Construction and Implementation of Evaporative Air Cooling System

A Thesis

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Department Of Mechanical Engineering

SONARGAON UNIVERSITY (SU)

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ABSTARCT

Evaporation cooling is an energy efficient and environmentally friendly air conditioning technology. Evaporation cooling has a great many advantages over other cooling processes. Due to the non-pollution creating environment. It is considered as one of the suitable ways to cool ones workplace or living place, because of the fact that it uses fresh air and replaces the air. It is based on a natural process of air cooling by water, it won't dry out the air, or irritate human skin, eyes, or other external parts of the human body. Moreover, evaporation cooling is an inexpensive cooling option which enhances the lifestyle of people. However, evaporation cooling requires an abundant water and is efficient when the relative humidity is low. Always an attempt is made to obtain the saturation efficiency at optimum water consumption rate. The feasibility of evaporation cooling under different climates, efficiencies of various evaporation cooling equipment's and critical parameters and techniques for improving the efficiencies as well as numerical modeling of evaporation cooling processes. Power supply is required for the total project. That's why we are using AC switch. The project can be turned on and off by the switch. The power supply coming from the switch is called switch mood power supply which convert from AC volts to DC 5 volts. We are running a motor inside with this switch mood power supply. Then using an exhaust fan. A temperature sensor is used. The function of which is to tell us how many degrees Celsius the output is in our evaporator.

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CHAPTER 1
INTRODUCTION

1.1 Introduction

Evaporation cooling is a physical phenomenon in which evaporation of a liquid, typically into surrounding air, cools an object or a liquid in contact with it . Evaporation cooling occurs when air, that is not too humid, passes over a wet surface, the faster the rate of evaporation the greater the cooling. [4] It brings the comfort by increasing the humidity in dry climates, improves the air quality, and makes the air more breathable. The most familiar example of this is cooling effect of evaporating perspiration on the human skin. In dry hot climates body temperature is partially controlled by the rapid evaporation of perspiration from the surface of the skin. [5] The evaporation rate is raised as air movement is increased.

Both of these facts can be applied to natural cooling of structures. This evaporation results in a reduced temperature and an increased vapor content in the air. The bigger the area of contact between the air and water the more evaporation occurs, resulting in more cooling and the addition of moisture. . In the fundamental basis for understanding any air conditioning, de humidification and evaporation cooling is psychometric. It consists of the interaction between heat, moisture and air. It is basically the study of air water mixture and is an essential foundation for understanding how to change air from one condition to another to rises its capacity to hold moisture. This makes moisture a very influential factor for heat gain, both for comfort and in calculation. [6-8]

The knowledge of the system consisting of a dry air and water vapor is essential for the design and analysis of air conditioning devices, cooling towers and industrial processes which requiring close control of the vapor content in air. Air moisture and heat interaction fortunately, this interaction can be combined in a single chart. This rate of evaporation of water purely depends on the temperature humidity of the air as well as the pressure of the particular place. Hence, sweat accumulates more on hot humid days in which the perspiration is impossible to evaporate. Energy demand worldwide for building cooling has increased sharply in the last few decades, which

has raised concerns over depletion of energy resources and contributing to global warming. Current energy demand estimates stand at between 40 and 50% of total primary power consumption. In hot climate countries, the highest share of building energy use is mainly due to space air conditioning using traditional HVAC systems [8-10]. Cooling through evaporation is a natural occurrence. Evaporation cooling lower the temperature of air using the principle of evaporation cooling unlike typical air conditioning systems which use vapor- compression refrigeration or absorption refrigerator. Evaporation cooling is the addition of water vapor into air, which causes a lowering of the temperature of the air.

The energy needed to evaporate the water is taken from the air in the form of sensible heat, which affects the temperature of the air, and converted into latent heat, the energy present in the water vapor component of the air, whilst the air remains at a constant enthalpy value. This conversion of sensible heat to latent heat is known as an adiabatic process because it occurs at a constant enthalpy value. Evaporative cooling therefore causes a drop in the temperature of air proportional to the sensible heat drop and an increase in humidity proportional to the latent heat gain.

Evaporative cooling operates by utilizing natural phenomena where water and air are the working fluids. Evaporative cooling process is a commonly used for cooling towers, air washers, condensers, fluid cooling and to the places where several heat sources are present. If the air used for evaporating cooling is not too humid, the faster rate of evaporation results in greater rate in the cooling. When air passes wet surface then evaporating cooling occurs. The arrival of vapors compression based air conditioning system has limited the use of the direct evaporative cooling system for air conditioning.

Vapor compression based airconditioner emits the ozone layer depletion gases, globalwarming potential gases that are a serious concern for ourenvironment, additionally; it consumes more energy. Due tothe harmful effect of VCRS system humans realized that useof evaporative cooling is better than Mechanical VCRSsystem.

1.2 Objective

The objectives of this project are:

- To Construction an Evaporator Air Cooling System.
- To implement an Evaporation Air Cooling System.
- To test the performance of the air cooling system.

1.3 Organization of Book

This project book consists of five chapter. The first chapter contains the statement of the introduction, objectives of the study and the project organization. Chapter two contains literature review in details. Chapter three describes the project theory and working principle, , working principle and shows the complete prototype of the project that we have built.. Chapter four deals with the result and discussion. In the final chapter, we have conclusion and future work of the project and also about some aspects we had to overcome while doing the project and lastly, we gave the conclusion of the book.

CHAPTER 2
LITERATURE REVIEW

2.1 LITERATURE REVIEW

In this paper we are going to explain the design of centralized air cooling system for college auditorium. The present building of college auditorium posed the problem of ill-ventilated atmosphere and suffocation in most of its part during the programs. Major part of the building exposed to the sun the roof being heated throughout the day. The object of air cooling is to establish a stable thermal environment which satisfies the majority of occupants with respect to comfort under all the climatic conditions to which the building is subjected.

Hence it was decided to provide the false ceiling and design air cooling system for college Auditorium for better comforts to the occupants during longer program. For the cooling system of auditorium requires two coolers with water requirement is estimated as 8 lit/sec and power requirement is 120 Watts. Solar and transmission heat gain through walls and roofs etc. Solar and transmission heat gain through doors, windows or wall glasses. Transmission gain through partition wall ceiling floor etc. Infiltration of direct air from some inlets like doors or windows. Internal heat gain from occupants, light appliances etc. Additional heat gain not accounted above, safety factors etc. Return duct heat gains, supply duct leakage, heat gain from door, fan and pump.[1]

This Evaporative cooling is an environmentally friendly air cooling system that operates using induced processes of heat and mass transfer, where water and air are the working fluids. [3]

In Bangladesh, Evaporative cooler is already being used in different industries that is imported from varies countries. But most of the cases these are not efficient due to installation error & lack of adjustment with climate change over the year. Initially this paper presents the construction of an evaporative cooler using a test bench of cooling tower for the air flow and water supply facility where local materials were used as evaporative pad. Afterwards; it presents installation in different situation & adjustment of the cooling units with the climate. It concludes that under proper installation, evaporative cooling system is very cost effective & has a very large potential to propitiate thermal comfort and can still be used as an alternative to conventional systems in regions where the design wet bulb temperature is low.[2]

CHAPTER 3

METHODOLOGY

3.1 History

This evaporator cooling system is so effective and safe process. It is mainly used in home, hospital, factory and industrial area. After it used, we reduce the cost of money to cool air. That's way we get good efficiency. Where very cost effective to buy air-condition but our system is reducing the cost. This machine is very easy to use and it works very effectively. A working procedure relevant image is added below –

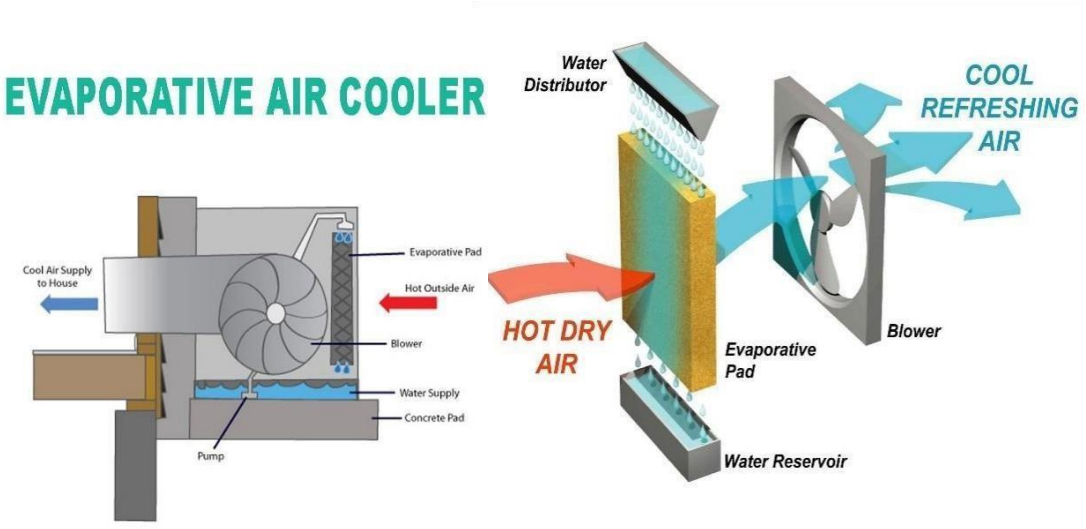


Figure 3.1: Evaporator Cooling Working Principle.

3.2 Principle of Evaporation Cooling

When trying to understand evaporation cooling, it may be the best to think of air as being like a sponge or cooling pads, in that regard, air has an ability to absorb moisture that it come in contact with. The amount of moisture that the air will absorb depends on the state of air and the temperature of the air. If the air is warm and contains only a small amount of moisture, it will more radially absorb moisture. As air cools, it volumes decreases, and with it, its ability to absorb moisture decreases. Cooling through evaporation is a natural occurrence and the most common we all experiences is perspiration, or sweat as perspiration evaporates, it absorbs the heat to cool our body. It is a heat and

mass transfer process that requires water for evaporation for the coolness in which heat is transferred from air to water and simultaneously the temperature of air decreases [7-9]

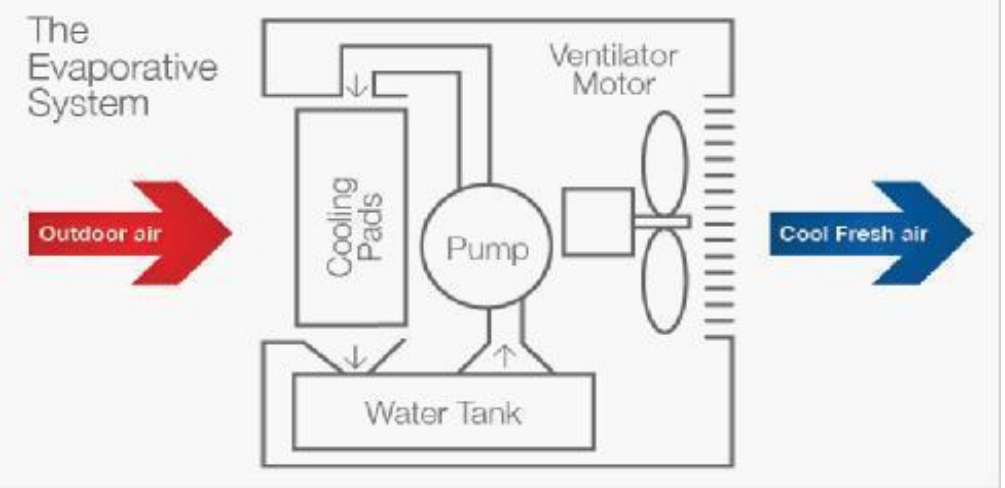


Figure 3.2: Working Principle of Evaporator Cooling System

The principle underlying evaporation cooling is the facts that water must have heat applied to it to change from liquid to vapor. When evaporation occurs, this heat is taken from the water that remains in the liquid state, resulting in a cooler liquid. The evaporation coolers are classified as:

1] Direct Evaporative [Working fluid as water and air in direct contact]

2] Indirect Evaporative cooler [Surface plates separates the working fluid].

3] Combination of both the Direct and Evaporative Coolers [With different cooling cycles][1]

3.3 Methodology

Our Methodologies of this project:

- Creating an idea for Design and construction of **Evaporator Cooling System.**
- And designing a block diagram & circuit diagram to know which components need to construct it.
- Collecting the all components and programming for the micro-controller to controlled the system.
- Setting all components in a PCB board & soldering. Then assembling the all block in a board and finally run the system & checking.

CHAPTER 4

DESIGN

4.1 Block Diagram:

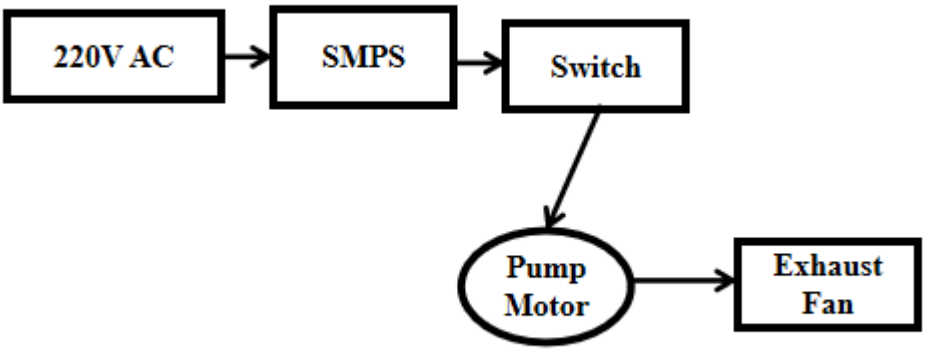


Figure 4.1: Block Diagram of Evaporation Cooling System.

4.2 Schematic Diagram

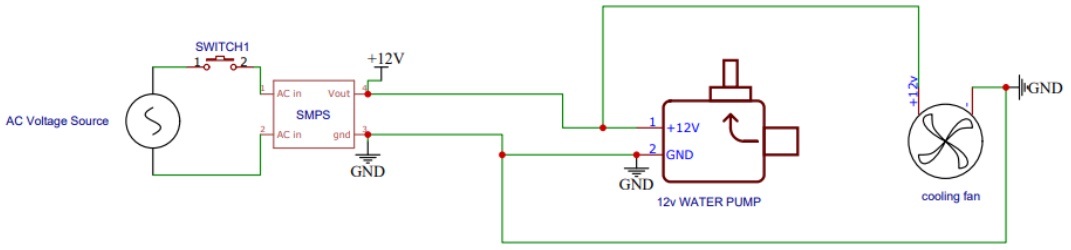


Figure 4.2: Schematic Diagram of Evaporation Cooling System

4.3 Components List:

1. SMPS (Switch Mood Power Supply)
2. DC Pump Motor
3. Evaporator Pad
4. Digital Temperature Meter
6. Wire
7. Exhaust Fan
8. Switch
9. Body Structure Material

4.4 Working Principle

Our project is designed to Air Cooler Evaporation System. We are using SMPS, Cooling Fan, pump motor and voltage regulator. Here the current from AC is entering the circuit at 5 volts via SMPS. SMPS is the main power converter of this system. Here we need fixed 5V dc current that's whey we use this power supply. An evaporation air cooler is a type of air conditioner that works by harnessing the power of evaporation to cool air temperatures. Here is a water tank in our system. Firstly we need to fill water in this tank. From this tank a pump motor will calculate this water. Pump motor will take in evaporator water store. The water will flow down from the evaporator and with the help of an exhaust fan the air will cool down and cool the air in front. Here the exhaust fan with hot air will blow air through the evaporator to the front. As a result of this hot air in contact with water, this air will actually cool down and flow forward. Thus the evaporator system cools the air. This is the main process of our system.

4.5 Cost Analysis:

No.	Product Name	Specification	Qty	Unit Price	Total Price
01.	SMPS	12V,10A	1	680	680
02.	Pump Motor	12V	1	280	280
03.	Evaporator Pad		1	890	890
04	Exhaust Fan	DC Fan 12V	1	300	300
05.	Digital Temperature Meter		1	180	180
06.	Others			1860	1860
					4190/=

Table 1: Cost Analysis.

CHAPTER 5

CONSTRUCTION

5.1 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 5.1: 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: 12V DC, 0-5A
- 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
- No Minimum Load.
- Compact Size Light Weight.
- High Efficiency, Reliability & low energy consumption
- Category – Switch Mode Power Adaptor (SMPS)

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.

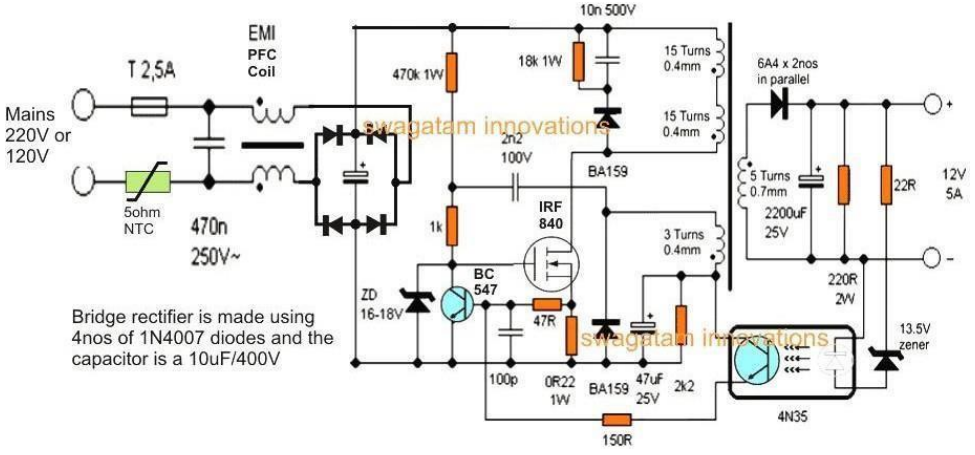


Figure 5.2: SMPS Circuit Design

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 Basic

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

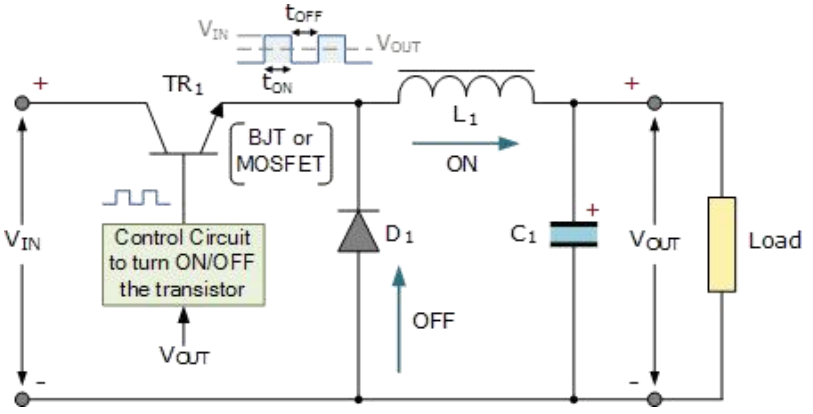


Figure 5.3: Power Supply Connection

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 78… 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.

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

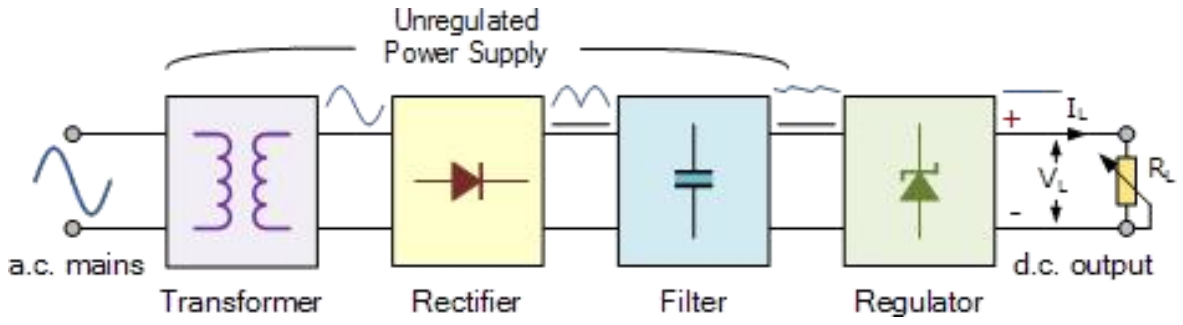


Figure 5.4: DC Power Supply Step

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.

5.2 Evaporator Pad

General Air 990-13 evaporator pad, sometimes called a humidifier/water filter, is an indispensable part of the humidifier. The pad soaks up water as it passes through the humidifier, and then circulates humidity into the air. This keeps your home or business nice and comfortable during the dry season. This pad is made of aluminum encased in a heavy wire frame, and is coated with a special absorbent material which evenly draws water across the pad, and increases the amount of humidity produced. While these pads work hard to provide clean and comfortable air, as time passes, pollutants and minerals

build up on the pad and diminish performance. It’s important to note that the pad cannot be cleaned, and must be replaced at least once a year to ensure superior performance and air quality.



Figure 5.5: Evaporator Pad

Distribution & Return System Features:

- High efficiency system
- Cover up to 80′ with one pump!
- Largest self contained PVC return gutter on the market today
- Easy to install, one-piece PVC trough
- Closed top or open top feature for easy visibility and regulation of water supply
- Submersible pumps
- Simple shut down for seasonally affected environments
- Optional stainless-steel return gutter wall mount brackets

Pad Features:

- Water is spread evenly over the pad surface as a film rather than droplets for uniform wetting
- 6” deep pads specially designed and coated for effective evaporation and maximum durability
- Pad surface dries quickly in absence of water to inhibit micro-organism growth
- Coated pads are tough and durable for repeated cleaning
- Improved life expectancy over standard pads
- Easy to install, remove, and replace pads

5.3 Digital Temperature Meter

A temperature meter is an instrument used to measure the temperature of beings or things. The most widely recognized temperature meter is a mercury thermometer used to measure the temperature of people. Attempts at standardized temperature measurement prior to the 17th century were crude at best. For instance in 170 AD, physician Claudius Galenus 18 mixed equal portions of ice and boiling water to create a "neutral" temperature standard. The modern scientific field has its origins in the works by Florentine scientists in the 1600s including Galileo constructing devices able to measure relative change in temperature, but subject also to confounding with atmospheric pressure changes.



Figure 5.7: Temperature Meter

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

5.4 Pump Motor

Introduction

This is a low cost, small size Submersible Pump Motor which can be operated from a 6 ~ 12V power supply. It can take up to 120 litters per hour with very low current consumption of 1.2A. Just connect tube pipe to the motor outlet, submerge it in water and power it. Make sure that the water level is always higher than the motor. Dry run may damage the motor due to heating and it will also produce noise.



Figure 5.8: Pump Motor

Feature

- 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

5.5 Cooling Fan

A fan is a powered machine used to create a flow of air. A fan consists of a rotating arrangement of vanes or blades, which act on the air. The rotating assembly of blades and hub is known as an impeller, rotor, or runner. Usually, it is contained within some form of housing, or case.



Figure 5.9: Cooling Fan

Feature

- Operation Humidity - 0%~95%
- Insulation Grade - According to IEC61858 Grade F
- Voltage V - 12V
- Frequency Hz - 50/60
- Current - 0.12/0.10
- Power(W) - 19/14
- Speed(R/Min) - 2500/2700

5.6 Complete Project Prototype Image :

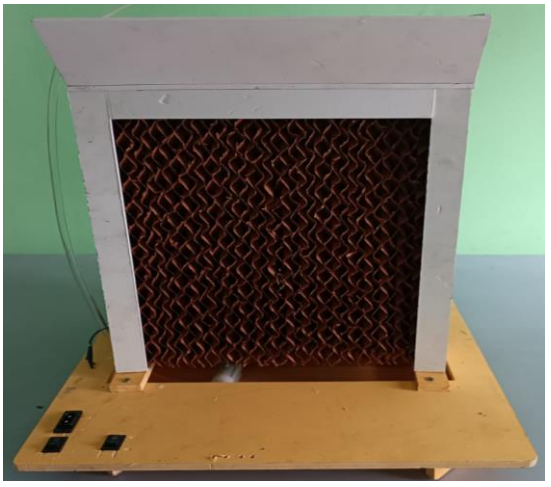


Figure 5.10: Project Prototype Image (Front View)

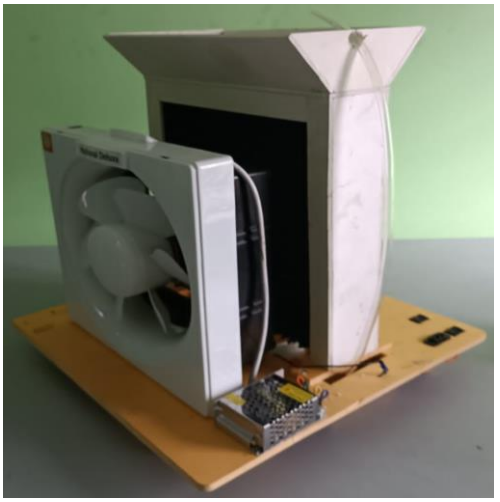


Figure 5.11: Project Prototype Image (Side View)

CHAPTER 6

RESULT & DISCUSSION

6.1 Result

We have been able to build our system by following all the objects and methodologies. At first we have set up the all components well for our system. When the system is first turned on, current will flow in the system by converting DC voltage from 220 volts AC for SMPS. Then pump motor will be start as a result, water will continue to circulate from the water reserve tank to the water distribution road through the water evaporator. In this way, when the evaporator is cold, the water inside it also cools and forms steam in the water. Now when the fan is turned on, when air is blown from one end, cold air is available from the other side. The efficiency of this project is very good. It is capable of working for a long time. We are satisfied its performance.

Without Water Spray

SL. No.	Ambient Temperature	Flow Rate	Suction Air flow Rate	Delivery Airflow Rate	In Temperature	Out Temperature
1.	32℃	Top Flow Rate	3.2 m3/min	9.0 m3/min	32℃	30.5℃
2.	34℃	Middle Flow Rate	3.0 m3/min	9.0 m3/min	34℃	32.5℃
3.	38℃	Down Flow Rate	2.8 m3/min	9.0 m3/min	38℃	35.5℃

With Fan & Water Spray

SL. No.	Ambient Temperature	Flow Rate	Suction Air flow Rate	Delivery Airflow Rate	In Temperature	Out Temperature
1.	32℃	Top Flow Rate	3.2 m3/min	9.0 m3/min	32℃	24℃
2.	36℃	Middle Flow Rate	3.0 m3/min	9.0 m3/min	36℃	25.2℃
3.	38℃	Down Flow Rate	2.8 m3/min	9.0 m3/min	38℃	26℃

6.2 Advantage

We usually lower temperature water than the room temperature, so that we can lower the room temperature easily which will not harm our environment. In our country, the cooling systems that we usually use it keep the room temperature low, but the humidity outside increases the temperature, which causes a lot of damage to our environment.

- Creates a comfortable and productive work environment.
- Good Indoor Air Quality.
- Energy-efficient ventilation and cooling solution.
- Environmentally friendly.
- Investment in this sustainable technique is often subsidized.
- No Oil consumption.
- Installation is simplified very much.
- Simple construction
- Ease of operation.

6.3 Application

The project has a major application in the

- It can be used for Industrial work.
- It can be used in factories.
- It can be used for indoor purpose.

6.4 Limitation

It is a demo project so we found some limitation. In future we will work for reduce this kind of limitation. These limitations are –

- It is a demo project so its accuracy is 85%.
- Project has no extra power supply.

6.5 Discussion

The evaporator cooling system works effectively and makes cooling process easy, more precise and reliable and is more advantageous than the conventional methods reducing manual efforts, errors and being much efficient. The proposed prototype allows achieving an economical and a low-cost cooling system. When we made this project then we face some of problem. We did not run it smoothly. After hard work and team work, we did it.

CHAPTER 7
CONCLUSION

7.1 Conclusion

As using the water for the evaporation purpose, which leads to decrease the temperature of the air also containing the most economically environmental effective system. In this project paper of evaporating cooling technology, methods are studied for the commercial and comfort purposes. Indirect evaporation coolers have shown higher values of effectiveness and more economically operated in the terms of energy consumption saving, particularly the M-Cycle. However, the combined system of direct and indirect cooling system has similar performance or even the higher but their system consists of higher initial cost and the major problems like noise & vibrations, pressure loss and friction loss. But our system gives the better output better than previous and save the costing.

7.2 Future Scope

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

- We will increase its working accuracy level.
- We will increase its cooling system.
- We will add a sensor and a display to measure and monitoring the cooling situation.

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Abbreviation

AC : Alternative Current

DC : Direct Current

SMPS : Switch Mood Power Supply