UGC & Govt. Approved
Sonargaon University (SU)
সোনারগাঁও ইউনিভার্সিটি (এসইউ)

Design & Construction of Shell and Tube Heat Exchanger

Thesis Done By

Md. Samrat Sheikh	ID: BME 1903019325
Joydeb Kumar Barman	ID: BME 1903019208
Zahidul Islam	ID: BME 1903019369
Md. Sohel Rana	ID: BME 1903019368
Riad Mahmud Bappi	ID: BME 1903019301

Submitted To

Tanvirul Abedien
Lecturer, Department of Mechanical Engineering
Sonargaon University (SU)
Dhaka-1215, Bangladesh

May, 2023

Design & Construction of Shell and Tube Heat Exchanger

Submitted by

Md. Samrat Sheikh	ID: BME 1903019325
Joydeb Kumar Barman	ID: BME 1903019208
Zahidul Islam	ID: BME 1903019369
Md. Sohel Rana	ID: BME 1903019368
Riad Mahmud Bappi	ID: BME 1903019301

Tanvirul Abedien

Lecturer, Department of Mechanical Engineering

SUBMITTED TO THE:

Department of Mechanical Engineering

SONARGAON UNIVERSITY (SU)

In partial fulfillment of the requirement for award of the degree

Of

Bachelor of Science in Mechanical Engineering

May, 2023

LETTER OF TRANSMITTAL

May, 2023

To

Tanvirul Abedien

Lecturer

Department of Mechanical Engineering.

Sonargaon University

Subject: Submission of Project Report**.**

Dear Sir,

We are pleased to submit the project report on "**Design & Construction of Shell and Tube Heat Exchanger".** It was a great pleasure to work on such an important topic. This project has been done as per instruction of your supervision and according to the requirements of the Sonargaon University.

We expect that the project will be accepted by the concerned authority we will remain happy to further explanation that you may feel necessary in this regard.

Thank You

Sincerely yours,

Signature of Supervisor

Md. Samrat Sheikh
BME 1903019325

Joydeb Kumar Barman
BME 1903019208

Zahidul Islam
BME 1903019369

Riad Mahmud Bappi
BME 1903019301

Md. Sohel Rana
BME 1903019368

DECLARATION

We do hereby solemnly declare that, the work presented here in this project report has been carried out by us and has not been previously submitted to any University/ Organization for award of any degree or certificate

We hereby ensure that the works that has been prevented here does not breach any existing copyright.

We further undertake to indemnify the university against any loss or damage arising from breach of the foregoing obligation.

Md. Samrat Sheikh

BME 1903019325

Joydeb Kumar Barman

BME 1903019208

Zahidul Islam

BME 1903019369

Riad Mahmud Bappi

BME 1903019301

Md. Sohel Rana

BME 1903019368

ACKNOWLEDGEMENT

First, we started in the name of almighty Allah. This thesis is accomplished under the supervision of **Tanvirul Abedien**, Lecturer, Department of Mechanical Engineering, Sonargaon University. It is a great pleasure to acknowledge our profound gratitude and respect to our supervisor for this consistent guidance, encouragement, helpful suggestion, constructive criticism and endless patience through the progress of this work. The successful completion of this thesis would not have been possible without his persistent motivation and continuous guidance.

The authors are also grateful to **Md. Mostofa Hossain**, Head of the Department of Mechanical Engineering and all respect teachers of the Mechanical Engineering Department for their co-operation and significant help for completing the thesis work successfully.

ABSTARCT

Eventually, economics plays a key role in the design and selection of heat-exchange equipment, and the engineer should bear this in mind when embarking on any new heat transfer design problem. The weight and size of heat exchangers used in space or aeronautical applications are very important parameters, and in these cases cost considerations are frequently subordinated in so far as material and heat exchanger construction costs are concerned; however, the weight and size are important cost factors in the overall application in these fields and thus may still be considered as economic variables The primary modes of heat transfer are conduction and then convection. This is not to imply that radiation is not important in heat exchanger design.

Heat exchanger is 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 chapter 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. A fin-and-tube heat exchanger model is presented in this paper. It uses empirical heat transfer and flow friction correlations identified in the literature. The model structure, its range of validity and accuracy are described in detail

.

TABLE OF CONTENTS

Letter of Transmittal	ii
Declaration	iii
Acknowledgement	iv
Abstract	v
Table of Contents	vi
Table of Figure	viii

CHAPTER-1 INTRODUCTION

1.1 Background	01
1.2 Aim and Objectives	02
1.3 Thesis outline	02

CHAPTER 2 LITERATURE REVIEW

2.1 Introduction	03
2.2 Related Work	03
2.3 Summary	05

CHAPTER-3 HARDWARE AND SOFTWARE ANALYSIS

3.1 Required Instrument	06
3.2 SMPS	06
3.3 Heat Exchanger	12
3.4 Digital Meter	14
3.5 Pump	15
3.6 Copper Pipe	17
3.7 Water Heater	17
3.8 Proteus Software Interface	18

CHAPTER-4 METHODOLOGY

4.1 Methodology	20
4.2 Heat Exchanger	20
4.3 Classification of heat exchanger	20

4.4 Tabular Exchanger 21
4.5 Double Pipe Heat Exchanger 21
4.6 System Design 23
4.7 Block Diagram 24
4.8 Heat Exchanger Flow Configuration 24
4.9 Circuit Design 25
4.10 Working Principle 26
4.11 Our Final Project View 27

CHAPTER-5 RESULT AND DISCUSSION
5.1 Discussion 28
5.2 Result 28
5.3 Advantage 31
5.4 Application 31
5.5 Precaution and Safety 32

CHAPTER-6 CONCLUSION
6.1 Conclusion 33
6.2 Future Scope 33

Reference 34

LIST OF FIGURES

FIGURE NO	FIGURE NAME	PAGE NO
3.1	SMPS	07
3.2	SMPS Circuit Design	08
3.3	Power Supply Connection	10
3.4	DC Power Supply Step	11
3.5	Heat Exchanger Tube	12
3.6	Heat Exchanger Tube Inside View	14
3.7	Digital Temperature Sensor	15
3.8	Water Pump	16
3.9	Copper Pipe	17
3.10	Water Heater	18
3.11	Proteus Software Interface	19
4.1	Classification of Heat Exchanger	21
4.2	Double Pipe	22
4.3	System Design Top View	23
4.4	System Design Side View	23
4.5	Block Diagram	24
4.6	Heat Exchanger Flow Configuration	24
4.7	Schematic Diagram	26
4.8	Our Final System Overview	27
5.1	Counter Flow System and Graph	29
5.2	Parallel Flow System and Graph	30

:

CHAPTER 1

INTRODUCTION

1.1 Background

A shell and tube heat exchanger are a class of heat exchanger designs. It is the most common type of heat exchanger in oil refineries and other large chemical processes, and is suited for higher-pressure applications. As its name implies, this type of heat exchanger consists of a shell (a large pressure vessel) with a bundle of tubes inside it. One fluid runs through the tubes, and another fluid flows over the tubes (through the shell) to transfer heat between the two fluids. The set of tubes is called a tube bundle, and may be composed of several types of tubes: plain, longitudinally finned, etc. In this paper we are concerned about the performance analysis of shell and tube type heat exchanger under different loading conditions. To do the same we have first designed a shell and tube type heat exchanger to get the dimensions of the parts involved and thereafter fabrication and testing of the actual working model has been done to see the effects of various parameters on the performance of the heat exchanger. Some of the works reviewed for the purpose are as described below:

Different types of classification of heat exchangers available in engineering practice are widely discussed on Froas and Ozisik [1] Walker [2] and Kakac, Shah, and Bergles [3]. Heat exchangers can be classified based on the transfer process, compactness, construction type, flow arrangement and heat transfer mechanism [4], [5]. Heat Exchanger performance is one of the most vital term in heat research field because of its vast range of applications. Numerous researches have been done already about the performance of heat exchanger.

Dubey et al. [6] investigated the performance of a shell and tube type heat exchanger under the effect of varied operation condition was analyzed and it was seen that the computational results were almost same compared with the experimental results. Kara et al. [7] made a computer-based design model for a shell-tube heat exchanger. In that exchanger single phase fluid flows on both shell and tube side. According to the conclusion of that paper, circulating cold fluid in shell side and hot fluid in tube side is advantageous. The heat transfer characteristics of a tube-tube heat exchanger (TTHE) was conducted by Rane et al. [8]. Work of Lunsford [9] is very informative in increasing the heat exchanger efficiency. Yao et al. [10] conducted an experiment on heat transfer enhancement of water-to-water shell and tube heat exchanger assisted by power ultrasonic. Alarm et al. [11] investigated the heat transfer characteristics of an air to water heat exchanger both numerically and experimentally.

1.2 Aims and Objectives

We have some specific objectives for this project and they are pointed below:

- Efficient heat transferring.
- To get difference between two water conditions temperature.
- Recycling the water with appropriate usages.
- Easy to dismantle, clean & repair.
- Compact in size & low cost.
- These exchangers are affordable compared to the plate type coolers.
- Custom Design available.
- End bonnets removal for servicing.
- Optimal solution for Swimming pool heating, Mining Machinery, Hydraulic power packs etc.

1.3 Thesis Outline

- **Chapter 1: Introduction.** This chapter is all about background study, problem identification, motivation and aims and objectives.
- **Chapter 2: Literature Review-** Here briefly describe about literature review.
- **Chapter 3: Hardware and Software -** This chapter is discussed about instrument and software. Hardware and Software details and its working procedure.
- **Chapter 4: Methodology –** Here briefly discuss about project methodology, Block Diagram, circuit diagram, required instrument cost analysis, working principle etc.
- **Chapter 5: Result & Discussion**: in this chapter we discuss about result analysis, advantages, application precaution etc.
- **Chapter 6: Conclusion** – This chapter is all about our project advantages, limitation, application and this project conclusion.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter is arranged on Literature Review. Here's a look at some of last year's literature, like our project. By reading them, we can overcome the mistakes of the previous project and make a more effective project.

2.2 Related Research/ Works

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. However, this increase is a function of the ratio of the mass flow rates.

[1] Vimal Kumar, Burhanuddin Faizee, Monisha Mridha and K.D.P. Nigamconducted an experiment on tube-in-tube heat exchanger and observed that with the increase in operating pressure in the inner tube, the overall heat transfer coefficient increases and the friction factor value in the inner-coiled tube was in agreement with the literature data.

[2] N. Ghorbani, H. Taherian, M. Gorji, H. Mirgolbabaei conducted a practical experiment on a vertical helically coiled heat exchanger and found that the coil surface area was the most influential geometrical parameter on the heat transfer coefficient and effect of tube diameter is almost negligible on overall heat transfer coefficient.

[3] Rahul Kharat, Nitin Bhardwaj, R.S. Jha experimented on the effect of various geometric parameters on a concentric helical coil heat exchanger. They plotted the graph between heat 13transfer coefficient versus tube diameter and coil gap and found that two most important design parameters are coil gap and tube diameter.

[4] J. S. Jayakumar conducted an experiment on helically coiled heat exchangers using CFD and found that the use of constant values for the heat transfer and thermal properties of the fluid resulted in inaccurate heat transfer coefficients. Based on the analysis results he developed a correlation in order to evaluate the heat transfer coefficient of the coil. In this study, analysis was done for both the constant wall temperature and constant wall heat flux boundary conditions. The Nusselt numbers that were obtained were found to be highest on the outer coil and lowest in the inner side. The coil parameters like the diameters of the pipes, the Pitch Circle Diameters have significant effect on the heat transfer and the effect of the pitch is negligible.

[5] Timothy J. Rennie studied the heat transfer characteristics for a double pipe helical heat exchanger for both counter and parallel flow with both the boundary conditions of constant heat flux and constant wall temperature. The results from the simulations were within the range of the pre-obtained results. The overall heat transfer coefficients were determined for dean numbers ranging from 38 to 350. He observed that the overall heat transfer coefficients varied directly with the inner dean number but the fluid flow conditions in the outer pipe had a major contribution on the overall heat transfer coefficient. So, he concluded that during the design of a double pipe helical heat exchanger, the design of the outer pipe should be given the highest priority in order to get a better overall heat transfer coefficient.

[6] J. S. Jayakumar, S. M. Mahajani, J. C. Mandal, Rohidas Bhoi studied the constant thermal and transport properties of the heat transfer medium and their effect on the prediction of heat transfer coefficients. Arbitrary boundary conditions were not applicable for the determination of heat transfer for a fluid-to-fluid heat exchanger. An experimental setup was made for studying the heat transfer and also CFD was used for the simulation of the heat transfer. The CFD simulation results were reasonably well within the range of the experimental results. Based on both the experimental and simulation results a correlation was established for the inner heat transfer coefficient.

Two fluids of different starting temperatures, flow through the heat exchanger. One flows through the tubes (the tube side) and the other flows outside the tubes but inside the shell (the shell side). Heat is transferred from one fluid to the other through the tube walls, either from tube side to shell side or vice versa. The fluids can be either liquids or gases on either the shell or the tube side. In order to transfer heat efficiently, a large heat transfer area should be used, leading to the use of many tubes. In this way, waste heat can be put to use. This is an efficient way to conserve energy.

Heat exchangers with only one phase (liquid or gas) on each side can be called one-phase or single-phase heat exchangers. Two-phase heat exchangers can be used to heat a liquid to boil it into a gas (vapor), sometimes called boilers, or cool a vapor to condense it into a liquid (called condensers), with the phase change usually occurring on the shell side. Boilers in steam engine locomotives are typically large, usually cylindrically-shaped shell-and-tube heat exchangers. In large power plants with steam-driven turbines, shell-and-tube surface condensers are used to condense the exhaust steam exiting the turbine into condensate water which is recycled back to be turned into steam in the steam generator.

2.3 Summary

The above has been discussed in detail in the past few literatures which has given us a lot of motivation to do this project.

Shell and tube heat exchangers are, simply put, a device that puts two working fluids in thermal contact using tubes housed within an outer cylindrical shell. These two integral pathways are usually built out of thermally conductive metals that allow easy heat transfer (steel, aluminum alloys, etc.). The tubes carry a fluid from their inlet to their outlet (the “tube-side” flow), while the shell passes a separate fluid over these tubes (the “shell-side” flow). The number of tubes, known as the tube bundle will dictate how much surface area is exposed to the shell-side flow, and therefore determines how much heat is transferred. These devices are among the most effective means of exchanging heat, as they are easily built, maintained, are compact, and provide excellent heat transfer. They are widely distributed in industry, being useful for condensers, turbine coolers, evaporators, feed water preheating, and much more.

CHAPTER 3

HARDWARE AND SOFTWARE ANALYSIS

3.1 Required Instrument

- SMPS
- Heat Exchanger
- Temperature Meter
- Pump Motor
- Water Heater
- Steel Pipe
- Switch

3.2 Switch Mode Power Supply (SMPS)

A switched-mode power supply (switching-mode power supply, switch-mode power supply, switched power supply, SMPS, or switcher) is an electronic power supply that incorporates a switching regulator to convert electrical power efficiently. Like other power supplies, an SMPS transfers power from a DC or AC source (often mains power) to DC loads, such as a personal computer, while converting voltage and current characteristics.

Unlike a linear power supply, the pass transistor of a switching-mode supply continually switches between low-dissipation, full-on and full-off states, and spends very little time in the high dissipation transitions, which minimizes wasted energy. A hypothetical ideal switched-mode power supply dissipates no power. Voltage regulation is achieved by varying the ratio of on-to-off time (also known as duty cycles). In contrast, a linear power supply regulates the output voltage by continually dissipating power in the pass transistor. This higher power conversion efficiency is an important advantage of a switched-mode power supply. Switched-mode power supplies may also be substantially smaller and lighter than a linear supply due to the smaller transformer size and weight.

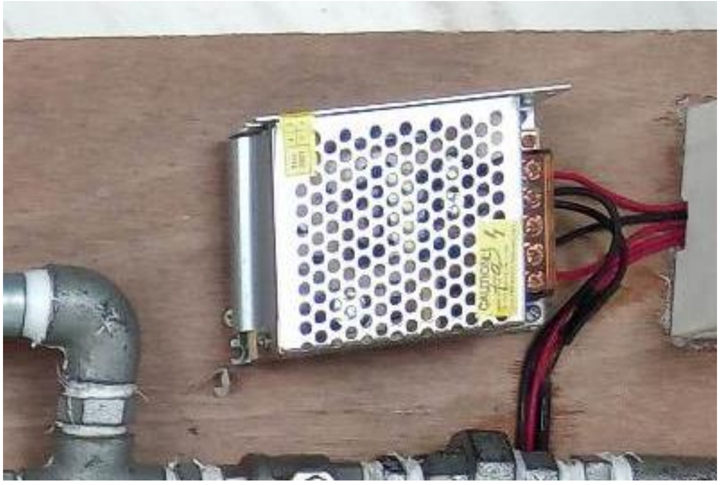

Figure 3.1: SMPS

Switching regulators are used as replacements for linear regulators when higher efficiency, smaller size or lighter weight are required. They are, however, more complicated; their switching currents can cause electrical noise problems if not carefully suppressed, and simple designs may have a poor power factor.

12V 5A Industrial SMPS Power Supply – 60W – DC Metal Power Supply – Good Quality – Non-Waterproof with Aluminum casing.

- Input Voltage: AC 100 – 264V 50 / 60Hz
- Output Voltage: 5V DC, 0-7A
- Output voltage: Adjustment Range: ±20%
- Protections: Overload / Over Voltage / Short Circuit
- Auto-Recovery After Protection
- Universal AC input / Full range
- 100% Full Load Burn-in Test
- Cooling by Free Air Convection
- High Quality and High Performance
- LED power supply with a metal body for hidden installation for LED lighting
- Design with Built-in EMI Filter, improve signal precision.
- Certifications: CE & RoHs

Switched-mode power supplies are classified according to the type of input and output voltages. The four major categories are:

- AC to DC
- DC to DC
- DC to AC
- AC to AC

A basic isolated AC to DC switched-mode power supply consists of:

- Input rectifier and filter
- Inverter consisting of switching devices such as MOSFETs
- Transformer
- Output rectifier and filter
- Feedback and control circuit

The input DC supply from a rectifier or battery is fed to the inverter where it is turned on and off at high frequencies of between 20 KHz and 200 KHz by the switching MOSFET or power transistors. The high-frequency voltage pulses from the inverter are fed to the transformer primary winding, and the secondary AC output is rectified and smoothed to produce the required DC voltages. A feedback circuit monitors the output voltage and instructs the control circuit to adjust the duty cycle to maintain the output at the desired level.

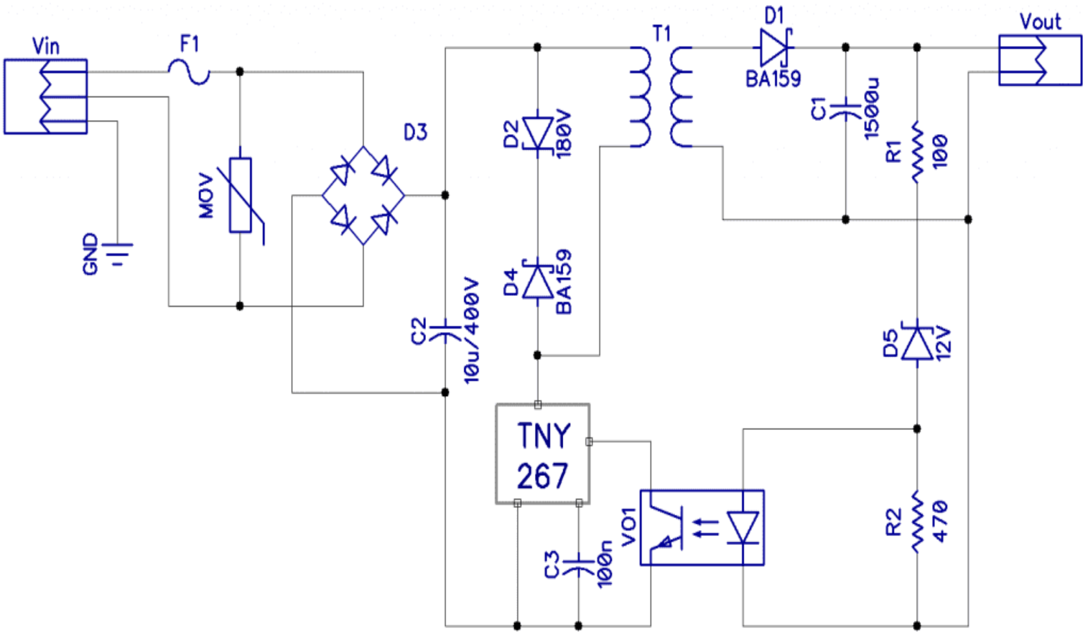

Figure 3.2: SMPS Circuit Design

Basic working concept of an SMPS

A switching regulator does the regulation in the SMPS. A series switching element turns the current supply to a smoothing capacitor on and off. The voltage on the capacitor controls the time the series element is turned. The continuous switching of the capacitor maintains the voltage at the required level.

Design basics

AC power first passes through fuses and a line filter. Then it is rectified by a full-wave bridge rectifier. The rectified voltage is next applied to the power factor correction (PFC) pre-regulator followed by the downstream DC-DC converter(s). Most computers and small appliances use the International Electro technical Commission (IEC) style input connector. As for output connectors and pin outs, except for some industries, such as PC and compact PCI, in general, they are not standardized and are left up to the manufacturer.

There are different circuit configurations known as topologies, each having unique characteristics, advantages and modes of operation, which determines how the input power is transferred to the output. Most of the commonly used topologies such as fly back, push-pull, half bridge and full bridge, consist of a transformer to provide isolation, voltage scaling, and multiple output voltages. The non-isolated configurations do not have a transformer and the power conversion is provided by the inductive energy transfer.

Advantages of switched-mode power supplies:

- Higher efficiency of 68% to 90%
- Regulated and reliable outputs regardless of variations in input supply voltage
- Small size and lighter
- Flexible technology
- High power density

Disadvantages:

- Generates electromagnetic interference
- Complex circuit design
- Expensive compared to linear supplies

Switched-mode power supplies are used to power a wide variety of equipment such as computers, sensitive electronics, battery-operated devices and other equipment requiring high efficiency

Switch Mode Power Supply

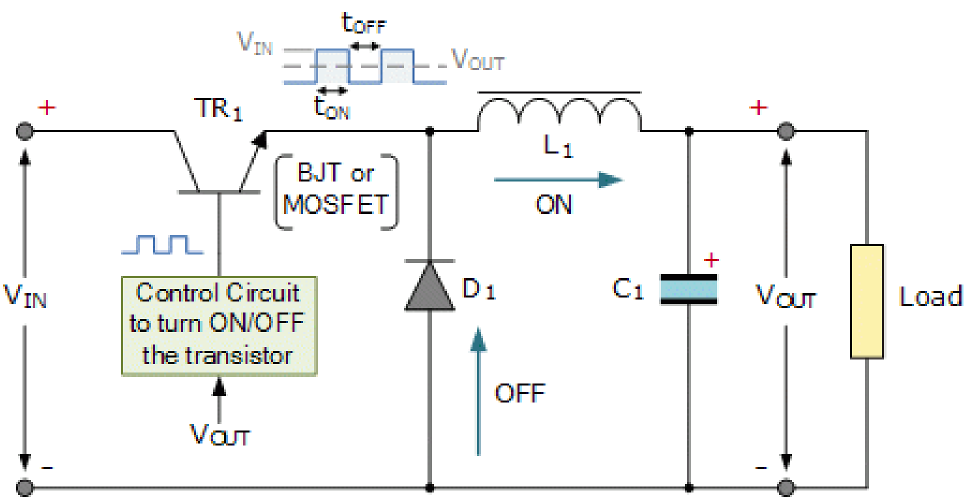

Figure 3.3: Power Supply Connection

Linear voltage IC regulators have been the basis of power supply designs for many years as they are very good at supplying a continuous fixed voltage output. Linear voltage regulators are generally much more efficient and easier to use than equivalent voltage regulator circuits made from discrete components such a zener diode and a resistor, or transistors and even op-amps. The most popular linear and fixed output voltage regulator types are by far the positive output voltage series, and the 79 negative output voltage series. These two types of complementary voltage regulators produce a precise and stable voltage output ranging from about 5 volts up to about 24 volts for use in many electronic circuits.

There is a wide range of these three-terminal fixed voltage regulators available each with its own built-in voltage regulation and current limiting circuits. This allows us to create a whole host of different power supply rails and outputs, either single or dual supply, suitable for most electronic circuits and applications. There are even variable voltage linear regulators available as well providing an output voltage which is continually variable from just above zero to a few volts below its maximum voltage output.

Most D.C. power supplies comprise of a large and heavy step-down mains transformer, diode rectification, either full-wave or half-wave, a filter circuit to remove any ripple content from the rectified D.C. producing a suitably smooth D.C. voltage, and some form of voltage regulator or stabilizer circuit, either linear or switching to ensure the correct regulation of the power supplies output voltage under varying load conditions. Then a typical D.C. power supply would look something like this:

Typical DC Power Supply

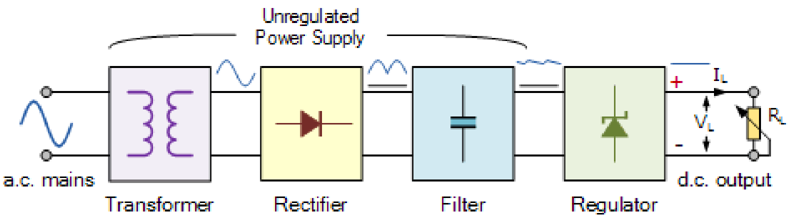

Figure 3.4: DC Power Supply Step

These typical power supply designs contain a large mains transformer (which also provides isolation between the input and output) and a dissipative series regulator circuit. The regulator circuit could consist of a single zener diode or a three-terminal linear series regulator to produce the required output voltage. The advantage of a linear regulator is that the power supply circuit only needs an input capacitor, output capacitor and some feedback resistors to set the output voltage.

3.3 Heat Exchanger

A heat exchanger is a system used to transfer heat between a source and a working fluid. Heat exchangers are used in both cooling and heating processes. The fluids may be separated by a solid wall to prevent mixing or they may be in direct contact. They are widely used in space heating, refrigeration, air conditioning, power stations, chemical plants, petrochemical plants, petroleum refineries, natural-gas processing, and sewage treatment. The classic example of a heat exchanger is found in an internal combustion engine in which a circulating fluid known as engine coolant flows through radiator coils and air flows past the coils, which cools the coolant and heats the incoming air. Another example is the heat sink, which is a passive heat exchanger that transfers the heat generated by an electronic or a mechanical device to a fluid medium, often air or a liquid coolant.

Figure 3.5: Gear Exchanger Tube

Types

Double pipe heat exchangers are the simplest exchangers used in industries. On one hand, these heat exchangers are cheap for both design and maintenance, making them a good choice for small industries. On the other hand, their low efficiency coupled with the high space occupied in large scales, has led modern industries to use more efficient heat exchangers like shell and tube or plate. However, since double pipe heat exchangers are simple, they are used to teach heat exchanger design basics to students as the fundamental rules for all heat exchangers are the same.

1. **Double-pipe heat exchanger**

(a) When the other fluid flows into the annular gap between two tubes, one fluid flows through the smaller pipe. The flow may be a current flow or parallel flow in a double pipe heat exchanger.

(b) Parallel flow, where at the same point, the hot and cold liquids join, flow in the same direction and exit at the same end.

(c) Counter flow, where at opposite ends, hot and cold fluids join, flow in the opposite direction and exit at opposite ends.

The figure above illustrates the parallel and counter-flow flow directions of the fluid exchanger. If this is done under comparable conditions, more heat is transferred to the counter-flow device than to the parallel flow heat exchanger. Owing to the large temperature differential arising from the high thermal voltage, the temperature profiles of the two heat exchangers display two significant disadvantages in the parallel-flow design. Which indicates that the partnership is a distinct disadvantage if it is intended a design is to increase the cold fluid temperature. Where two fluids are expected to be taken to exactly the same temperature, the parallel flow configuration is beneficial. While the counter flow heat exchanger has more significant advantages compared to parallel flow design. Where it can reduce thermal stress and produce more uniform rate of heat transfer.

2. Shell-and-tube heat exchanger

In a shell-and-tube heat exchanger, two fluids at different temperatures flow through the heat exchanger. One of the fluids flows through the tube side and the other fluid flows outside the tubes, but inside the shell (shell side).

Baffles are used to support the tubes, direct the fluid flow to the tubes in an approximately natural manner, and maximize the turbulence of the shell fluid. There are many various kinds of baffles, and the choice of baffle form, spacing, and geometry depends on the allowable flow rate of the drop in shell-side force, the need for tube support, and the flow-induced vibrations. There are several variations of shell-and-tube exchangers available; the differences lie in the arrangement of flow configurations and details of construction.

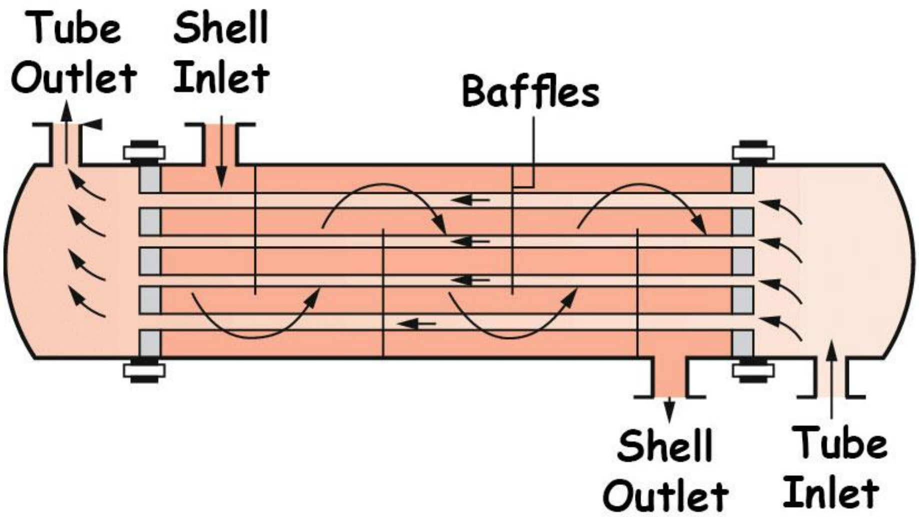

Figure 3.6: Heat Exchanger Tube inside view

3.4 Digital Thermometer

A thermometer is a device that measures temperature or a temperature gradient (the degree of hotness or coldness of an object). A thermometer has two important elements: (1) a temperature sensor (e.g. the bulb of a mercury-in-glass thermometer or the pyrometric sensor in an infrared thermometer) in which some change occurs with a change in temperature; and (2) some means of converting this change into a numerical value (e.g. the visible scale that is marked on a mercury-in-glass thermometer or the digital readout on an infrared model). Thermometers are widely used in technology and industry to monitor processes, in meteorology, in medicine, and in scientific research.

Some of the principles of the thermometer were known to Greek philosophers of two thousand years ago. As Henry Carrington Bolton (1900) noted, the thermometer's "development from a crude toy to an instrument of precision occupied more than a century, and its early history is encumbered with erroneous statements that have been reiterated with such dogmatism that they have received the false stamp of authority." The Italian physician Santorio Santorio (Sanctorius, 1561-1636) is commonly credited with the invention of the first thermometer, but its standardization was completed through the 17th and 18th centuries. In the first decades of the 18th century in the Dutch Republic, Daniel Gabriel Fahrenheit made two revolutionary breakthroughs in the history of thermometry. He invented the mercury-in-glass thermometer (first widely used, accurate, practical thermometer) and Fahrenheit scale (first standardized temperature scale to be widely used).

Figure 3.7: Digital Temperature Sensor

Specification:

- Temperature range: -50~ +110°C
- Using environment: Temperature: -5~ +50°C Humidity: 5%~80%
- Accuracy: ±1°C
- Size: 47*28*14mm
- Weight: 22g
- Color: Black and white

3.5 Pump

A **pump** is a device that moves fluids (liquids or gases), or sometimes slurries, by mechanical action, typically converted from electrical energy into hydraulic energy. Mechanical pumps serve in a wide range of applications such as pumping water from wells, aquarium filtering, pond filtering and aeration, in the car industry for water-cooling and fuel injection, in the energy industry for pumping oil and natural gas or for operating cooling towers and other components of heating, ventilation and air conditioning systems. In the medical industry, pumps are used for biochemical processes in developing and manufacturing medicine, and as artificial replacements for body parts, in particular the artificial heart and penile prosthesis.

Fig. 3.8: Centrifugal water Pump.

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" male thread
- Voltage: 6-12V DC
- Maximum Rated Current: 1.2A
- Power: 16.8W
- Max Flow Rate: 700 L/H
- Max Water Head: 5M
- Max Circulating Water Temperature: 60°C

3.6 Copper Pipe:

Copper pipes are commonly used for exchange heat to the another medium 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 3.9: Copper Pipe

3.7 Water Heater:

A water heater is a device that used to heat water or fluid. In this experiment water heater is used to heat up the water of hot cycle. **Water heating** is a heat transfer process that uses an energy source to heat water above its initial temperature. Typical domestic uses of hot water include cooking, cleaning, bathing, and space heating. In industry, hot water and water heated to steam have many uses.

Domestically, water is traditionally heated in vessels known as water heaters, kettles, cauldrons, pots, or coppers. These metal vessels that heat a batch of water do not produce a continual supply of heated water at a preset temperature. Rarely, hot water occurs naturally, usually from natural hot springs. The temperature varies with the consumption rate, becoming cooler as flow increases.

Fig. 3.10: Water heater

CHAPTER 4

METHODOLOGY

4.1 Our methodologies for the project

Our methodologies for the project:

- Creating an idea for design and construction of **shell and tube heat exchanger**. And designing a block diagram & circuit diagram to know which components we need to construct it.
- Collecting all the components and programming the micro-controller to control the whole system.
- Setting up all the components in a PCB board & then soldering. Lastly, assembling all the blocks in a board and to run the system & for checking purposes.

4.2 Heat exchanger

Heat exchanger may be defined as an equipment which transfers the energy from a hot fluid to a cold fluid, with maximum rate and minimum investment and running cost. The rate of transfer of heat depends on the conductivity of the dividing wall and convective heat transfer coefficient between the wall and fluids. The heat transfer rate also varies depending on the boundary conditions such as adiabatic or insulated wall conditions. Some examples of heat exchangers are:

I. Intercoolers and pre heaters;
ii. Condensers and boilers in refrigeration units;
iii. Condensers and boilers in steam plant;
iv. Regenerators;
v. Oil coolers and heat engines;
vi. Automobile radiators etc.

4.6 System Design and Components

The main processing brain of the system is the rack & pinion mechanism. This system created power will store in battery. After press the switch on then the system will be on and ready for operation. Here this system will able to generate power when a car cross over the speed breaker. Here we use voltmeter, generator motor, capacitor, led light, rack & pinion mechanism etc. All of this equipment’s are combined work together and full fill our required as we desire.

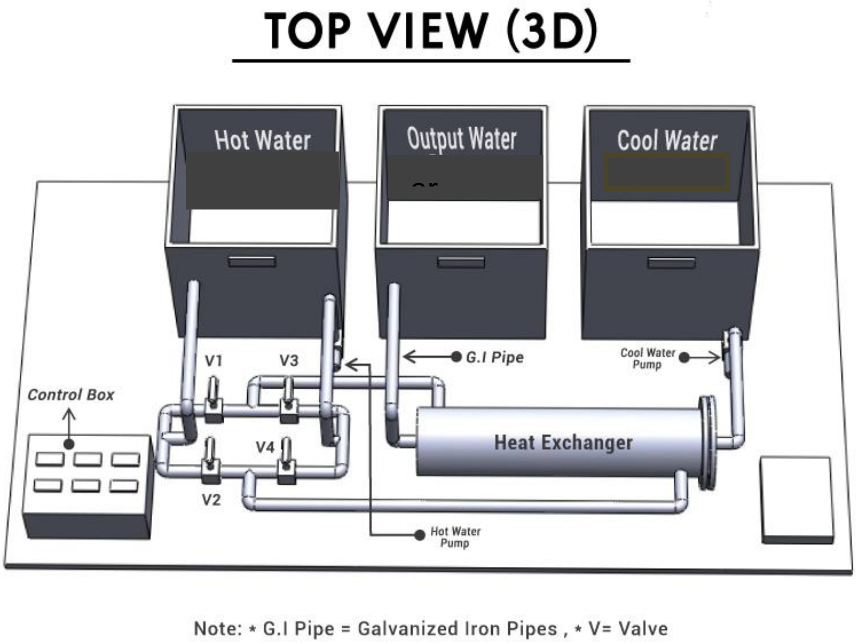

Figure 4.1: System Design Top View

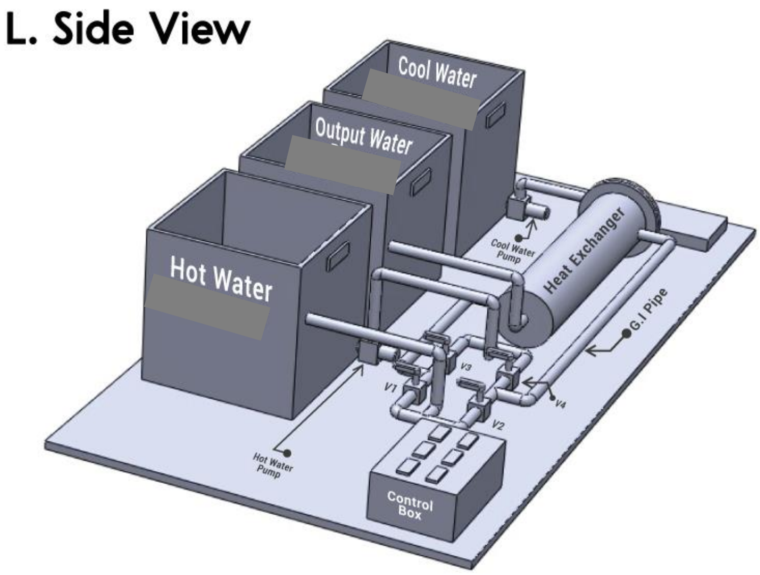

Figure 4.2: System Design Side View

4.7 Block Diagram

In this diagram we will show by block the individual parts.

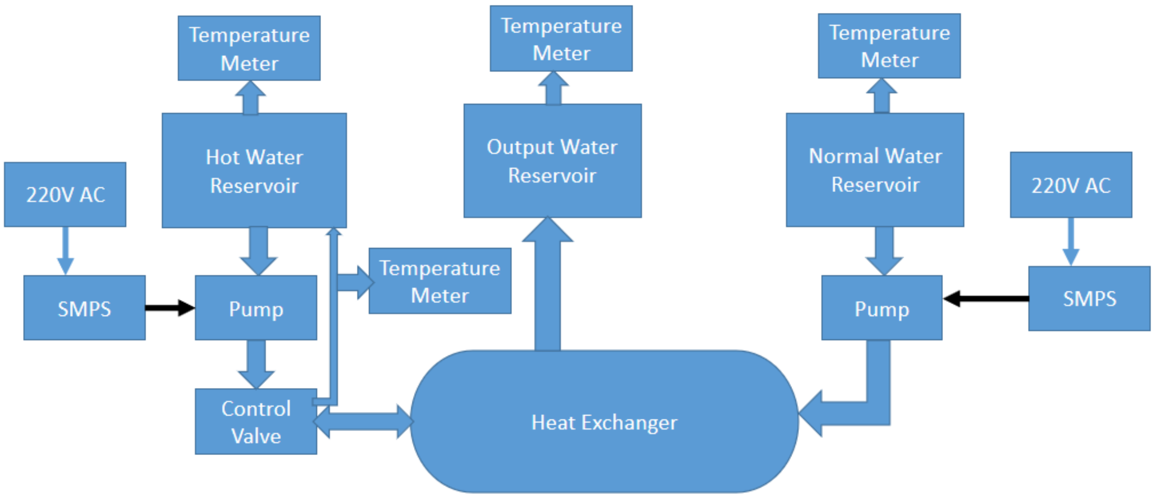

Figure 4.3: Block Diagram

4.8 Heat Exchanger Flow Configurations:

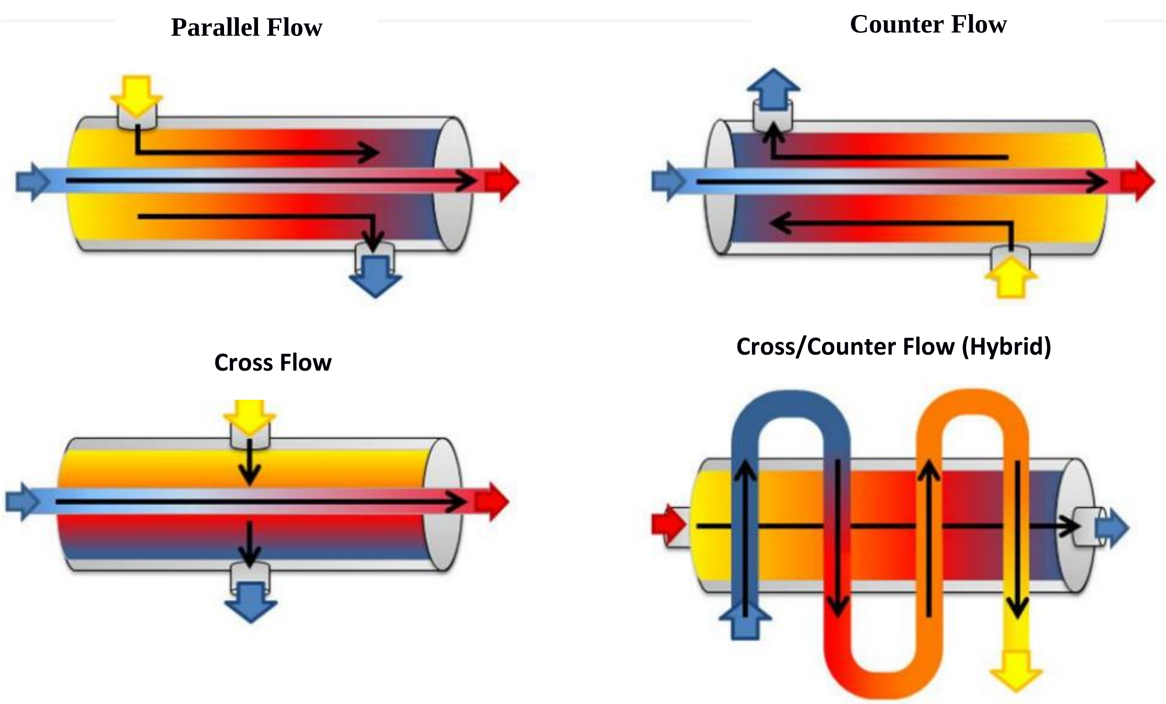

Figure 4.4: Heat Exchanger Flow Configuration

Counter Flow:

Counter flow heat exchangers use flows in the opposite direction of each other. Shell and tube, and double pipes heat exchangers are examples of common exchangers using counter flow configurations. The best design for shell and tube and double-pipe exchanger is counter flow configuration, and the heat transfer between the fluid is the maximum. In counter flow, the efficiency is higher than the parallel, and temperature in the cooling fluid outlet can exceed the warmer fluid inlet temperature.

Parallel Flow:

A parallel flow heat exchanger is a type of exchanger having a parallel fluid direction. In other words, the fluids having a high temperature and a cold temperature both move towards the same direction through separate tubes, which allows the heat to be transferred from a high-temperature liquid to a low-temperature liquid. This process is less efficient compared to the counterflow method because this process cannot absorb a maximum amount of temperature from the warm liquid. This is because when the two liquids move in the same direction, the temperature difference between the two liquids becomes gradually low. However, this method is important when the flows at the outlet have a similar temperature together, and we also need these flows to have a closely similar temperature.

4.9 Circuit Design Analysis

The schematic diagram here is representing the electrical circuit and the components of our System. Here we connect equipment with the smart wire connection.

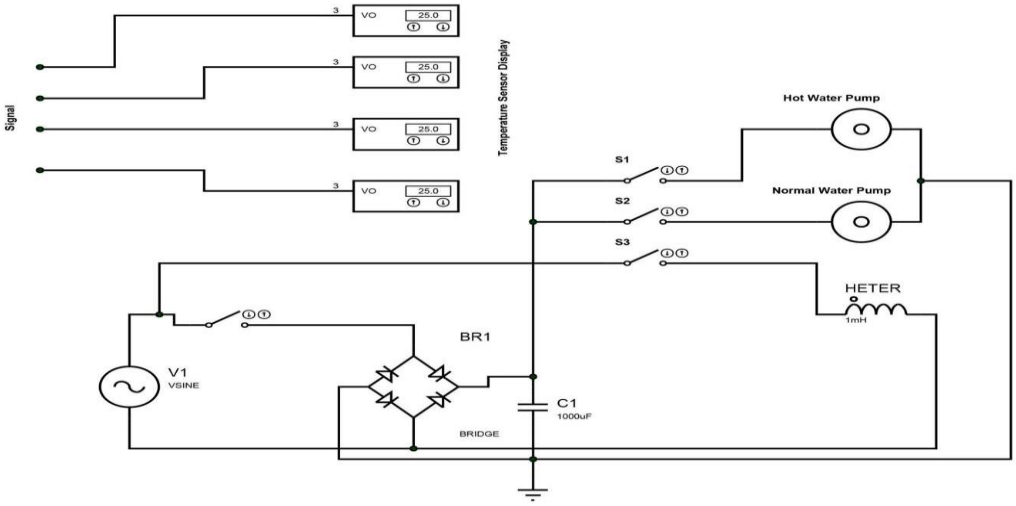

Figure 4.5: Circuit Diagram of our system

4.10 Working Principle:

The working principle of these heats exchangers is simple. A tube-in-tube heat exchanger can achieve a net countercurrent flow, which allows temperature crossovers to be achieved so that the cold fluid can be heated above the hot fluid outlet's temperatures. The hot or cold liquid never comes into contact with the fluid that is heating or cooling it. The inner and outer tubes each hold hot or cold fluid. This method is known as the indirect heat transfer method. The fluid in the outers tube enters the fluid in the inner tube from the opposite end of the tube. This is called counter-flow or contraflow.

In tube heat exchangers find use in tube preheating and cooling sections where a direct steam injection heat exchanger is required. The heat exchangers on the preheat & cooling sections are by indirect heat transfer method, but the final heating is done by directly injecting steam into the product, which is known as Direct Steam Injection or Direct Steam Infusion.

So, the plan of this project is there will be two water tank and both have temperature meter, then from the Hot Water Reserve Tank, hot water will be pass through the pump motor to coper pipe through the water-cooling heat sink and to power up the Pump Motor we setup SMPS Power Supply, now water will go through the Aluminum & Copper Metal pipe, so the cool water will store in Recycle Water tank. We also setup a Temperature Meter on Recycle Water Tank, so we can measure the difference between the Hot water and Cold water.

4.11 Experimental Setup of Our System

Here is our structural setup of our design is given below -

Figure 4.6: Our System Structural Grinding set up

Figure 4.7: Our System Structural Pipe Fitting set up.

Figure 4.9: Our System Structural Final image

CHAPTER 5

RESULT AND DISCUSSION

5.1 Discussion

While working on our project, we did face some difficulties as it is a very complex system but the end results, we came up with were quite satisfactory. We have put the whole system through several tasks to validate our work and also have taken necessary notes for future improvements. Some future recommendations that we have involves improvement in system design and wiring, adding features for more efficient.

5.2 Result Analysis

Getting Value -

- Cold water Properties

  $m_c = 0.14Kg/S$

  $cp_c = 4.187\ KJ/Kg.K$

  $T_{c\ in} = 28℃$

  $T_{c\ out} = 45℃$

- Hot water Properties

  $m_h = 0.12Kg/S$

  $cp_h = 3.976\ KJ/Kg.K$

  $T_{h\ in} = 55℃$

  $T_{h\ out} = 40℃$

  A =?

Let, U = 420 W/m^2c

- Applying Counter Flow:

We know that,

Q = $m_c cp_c(T_{c\ out} - T_{c\ in}) = m_h\ cp_h\ (T_{h\ in} - T_{h\ out})$

$\therefore\ Q = m_c\ cp_c\ (T_{c\ out} - T_{c\ in})$

= 0.14 ×4.187 (45-28)

= 0.586 × 17

= 9.96 KW

= 9.96 ×10^3 $Watts$

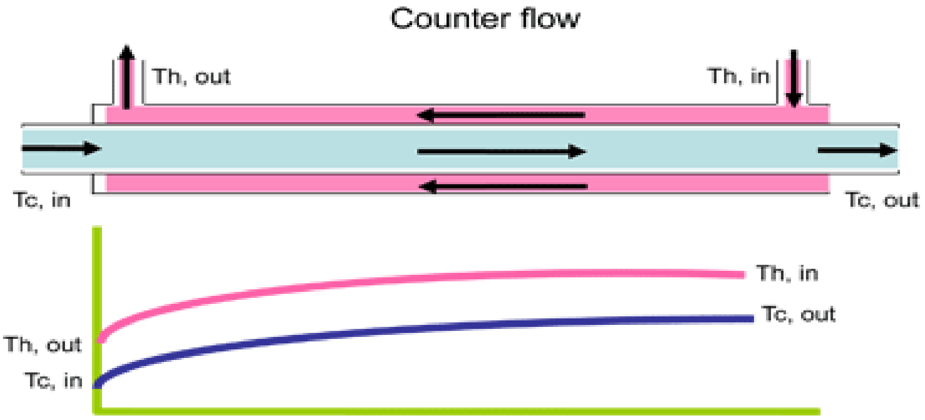

Figure 5.1: Counter Flow System and Graph

$\therefore \Delta T_1 = (T_{h\ in} - T_{c\ out})$
$= 55 - 45$
$= 10°C$

$\therefore \Delta T_2 = (T_{h\ out} - T_{c\ int})$
$= 40 - 28$
$= 12°C$

$$\therefore \text{LMTD Method} = \frac{\Delta T_1 - \Delta T_2}{L_n \frac{\Delta T_1}{\Delta T_2}}$$

$$= \frac{10 - 12}{Ln \frac{10}{12}}$$

$$= 10.96°C$$

$\therefore Q = U.A.LMTD$

$$\therefore A = \frac{Q}{U.LMTD} = \frac{9.96 \times 10^3}{420 \times 10.96} = 2.16\ m^2$$

$\therefore$ Area of Heat Exchanger $A = 2.16\ m^2$

5.3 Advantages

There are certainly many advantages of our project and some of the major ones have been given below:

- Do not waste time.
- Very Cost Effective.
- Very fast heat exchange can be done.
- Recycle the water in a manner.
- More accuracy.
- Can usable in any area of Water Recycling

5.4 Application

Our project has many application areas and actually we need to use it in many places to verified the exact person which have the proper access. Some of the application areas of the project has been pointed out below:

- Ensuring quality control in mass production.
- By some modification it can be used to control the water cooling.
- By some modification it can be used to measure the weight of the water.
- By increasing its pipe capacity, it can be used in industry's.
- It is also very useful in laboratories and workshops.
- It's can be widely used any productive industry.

5.5 Precautions and Safety measures:

- To be careful and to wear hand gloves due to protect possible electric shock.
- To be check every pipe joint for possible water leakage.
- Carefully open and close the valves for various flow.
- Carefully note down temperature meter readings.
- To be careful about electricity leakage into water.
- Carefully handle with hot water.

CHAPTER 6

CONCLUSION

6.1 Conclusion

Fouling and corrosion are the major unresolved crisis in heat exchanger operation. Though the fouling deposition problems and the impact to the economy are a serious concern, still there is lack of awareness in concerned authorities. In addition, the penalties of corrosion are numerous and varied and the effects of these on the efficient, reliable and safe operation of equipment or structures are often more serious than the simple loss of a mass of metal. Therefore, the present paper will promote concerned organization in different countries, seriousness of this problem and application of possible mitigation approach. For an industry, the proper cleaning method and control play important role to reduce the production costs. Production cost significantly increases due to chemical usage, maintenance work and downtime loss and water wastage. Consequently, the related authorities need to comprehend the importance of corrosion control, fouling cleaning and enforce a specific standard of cleaning procedure in the industries.

6.2 Future Scope

The model can be improved by making some changes in the program and components.
Some suggestions are given below.

1. By using the same set of tabulators, heat transfer augmentation for various fluids can be studied.

2. Instead of using steam as isothermal source to maintain constant wall temperature hot water can be used as isothermal source.

3. These variant tabulators can be used for heat transfer augmentation studies also in refrigeration system.

4. For the same set of tabulators, heat transfer and friction characteristics can be studied for laminar flow condition.

REFERENCE

[1] A.P. Frass and M. N. Ozisik, Heat Exchanger Design, Wiley, New York, 1965.

[2] G. Walker, Industrial Heat Exchangers, Hemisphere, Washington, 1982.

[3] S. Kakac, R. K. Shah and A. E. Bergles (eds), Low Reynolds Number Flow Heat Exchangers, Hemisphere, Washington, 1982.

[4] M. N. Ozisik, Heat Transfer - A Basic Approach, McGraw-Hill Book Company, International edition, 1985.

[5] J. P. Holman, Heat Transfer, McGraw-Hill Book Company, 10th Edition, 2009.

[6] V. V. P. Dubey and R. Rajat, “Performance Analysis of Shell and Tube Type Heat Exchanger Under the Effect of Varied Operating Condition”, IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), vol. 11, no. 3, Ver. VI, pp. 08-17, 2014.

[7] K. M. Lunsford, “Increasing Heat Exchanger Performance”, Bryan Research and Engineering, Inc. - Technical Papers, Hydrocarbon Engineering, 1998.

[8] Y. Yao, X. Zhang and Y. Guo, “Experimental Study on Heat Transfer Enhancement of Water-water Shell-and- Tube Heat Exchanger Assisted by Power Ultrasonic”, in Proc. of the International Refrigeration and Air Conditioning Conference, School of Mechanical Engineering, Purdue University, July 12-15, 2010, paper-1110.

[9] M. D. Alam, S. T. Hossain, M. H. S. Simanto, M. S. U. Mithu and M. A. Islam, “Experimental and Numerical Investigation of an Air to Water Heat Exchanger”, in Proc. of the3rd International Conference on Mechanical, Industrial and Energy Engineering, Khulna, Bangladesh, Dec 26-27, 2014, paper-140305.