EXPERIMENTAL ANALYSIS OF THE PERFORMANCE OF MECHANICAL / INDUCED DRAFT COOLING TOWER WITH DIFFERENT QUANTITY OF CIRCULATING FLUID

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A Thesis

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STUDENT DECLARATION

This is to certify that the thesis entitled, **"experimental analysis of the performance of mechanical / induced draft cooling tower with different quantity of circulating fluids"** is an outcome of the investigation carried out by the author under the supervision of**,** Md. Ahatashamul Haque Khan Shuvo, Asst. Professor Department of mechanical engineering Sonargaon university (SU). This thesis or any part of it has not been submitted to elsewhere for the award of any other degree or diploma or other similar title or prize.

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ABSTRACT

Cooling towers are evaporative heat transfer devices in which atmospheric air cools warm water with direct contact between the air and the water by evaporating cooling of water.

This was done by establishing and modifying experimental set up and varying the quality of circulating fluids at different ratio. Natural and induced draft cooling tower experiment gives us the various data required for calculation. From the result obtained a comparative study on terms of tower characteristics (kav/L), water to air flow ratio (L/G), efficiency, range, percentage of make-up water and evaporation heat loss are presented in graphical form. The graph showed that the performance of cooling tower is affected by the type of cooling tower and the quality of circulating fluids.

The graphical analysis shows the cooling tower characteristics and efficiency decrease with an increase in (L/G) the induced draft cooling tower shows better performance than natural draft cooling tower.

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Chapter-01
Introduction

1.1 Introduction

Cooling tower is equipment to reduce outlet temperature of water stream by extracting heat from water by addition of sensible heat to air up to Saturated condition and evaporation of water itself which dissipate to environment and CT used in chemical, petrochemical industries, air conditioning and refrigeration system. In the last decade numerous researchers have work on the performance of cooling tower with different parameter like WBT, entropy, energy and temperature of water involve which affected the component such as drift eliminator, fill area and purpose is to increase heat transfer rate of water with direct contact of air. The main cause to reduce heat transfer is scaling and fouling of each component of cooling tower, researchers investigate method to remove scaling and fouling. In manufacturing industries for process cooling. In heating-ventilation and air conditioning (HVAC) cooling tower operation based on sensible cooling and evaporative cooling. In sensible cooling hot water is cooled to a lower temperature without phase change of water. But in evaporative cooling few of water content is evaporated during the process by absorbing heat from rest of the water. It is found that most of the heat transfer takes place in cooling tower are due to this evaporation. Through evaporative Process 70 percent of heat is dissipated to atmosphere. On the basis of heat load conditions various types of cooling tower is designed and manufactured. Each types of cooling tower have different size and dimensions for different application. Cooling towers can be classified on the basis of air flow, shape, construction, fill and heat transfer. In this thesis project we try to study performance of two types of cooling tower. One of them is counter flow natural draft cooling tower and another one is induced draft cooling tower. Natural draft cooling tower is the one which uses the atmospheric air flow and in case of induced draft air induced inside the cooling tower with the use of an induced fan. Firstly natural draft and induced draft cooling tower are studied and their performance are compared. Effectiveness of cooling tower at different operating condition (flow rate, water inlet temperature) are calculated to identify the optimum condition. For water inlet outlet temperature reading thermocouple were used to obtain digital on an electronic display.

1.2 Objective

- To design and construction of Mechanical / induced draft cooling tower.
- To test and analysis the Performance of Mechanical / induced draft cooling tower using different quantity of circulating fluid.

1.3 Historical Background

Modern water cooling towers were invented during the industrial age to disintegrate waste heat from industrial processes when natural cooling water sources were unavailable. By the early 20th century, advances in cooling towers were fueled by the rapidly growing electric power industry. The cooling loads created by the generation of electric power led to the development of large, custom-built structures typically constructed of wood. Cooling tower development continued to be based on the needs of these power-and-process users until the emergence of the commercial air conditioning market, which led the development of the modular, independently certified cooling towers of today. The development of the commercial air conditioning industry defined new criteria for cooling tower development. Contrary to process cooling towers, equipment intended for air conditioning applications had to be compact enough to fit in the restricted spaces available on commercial buildings. Cooling towers also had to meet the construction schedules of the rapidly growing demand for air conditioned buildings that characterized post-World War II America. With most air conditioning installations located in heavily populated urban areas, sound became a very important application consideration,

And many municipal building or fire codes discouraged the use of combustible materials, including wood, in cooling tower construction. The above criteria could not be easily met by many cooling tower designs of the day that traced their origins to industrial applications.

By the late 1950s, factory-assembled cooling towers, incorporating quiet centrifugal fans and constructed of galvanized steel, were developed for commercial air conditioning projects. Innovations during the 1960s combined the cold water basin and fan sections of these factory- assembled, forced-draft cooling towers into one piece. This design innovation reduced space requirements and operating weights, facilitated cleaning of the cold water

basin, provided protection for mechanical components, and simplified access to the fan-drive system.

By the 1970s, the application of these cooling towers on commercial air conditioning systems accounted for approximately half of the HVAC cooling tower installations.

The energy crisis of the mid-1970s placed increased awareness on energy efficiency in all aspects of American life, including commercial air conditioning systems. The operating characteristics of the centrifugal fan cooling tower began giving way to the energy reduction offered by the propeller fan units of industrial-style cross flow cooling towers. In the ensuing years, design strategies focused on incorporating the HVAC cooling tower characteristics into the propeller fan, industrial cross flow cooling tower.

As development progressed into the 1980s and 90s, designs continued to concentrate on increasing thermal efficiency, simplifying maintenance, and reducing installation costs. The development of new, high-efficiency film fills, produced from lightweight, flame-retardant PVC, reduced the size and weight of cross flow cooling towers. Propeller fans, originally selected solely on air-handling considerations, incorporated sound characteristics as important selection criteria. New, belt-driven fan-drive systems were developed to provide reliable unit operation and reduce maintenance costs associated with the gear-driven systems of industrial style units. Internal piping systems that reduced field piping requirements and allowed service personnel to perform routine maintenance of the water distribution system without mounting the fan deck were developed for cross flow cooling towers. Today, factory-assembled, cross flow cooling towers are considered to be the preferred configuration for air conditioning applications for their dependable, year-round operating reliability, accessible maintenance features, and low installation costs.

A significant milestone of the 1980s was the resurgence of a certification standard for the independent verification of cooling tower thermal performance. It had long been recognized that the thermal processes involved with cooling tower performance were not well understood, making the accurate prediction of thermal capabilities very difficult. Consequently, thermal ratings published by cooling tower manufacturers were only as reliable as the manufacturers' best available technology.

In 1981, the Cooling Tower Institute (currently the Cooling Technology Institute or CTI) updated and revised its certification standard STD-201. STD-201 established a procedure for manufacturers to voluntarily obtain independent verification that a line of cooling towers

performs in accordance with the manufacturers' published thermal performance ratings. CTI certification ensures that owners and operators receive full value for their investment because the cooling tower performs at full-rated capacity. Furthermore, it eliminates the potential for years of excessive operating costs due to deficient equipment, and can actually reduce first cost by eliminating the need to oversize equipment or to perform a field acceptance test to verify performance.

In 1996, STD-201 was expanded to include closed-circuit, as well as traditional open-circuit, cooling towers. Today, many manufacturers actively participate in the CTI Certification Program by voluntarily submitting their open- and closed-circuit cooling tower lines to the scrutiny of the certification process. By the 1950s, galvanized steel had become the principal material of construction for factory-assembled cooling towers. The protective zinc layer of galvanized steel provided effective corrosion protection from the naturally corrosive environment found in service. Combined with an effective water treatment program, galvanized steel cooling towers are designed to provide exceptionally long service life for Evaporative cooling equipment.

In the 1970s, EPA regulations restricted the use of chromates, a widely used, highly reliable corrosion inhibitor in many cooling systems, including HVAC systems. The resultant changes in water treatment programs were less effective at controlling corrosion rates, thereby increasing maintenance costs and potentially impacting the life of galvanized steel evaporative cooling equipment. In response, cooling tower manufacturers began using higher grades of galvanized steel for additional corrosion protection and incorporating non-metallic materials, where suitable. Stainless steel components became available as added-cost options for projects desiring extended equipment life. The need for corrosion protection beyond that provided by galvanized steel alone, without the high cost of stainless steel, was answered in 1981 by the development of special hybrid polymer coating systems for galvanized steel. This cost-effective, additional corrosion protection for galvanized steel is still in widespread use today. Today's leading cooling towers combine the latest in advanced materials technology to achieve the optimum balance between corrosion resistance, product durability, long life, and cost. Based on their specific function, cooling tower components are designed using the materials with the best combination of corrosion resistance and physical properties.

1.4 Motivation

In this age of industrialization there is continuous growth manufacturing industries, chemical industries, nuclear and thermal power plant. Each of these sector deal with heats and heat transfer. A lots of waste heat is generated. Rejection of this heat is a major concern in all these industries. So this a main motivation factor. Besides this there are few other motivation factor like reducing thermal pollution due to waste heat, to study heat transfer in different mode practically and keen interest to work in power generation sector.

1.5 Thesis Organization

- In chapter one introduction, objectives, history of cooling tower and motivation to work in this project has been highlighted.
- In chapter two basic concept on heat transfer, first law and second law of thermodynamics, modes of heat transfer, cooling tower and classification of cooling tower has been discussed.
- In chapter three mathematical modeling, parameters and constructional element is discussed. In chapter four experimental set up and procedure are explained.
- In chapter five result and discussion on findings of the experiment is being high lightened through graphical analysis.
- In chapter six of this paper is comprised of conclusion, limitation and recommendation.

Chapter-02
LITERATURE REVIEW

2.1 Basic Concept

The cooling tower are mostly chemical industries, process industries, power plant and heating ventilation and air conditioning where high heat transfer performance and high effectiveness are mostly required. There factors that affect the performance of counter flow cooling tower like water flow rate, air flow rate, fill porosity, water to air ratio, fouling, heat ,leakage in the atmosphere. We have worked on cooling tower by using Merkel equation and Poppe's equation to calculate effectiveness of cooling tower by considering the effect of water and air flow rate, ambient wet bulb temperature, tower characteristics. Following are the main objectives:

- To observe the effects of process variables on the outlet temperature of the water. Such as

    1. Inlet water flow
    2. Inlet air velocity
    3. Water flow rate

For this following step needs to be perform

a. Modeling of cooling tower
b. Experimental reading and data collection
c. Effectiveness calculation
d. Optimization of effectiveness

2.2 First Law of Thermodynamics

Fact about converting mechanical work into heat energy is introduced before many years ago. Normally the unit of heat energy is kcal or kj. This is the amount of heat required by 1 kg of water to raise its temp by 1°c or 1k.since amount of heat varies with temperatures of water that's why defining particular value of temperature for this unit is worthwhile. The amount of heat received or rejected by a working body during the process of heating or cooling is given by Q=mc (T_2-T_1) where

Q = heat gained or lost by the body, kcal

M =mass of the body, kg

T_2-T_1 = temperature rise of body °c or °k

C= an experiment factor kcal/kg°k

Specific heat the substance is defined as the amount of heat that enters or leaves a unit mass of the substance when it experiences 1 Degree change in temperature. As Specific heat is a function of temperature so,

$$\Delta Q=mcdT$$

The product m×c is separately termed as heat capacity or water equivalent of the body. Adiabatic index is the ratio of C_p/C_v

C_p for air is 0.240 kcal/kg°k

C_v for air is 0.1715 kcal/kg°k

We also know Q=W/J where

Q= quantity of heat in kcal that is converted into work W= work in mkg that is obtained at the expense of heat

J= coefficient of proportionality called mechanical equivalent of heat.

We may summarize the different aspects of thermodynamic work and heat:

Work and heat are not properties of the system. They exist only during interaction between the system and the boundary. They appear when change of state occurs and disappear when the process has been completed.

When a system is undergoing a change of state, work and heat cross the system boundary and properties of the system change. Work and heat are path functions and inexact differential. Heat is transferred because of difference in temperature between the system and its surroundings. Work transfer is however by reasons other than temperature. Mechanical work is only one form of thermodynamic work and is calculated with the help of equation

W= pdv

A fluid flow through a pipe of uniform area of cross section and velocity over the cross section is uniform. Force = pressure intensity × cross sectional area, F=pA

Work done/sec, W=force × velocity

=pAC

= pV

Where c is uniform velocity and v is the volume of gas flowing per second. The analysis of the steady flow system is based on following assumption: Rate of mass inflow is same as rate of mass outflow and the mass of the fluid remains constant within the system. No change in chemical composition of the system and hence no change in chemical energy is involved. Both at entry and exit the fluid is uniform in composition state and velocity. Rate at which heat and work traverse the boundaries are constant. State of fluid at any point is same at all times [1]

2.3 Second Law of Thermodynamics

Statement of second law is impossible to construct an engine working on cyclic process whose sole purpose is to convert all the heat supplied to it into equivalent amount of work". According to this law working on cyclic process means there is no change in internal energy for the complete cycle, cannot receive heat from a heat source and delivery work W=Q.

It was stated that all forms of energy are not equally amenable to transformation which means some forms of energy are more valuable than others. In particular it is known to us that work energy can easily be converted into heat energy like stirring operation. On the other hand it is not possible to convert heat into work easily. It will be realized that large reservoir of heat at room temperature cannot do any work because it cannot transfer heat.

The conditions for a reversible process may be laid down as follows:

- There should be no friction, solid or fluid.
- Heat must be transferred only through an infinitely small temperature difference.

The process in series of the process must proceed in series of equilibrium States for example the process must precede at infinitely slow pace For this reason we may say that reversibility is neither attainable nor desirable in practice. However it may be used to set a

standard efficiency. Endeavour should be made to attend this efficiency whilst still maintaining satisfactory rate of working.

The second law of thermodynamic is directly linked with the thermal efficiency of engine. The efficiency is defined as the ratio of work output from a system to heat input into the system. But for the restriction put by the second law of thermodynamics it would have been possible to convert all heat into work and achieve an ideal efficiency of hundred percent. However according to second law of thermodynamics it in it is necessary to have heat sink to which some heat energy is to be rejected does if Q1 and Q2 are heat energy is supplied to and rejected by an engine working on a cyclic process then thermal efficiency is given by [1]

Nth =W/Q1= (Q1-Q2)/Q1

The time I turn down the time that time the time that time that time efficiency however does not serve the purpose adequately in case of heat pump and refrigerator the main purpose of heat pump is to supply heat say Q1 heat source at higher temperature and during this cycle work is supplied to a pump. This is called coefficient of performance or C.O.P.

C.O.P (pump) =Q1/W=Q1/Q1-Q2

In the same way since the purpose of refrigerator is to draw out heat Q2 from the food stuff with the help of work W the coefficient of performance for refrigerator may be written as:

C.O.P (refrigerator) =Q2/W=Q2/Q1-Q2

It will be realized from the foregoing deliberations that amount of heat transferred by all engines working on Carnot cycle and between the same limits of temperature will be same and hence their efficiencies will be equal. However Carnot cycle consists of reversible process .If an engine works on a cycle consisting of one or more irreversible processes then its efficiency will be different from the Carnot engine. Carnot showed that efficiency of such an engine will always be less than that of Carnot engine .This fact is known as Carnot's theorem and may be stated as follows

- No engine on a cyclic process is more efficient than Carnot engine when working between the same limits of temperature.

2.4 Modes of Cooling Tower Heat transfer

Heat transfer which is the spread of energy from one region to another which is the result of temperature gradient takes place by the following modes:

2.4.1 Heat Transfer by Evaporation (Latent Heat transfer)

Evaporation is a process of phase change in which a substance transitions from a liquid state to a gas (vapor) at temperatures below its boiling point. This phase transition occurs due to the absorption of energy, which is referred to as *latent heat*. Latent heat is the heat required to change the phase of a substance without changing its temperature.

In the case of evaporation, the heat transfer is linked to the energy needed for liquid molecules to overcome inter molecular forces and transition into the gas phase.

- **Molecular Perspective**: During evaporation, the molecules at the surface of the liquid absorb heat from their surroundings. These high-energy molecules overcome the inter molecular forces that hold them in the liquid state, escaping into the air as vapor.
- **Energy Balance**: The energy required for evaporation comes from the surroundings. In many natural scenarios, this energy is supplied by the sun, by wind, or by other heat sources like the ground.
- **Air Movement (Wind Speed)**: Wind or air movement removes vapor molecules from the liquid's surface, preventing saturation of the air with water vapor and thus allowing more evaporation.

2.4.2 Heat Transfer by Convection (Sensible Heat Transfer)

Convection transfers heat within a fluid by mixing of one portion of another. Convection is applicable only in case of fluid medium. It directly connected with the transport of medium itself. Convection constitutes the micro-form of the heat transfer since macroscopic particles of a fluid moving in space cause the heat exchange.

This mode of heat transfer is met with in situations where energy is transferred as heat to a flowing fluid at any surface over which flow occurs. This mode is basically conduction in a very thin fluid layer at the surface and then mixing caused by the flow. The heat flow

depends on the properties of fluid and is independent of the properties of the material of the surface. [2]

(a) Free or natural convection:

Free or natural convection occurs where the fluid circulates by virtue of the natural differences in densities of hot and cold fluids; the denser portions of the fluid move downward because of the greater force of gravity, as compared with the force on the less dense. [2]

2.5 Cooling Tower

A cooling tower is a device that is used to cool a water stream while simultaneously rejecting heat to the atmosphere. In systems involving heat transfer, a condenser is a device that is used to condense the fluid flowing through it from a gaseous state to a liquid state by cooling the fluid. This cooling to the fluid flowing through a condenser, is generally provided by a cooling tower. Cooling towers may also be used to cool fluids used in a manufacturing process. As a result, we see that cooling towers are commonly used in

1. HVAC (Heating Ventilation and Air-Conditioning) to reject the heat from chillers
2. Manufacturing to provide process cooling
3. Electric power generation plants to provide cooling for the condenser

Cooling tower operation is based on evaporative cooling as well as exchange of sensible heat. During evaporation of cooling in cooing tower, a small amount of the water that is being cooled is evaporated in affecting stream of air to cool the rest of the water. Also when hot water comes in contact with cool air, there is sensible heat transfer whereby the water is cooled. The major amount heat transfer to the air is through evaporative cooling while only about 25% of the heat transfer is through sensible heat. [3]

2.5.1 Types of Cooling Tower

Cooling towers can be classified in many different ways as follows

- Classification based on heat transfer method
    - Wet cooling tower
    - Dry Cooling tower
    - Fluid Cooler

- Classification on the Basis of Shape
  - Package type
  - Field Erected type
- Classification on the Basis of Construction
  - Field Erected
  - Factory assembled
- Classification on The Basis of Air Flow
  - Cross flow
  - Counter flow
- Classification on the basis of Air Draft
  - Atmospheric tower
  - Natural Draft Tower
  - Mechanical Draft Tower
    1. Forced Draft
    2. Induced Draft
- Classification based on type of Fill
  - Spray Fill
  - Splash Fill
  - Film Fill

2.5.1.1 On the basis of Heat Transfer Mode

Wet cooling towers are the most common type of cooling towers and the ones referred to when talking about cooling towers. As explained earlier, they operate on the principle of evaporative cooling. The water to be cooled and the ambient air come in direct contact with each other. This thesis will look mainly at the performance prediction of wet cooling towers since they are the most widely used.

In a dry cooling tower there is a surface (e.g. tube of a heat ex-changer) that separates the water from the ambient air. There is no evaporative cooling in this case. Such a tower may be used when the fluid to be cooled needs to be protected from the environment. In a fluid cooler water is sprayed over tubes through which the fluid to be cooled is flowing while a fan may also be utilized to provide a draft. This incorporates the mechanics of evaporative

cooling in a wet cooling tower while also allowing the working fluid to be free of contaminants or environmental contact.

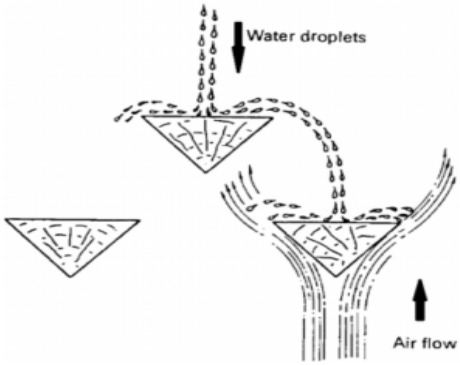
2.5.1.2 On the Basis of Shape

Package type cooling towers are pre-assembled and can be easily transported and erected at the location of use. These are generally suitable for applications where the heat load to be rejected is not very large (most HVAC and process load applications). Field erected type of towers are usually much larger to handle the larger heat rejection loads and are custom built as per customer requirements. Most of the construction /assembly of the tower takes place at the site where the tower will be located. This thesis will be to build a model that predicts the performance of package type towers. Although the performance of field erected type towers may be similar to package type towers, the predicted performance may not be very accurate as a result of the unique and requirement specific construction of field erected type towers.

2.5.1.3On the Basis of Air Flow

In a cross flow tower the direction of air flow is perpendicular to that of the water flow i.e. the water flows vertically downward through the fill, while the air flows horizontally thorough the fill. In a counter flow tower, the direction of air flow is directly opposite to that of the water flow i.e. as the water flows vertically downwards through the fill, the air flows vertically upwards through it.

Figure shows the configuration of cross flow and counter flow cooling tower Configurations.



Chapter-03
METHODOLOGY

3.1 Mathematical Modeling

Merkel developed a theory for cooling tower heat transfer process based on enthalpy difference as driving force. Each water particle is assumed to be surrounded by air film. The enthalpy difference between the film of air and surrounding air is driving force of heat transfer in cooling tower. The integrated form of Merkel equation is

$$Ldt = kadv(h-h') = Gdh$$

Where,

k= mass transfer coefficient

a= contact area per unit volume (m2/m3)

v= active cooling volume (m3/m2)

L= water flow rate, kg/m2/s

h'= enthalpy of saturated air at temperature, (kJ / kg)

h= enthalpy of air steam, (kJ / kg)

G= air flow rate, kg/m2s

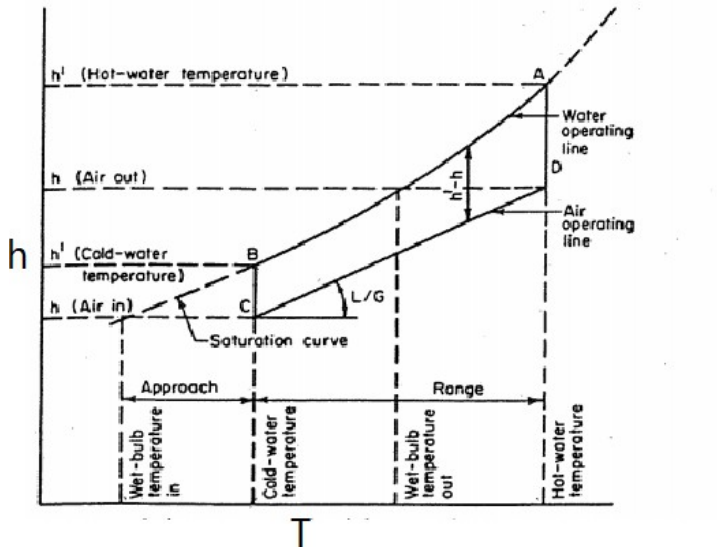
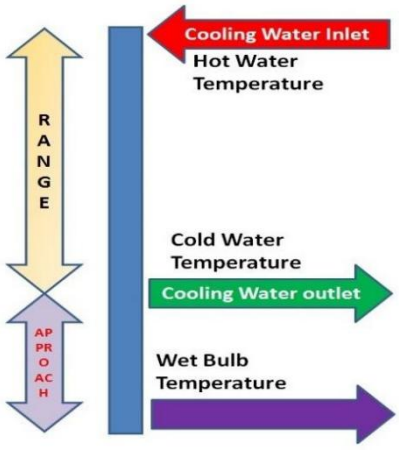


Fig 3.1: Cooling tower process Heat Balance

This diagram is important to understand cooling process take place in cooling tower. C is the point of cold air in. So the enthalpy difference between point B and C (h-h') is the driving force for heat transfer taking placing. Air takes heat from water and reach along straight line up to and slope of straight line (L/G) which is the ratio of total mass flows of water and dry air in cooling tower.

The coordinates of figure indicates directly enthalpy and temperature of any point on the Water operating line. And on air operating line, temperature and enthalpy is found by projecting the point horizontally to saturation curve then vertically to saturation curve, then velocity of saturation curve.

Cooling range & Cooling Tower Approach:



Cooling Range:

Difference between the water inlet & outlet temperature is known as cooling range.

$$R_a = T_{wi} - T_{wo} \qquad (1)$$

Rate of water loss and the makeup:

Cooling tower water loss is due to evaporation loss mainly. Besides there is drift loss, windage, blow down, leakage etc.

The rate of water loss (lb/hr.) = (Humidity Out – Humidity in)

The water that is added to the circulating water system to replace the water lost is called make up water.

Rate of make-up water = rate of the loss

3.2 Parameters

Relative humidity:

The ratio of the vapor pressure of moisture in the sample to the saturation pressure at the dry bulb temperature of the sample is called relative humidity.

Dew point temperature:

The saturation temperature of the moisture present in the sample of air, it can also be defined as the temperature at which the vapor changes into liquid (condensation).

Specific Humidity:

Specific humidity is defined as the proportion of the mass of water vapor per unit mass of the moist air sample (dry air plus the water vapor); it is closely related to humidity ratio and always lower in value.

Absolute humidity:

The mass of water vapor per unit volume of air containing the water vapor is called absolute humidity. This quantity is also known as the water vapor density.

Specific enthalpy:

Specific enthalpy - h - (J/kg, Btu/lb) of moist air is defined as the total enthalpy (J, Btu) of the dry air and the water vapor mixture - per unit mass (kg, lb) of dry air.

Specific volume:

Specific volume indicates the space occupied by air. It is the increase of density and is expressed as a volume per unit weight.

3.3 Consideration

- Range is the difference between the cooling tower water inlet and outlet temperature.
- "Approach" is the difference between the cooling tower outlet cold water temperature and ambient wet bulb temperature.
- Cooling tower effectiveness (in percentage) is the ratio of range, to the ideal range, i.e., difference between cooling water inlet temperature and ambient wet bulb temperature, or in other words it is = Range / (Range + Approach).
- Cooling capacity is the heat rejected in kCal/hr or TR, given as product of mass flow rate of water, specific heat and temperature difference.
- Evaporation loss is the water quantity evaporated for cooling duty. Evaporation loss, Q_3 = Δw × $\dot{m}_a$× 2268 (Kj/kg)
- Liquid/Gas (L/G) ratio, of a cooling tower is the ratio between the water and the air mass flow rates.

3.4 Component

Design and parameters:

- Heat rejection: 200 W
- Water flow rate: 10L/min
- Water inlet temperature: 40 ˚C
- Water outlet temperature: 25 ˚C
- Range temperature: 10 ˚C
- Approach:
- Evaporation loss: 0.82%
- Drift loss: <0.01%
- Make-up water: <1.5%
- Inlet water pressure head: 4.2 KPA

Material of construction:

- Basin: GP Sheet 21 Gauge
- Casing: GP Sheet 21 Gauge
- Access door: NIL
- Fan stack: NIL
- Distribution basin: GP Sheet 21 Gauge
- Louver: Pre air
- In-fill: GP Sheet Holing 3 mm Hole
- Safety cage: Nil
- Safety guard rail: Nil
- Bolts and nuts: Nil

Physical data:

- Length: 26.6 Inch
- Height: 32 Inch
- Weight: 26 Inch

3.4.1 Blower Fan

Heavy Duty Premium Quality AC Axial Cooling Fan

Product: 250 mm (10”) NK Axial Cooling Fan

Brand: NK

Model: NK20080MP

Type: Axial Flow Fan

Motor: Pure Copper Motor

Blade: Plastic

Air Volume: 890 CFM

Blade: 5Blade

Voltage: 220v, 50Hz

Power: 110W

Bearing System: Ball Bearing

Speed: 3000rpm

Noise dBa: 65

Weight: 1600g



Fig 3.2 : Blower Fan

Water Distribution System

- Sprinkler distribution system
- Inlet pipe: DN15
- Outlet pipe: DN15
- Float valve: DN15
- Make up: DN15
- Overflow: Nill
- Drain: Nill

3.4.3 Pump

A pump is a device that moves fluids (liquids or gases) by mechanical action. Pumps can be classified into three major groups according to the method they use to move the fluid: direct lift, displacement, and gravity pumps. Pumps operate by some mechanism and consume energy to perform mechanical work by moving the fluid. Pumps operate via many energy sources, including manual operation, electricity, engines, or wind power, come in many sizes, from microscopic for use in medical applications to large industrial pumps.

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.



Fig 3.3: DC Pump Details

Voltage DC: 12V

Power: 8 W

H. Max: 10L/min

3.4.3 Power Supply

An **AC to DC power supply**, also known as a **rectifier** or **AC-DC converter**, is used to convert alternating current (AC) from a wall outlet (typically 110V or 220V, depending on your region) into direct current (DC), which is needed by devices like 12V DC pumps, electronics, and other DC-powered systems.

Input power: 220 V

Output Power: DC 24 V



Fig 3.4: Power Supply

3.4.5 Thermocouple

A thermocouple is a simple, robust and cost-effective temperature sensor used in a wide range of temperature measurement processes. It consists of two dissimilar metal wires, joined at one end. When properly configured, thermocouples can provide measurements over a wide range of temperatures.

There are many types of thermocouples, each with its own unique characteristics in terms of temperature range, durability, vibration resistance, chemical resistance, and application compatibility. Type J, K, T, & E are “Base Metal” thermocouples, the most common types of thermocouples. Type R, S, and B thermocouples are “Noble Metal” thermocouples, which are used in high temperature applications. [4]



Fig 3.5: Thermocouple Sensor [5]

3.4.6 Thermocouple Controller

As the name implies, a thermocouple controller is an instrument used to control temperatures, mainly without extensive operator involvement. A controller in a temperature control system will accept a temperature sensor such as a thermocouple or RTD as input and compare the actual temperature to the desired control temperature, or set point. It will then provide an output to a control element. A good example would be an application where the controller takes an input from a temperature sensor and has an output that is connected to a control element such as a heater or fan. [7]



Fig 3.6: Thermocouple Controller [7]

Chapter-04
Experimental Set Up & Procedure

4.1 Development Experimental Setup



Fig : Top View



Fig : Side View

4.2 Water Circuit

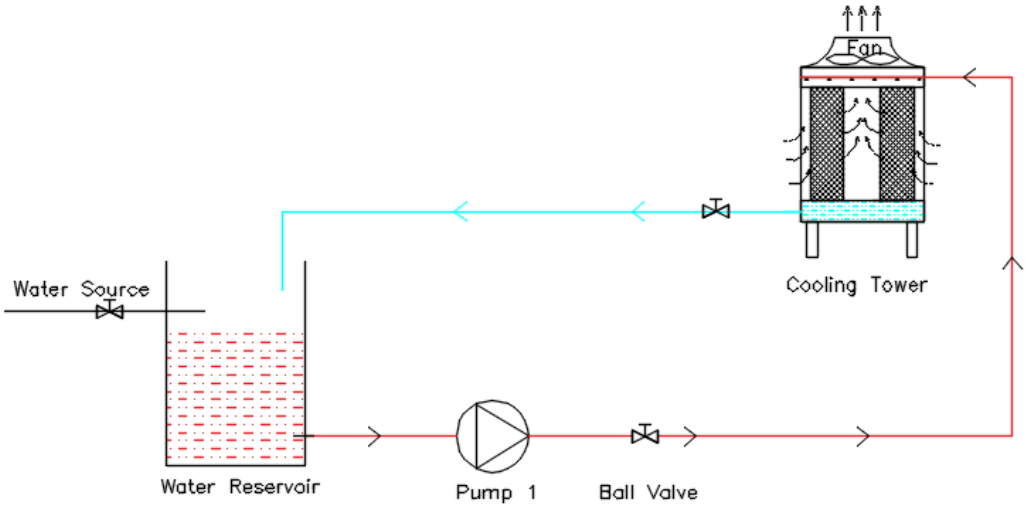
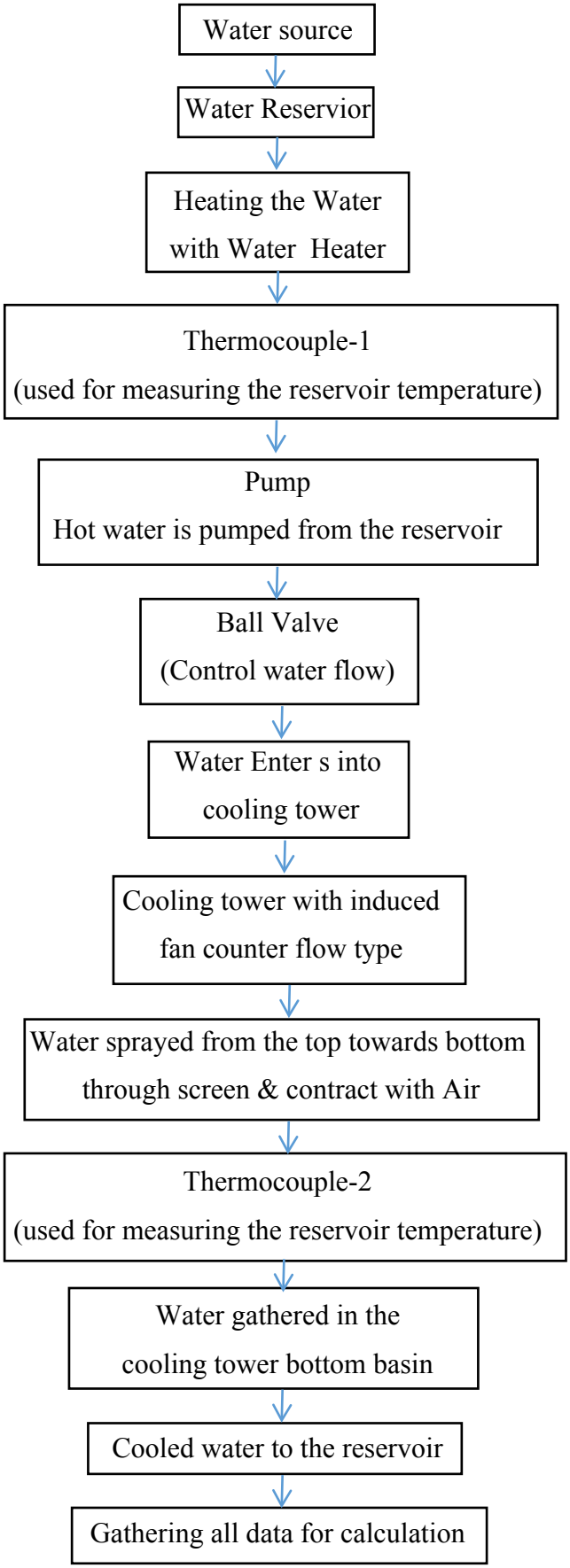


Fig 4.2: Water Circuit

Description:

In this circuit a heat source is used to heat the water present in the reservoir. Here as a heat source gas and burner is used. When the water being heated then the flow started. A gate valve is used to control the speed of the water. Just after gate valve a thermocouple is placed to measure the dry bulb temperature of the water. A pump is used to circulate the flow of water and another gate valve is used to control the speed of the water. A flow meter is used to measure the flow rate of the water and a thermocouple is used. During passes through cooling tower the temperature of the hot water is reduced. Again a pump is used to ensure the circulation of water through pipe and a gate valve is used to control the speed of the water. Then wet bulb temperature of the water is measured once again and water returns to reservoir and cycle continues.

4.3Flow Chart:



Description:

In this experiment we firstly collect water from water source to water reservoir. using a additional water heat to heat the water up to required experiment temperature . in the reservoir used a thermocouple for measuring the inlet water temperature.

After that the pump pumped hot water from the reservoir to cooling tower top basin through passing a pipe line to spray water on top. Ball Valve are uses for control flow . In the system Water Enter s into cooling tower from the top.

Top of the Cooling tower seat a induced fan counter flow type to extract the air . Water sprayed from the top towards bottom which is passing different screen with segregate water molecular.

Finally the water reached to the bottom basin of the cooling tower ,used Thermocouple-3 for measuring the outlet water temperature .

Cooled water enter in to the reservoir and cycle continues.Collect all necessary data for calculation.

4.4 Air Circuit

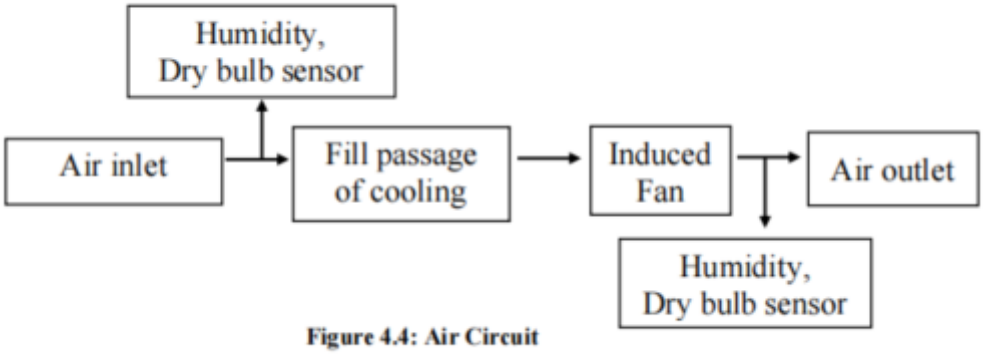


Figure 4.4: Air Circuit

Description:

Air enters through the lower passage of the cooling tower, while entering through the passage there is a dry bulb sensor which gives us the value of humidity of air entering the passage. Continuous air goes through the fill of the cooling tower and it cools down while the induced fan dissipates the heat from the air. Cooled air is then goes out through the upper portion of the cooling tower and into the atmosphere. With the help of another dry bulb sensor we get the value of humidity of the air going out in the atmosphere.

Chater-05
Result & Discussion

5.1 Cooling Tower Characteristics Analysis

In this experiment we have determined tower characteristics at varying air and water flow rate ratio.

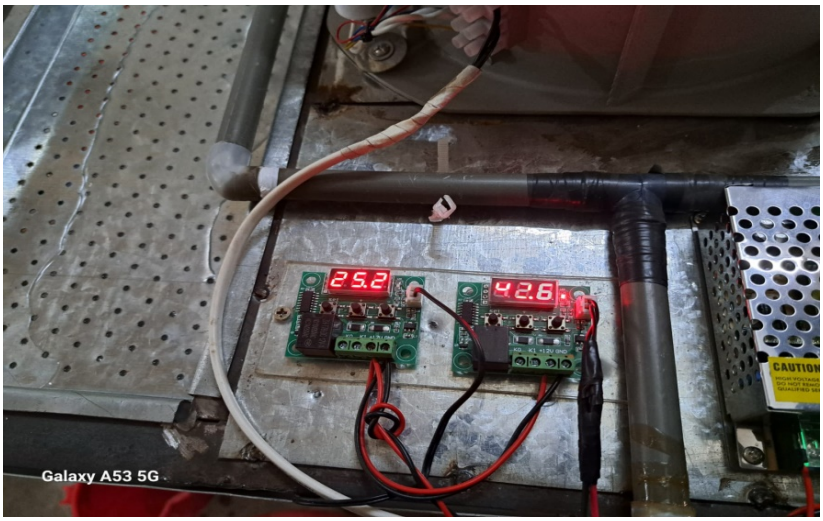


Fig 5.1: Experiment test run Picture

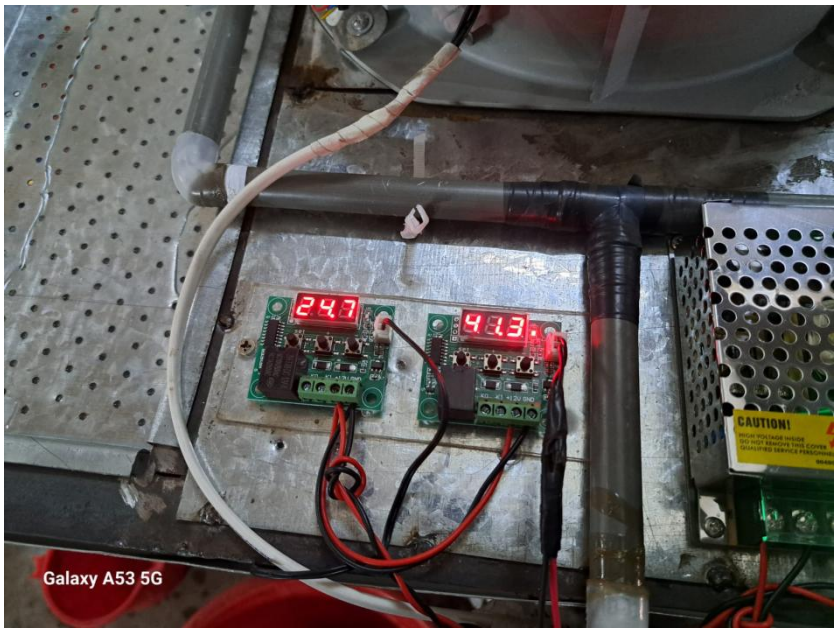


Fig 5.2: Experiment test run Picture

5.2 Data Collection & Calculation

1. Cooling Range: $R_a = T_{wi} - T_{wO}$

Inlet Water temperature T_{wi} = 42.6 ˚C

Outlet Water temperature T_{wo} = 25.2 ˚C

$R_{a=}$ 42.6-25.2 = 17.4 ˚C

2. Cooling Approach

R_{th}= T_{w_i}–T_2

Outlet Water temperature T_{wi}= 25.2 ˚C

Wet bulb temperature T_2= 22 ˚C

R_{th}=25.2-22= 3.2˚C

3. Cooling Efficiency= $\frac{Range}{Range+Approach}$×100%

Inlet water temperature = 42.6˚C

Outlet Water temperature= 25.2˚C

Wet bulb temperature= 22˚C

17.4/17.4+3.2x100= 84.46%

4. Change in Heat Content Water, Q_1= $\dot{m}_w$ × c_p× ΔT

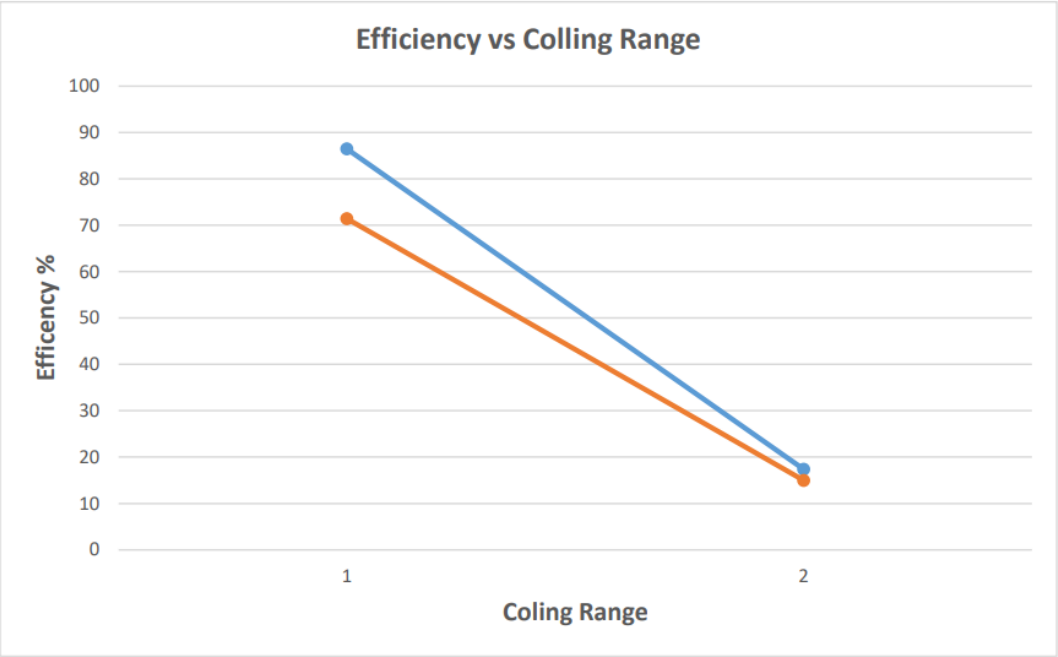
Q1=1x4.2x(42.5-25.2)

72.66 J/Kg

5.3 Table

Result: Mechanical Induced Draft Cooling Tower.

Observation	**Mass Ltr**	**Cooling Range + Approach , R_{th} (˚C)**	**Cooling Range, R_a (˚C)**	**Cooling efficiency η %**	**Change in Heat Content Water, Q_1 (J/kg)**
1	**25**	**20.6**	**17.4**	**86.46 %**	**34.4**
2	**20**	**18**	**15**	**71.42 %**	**33.0**
3	**15**	**14**	**12**	**85.71%**	**26.4**
4	**10**	**14**	**10**	**71.41 %**	**22**



5.4 Figure : Efficency vs Cooling Range

Description:

Cooling Tower Performance Graph: A typical graph would plot cooling range on the x-axis (showing how much the water is cooled) and cooling efficiency on the y-axis (showing how effectively the cooling tower operates). As cooling range increases, cooling efficiency may improve up to a certain point before plateauing or declining due to factors like environmental conditions, water quality, and tower design.

Relationship: A higher cooling range often correlates with increased water evaporation, which typically leads to better cooling efficiency in ideal conditions, though operational limitations may exist

Chapter-06
Conclusion

6.1 Conclusion

A comparative study is tried to be carried out in this paper between different cooling fluids with different quality and quantity. First water was taken as cooling fluid and then toner was mixed with water to see whether the efficiency of the cooling tower increases or not. The tower characteristics ,efficiency, make up water and heat loss due to evaporation of natural and induced draft cooling with different quality of circulating fluids were evaluated.

From this comparative study it is seen that using toner and water mixture the efficiency of the tower increases. When water was used in mechanical natural draft cooling the efficiency was in average 70% and cooling range was 10^{o} C - 12^{o} C

6.2 Limitation

- Heat source we designed is not controllable and is time consuming.
- We did not calculate the heat content variation due to friction in pipe.
- Flow meter we used have limitation of maximum value 30 L/m.
- No drift eliminator was used.
- Heat loss due to conduction convection drift and windage was not calculated.
- Sensor we used was able to sense air dry bulb temperature and humidity. Then we had to go to psychometric chart to find wet bulb temperature which have probability of having human error.
- Health hazard and environmental hazard of toner was not considered.
- There was a single circuit as a result the cooled water was getting mixed with hot water from the reservoir, as a result the temperature was dropping in the reservoir that was being heated.

6.3 Recommendation

- In this experimental study the heat loss through the pipe & pipe were not being considered. So in further studies these heat losses can be calculated for getting a better result.
- In this thesis work air mass flow rate was assumed as constant throughout. For further study air mass flow rate at each cell of cooling tower can be calculated.
- In our experimental studies, we could not make arrangement for varying the value of air mass flow. So in further approach, induced fan (ID fan) with varying speed capacity can be used. Thus cooling tower performance for carrying air mass flow can be analyzed.
- The cooling water used in our experiment was natural supplied water which contains large fraction of iron. This iron was deposited on flow meter and flow meter accuracy was hampered. So, water treatment plant can be established.
- In our experimental studies we have used a mixture of water and toner. And toner has detrimental effect on environment. So further studies on how to reduce the environmental and health hazard can be done.
- Cost effectiveness of using toner can be studied further.
- A water temperature control system can be developed in further study.
- Heat source we used was combined of 200 w. So time taken to achieve the desire temperature was quite long. So by increasing heat source capability time taken can be reduced.
- To increase the efficiency of the tower the present single circuit can be divided into two different circuit. One is hot water and another is cold water circuit.
- To exchange heat between these two circuit stated in previous point a heat exchanger must be used. In this case a counter flow single pass or double pass shell and tube heat exchanger can be used.

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