DESIGN, CONSTRUCTION AND PERFORMANCE TEST OF INDUSTRIAL WATER COOLING TOWER

Supervised By:

Shaninur Rahman
Lecturer
Department of Mechanical Engineering

Submitted By:

Ashim Kumar Roy
ID: BME-1901017430

Md. Alamgir Sarker
ID: BME-1901017418

Shomon Ahammad
ID: BME-1901017217

Uzzal khandaker
ID: BME-1901017273

Sarowar Hosen
ID: BME-1602009345

A thesis submitted in partial fulfilment of the requirements for the degree of
B. Sc. Engineering in Mechanical Engineering

Sonargaon University
147/I, Green Road, Pranthapath, Dhaka-1215
14 September, 2022

DESIGN, CONSTRUCTION AND PERFORMANCE TEST OF INDUSTRIAL WATER COOLING TOWER

Supervised By:

Shaninur Rahman
Lecturer
Department of Mechanical Engineering

Submitted By:

Ashim Kumar Roy
ID: BME-1901017430

Md. Alamgir Sarker
ID: BME-1901017418

Shomon Ahammad
ID: BME-1901017217

Uzzal khandaker
ID: BME-1901017273

Sarowar Hosen
ID: BME-1602009345

A thesis submitted in partial fulfilment of the requirements for the degree of
B. Sc. Engineering in Mechanical Engineering

Sonargaon University
147/I, Green Road, Pranthapath, Dhaka-1215
14 September, 2022

Acknowledgement

We would like to express our deepest gratitude to our supervisor Shahinur Rahman, Lecture, Sonargaon University for his guidance on this project us be path of conducting successful research and above all for always being there as our mentor. He shared his wisdom with as in analyzing subject matters and at the same time valued our thinking approach to Synthes sizing those topics. We shall forever cherish the memories of working with him.

We acknowledge with appreciation the co-operation of Md. Mostafa Hossain (Professor and Head of Department Mechanical Engineering , Sonargaon University) for him help at various stage of project work.

We acknowledge with appreciation the co-operation of Md. Alamgir Hossain Dean (Professor, Science & Engineering, Department Mechanical Engineering , Sonargaon University) for him help at various stage of project work.

We deeply thank our friends and families for always believing in us even at the moment when we were losing our confident.

"AUTHORS"

ABSTRACT

A cooling tower is a device used to lower the temperature of a water stream by rejecting waste heat to atmosphere. It is also known as a heat rejection device where it will lower the temperature by extracting waste heat to the atmosphere though the cooling of a water stream. Generally, the cooling tower may use the evaporation process of water to remove waste heat to atmosphere thus it will lower the working fluid to near the wet-bulb air temperature.

Commonly cooling tower is widely used in the process industry for employing water by using re-circulated cooling water systems. The cost for this process is inexpensive and very dependable on removing low grade heat from process. In this experiment, the objective are to determine the correlation of water to air mass flow ratio with the increasing water flow rate and to determine the cooling load effect, the effect of different flow rates on the wet bulb approach.

Besides that, this experiment also carried out to estimate the evaporation rate of water from the tower. This experiment was carried by using three variable that are heating load, blower damper and water flow rate. The manipulated variable for this experiment are heating load and blower damper opening while the constant variable is the water flow rate

Table of contents

	Page No
Acknowledgement	I
Abstract	Ii
Table of Contents	Iii
List of Figure	Iv

Chapter 01		Introduction	Page No
	1.1	Introduction	01
	1.2	Objective of the study	02
	1.3	Project Drawing	03
	1.4	Methodology of the Study	03
Chapter 02		Objectives	
	2.1	Objectives	04
Chapter 03		Apparatus Required	
	3.1	Apparatus Required	05
	3.2.1	Cooling fan dc 12 volt	05
	3.2.2	Water pump dc 12 volt	06
	3.2.3	Adaptor dc 12 volt	06
	3.2.4	Digital temperature meter	07
	3.2.5	Hose pipe	08
	3.2.6	On Off switch	08
	3.2.7	Fill	09
Chapter 04		Theory/ Methodology	
	4.1	Theory	10
	4.2	Working Principle	10
	4.3	Methodology	11
Chapter 05		Experimental Setup	
	5.1	Experimental Setup	12
	5.1.1	The process of starting	13
Chapter 06		Experimental Data	
	6.1	Experimental Data Table	14
	6.2	Equitation	14
	6.3	Calculations of cooling tower experiment	14
Chapter 07		Results	
	7.1	Results	15
	7.2	Result of Table	15
Chapter 08		Discussion	
	8.1	Discussion	16
	8.1.2	Cooling tower discussion	16
Chapter 09		Conclusion	
	9.1	Conclusion	17
		References	18

List of Figure

Figure No	Title of the figure	Page No
1.1	Cooling tower project Drawing	02
3.1	Cooling fan dc 12 volt	04
3.2	Water pump dc 12 volt	04
3.3	Adaptor dc 12 volt	05
3.4	Digital temperature meter	05
3.5	Hose pipe	06
3.6	On Off switch	06
3.7	Fill	07
5.1	Experimental Setup	09

List of Table

Table No	Title of the Table	Page No
1.1	Process of starting	10
1.2	Experimental Data	11
1.3	Result of Table	12

Chapter: 1

Introduction

1.1 Introduction

To put it in simple words, a cooling tower is a device that cools the hot water used in mill machinery through a process to make it suitable for re-use in machinery.
Through which the same water temperature can be reduced and used again and again.

The machines and processes of industry, as well as those devoted to human comfort and well-being, generate tremendous amounts of heat which must be continuously dissipated if those machines and processes are to continue to operate efficiently.

Although this heat is usually transferred to a cool, flowing volume of water, final rejection is always to the atmosphere and, invariably, is accomplished by some form of heat exchanger. Many of those termi- nal heat exchangers are not easily recognized as such because they are better known as “creeks”, “rivers”, “lakes”, etc.

The natural process of evaporation makes them very effective heat transfer mediums, although somewhat inefficient due to their limited surface area and their total dependence upon random winds.

A cooling tower is a specialized heat exchanger in which air and water are brought into direct contact with each other in order to reduce the water's temperature. As this occurs, a small volume of water is evaporated, reducing the temperature of the water being circulated through the tower.

Water, which has been heated by an industrial process or in an air-conditioning condenser, is pumped to the cooling tower through pipes. The water sprays through nozzles onto banks of material called "fill," which slows the flow of water through the cooling tower, and exposes as much water surface area as possible for maximum air-water contact. As the water flows through the cooling tower, it is exposed to air, which is being pulled through the tower by the electric motor-driven fan. [1]

1.2 Objective of the study

The aim of the project to design and development of a smart Industrial cooling tower for multipurpose work in less time.

The process of cooling the hot water of the mill factory very fast through the use of cooling tower.

The water temperature can be reduced very fast by using the cooling tower.

A cooling tower is designed to remove heat from a building or facility by spraying water down through the tower to exchange heat into the inside of the building. Air comes in from the sides of the tower and passes through the falling water. As the air passes through the water, heat is exchanged and some of the water evaporates. This heat and evaporated water flow out the top of the tower in the form of a fine cloud-like mist. The cooled water is collected at the bottom of the tower and pumped back into the plant or building for reuse. Cooling towers provide large scale air-conditioning where land and (or) water are expensive, or regulations prohibit the return of once-through cooling waters [2]

The structure of a cooling tower must accom-modate long duration dead loads imposed by the weight of the tower components, circulating water, snow and ice, and any build up of internal fouling; plus short term loads caused by wind, maintenance and, in some areas, seismic activity. It must maintain its integrity throughout a variety of external atmo-spheric conditions, and despite a constant internal rainstorm. Wide-ranging temperatures must be accepted, as well as the corrosive effects of high humidity and constant oxygenation.

Were it not for the fact that a cooling tower struc-ture must also provide the least possible impedance to the free contact of air and water, the solution to the above problems would be relatively routine. That requirement, plus the constant vibratory forces imposed by mechanical equipment operation, dic-tate structural considerations, and variations, which are unique to the cooling tower industry. Although basic design concepts are predicated upon ni-versally accepted design codes, reputable cooling tower manufacturers will modify these codes as necessary to compensate for effects deemed not to have been foreseen by the original authority.

The components to be considered in this Section are the cold water basin, framework, ater distri-bution system, fan deck, fan cylinders, mechanical equipment supports, fill, drift eliminators, casing, and louvers. [2]

1.3 Project Drawing

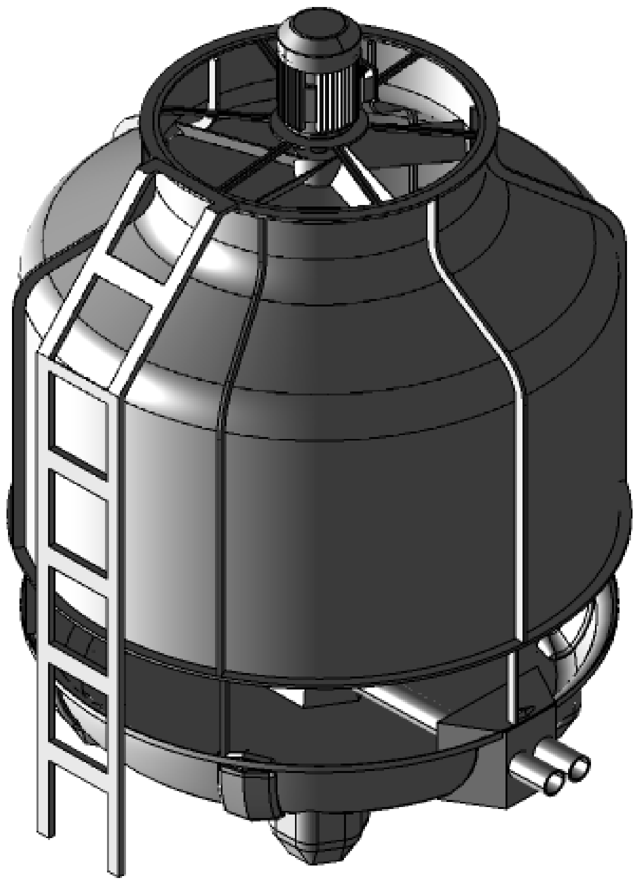

Figure: 1.1 Cooling tower project Drawing

1.4 Methodology of the Study

The world spend more and more power for many devices, lights, heaters, computers, refrigeration and air conditioning processes, and many electric machines, so we must thinking how to reduce using of power. One of these devices using in power plant and big factory is called cooling tower. In present paper, we used a detailed model of counter flow wet cooling towers in investigating the performance characteristics, The thermal performance of the cooling towers is clearly explained in terms of varying air and water temperatures, as well as, the methodology of cooling tower is clearly defined. Numerical solution is used for the calculations of cooling tower parameters which are playing important role in the design of the tower.

Chapter 02

Objectives

2.1 Objectives

Increased use of equipment and higher thermal comfort requirements have led to an increased demand for cooling systems in buildings, particularly office buildings.

Chilled ceilings are able to remove considerable loads at a relatively small temperature difference between room air and ceiling. This is because heat transfer is made by combined radiation and convection. The use of water instead of air as a transport medium also decreases system size and initial cost.

Close (or indirect contact) cooling towers can be applied to chilled ceilings, with inlet temperatures of 20 to 25ºC. For this application small size cooling towers have to be developed.

The combination of these components produces an efficient and ecological cooling system, which can be used either in new or retrofitted buildings. [3]

- To improve and optimize existing closed cooling tower technology to suit the system
- To develop a simple and cheap control strategy for the system
- To minimize investment and running cost
- To find out system applicability, depending on climate

Chapter 03

Apparatus Required

3.1 Apparatus Required

Below are the names, pictures and descriptions of the equipment we used to build a cooling tower.

3.2.1 Cooling fan dc 12 volt

Cooling tower fans must move large volumes of air efficiently, and with minimum vibration. The materials of manufacture must not only be compatible with their design, but must also be capable of with standing the corrosive effects of the environment in which the fans are required to operate. Their im portance to the mechanical draft cooling tower's ability to perform is reflected in the fact that fans of improved efficiency and reliability are the object of continuous development. [4]

Access to various components of a cooling tower is usually influenced by the manufacturer's recom- mendations, whereas safety considerations are the result of intelligent interpretation of the guide- lines promulgated by the Occupational Safety and Health Administration (OSHA). Both aspects take the user's unique requirements into consideration to the greatest possible degree. On towers of relatively low height, where maintenance access may be gained by the use of mobile platforms or portable ladders, fixed access ladders and safety handrails are not man- datory. This also applies to small atmospheric and forced draft towers where no eleva- tion of the tower is specifically decked as a working platform. [5]

Figure: 3.1 Cooling fan

3.2.2 Water pump dc 12 volt

Electric motors are used almost exclusively to drive the fans on mechanical draft cooling towers, and they must be capable of reliable operation un- der extremely adverse conditions. The high humidity produced within the tower, plus the natural ele- ments of rain, snow, fog, dust, and chemical fumes present in many areas combine to produce a severe operating environment. [6]

Figure: 3.2 Water pump

3.2.3 Adaptor dc 12 volt

We have used a 12 volt DC adaptor for the power supply

A **power supply** is an electrical device that supplies electric power to an electrical load. DC **power supply 12v** primary function of a power supply is to convert electric current from a source to the correct voltage, current, and frequency to power the load. As a result, power supplies are sometimes referred to as electric power converters. Some power supplies are separate standalone pieces of equipment, while others are built into the load appliances that they power

Power supplies are categorized in various ways, including by functional features. For example, a regulated power supply is one that maintains constant output voltage or current despite variations in load current or input voltage. Conversely, the output of an unregulated power supply can change significantly when its input voltage or load current changes. [7]

Figure: 3.3 Adaptor

3.2.4 Digital temperature meter

We used a digital temperature meter to accurately determine the water temperature, through which we can first see the temperature of the hot water and then the temperature of the cold water processed through the cooling tower. And through this digital temperature I can measure the difference between cold and hot water

Figure: 3.4 Digital temperature meter

3.2.5 Hose pipe

We used a hose pipe to carry the water from the hot water tank through the pump to the cooling tower, the hose pipe is hot water temperature tolerant. And water can flow beautifully through this hose pipe

Figure: 3.5 Hose pipe

3.2.6 On Off switch

We used two on off switches to control the power of the 12 volt DC adapter. The power supply is provided by turning on and off the two switches separately

Figure: 3.6 On Off switch

3.2.7 Fill

The single most important component of a cooling tower is the fill. Its ability to promote both the maximum contact surface and the maximum con-tact time between air and water determines the efficiency of the tower. And, it must promote this air-water contact while imposing the least possible restriction to air flow. Maximum research and development effort goes into the design and application of various types of fill, and technological advances are cause for celebration.

Most reputable cooling tower manufacturers design and produce fill specifically suited to their distribution, fan, and support systems; developing all in concert to avoid the performance-degrading effects of a misapplied distribution system, or an air-impeding support structure. Those who are less meticulous will adapt commercially available com- opponents (fill, fans, driveshaft's, distribution systems, etc.) into the shape and appearance of a cooling tower, relying upon the laboratory ratings of these components to remain dependable in less-than-laboratory conditions.

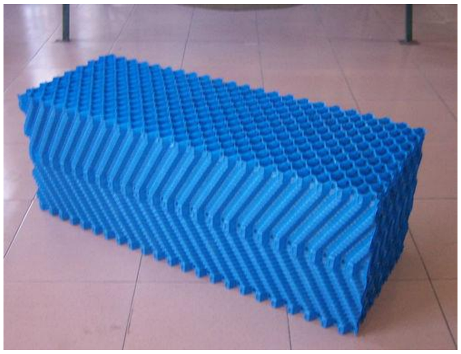

Figure: 3.7 Fill

Chapter 04

Theory

4.1 Theory

The experimental setup of a laboratory scale cooling tower consists of a water distribution system, packing centrifugal blower, pump, glass column, load tank, makeup tank, float valve, variable area flow meter, inclined tube manometer, connections for orifice differential pressure ,connection for pressure drop across packing, droplet arrester, thermometer for measuring the inlet and outlet temperature of air and water. To slow down the water flow from the tower the packed glass column is used. The objective of the analysis was to calculate the amount of water evaporated from cooling tower at different conditions. cooling range, approach, efficiency, effectiveness, and the study of characteristics of cooling tower by plotting graphs between various quantities .

Cooling range is the difference between the cooling tower inlet and our temperature. The range is high means the efficiency of cooling tower is high. So the temperature of the water is reduced effectively. The difference between the cooling tower outlet temperature of water and ambient wet bulb temperature is called approach. The approach should be low to the greater performance of cooling tower the ratio of range and the ideal range means the effectiveness. The effectiveness should be higher for higher performance of cooling tower. [8]

4.2 Working Principle

- Water cooling tower is cooling by evaporation of water in the steam of atmospheric air and heat transfer by contact with air.

- How water from the various sources such as machines or heating processes flows thro pipes to distribution system of cooling tower which produces even water distribution to all the area of fills by the spray nozzles, on the fills the water film is formed from the surface of which evaporation of water in encounter air flow.

- Then larger the surface area of the fills the more intensive is the evaporation of water and the more efficient is cooling tower. Evaporation is accompanied by expenditure of energy required to convert liquid to vapor.

4.3 Methodology

Water cooling tower is cooling by evaporation of water in the steam of atmospheric air and heat transfer by contact with air.

How water from the various sources such as machines or heating processes flows thro pipes to distribution system of cooling tower which produces even water distribution to all the area of fills by the spray nozzles, on the fills the water film is formed from the surface of which evaporation of water in encounter air flow.

Then larger the surface area of the fills the more intensive is the evaporation of water and the more efficient is cooling tower. Evaporation is accompanied by expenditure of energy required to convert liquid to vapor.

Humidity of the air is increasing when water Evaporating. With the help of the fan is fed a steady air flow with low humidity.

Chapter 05

Experimental Setup

5.1 Experimental Setup

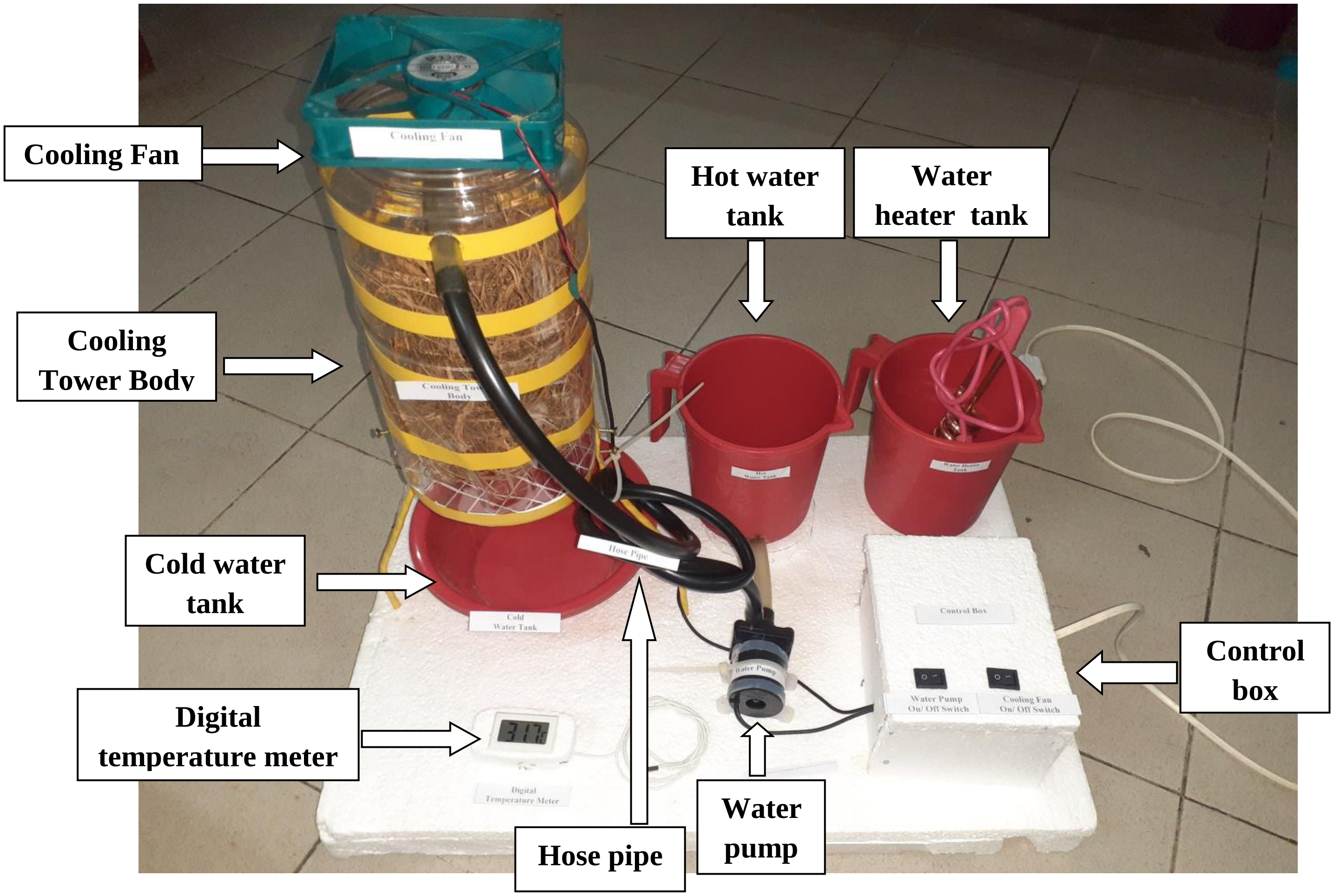

Figure: 5.1 Experimental Setup

5.1.1 The process of starting

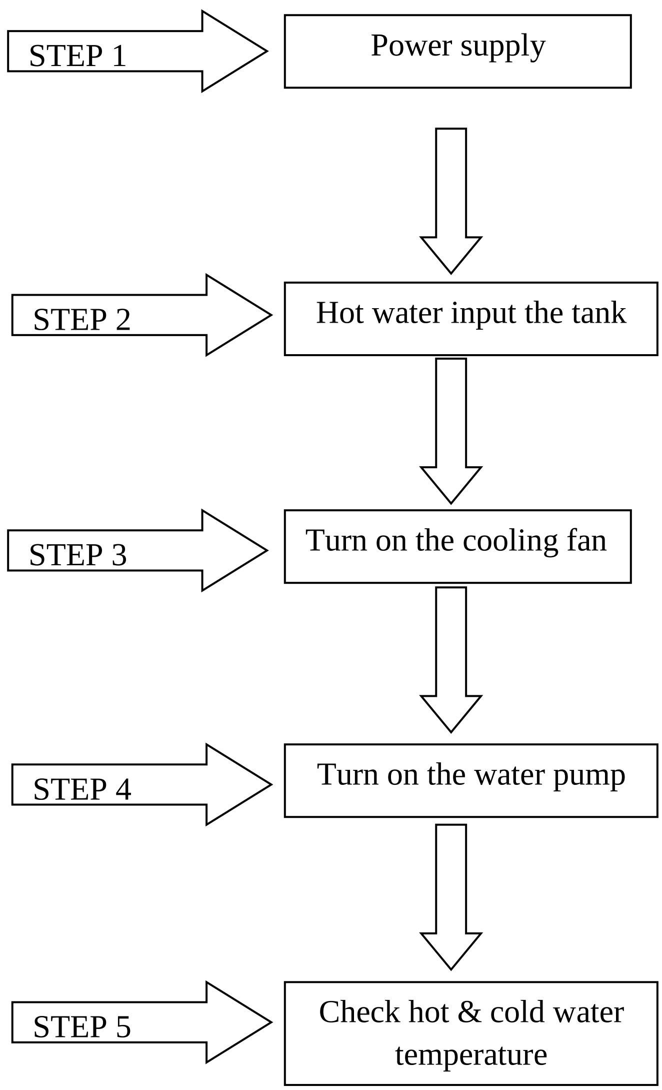

Table: 1.1 Process of starting

Chapter 06

Experimental Data

6.1 Experimental Data Table:

Particulars	Experiment-1	Experiment-2
Ambient Wet Bulb Temperature	30.4 °C	30.5 °C
Cooling Tower I/L water temperature	39.8 °C	40.0 °C
Cooling Tower O/L water temperature	34.4 °C	34.5 °C
Cooling Tower Range	5.4 °C	5.5 °C
Cooling Tower Approach	4 °C	5 °C

Table: 1.2 Experimental Data

6.2 Equitation

Range = Cooling Tower Inlet Water Temperature - Cooling Tower Outlet Water Temperature

39.8-34.4 = 5.4 °C

Approach = Cooling Tower Outlet Water Temperature - Ambient Wet Bulb Temperature

34.4 - 30.4 = 4 °C

6.3 Calculations of cooling tower experiment

1. Air flow rate
2. Amount of water evaporated within the cooling tower
3. Make-up water as a percentage of cooling water flow rate
4. Wet bulb temperature of air
5. Dry bulb temperature of air
6. Cooling tower inlet water temperature
7. Cooling tower outlet water temperature
8. Exhaust air temperature
9. Electrical readings of pump and fan motors

Chapter 07

Results

7.1 Results

In this study, we performed the experiment for ten different conditions or set ups. From these experiments, it is observed that the cooling tower efficiency is mainly dependent on three factors.

Range = 39.8-34.4 = 5.4 °C

Approach = 34.4 - 30.4 = 4 °C

7.2 Result of Table

Process Name	First step
Normal water temperature	30.4 °C
Inlet water temperature	39.8 °C
Outlet water temperature	34.4 °C
Range	5.4 °C
Approach	4 °C

Table: 1.3 Result of Table

Chapter 08

Discussion

8.1 Discussion

1. With this project we will be able to easily reuse hot water coolers in the industry
2. Industrial cooling towers can be used to remove heat from various sources such as machinery or heated process material
3. we are hopeful that this project will be famous, familiar and growth day by day.
4. Although it was a little difficult at the beginning of the work, we got the expected results after completing it.
5. So we believe that this project will be very useful in our modern life.

8.1.2 Cooling tower discussion

It is observed that the cooling tower efficiency is directly proportional to the number of plates inside the cooling tower. If the number of plates are increased, efficiency also increases and vice versa. More number of plates means more contact surface and more time for the heat transfer to occur. thus increase in efficiency. Also efficiency increases if the exhaust fans are switched ON. This is because exhaust fans suck out the hot air from the cooling tower and helps in a better heat transfer between the hot water and fresh air. [10]

Chapter 09

Conclusion

9.1 Conclusion

Cooling towers are specialized heat exchangers, but instead of the usual conduction - convection heat transfer of shell and tube heat exchangers, it generates cooling by bringing water and air into contact. This cooling is achieved through evaporative cooling and sensible heat transfer.

The performance of cooling tower is closely related to tower Characteristic and different types of losses generated in cooling tower. Even though losses are generated in the cooling tower, the cooling is achieved due to heat transfer between air and water. Cooling towers represent a relatively inexpensive and dependable means of removing low grade heat from cooling water so that the water can be reused in the industrial process.

The fabricated cooling tower setup can be used in places where there is scarcity of fresh water. It is suitable for small scale industries or buildings that requires relatively lesser mass flow rate of cooling water.

References:

[1] John C. Hensley, Cooling Tower Fundamentals, SPX Cooling Technologies, Inc. Overland Park, Kansas USA, 2009.

[2] USGS. National Handbook of Recommended Methods for Water Data Acquisition: Thermoelectric Power Generation 2017

[3] John C. Hensley, Cooling Tower Fundamentals, SPX Cooling Technologies, Inc. Overland Park, Kansas USA, 2009.

[4] https://paginas.fe.up.pt/~jfacao/ecocool/Objectives.html

[5] John C. Hensley, Cooling Tower Fundamentals, SPX Cooling Technologies, Inc. Overland Park, Kansas USA, 2009.

[6] John C. Hensley, Cooling Tower Fundamentals, SPX Cooling Technologies, Inc. Overland Park, Kansas USA, 2009.

[7] https://www.multanelectronics.com/product/power-adapter-12v-6a-power-supply-transformers-ac-dc/

[8] P. Sellamuthu1 Dr. C Manoharan2 Dr R Senthilkumar3, 1.Associate Professor, Department of Mechanical Engineering, V.M.K.V. Engineering College, Salam 636 308 & Research Scholar, Anna University, Tamil Nadu

[9] John C. Hensley, Cooling Tower Fundamentals, SPX Cooling Technologies, Inc. Overland Park, Kansas USA, 2009.

[10] John C. Hensley, Cooling Tower Fundamentals, SPX Cooling Technologies, Inc. Overland Park, Kansas USA, 2009.

Under the reference of our project guide.