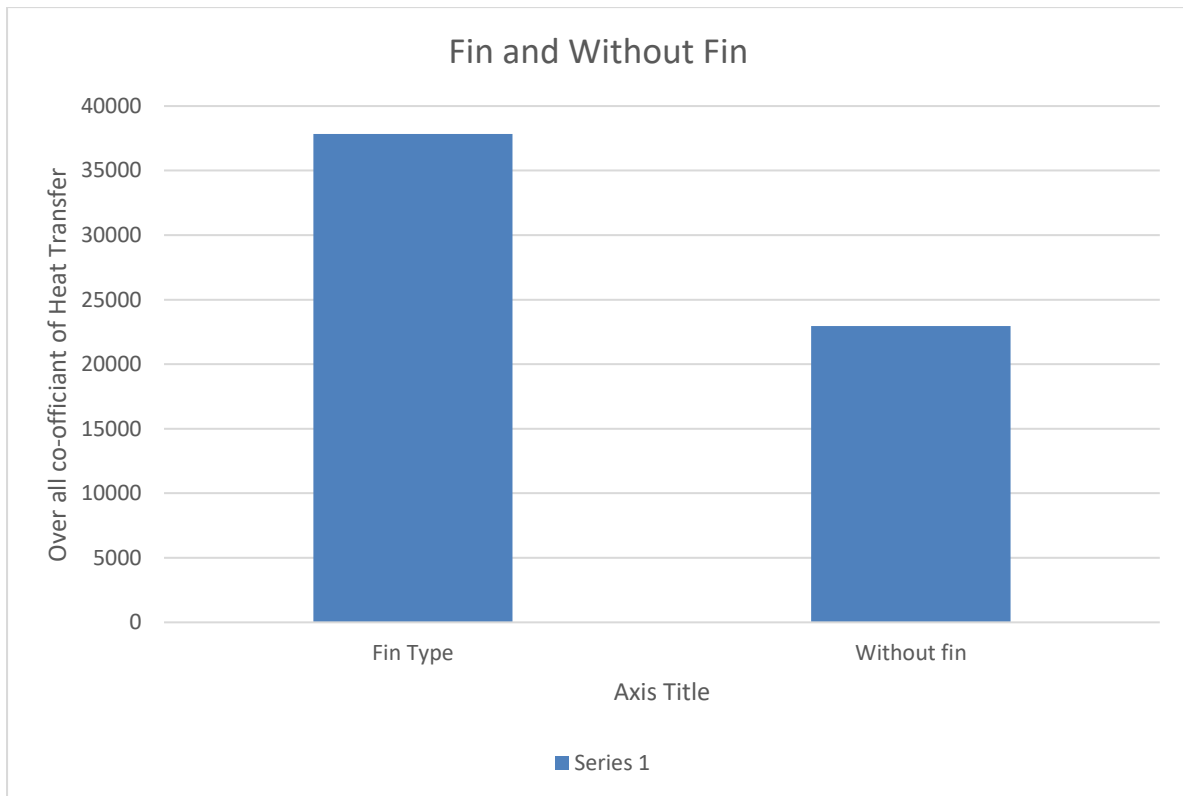
$$Q = UALMTD$$

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

$$= \frac{11782.68}{0.021 \times 24.44}$$

$$U = 22957.44 \text{ Watt/m}^2\text{C}$$

4.4 Flow Chart:



4.5 Result:

3.5.1 Heat Transfer Coefficient with Fin:

$$U_{cu} = 37829.1 \text{ watt}/m^2\text{C}$$

3.5.2 Heat Transfer Coefficient without Fin:

$$U_{cu} = 22957.44 \text{ watt}/m^2\text{C}$$

4.5 Discussion:

4.5.1 Copper tube with fin provided better heat exchange in counter flow.

Chapter -5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion:

To conclude, it is apparent that despite the contradiction with some of the literature, both the hot and cold mass flow rates had a positive impact upon the heat exchanger's performance, i.e. the higher the mass flow rate, the better the performance. However, it seems that there is a general limit of how high the mass flow rate can be set, as the effectiveness (as suggested by the literature) dropped when the mass flow rate was very high. The hot inlet temperature also had a positive impact upon the heat exchanger performance, however, there could be a limit from which point the performance worsens. Varying the types arrangement showed that the fin type yields better results than the plain type, and this is because the average temperature difference between the hot and cold streams is much more uniform when undergoing counter flow as. Lastly, the ambient temperature had almost no noticeable effect upon the heat exchanger's performance; however, this could have been because of the very low temperature range that was used for the investigation.

5.2 Recommendation for Future Work:

In the event that any future experiments take place to further assess the performance of heat exchangers, the following tests are recommended:

5.2.1 Investigation of the effect of cold inlet temperature on the performance of heat exchangers with temperatures ranging from 5°C to 25°C.

5.2.2 Investigation of the effect of ambient temperature on the performance of heat exchangers with temperatures ranging from 15°C to 30°C.

5.2.3 Investigation of the effect of insulation of the pipes on the performance of the heat exchangers, and the required critical radius of insulation to prevent heat loss to the environment.

References

1. Y. Kim, Y. Hwang, Experimental Study on the Vortex Flow in a Concentric Annulus with a Rotating Inner Cylinder, *KSME International Journal* 17 (2003) 562~570.
2. G. Taylor, Distribution of velocity and temperature between concentric rotating cylinders, *Proceedings of the Royal Society of London. Series A* 151(1935)494-512.
3. G. Taylor, Stability of a viscous liquid contained between two rotating cylinders, *Philosophical Transactions Royal Society of London* 223 (1923)289-343.
4. B. Mathew , H. Hegab, Performance of Counter flow Micro Channel Heat Exchangers Subjected to External Heat Transfer, *Heat Transfer Engineering* 31(3)(2010)168-178.
5. M. Molki , K. N. Astill, and E. Leal, Convective heat-mass transfer in the entrance region of a concentric annulus having a rotating inner cylinder, *Int. J. Heat and Fluid Flow* 11(June 1990)120-128.
6. Y. Lei, B. Farouk , Three-dimensional mixed convection flows in a horizontal annulus with a heated rotating inner circular cylinder, *Int. J. Heat Mass Transfer* 35(August 1992)1947-1956.
7. M. Bouafia, A. Ziouchi, Y. Bertin , J. Saulnier , Experimental and numerical study of heat transfer in an annular gap without axial flow with a rotating inner cylinder, *Int. J. Thermal Sciences* 38(1999)547-559.
8. P. L. Greaves , R. I. Grosvenor , B. W. Martin , Factors affecting the stability of viscous axial flow in annuli with a rotating inner cylinder , *Int. J. Heat and Fluid Flow* 4 (1983)187-197.
9. T.S. Lee , Numerical computation of fluid convection with air enclosed between the annuli of eccentric heated horizontal rotating cylinders , *Computers & Fluids* 21(1992) 355-368.
10. H. Pfitzer, H. Beer, Heat transfer in an annulus between independently rotating tubes with turbulent axial flow , *Int. J. Heat and Mass Transfer* 35(1992) 623-633.
11. F. Al-Sadah , Finite difference analysis for heat transfer in a vertical annulus
12. , *Engineering Analysis with Boundary Elements* 8 (1991) 273-277.
13. C.C. Wan, J. Coney, An experimental study of diabatic spiral vortex flow , *Int. J. Heat and Fluid Flow* 3(1982)31-38.
14. P. Hsu , The inverse estimation of the thermal behavior and the viscosity of fluid between two horizontal concentric cylinders with rotating inner cylinder, *Applied Thermal Engineering* 28 (2008)380-387.

15. C.J. Ho, F.J. Tu, An investigation of transient mixed convection heat transfer of cold water in a tall vertical annulus with a heated rotating inner cylinder, *Int. J. Heat and Mass Transfer* 36(1993)2847-285.
16. J.M. Nouri, J.H. Whitelaw, Flow of newtonian and non-newtonian fluids in a concentric annulus with rotation of the inner cylinder, *J. Fluid Eng.* 116 (1994)821–827.