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Senior Design Project Report

Design & Fabrication of a Desert Cooler

In partial fulfillment of the requirements for the

Degree of Bachelor of Science in Mechanical Engineering

Team 6

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Abstract

The principle used by desert coolers are anytime when unsaturated air comes in contact with water, it goes through evaporation and evaporated. The temperature of the air decreases as the moisture in the air rises. This air can be used for ventilation and is cooler than its surroundings. A desert cooler is a simple device that generates air moisture and blows this cool air into the environment. A motor fan or a bower and a pump provide the typical configuration of a desert cooler. This device is highly economical and helpful in hot and dry areas. Also, both initial and operating costs are low. But in humid areas this device is not effective. Evaporative cooling is the concept by which a desert cooler operates. Evaporative cooling is a mechanism in which sensible heat is removed and moisture is added to the air. A desert evaporative air cooler with a performance analysis of each of its features will be designed in detail for this project.

Acknowledgments

First, we thank Allah for arriving at the day when we complete the final year project. In addition, the project is not easy. But thanks to the guidance and advice of our adviser Dr. Waqar Khan, we were able to start the project better. Also, we owe our sincere gratitude to Dr. Mohamed Al Mahdi, our task manager and instructor. Who showed us how to start the tasks for any project. Lastly, don't forget the efforts of the team members where the tasks were distributed nicely and every member was efficient and productive.

List of Acronyms (Symbols) used in the report:

Symbols	Definition
$\boldsymbol{\varepsilon}$	The effectiveness of desert air cooler
$\boldsymbol{T_1}$	Dry bulb temperature of inlet air
$\boldsymbol{T_2}$	Dry bulb temperature of outlet air
$\boldsymbol{T_3}$	Wet bulb temperature of inlet air
$\boldsymbol{m_a}$	The mass flow rate of air
ρ	Density of air at the entry of the cooler
A	Frontal area of the cooler′s opening
$\boldsymbol{V_a}$	Air velocity at the entry of the cooler
$\boldsymbol{Q_c}$	The cooling capacity
$\boldsymbol{C_P}$	Specific Heat
$\boldsymbol{Q_{co}}$	The water consumption of the evaporative cooler
$\boldsymbol{\omega_1}$	Humidity Ratio of Dry bulb temperature of inlet air
$\boldsymbol{\omega_2}$	Humidity Ratio of Dry bulb temperature of outlet air
$\boldsymbol{\omega_2}$	Humidity Ratio of Wet bulb temperature of inlet air
$\boldsymbol{RH}$	Relative Humidity
$\boldsymbol{h_1}$	Specific Enthalpy of Dry bulb temperature of inlet air
$\boldsymbol{h_2}$	Specific Enthalpy of Dry bulb temperature of outlet air
$\boldsymbol{h_3}$	Specific Enthalpy of Wet bulb temperature of inlet air
COP	Coefficient of performance
$\boldsymbol{P_{Consumed\ blower\ (air)}}$	Power of consumed blower (air)
$\boldsymbol{P_{Consumed\ pump\ (water)}}$	Power of consumed pump (water)

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Chapter 1: Introduction

1.1 Project Definition

A desert cooler is a simple device which creates moisture in air and then blows this cool air into the environment. The typical arrangement of a desert cooler includes a motor fan or a bower and a pump. For this project, a desert evaporative air cooler will be designed in detail with the performance analysis of each of its feature.

1.2 Project Objectives

The objectives of fabrication and design of desert cooler are given below:

1) Provide Room cooling and provide air crossing.
2) Keep the build extremely economical and effective.
3) Increase efficiency through accurate placing of desert cooler.
4) Study of complete design of a Desert Cooler.

1.3 Project Specification

These devices are extremely economical (both initial and running costs are low) and are useful in hot and dry areas. However, this device is not effective in humid areas. The principle on which a desert cooler works is 'Evaporative cooling' Evaporative cooling is a process in which sensible heat is removed and moisture added to the air (Watt, 1986).

1.4 Applications

Desert evaporative heat cooler finds its application in multiple situations. Due to their inexpensive design and efficient cooling results, they are found in huge quantities in:

1. They are widely used as domestic cooling systems in domestic household. They are cheap and use very low power.
2. Large Desert Coolers are used in Store rooms to make sure the inventory remains cool.
3. They are widely used for cooling for multiple purposes in dry and arid climates.

Chapter 2: Literature Review

2.1 Project background

The analysis of Literature review shows that several attempts have been made to make the desert cooler energy efficient using various fibers such as date palm fibers, jute and luffa for wetted cooler pads and have maximum cooling efficiency evaluated the output [1]. A Modified Desert Cooler (MDC) was introduced that cools the air is therefore more effective than the traditional desert cooler. For drinking purposes, like supplying cold-pure water. It also has a reduced air moisture content that passes through the desert Cooler up to a certain degree [2]. Poonia M.P. A et al.[3] have produced a Cooler cum fridge that offers air cooling, cooling Drinking water and with storing vegetables and medication affecting the productivity of the hotter desert. It's an energy saver, Equipment that is useful. A Desert Cooler performance was investigated by Khond[4] Four distinct pad materials are used, i.e. stainless steel wire mesh, Khus, coconut coir, and wood fur. It was noted by them that in stainless steel wire mesh, the minimum water consumption was found and maximum cooling performance was found using wood wool. Many researchers have presented analytical models and techniques for the measurement and optimization of desert cooler efficiency. Three analytical models were proposed by Erens and Dreyer [5] and the shape of the cooler has been optimized. Numerically, Guo and Zhao [6] Analysis of the thermal efficiency of indirect evaporative air Refrigerator. An analytical model was developed by Ren and Yang [7] for the under actual operating conditions, combined heat and mass transfer processes Conditions of counter-flow parallel configurations. In order to analyze the various forms of indirect evaporative coolers, ShariatyNiassar & Gilani [8] used the CFD technique. The focus of Navon and Arkin

[9] was to provide thermal comfort with a directindirect evaporative cooler. Amr Sayed et al, in their reports. Housing issues and the indoor climate were taken into account [10] Thermal comfort was due to that.

2.2 Previous Work

Whenever unsaturated air comes in contact with water, it goes through evaporation and evaporated. This is the principle used by Desert coolers. When the moisture in the air increases, the temperature of the air decreases. This air is cooler than its surrounding and can be used for cooling (J.M. Wu, Numerical investigation of the heat and mass transfer in a direct evaporative cooler, 2009).

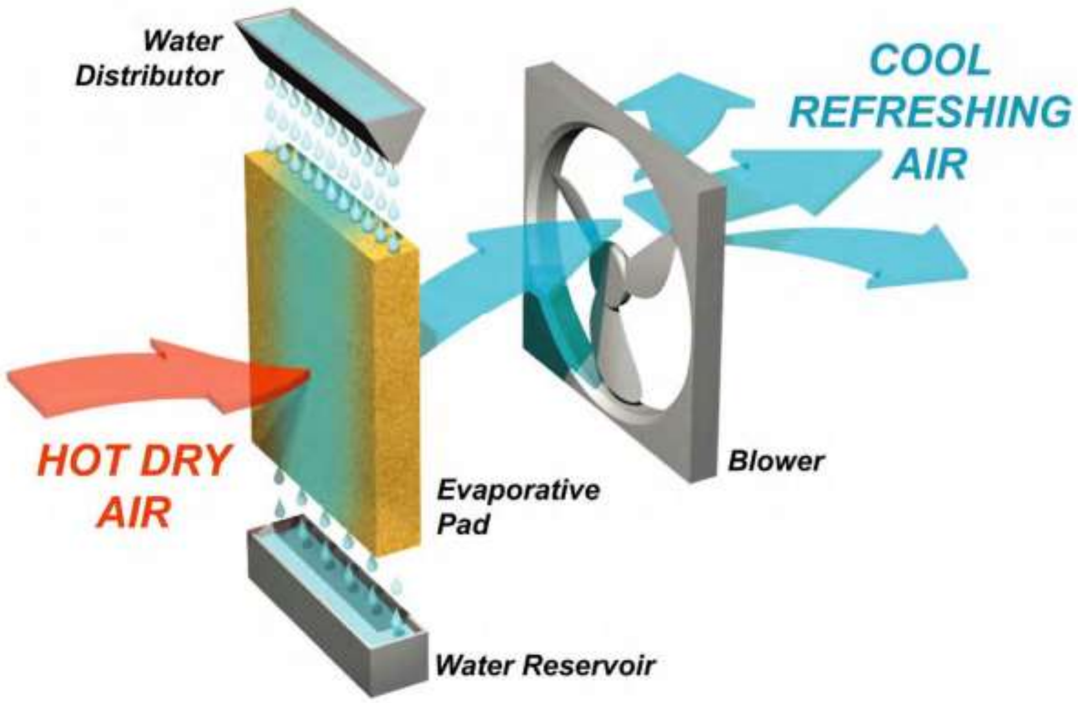

Figure 1: Working of evaporative coolers

The hot dry air enters the evaporative pad and it comes out cooler than the air surrounding it. Now to spread this cool air, a blower is used to speak cool and refreshing air into the surrounding to decrease the temperature of the surrounding.

This uses very low power as compared to traditional air conditioner. This makes the design extremely cheap and inexpensive. Also the maintenance of desert cooler is very easy. This is a form of direct evaporative cooling system.

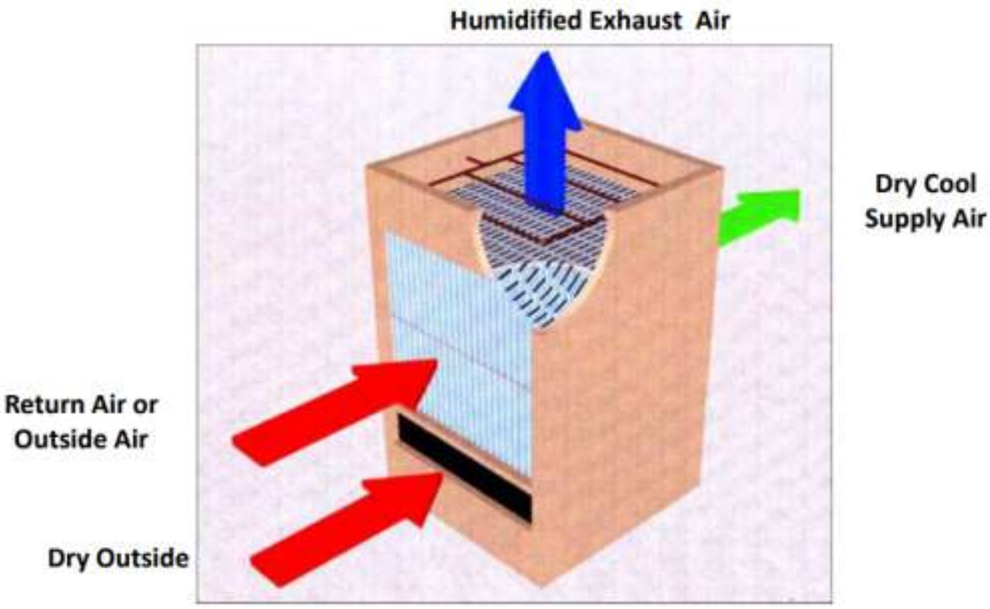

Figure 2: Indirect Evaporative Cooling

There is another version or non-typical type of desert cooler. In this type of cooler, two different air stream work in order to supply cool dry air to the surrounding (J.M. Wu, 2009)

There has been much work done in this field because the cooling effect of evaporation has been known to mankind since a very long time. Persian Wind Tower & Rain Cistern has been known to make dry evaporative cooling towards since 1500 AD.

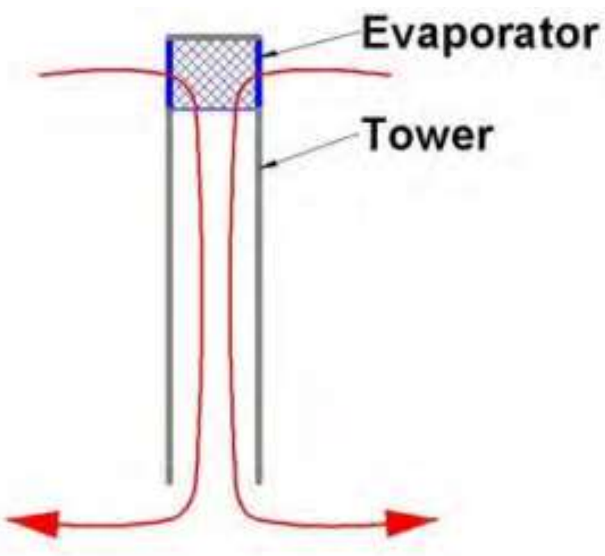

Figure 3: Evaporator Tower

Figure 4: Wind Towers

They were also called wind tower and worked on the same principle which is evaporation. The water evaporates and the wind becomes cooler through it.

2.3 Comparative Study

Desert cooler work only in areas which are dry and arid because it is free of moisture. If there is already moisture present in the air, the desert cooler will not function properly.

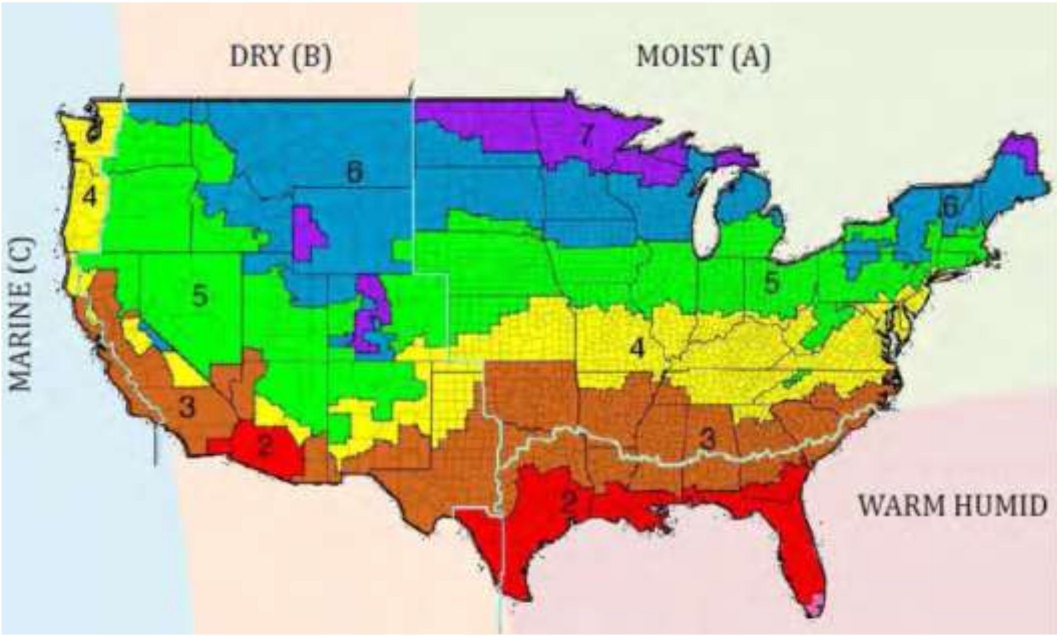

Figure 5: Dry Areas

The use of desert coolers is more prominent than any other cooling machine in dry areas because it the most common form of evaporative cooling. Desert Coolers are mostly used in residential, commercial kitchens, and warehouses or where comfort requirements are more relaxed. It requires larger ductwork for high airflow. It can relieve air pressure. It has very high Effectiveness (WB depression) 65-95% (Nag). Desert Cooler can bring a typical temperature drop of 30 Degree Fahrenheit. However desert cooler adds humidity to air.

Figure 6: A common Desert Cooler

Chapter 3: System Design

3.1 Design Constraints and Design Methodology

3.1.1: Geometrical Constraints

During our start of the project, we encountered many difficulties. First of all, we faced difficulty collecting parts from the market due to the different names between scientific names and market names. For example, the evaporator pads are called a filter on the market. This was strange to us. Also, speed regulator is called a 3 position fabric selector switches. In addition, looking at the CAD (solid work) design, we see that the digital thermometer is next to the speed regulator, but when we actually wanted to do that, the decision was changed and we made it on the same side but further away, that as in the figure (7) for better shape and not to tangle of the speed regulator wires and the digital thermometer wires.

Figure (7) Speed Regulator & Digital Thermometer

In addition, we were confused about the material for the cooler body. The adviser consulted Dr. Waqar, who told us that performance and economics must be taken into account before choosing the material and do not forget material standards codes. So we decided to choose plastic because it is more economics and less corrosion. This material we choose is high density of Polypropylene (PP) from polymers as in the figure (8).

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Table 2-4

(Continued)

Family	Classes	Short Name
Polymers *(continued)*	Polyesters	Polyester
	Polyetheretherkeytone	PEEK
	Polyethylene	PE
	Polyethylene terephalate	PET or PETE
	Polymethylmethacrylate	PMMA
	Polyoxymethylene(Acetal)	POM
	Polypropylene	PP
	Polystyrene	PS
	Polytetrafluorethylene	PTFE
	Polyvinylchloride	PVC
Elastomers	Butyl rubber	Butyl rubber
(engineering rubbers,	EVA	EVA
natural and synthetic)	Isoprene	Isoprene
	Natural rubber	Natural rubber
	Polychloroprene (Neoprene)	Neoprene
	Polyurethane	PU
	Silicon elastomers	Silicones
Hybrids		
Composites	Carbon-fiber reinforced polymers	CFRP
	Glass-fiber reinforced polymers	GFRP
	SiC reinforced aluminum	Al-SiC
Foams	Flexible polymer foams	Flexible foams
	Rigid polymer foams	Rigid foams
Natural materials	Cork	Cork

Figure (8) Table 2-4 Material Families &Classes

3.1.2: Sustainability

To ensure longevity, the design of the device needs to be performed in such a way that components operate for a long time. Before the time for which design is completed, components must not malfunction. When considering sustainable activity, the choice of components and material selection matters.

3.1.3: Environmental

This design poses no threats to environment as much as its operation. Desert coolers are useful in hot and dry areas. They are not effective in humid areas. It does not harm the environment much because it does not contain Freon gas. There is however a temperature constraint of minimum outdoor temperature above 34^0C.

3.1.4: Social

The social impact of the desert cooler is very beneficial for desert people, as desert families use it with high temperatures, especially in relatives' gatherings in tents on occasions.

3.1.5: Economic

This design is very economically beneficial since it poses no environmental risks and is therefore very beneficial to society. Because of the load typical air conditioning systems take, economic cooling has become the most critical feature of the design industry. A desert cooler that operates on the theory of evaporation is another such system that will be developed and manufactured in this project. As compared to its counterparts, this method of evaporative cooling is extremely inexpensive.

3.1.6: Safety

Some people do not realize that the water system in the evaporative air conditioner is open, which makes it vulnerable to bacteria and germs, which are transmitted to family members upon direct exposure to the air from it, causing them to have many health problems, including Intestinal influenza and Pneumonia Usurious crises.

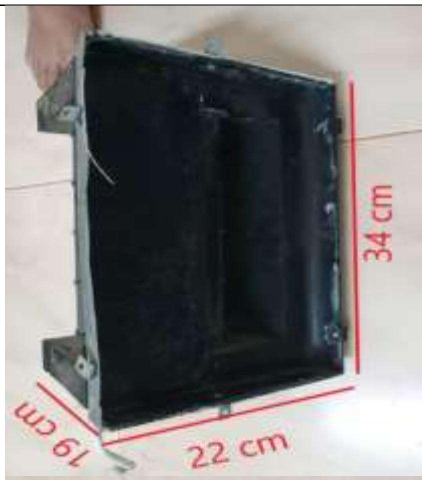
3.1.7: Ethical

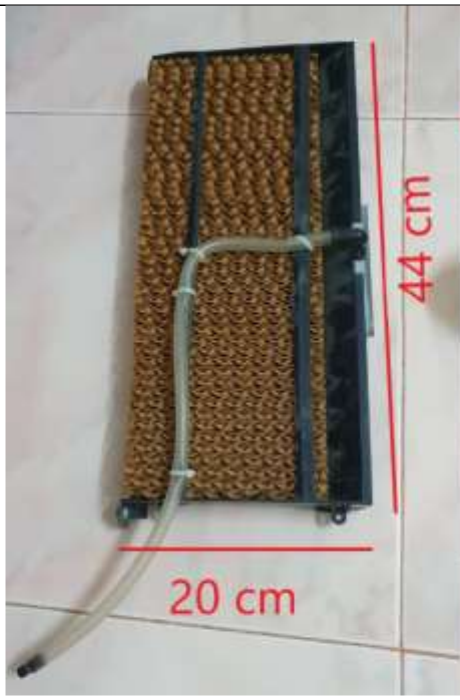
Desert cooler is not exclusive, it has been around since ancient times and it developed with the passage of time until it became ready to be modern and changed parts of the pieces, but with the same idea. In our project, we worked on it to be simple and with the same basic idea.

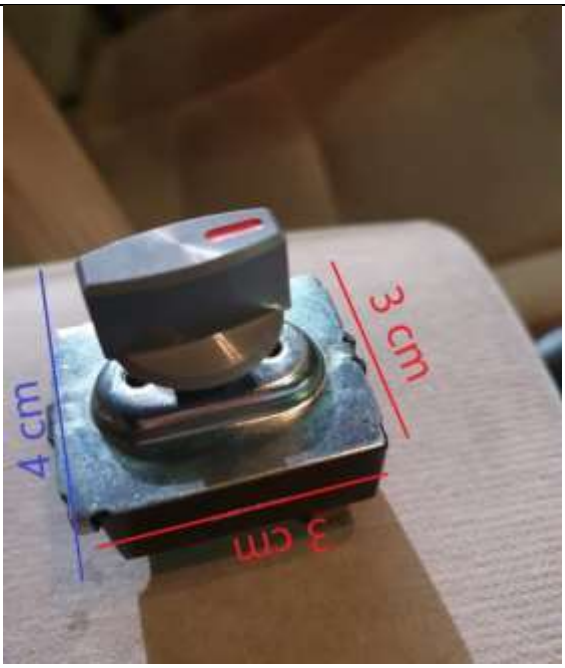
3.2Engineering Design Standards

The complete product has several different components and parts. We must take into account the codes and standards for each mechanical component in the design. During the design process, these engineering specifications promote what parts or dimensions are to be taken and where to make assumptions. This makes the design unique or maybe not unique by use available parts in the market. If any component is needed again or the earlier component has failed, parts may then be interchangeable. And this also guarantees part compatibility. Various standards available, such as ASME (American Society of Mechanical Engineers), ISO (International Organization for Standardization), ASTM(American Society for Testing and Materials), IEC (international standard of the International Electrotechnical Commission for rotating electrical machinery) standards, can be used to build components including bearings, nuts, bolts, Blower motor, Evaporator pads, Water pump, Digital thermometer, Fabric selector switch, Cooler body. The motor uses the standard IEC 60034-1 and The Evaporating Cooling Pad (ECP), made of cellulose paper.

Table(1) Parts &Dimensions & Figure

PARTS	DIMENSIONS	UNIT	FIGURE
Blower with motor	34×22×19	cm	

Evaporator pads	44×5.3×20	cm	 
Water pump	7×6×13	cm	
Digital thermometer	4.3×2.3×1.5	cm	

Fabric selector switch	3×3×4	cm	
Cooler body	73.5×44×51.2	cm	

3.3 Theory and Theoretical Calculations

3.3.1 Data Collection

A desert cooler design requires the implementation of an adiabatic mechanism in which air and water are contracted. Using a spray of water droplets or using a water film dispersed over a wet matrix, this contraction can be accomplished. In this form of design, recirculation of water is preserved. For the pump and the blower, there is a different motor, so they can be used separately. The air temperature within the chamber decreases as the water evaporates across a wide surface area, which is pumped out with the use of a blower in the horizontal plane. On all four sides of the ambient air in the chamber, there are air blowers.

For the purposes of this standard, the following are given for

Definitions are applicable:-

1- Evaporative Air Cooler:-

A device which cools air by evaporation of water.

2- Evaporative Air Cooling:-

It involves the process of evaporating water into air stream. Air is cooled by direct contact with water through a wetted surface. The heat and mass transfer process between the air and water lowers the air dry bulb temperature at constant wet bulb temperature.

3- Temperature (Dry Bulb):-

The temperature of air read on a thermometer placed in such a way as to avoid errors due to radiation.

4- Temperature (Wet Bulb):-

The steady temperature finally given by a thermometer having its bulb covered with gauze or muslin moistened with distilled water and placed in air with relative velocity of not less than 2.5 m/s.

Design calculation

3.3.2.1 The equation to calculate the effectiveness of desert air cooler

The degree to which the temperature of the exiting air dry bulb exceeds the temperature of the wet bulb entering air is expressed as cooling efficiency. It is conveyed as:

$$\varepsilon = \frac{T_1 - T_2}{T_1 - T_3} \times 100 \tag{1}$$

Where:-

T_1 = dry bulb temperature of inlet air.

T_2 = dry bulb temperature of outlet air.

T_3 = wet bulb temperature of inlet air.

3.3.2.2 Outlet air condition

The cooled leaving air leaves the evaporative cooler to the space to be conditioned and the humidified. The leaving air temperature, T2, is determined from equation (2):-

$$T_2 = T_1 - \varepsilon \times (T_1 - T_3)$$

(2)

3.3.2.3 Pressure

The pressure is Zero Static. It is the pressure generated at the air cooler outlet that is equal to the static pressure at the air cooler inlet.

3.3.2.4 Air Capacity

Based on air delivery at static pressure 'Zero,' The minimum air capacity of the evaporative air coolers, should be as follows:-

750 $m^3/_h$	1000 $m^3/_h$	1260 $m^3/_h$	1500 $m^3/_h$	1800 $m^3/_h$	2000 $m^3/_h$	2500 $m^3/_h$	3000 $m^3/_h$	4000 $m^3/_h$	5000 $m^3/_h$	6000 $m^3/_h$	8000 $m^3/_h$

- With the agreement between the manufacturer and the buyer other capabilities may also be offered in compliance.

3.3.2.5 Air Flow Rates

Calculated the mass flow rate of air through the evaporative cooler is a function of the air velocity, the density and velocity of air at the entry and the basis of frontal area of the cooler. From equation the mass flow rate of air is determined:-

$$m_a = \rho \times A \times V_a \tag{3}$$

Where:-

m_a= The mass flow rate of air $^{kg}/_{s}$

ρ = density of air at the entry of the cooler, kg/m3

A = frontal area of the cooler′s opening, m2

V_a = air velocity at the entry of the cooler, m/s

3.3.2.6 Cooling Capacity

The cooling capacity (Q_C) of a direct evaporative cooler is determined from equation below:-

$$Q_c = m_a \times C_P \times (T_1 - T_2) \times 3.6\,^{kj}/_{h} \tag{4}$$

3.3.2.7 Consumption of Water

The water consumption of the evaporative cooler, (Q_{co}) is determined from equation below:-

$$Q_{co} = m_a \times (\omega_1 - \omega_2) \tag{5}$$

As stated earlier, ω1 and ω2 are determined from the psychrometric chart see figure (9) below:-

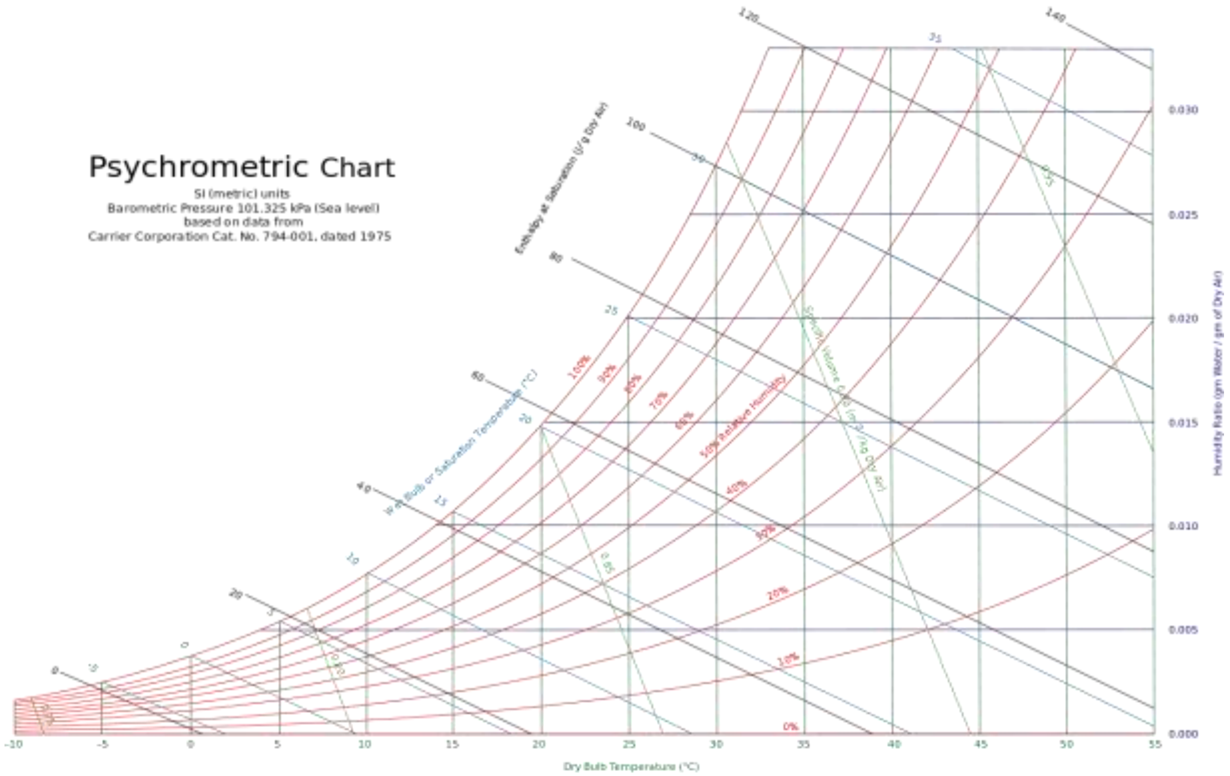


Figure (9) Psychormetric Chart

3.4 Product Subsystems and selection of Components

3.4.1 Blower with Motor

Figure (10) Blower with Motor

The motor uses the standard IEC 60034-1 which only works in a horizontal position.

See table #2. Please see figure 3 for more size.

Table(2) Technical specifications of motor

Technical specifications	
Manufacturer	ZHONGSHAN
Models	W15
Power (W)	75
Voltage (V)	220-240V
Frequency (Hz)	50/60Hz
Capacitor (MFD)	1.5
Year of Establishment	2011
Application	Desert Cooler

3.4.2 Evaporator pads

We are selected the Evaporator Cooling Pads, which is extremely praised in the market. Also, it fit our project. See the table#3. The Evaporating Cooling Pad (ECP), made of cellulose paper is engineered from cross-sectional, specially treated flute media capable of absorbing and retaining water to provide the maximum cooling efficiencies. The cellulose media is treated with stiffening and wetting agents to provide the cooling, without any water carryover. Our pads are designed for tropical and subtropical countries, ensures greater performance during summer seasons. The pad media is treated with anti-rot and rigidifying resins. The media is cross-corrugated to maximize the mixing of air and water.

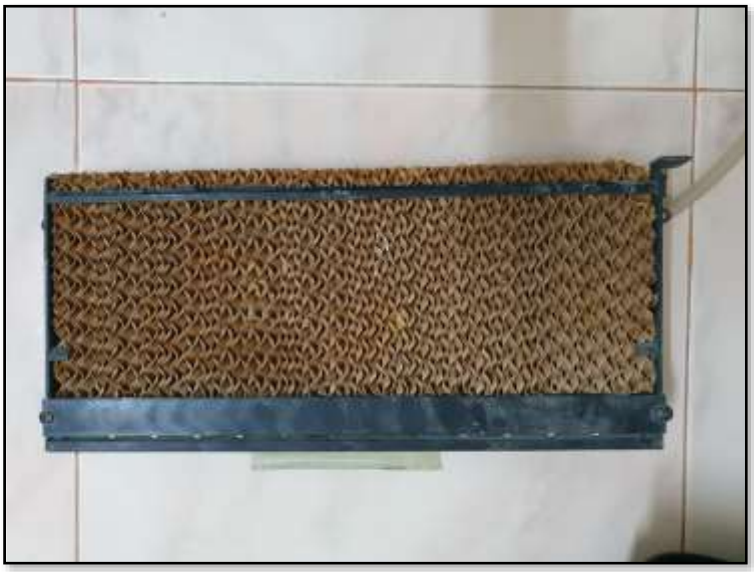


Figure (11) Evaporator pads

Table (3) Technical specifications of Evaporator pads

Part Specification	
Cooler Type	Evaporator
Usage/Application	Cooler
Color	Brown
Material	PVC

3.4.3 Water pump

Water Pump Manufacturer is The Resun Titan is a quality submersible pump with a simple and flexible design. Enjoys a good reputation in the market and is the same series pumps used on the Titan filters.

Figure (12) Water pump

Features:

1- 2 Way Outlet with flow control valve
2- Outlet can rotate to desired flow direction
3- Stainless steel impeller shaft
4- Durable magnetic rotor
5- 3 suction cup mount
6- Easy to clean
7- Ideal for fresh water
8- Low noise

Table(4) Technical specifications of Water pump

Resun Titan Specification	
Model	SP-1100
Voltage	100-120/220-240V
Frequency	50/60Hz
Power	8W
Output	500L/H
Recommended Aquarium	150L

3.4.4 Digital Thermometer

Figure (13) Digital Thermometer

Features:-

- Manufacturer by Elitech
- LCD display
- Insert design
- Simple appearance
- Especially applied in refrigerator, chiller, deepfreeze etc.
- Two button batteries for longer use t time

Technical parameter:-

- Temperature range: -50C~+70C
- Using environment: Temperature: -5C~+50C
- Humidity: 5%~80%
- Accuracy: ±1C
- Resolution: 0.1
- Power: two button battery (LR44, 1.5v)

Instruction:-

- Open the battery cover to put in two LR44 batteries correctly, pay attention to the polarity.
- Display when put in the batteries. Pls take out the batteries when not use for long time
- LCD display H C when temperature is higher than 70C
  LCD display L C when temperature is lower than -50C

3.4.5 Fabric selector switch

Figure (14) 3 Position Fabric Selector Switch

3.4.6 Cooler body

We choose plastic for Cooler body. This material we choose is high density of Polypropylene (PP) from polymers as in the figure (15). Manufacturer by KEYWAY, model K-1200.

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Table 2-4
(*Continued*)

Family	Classes	Short Name
Polymers (*continued*)	Polyesters	Polyester
	Polyetheretherkeytone	PEEK
	Polyethylene	PE
	Polyethylene terephalate	PET or PETE
	Polymethylmethacrylate	PMMA
	Polyoxymethylene(Acetal)	POM
	Polypropylene	PP
	Polystyrene	PS
	Polytetrafluorethylene	PTFE
	Polyvinylchloride	PVC
Elastomers (engineering rubbers, natural and synthetic)	Butyl rubber	Butyl rubber
	EVA	EVA
	Isoprene	Isoprene
	Natural rubber	Natural rubber
	Polychloroprene (Neoprene)	Neoprene
	Polyurethane	PU
	Silicon elastomers	Silicones
Hybrids Composites	Carbon-fiber reinforced polymers	CFRP
	Glass-fiber reinforced polymers	GFRP
	SiC reinforced aluminum	Al-SiC
Foams	Flexible polymer foams	Flexible foams
	Rigid polymer foams	Rigid foams
Natural materials	Cork	Cork

Figure (15) Table 2-4 Material Families &Classes

Figure (16) Table Cooler body

3.5 Manufacturing and assembly (Implementation)

After approval of the design specification and validation, all the parts were connected together. In any environment with dry air and an outside temperature of 35 degrees Celsius, this final assembly can be used for evaporative cooling. This desert cooler offers a very cheap alternative to the problem of air conditioning.

3.5.1 Blower Motor by Solidwork

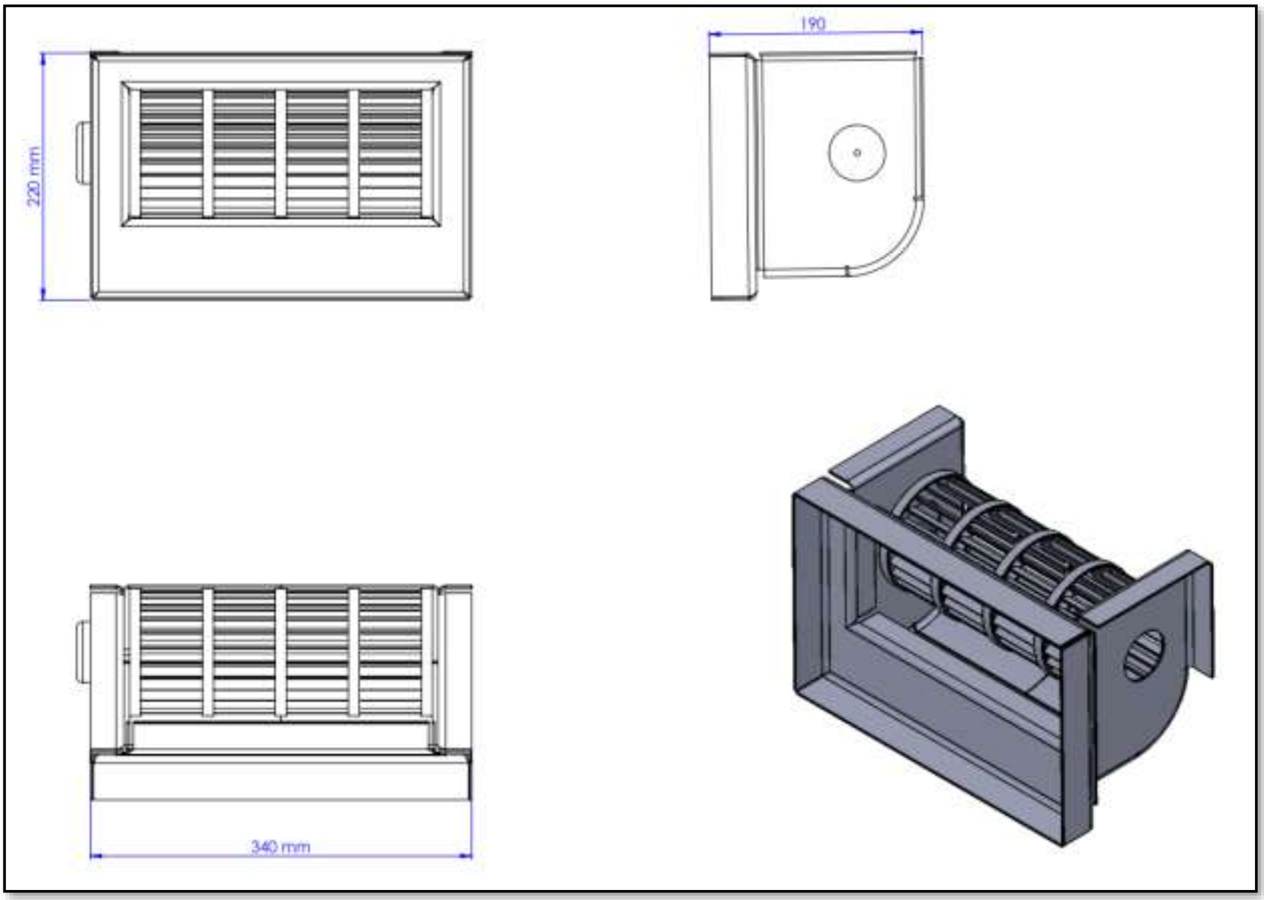

Figure (17) Blower with Motor by Solidwork

3.5.2 Evaporator pads by Solidwork

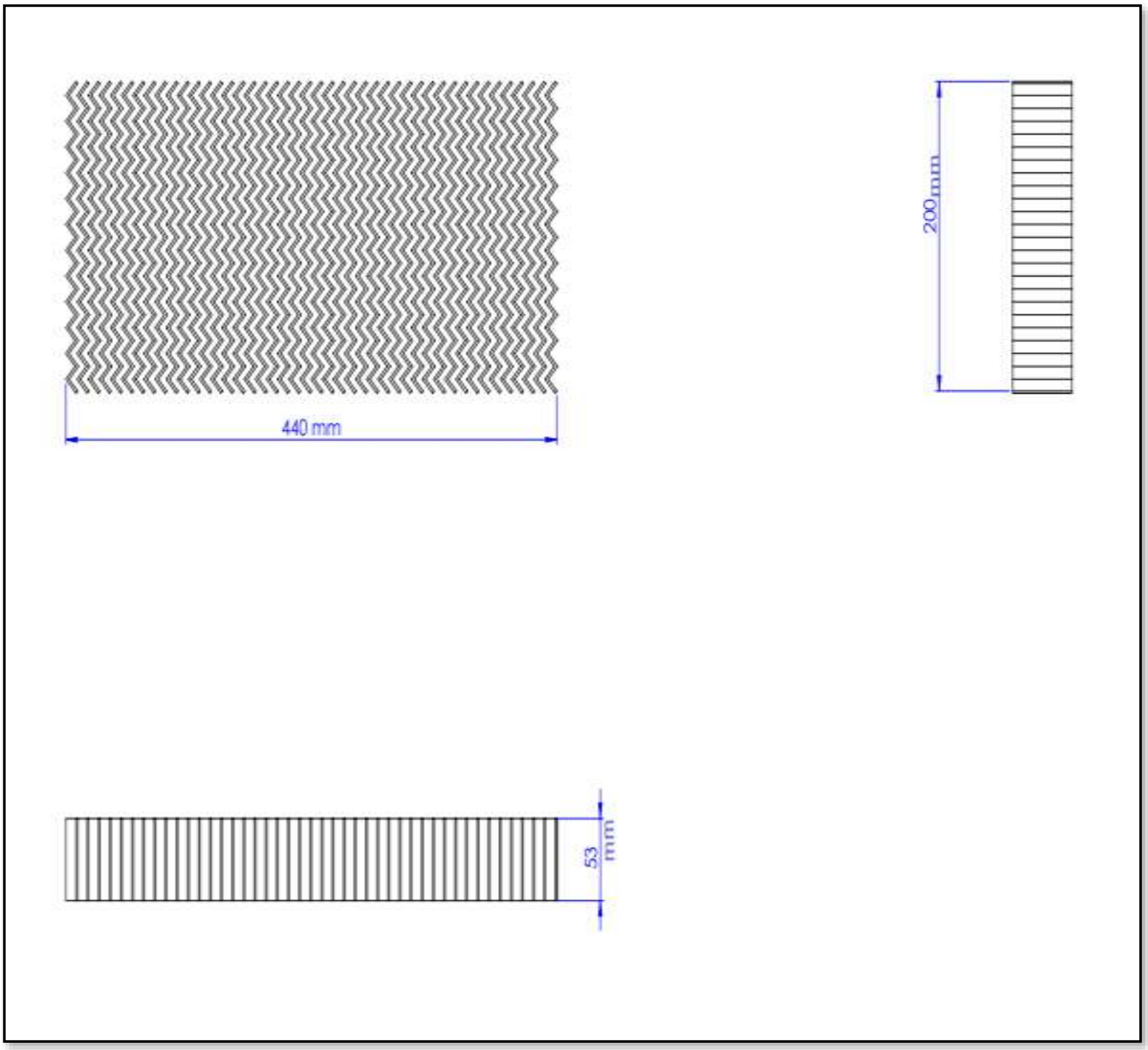

Figure (18) Evaporator pads by Solidwork

3.5.3 Water pump by Solidwork

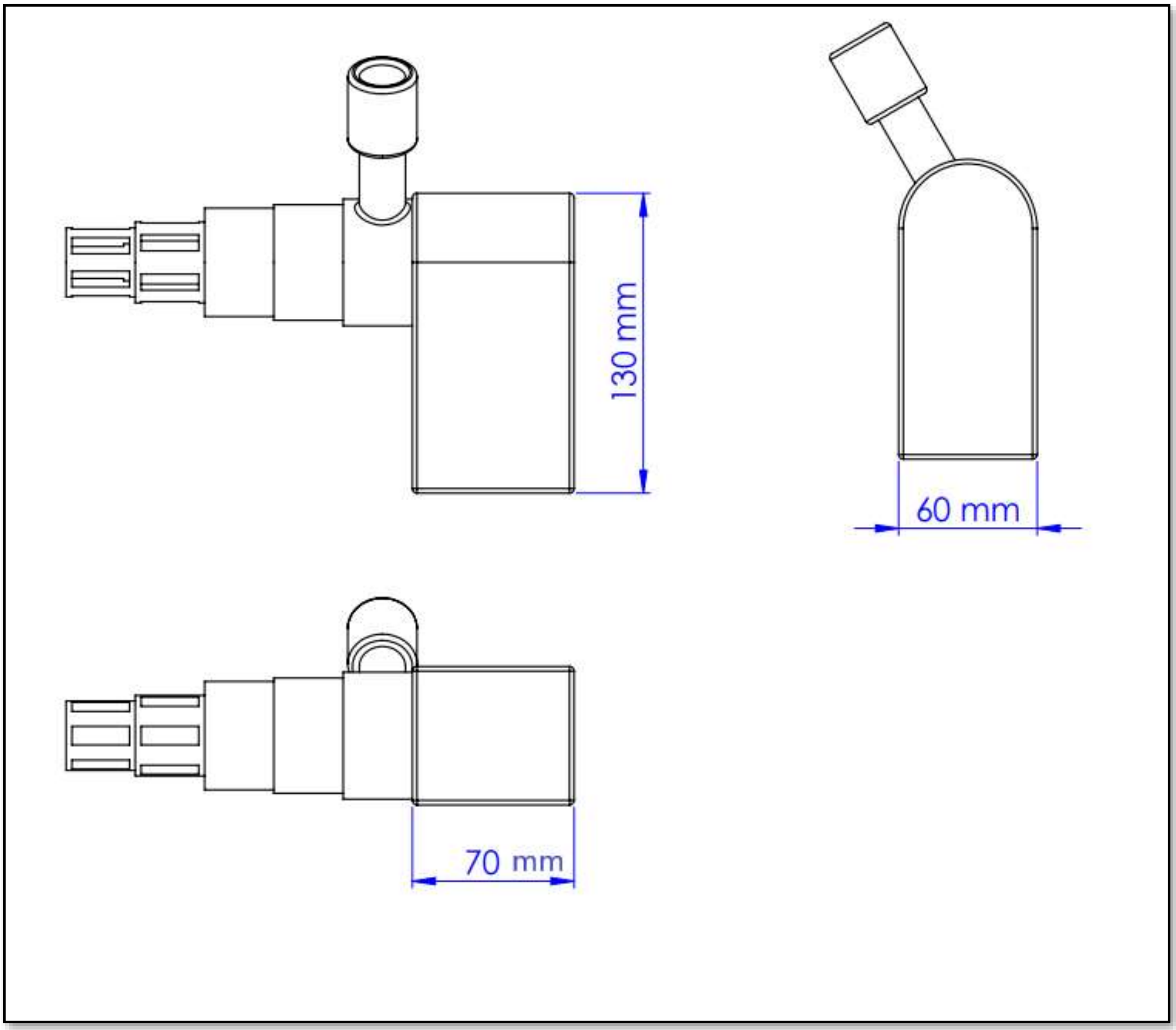

Figure (19) Water pump by Solidwork

3.5.4 Digital Thermometer by Solidwork

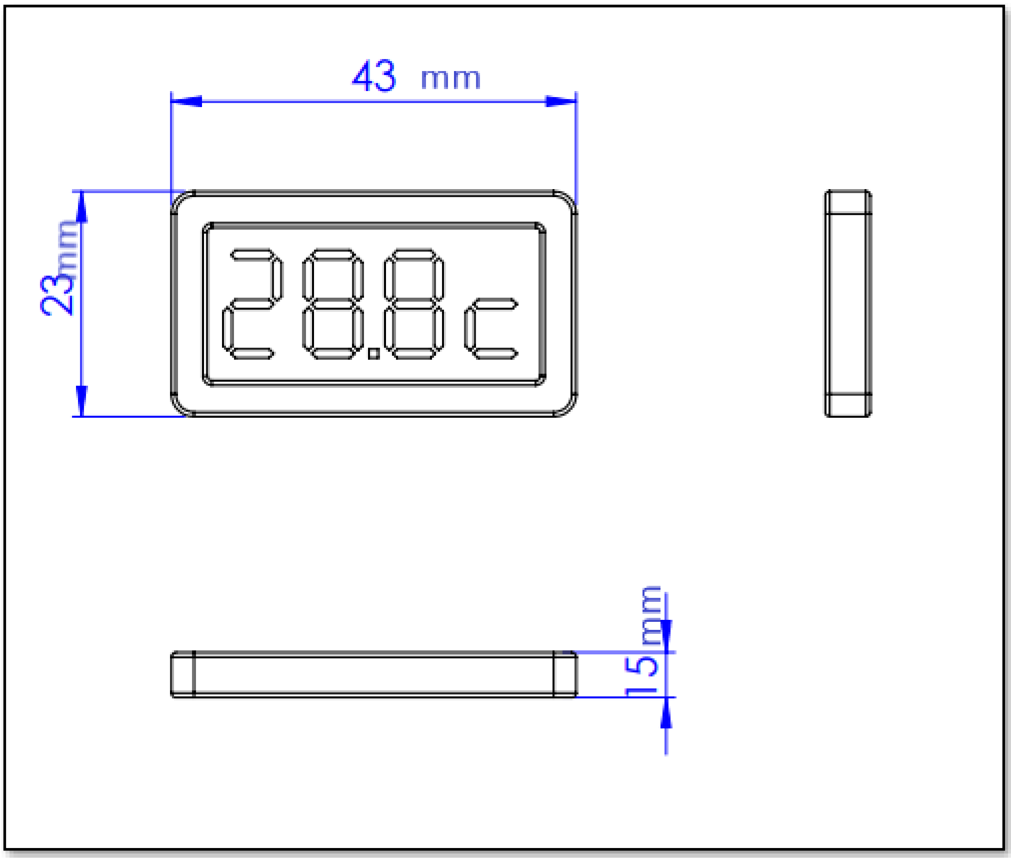

Figure (20) Digital Thermometer by Solidwork

3.5.5 Cooler body by Solidwork

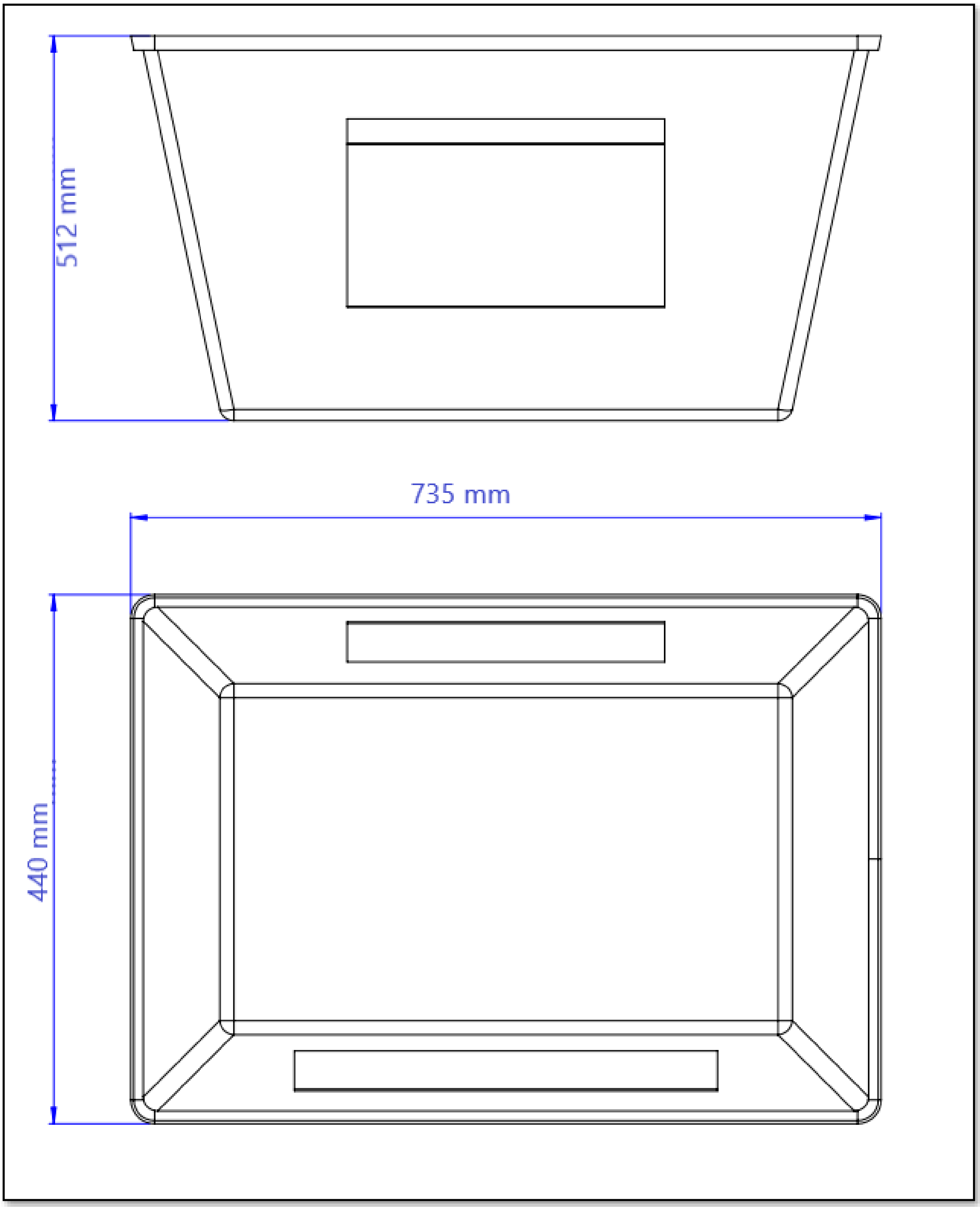

Figure (21) Table Cooler body by Solidwork

3.5.6 Assembly of Desert Cooler by Solidwork

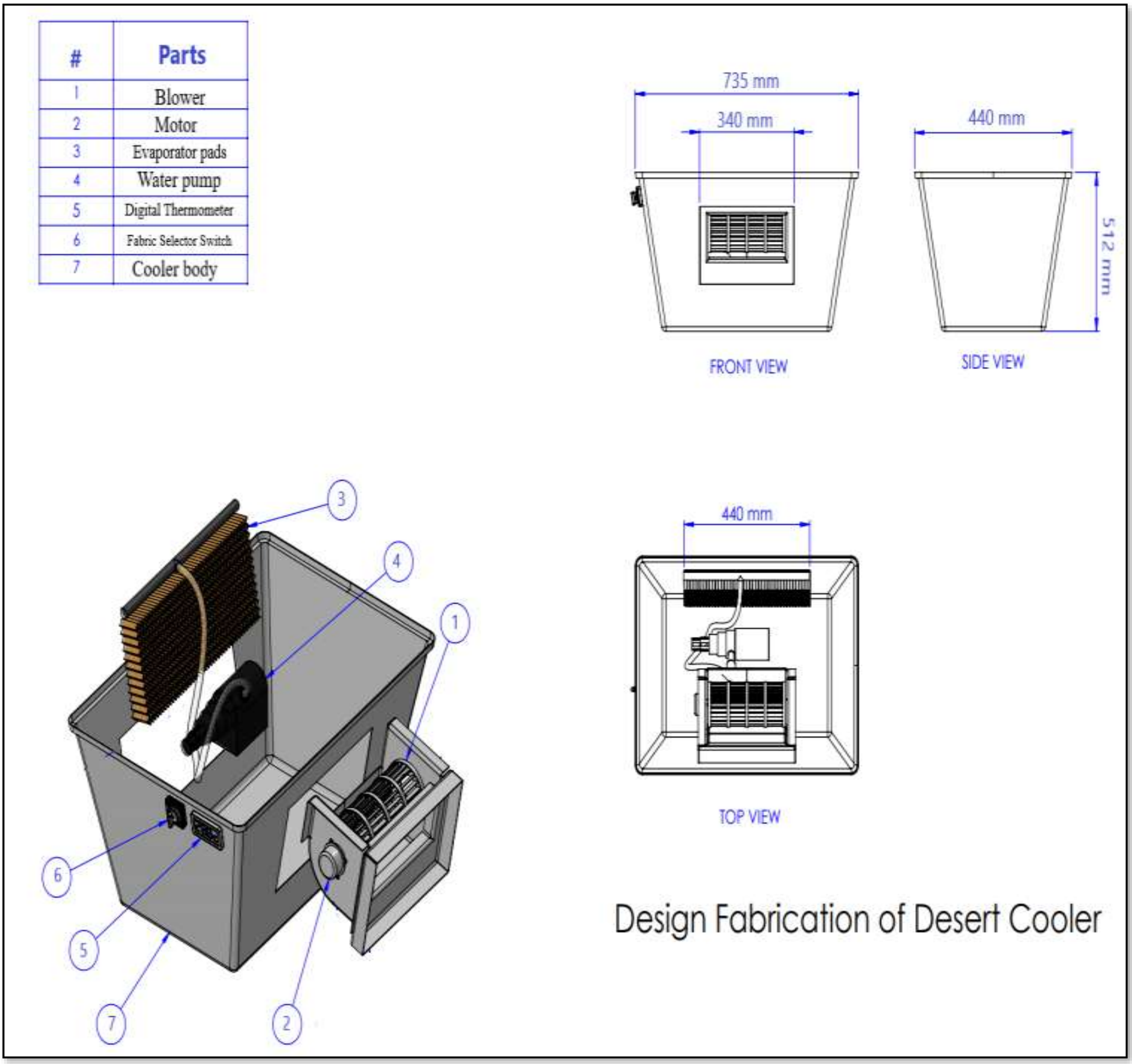

Figure (22) Assembly of Desert Cooler by Solidwork

3.5.7 Assembly of Desert Cooler with our team 06

Figure (23) Assembly of Desert Cooler with our team 06

Chapter 4: System Test and Analysis

4.1 Experimental Setup, Sensors and Data Acquisition System

4.1.1 Digital Thermometer

Temperature-sensing instruments that are conveniently portable have permanent probes, and a convenient digital monitor are a digital room thermometer or digital meter. The way a digital thermometer functions depends on its sensor type. In addition, there are three types of sensors which are thermistor, thermocouple and resistance temperature detector. The digital thermometer we used has thermocouples as sensor. With two wires of various metals of thermocouples are made, connected together at one end to form a junction. The two dissimilar metals begin to deform as the temperature changes, causing a change a resistance shift.

Figure (24) Digital Thermometer

Features:-

- Manufacturer by Elitech
- LCD display
- Insert design
- Simple appearance
- Especially applied in refrigerator, chiller, deepfreeze etc.
- Two button batteries for longer use t time

Technical parameter:-

- Temperature range: -50C~+70C
- Using environment: Temperature: -5C~+50C
- Humidity: 5%~80%
- Accuracy: ±1C
- Resolution: 0.1
- Power: two button battery (LR44, 1.5v)
- Dimension: 4.3cm ×2.3cm ×1.5cm

Instruction:-

- Open the battery cover to put in two LR44 batteries correctly, pay attention to the polarity.
- Display when put in the batteries. Pls take out the batteries when not use for long time
- LCD display H C when temperature is higher than 70C
- LCD display L C when temperature is lower than -50C

4.1.2 Digital Thermometer & Humidity

The Functions of instrument are Two-probe temperature measurement. Temperature, humidity, and time show simultaneously according to human comfort. In addition, Clock function; three kinds of placement; Suitable for refrigerator, office, household, refrigerating equipments, modern planting greenhouses, air-conditioned bus.

Figure (25) Digital Thermometer, humidity

Technical parameters:-

- Temperature measuring range:-
1. Outdoor: -50°C~70°C
2. Indoor:-30C~+50C
- Humidity measuring range:- 20%~99% (Relative humidity)
- Resolution:-
- Temperature:0.1°C
- Humidity: 1% RH
- Power:DC1.5V 7# alkaline battery
- Dimensions: size:115X64X19(mm) Screen size:63X43(mm)

4.2 Results, Analysis and Discussion

In this section, we will show you the results, analysis and discussion. At first we started experimenting and taking the readings in Dammam on the date Dec 3, 2020 at 01.00 PM, as the temperature was 29.4$^\circ C$ and the humidity was 45% as in the tables (5) and Figure (26).

Table (5) The Weather Data of Dammam, KSA at Dec 3, 2020 from 13:00 to 16:00. [21]

#	Times	T℃ (dry bulb Temperature)	RH(%) (Relative Humidity)
1	13:00	29.4	45.0
2	14:00	28.9	47.0
3	15:00	27.8	52.0
4	16:00	26.2	60.0

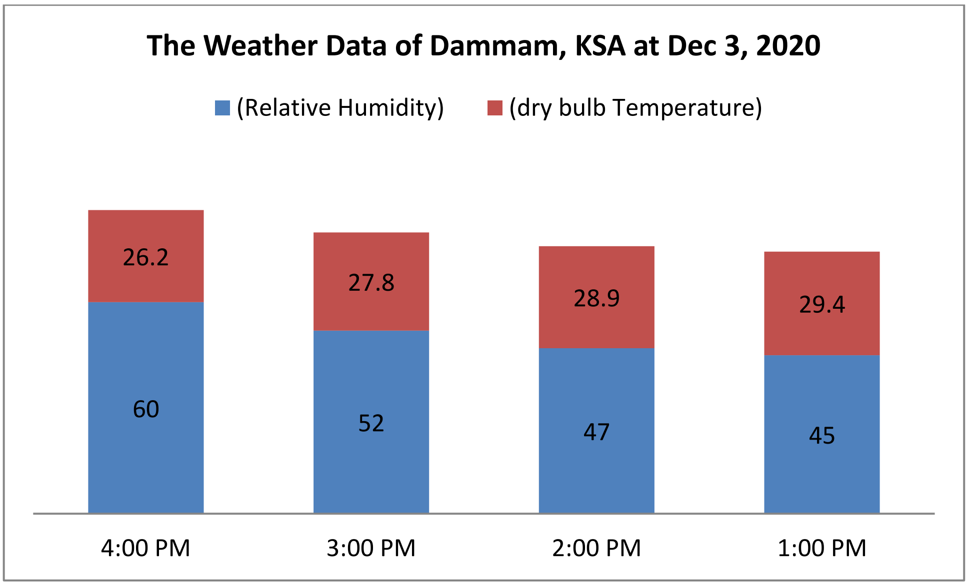

Figure (26) the Weather Data of Dammam, KSA at Dec 3, 2020

But in the room where we took the readings the temperature was 26.2$℃$ and the humidity was 60%. The readings we took of (Pepsi) Box Temp, Tank water Temp, Exit air Temp and Humidity from 0 to 60 min, see table (6).

Figure (27) Take readings from the experiment

Table (6) Data of the Results

Time (Minutes)	**(Pepsi) Box Temp**	**Tank water Temp**	**Exit air Temp**	**Humidity**
0	24.5	24.1	25.6	66%
5	23.4	21.6	23.7	67%
10	23.2	21.1	22.6	66%
15	23.1	21.0	22.4	67%
20	23.0	20.8	22.2	67%
25	23.0	20.8	22.1	67%
30	23.0	20.8	22.2	67%
35	23.0	20.8	22.2	67%
40	23.2	21.1	22.5	67%
45	23.2	21.1	22.5	67%
50	23.1	21.0	22.3	67%
55	23.2	21.1	22.5	67%
60	23.2	21.1	22.5	67%

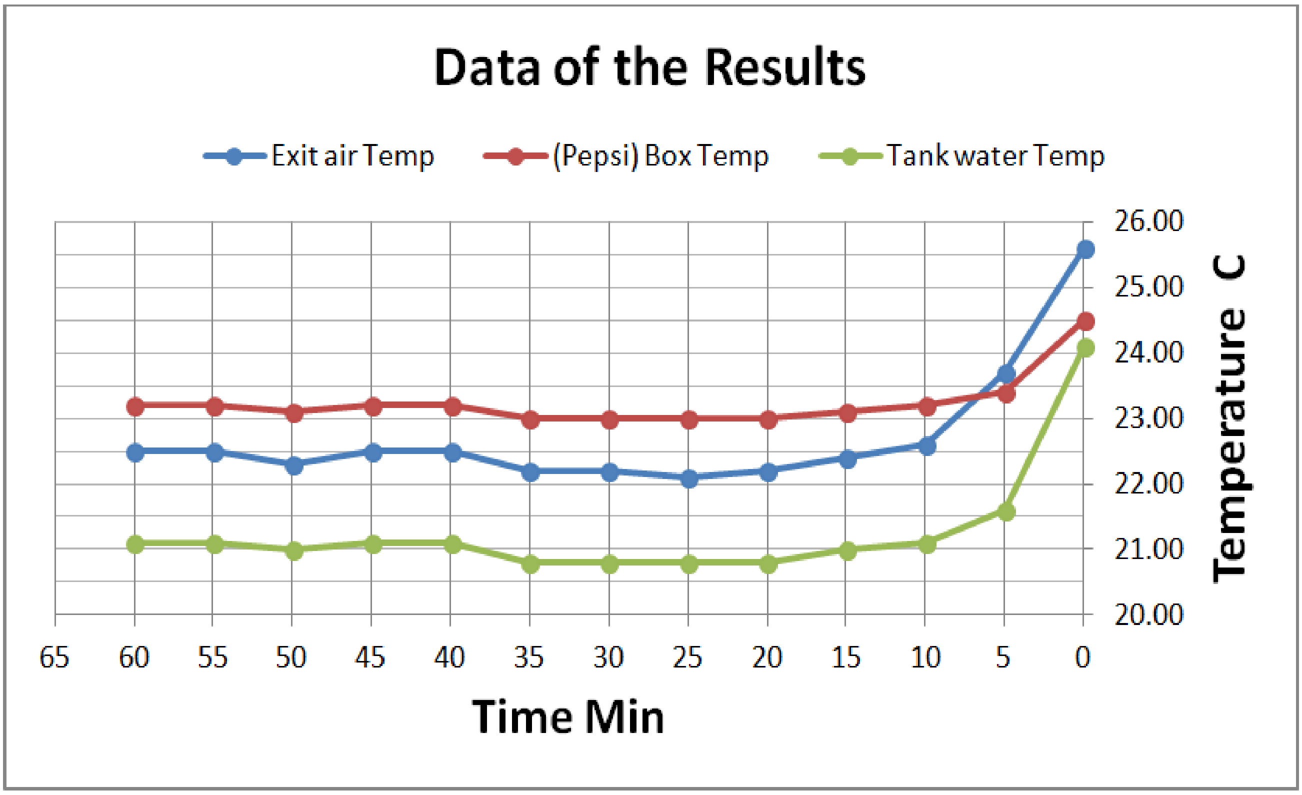

Figure (28) Data of the Results Chart

At first we see from figure (28) the temperature of the tank water and box Temp and the air coming out of the cooler starts high and with the passage of time the temperature begins to drop. From 0 to 5 minutes there is a sharp drop in all temperatures, and from 5 to 60 minutes, a slight descent begins with steadiness.

After taking the readings from the experiment, we will take the last reading, which is after 60 minutes of operating the evaporative cooler, specifically the temperature of the Leaving Air Condition from the evaporative cooler is ($\boldsymbol{T_2} = 22.5\boldsymbol{℃}$), which is (dry bulb temperature of outlet air) and $\boldsymbol{RH_i}(\mathbf{67}\%)$as shown in Table (2). We will take the room air temperature, which is ($T_1 = 26.2℃$), which is the air entering the coolant (dry bulb temperature of inlet air) and $RH_0(60\%)$. In addition, at (T_1 26.2℃)and $RH_0(60\%)$ we determined from the psychrometric chart the T_3 (wet bulb temperature of inlet air) and ω_1. Also, at ($T_2 = 22.5℃$) and $RH_i(67\%)$ we determined from the psychrometric chart the ω_2 . See figure (29).

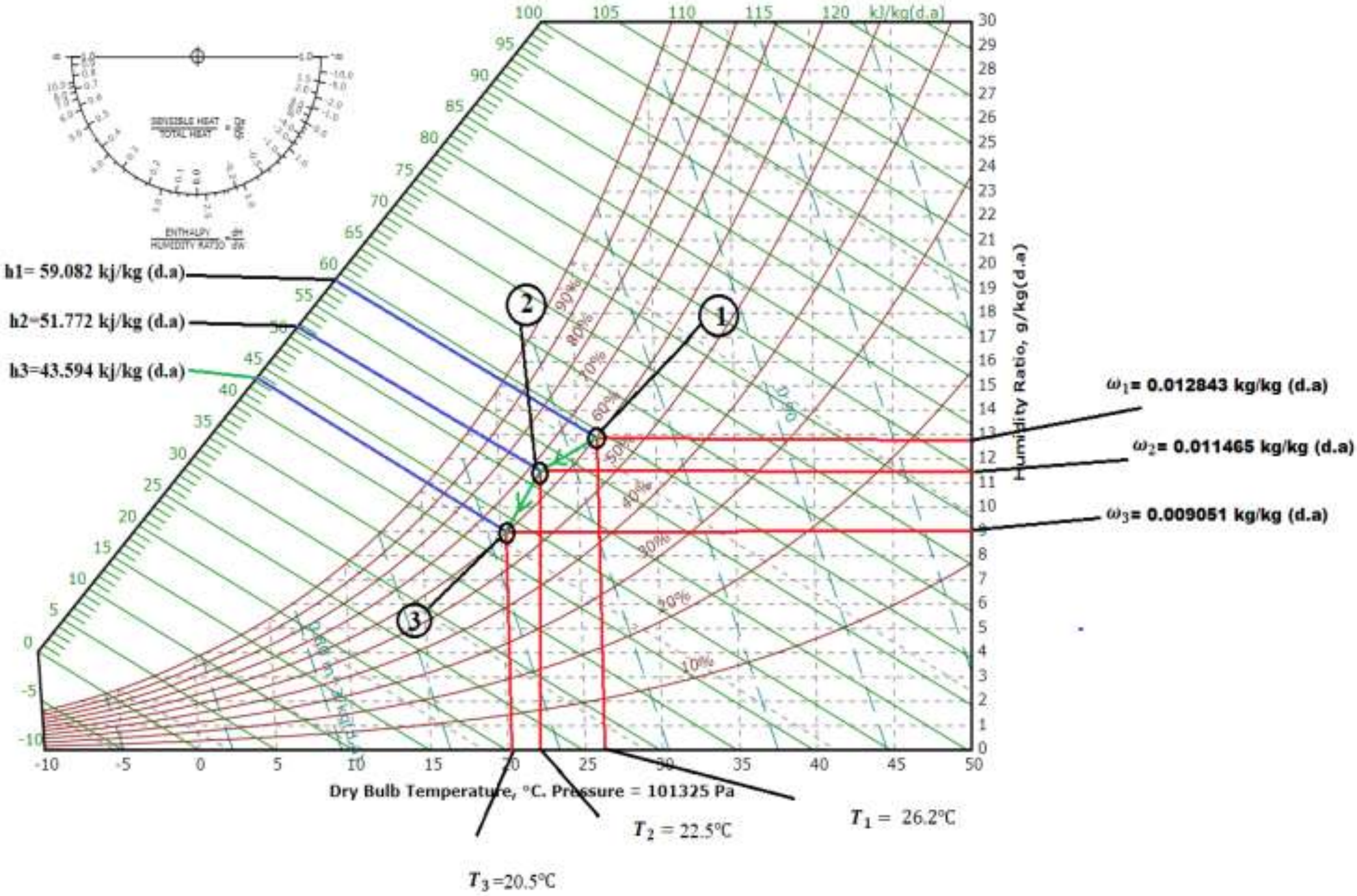

Figure (29) the Results of the Psychrometric Chart

Table (7) Data of the Results of the Psychrometric Chart

Dry bulb temperature of inlet air$(T_1 ℃)$	**26.2℃**
Dry bulb temperature of outlet air$(T_2 ℃)$	22.5℃
Wet bulb temperature of inlet air$(T_3 ℃)$	20.5℃
Relative Humidity$(RH_1\%)$	60%
Relative Humidity$(RH_2\%)$	67%
Relative Humidity$(RH_3\%)$	60%
Humidity Ratio $(\omega_{1=\frac{kg}{kg}(d.a)})$	$0.012843\ \frac{kg}{kg}\ (d.a)$
Humidity Ratio $(\omega_{2=\frac{kg}{kg}(d.a)})$	$0.011465\ \frac{kg}{kg}\ (d.a)$
Humidity Ratio $(\omega_{3=\frac{kg}{kg}(d.a)})$	$0.009051\ \frac{kg}{kg}\ (d.a)$
Specific Enthalpy $(h_1) = \frac{kj}{kg}(d.a)$	$59.082\ \frac{kj}{kg}(d.a)$
Specific Enthalpy $(h_2) = \frac{kj}{kg}(d.a)$	$51.772\ \frac{kj}{kg}(d.a)$
Specific Enthalpy $(h_3) = \frac{kj}{kg}(d.a)$	$43.594\ \frac{kj}{kg}(d.a)$

After taking the information from the psychrometric chart which is in table (7), we use the following equations:-

The effectiveness of desert air cooler:-

$$\varepsilon = \frac{T_1 - T_2}{T_1 - T_3} \times 100 \tag{1}$$

$$\varepsilon = \frac{26.2 - 22.5}{26.2 - 20.5} \times 100 \quad = 64.91\%$$

Outlet air condition:-

The cooled leaving air leaves the evaporative cooler to the space to be conditioned and the humidified. The leaving air temperatureT_2 is determined from equation (2):-

$$T_2 = T_1 - \varepsilon \times (T_1 - T_3) \tag{2}$$

T_2 =26.2−0.6491×(26.2−20.5) = 22.5$\boldsymbol{℃}$

Air Flow Rates:-

Calculated the mass flow rate of air through the evaporative cooler is a function of the air velocity, the density and velocity of air at the entry and the basis of frontal area of the cooler. From equation the mass flow rate of air is determined:-

$$m_a = \rho \times A \times V_a \tag{3}$$

Where:-

m_a= The mass flow rate of air $^{kg}/_{s}$

ρ = density of air at the entry of the cooler, kg/m3

A = frontal area of the cooler′s opening, m2

V_a = air velocity at the entry of the cooler, m/s

First of all, density of air (ρ) at the entry of the cooler we can find it from Table (8) Effect of temperature on density of air.

Table (8) Effect of temperature on density of air [22]

Temperature T (℃)	**Density of air ρ ($^{kg}/_{m^3}$)**
30	1.1644
25	1.1839
20	1.2041

From Table (8) Effect of temperature on density of air. We can use this method to find density of air.

$$\frac{T_{26.2} - T_{30}}{T_{25} - T_{30}} = \frac{\rho - \rho_{1.1644}}{\rho_{1.1839} - \rho_{1.1644}}$$

30	**1.1644**
26.2	$\boldsymbol{\rho}$
25	**1.1839**

$$\frac{\mathbf{26.2 - 30}}{\mathbf{25 - 30}} = \frac{\rho - \mathbf{1.1644}}{\mathbf{1.1839 - 1.1644}}$$

$$\frac{26.2 - 30}{25 - 30} \times (1.1839 \ - 1.1644) + 1.1644 = \rho$$

$$\rho = 1.17922 \frac{kg}{m^3}$$

Secondly, to find A which frontal area of the cooler′s opening is as we see in figure (30) below.

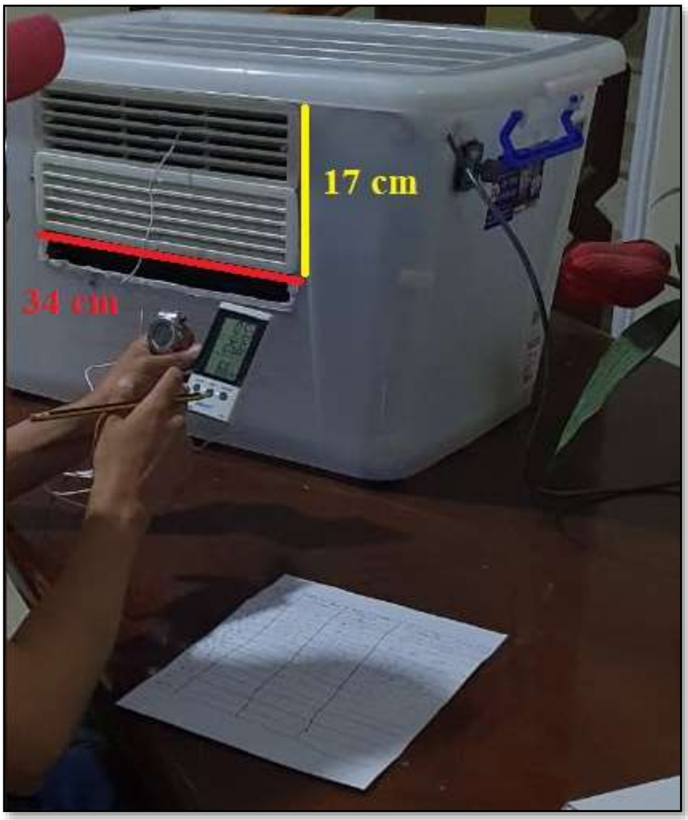

Figure (30) the frontal area of the cooler′s opening

So, A= 34 $cm \times 17\ cm$= 578 cm^2= 0.0578m^2

A= 0.0578m^2

Finally, Air Velocity (V_a)through the Cooling pads of evaporative cooling in the experiment we assume the air velocities through the pads were at 0.5, 0.75, 1.0, 1.25 and 1.75m/s but not 0 m/s and not 2 m/s or up it. And we have calculated from above:-

$\rho = 1.17922 \frac{kg}{m^3}$ & A= 0.0578m^2

Table (9): Mass flow of Air at different selected Air Velocities

V_a (m/s)	**0.5**	**0.75**	**1.0**	**1.25**	**1.75**
$m_a\left({}^{kg}/_{s}\right)$= $m_a = \rho \times A \times V_a$	0.034	0.051	0.068	0.085	0.119

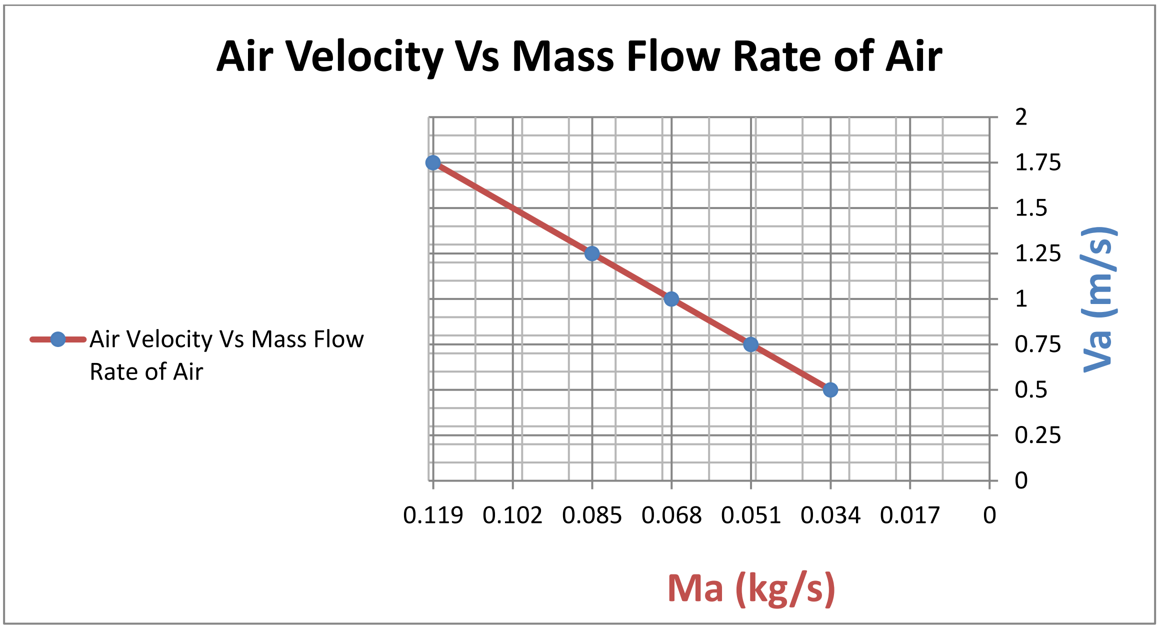

Figure (31) Air Velocity Vs Mass Flow Rate of Air

Mass Flow Rate of Air varies linearly with Air Velocity as shown in figure (31). And, the more Mass Flow Rate of Air the more Air Velocity.

Cooling Capacity & Consumption of Water:-

The cooling capacity (Q_C) of a direct evaporative cooler and the water consumption of the evaporative cooler, (Q_{co}) are determined from equations below:-

$$Q_c = m_a \times C_P \times (T_1 - T_2) \quad (4)$$

$$Q_{co} = m_a \times (\omega_1 - \omega_2) \quad (5)$$

Coefficient of performance (COP):-

Or Energy efficiency is the ratio between the cooling capacity of a cooler (Q_c) and its power consumption which are Power consumed to by blower (air) and pump (water). It can be written as equation follows [4]

$$\text{COP} = \frac{Q_C}{P_{Consumed\ blower\ (air)} + P_{Consumed\ pump\ (water)}} \quad (6)$$

We know that from chapter 3:

$P_{Consumed\ blower\ (air)} = 75W$ = 0.075 kW

$P_{Consumed\ pump\ (water)} = 8W$ = 0.008 kW

For specific heat capacity of Air C_P we determine from table (10).

Table (10) Ideal gas specific heat capacities of air [23]

Temperature (C)	**Temperature (K)**	C_P $kJ/kg.K$
-23.15	250	1.003
26.2	299.35	1.0049
26.85	300	1.005

As we know above:-

C_P= 1.0049 $kJ/kg.K$

T_1= 26.2℃

T_2= 22.5℃

m_a= 0.034, 0.051, 0.068, 0.085 and 0.119

$\omega_1 = 0.012843 \frac{kg}{kg}(\boldsymbol{d.a})$

ω_2= $0.011465 \frac{kg}{kg}(\boldsymbol{d.a})$

Table (11) from equations (3) & (4) & (5) we determine the data with different Ma

V_a (m/s)	0.5	0.75	1.0	1.25
$m_a\left({}^{kg}/{}_{s}\right)$= $m_a = \rho \times A \times V_a$	0.034	0.051	0.068	0.085
$Q_c(\frac{kJ}{h}) = Q_c = m_a \times C_P \times (T_1 - T_2) \times 3600$	455.09	682.64	910.19	1137.74
$Q_{co}\left(\frac{\text{kg}}{\text{h}}\right) = Q_{co} = m_a \times (\omega_1 - \omega_2) \times 3600$	0.1686	0.2530	0.3373	0.4216

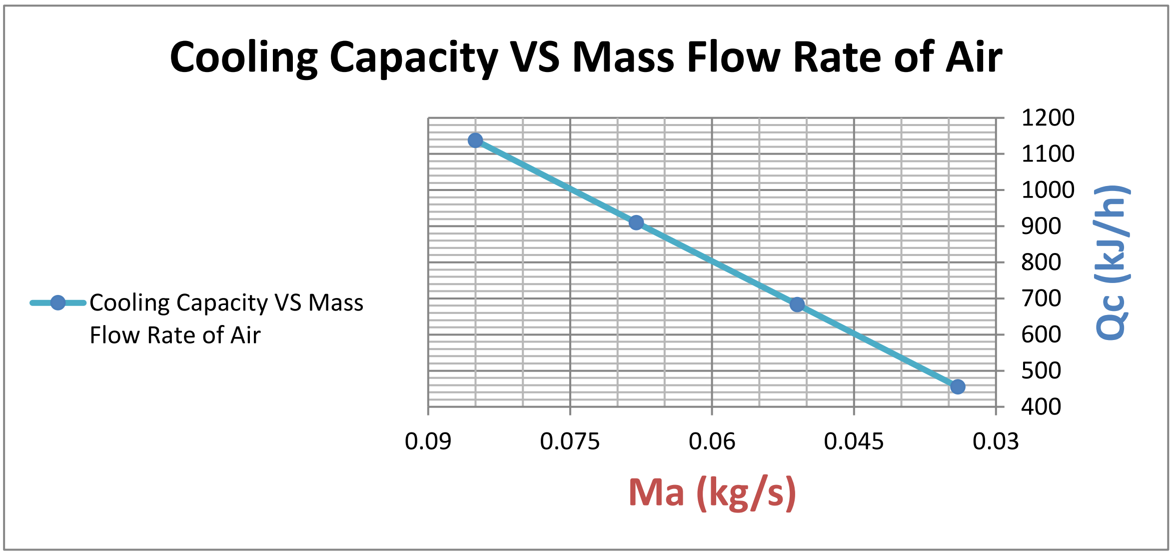

Figure (32) Cooling Capacity Vs Mass Flow Rate of Air

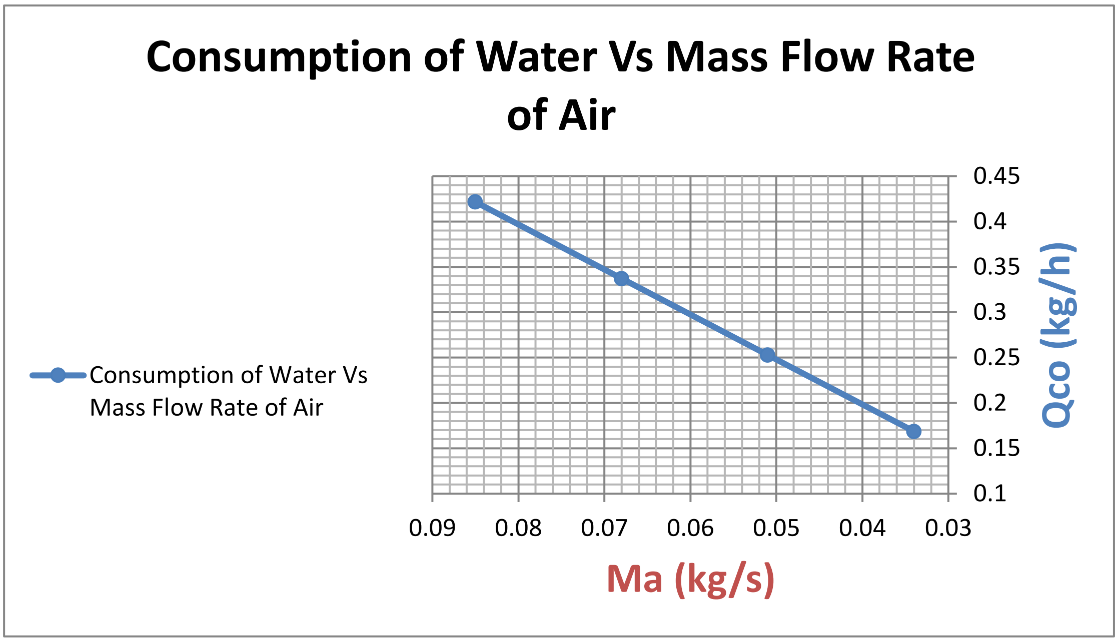

Figure (33) Consumption of Water Vs Mass Flow Rate of Air

The Mass Flow Rate of Air varies linearly with Cooling Capacity as shown in figure (32). The more Mass Flow Rate of Air the more Cooling Capacity. Also, same thing with Consumption of Water varies linearly with Mass Flow Rate of Air as shown in figure (33).The more Consumption of Water the more Mass Flow Rate of Air.

Table (12) from equations (4) & (6) we determine the data at different Air Mass Flow Rates

$\mathbf{m_a}\ (\mathbf{kg/s})$	**0.034**	**0.051**	**0.068**	**0.085**
$Q_c(\frac{kJ}{s} = kW) = Q_c = m_a \times C_P \times (T_1 - T_2)$	0.1264	0.1896	0.2528	0.3160
$\mathbf{COP} = \frac{Q_C}{P_{Consumed\ blower\ (air)=0.075kW} + P_{Consumed\ pump\ (water)=0.008kW}}$	1.5228	2.2843	3.0457	3.8072

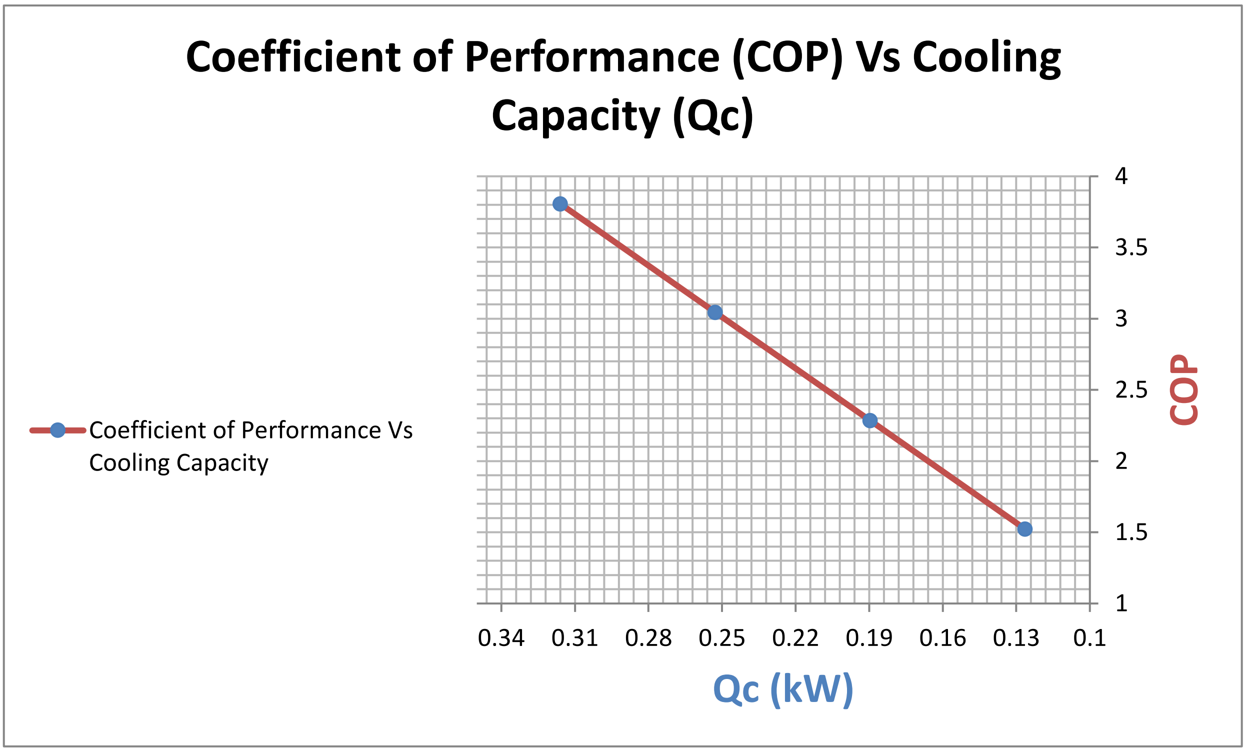

Figure (34) Coefficient of Performance Vs Cooling Capacity

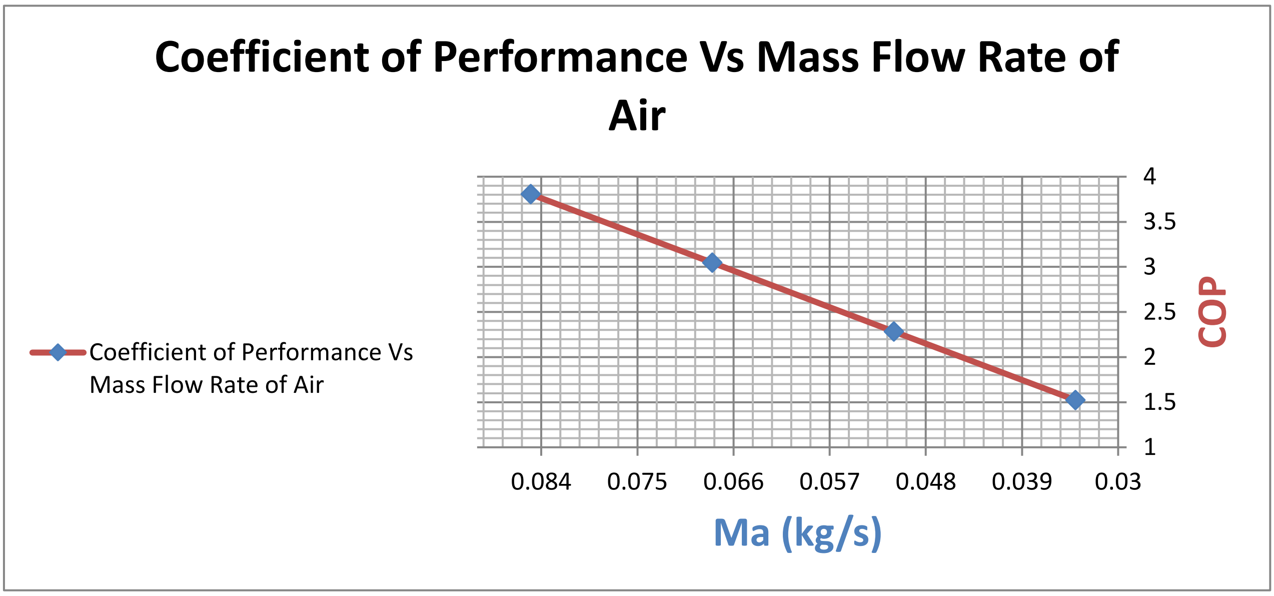

Figure (35) Coefficient of Performance Vs Mass Flow Rate of Air

Coefficient of Performance varies linearly with Cooling Capacity as shown in figure (34).The more Coefficient of Performance, the more Cooling Capacity. Also, same thing with Coefficient of Performance varies linearly with Mass Flow Rate of Air as shown in figure (35).The more Coefficient of Performance, the more Mass Flow Rate of Air.

Chapter 5: Project Management

5.1 Project Plan

A senior project includes of many tasks and each task is assigned to one or more members. Members were given criteria and a specific time in order to successfully complete the tasks assigned to them to achieve excellent project results, as in the following tables (13) and (14).

Table (13) from Tasks and their Duration

#	Tasks			Start	End	Duration
1	Introduction	**Chapter (1)** Project allocation + Introduction	Project Definition	23/09/2020	23/09/2020	1
			Project Objectives	25/09/2020	25/09/2020	1
			Project Specifications	27/09/2020	27/09/2020	1
			Applications	29/09/2020	29/09/2020	1
2		**Chapter (2)** Literature Review	Project Background	29/09/2020	29/09/2020	1
			Previous Work	30/09/2020	30/09/2020	1
			Comparative Study	02/10/2020	02/10/2020	1
3	System Design	**Chapter (3)** Design	Design Constraints & Design Methodology	05/10/2020	07/10/2020	3
		Equipment & Material selection	Engineering Design Standards & Selected The Appropriate Items	09/10/2020	14/10/2020	6
		Theory & Theoretical Calculations	Main Calculations Required Detailed Calculations To Your Design	14/10/2020	20/10/2020	7

		Prototype assemble	System integration, describe , procedures and Implementation	22/10/2020	31/10/2020	10
4	System Testing & Analysis	**Chapter (4)** Testing & Analyses	Experimental Setup, Sensors and data acquisition system	14/11/2020	17/11/2020	4
			Results, Analysis and Discussion	19/11/2020	23/11/2020	5
5	Project Management & Project Analysis	**Chapter (5)** Project Management	Project Plan	25/11/2020	25/11/2020	1
			Contribution of Team Members	27/11/2020	26/11/2020	2
			Project Execution Monitoring	30/11/2020	01/12/2020	2
			Challenges and Decision Making	03/12/2020	04/12/2020	2
			Project Bill of Materials and Budget	06/12/2020	07/12/2020	2
6		**Chapter (6)** Project Analysis	Life-long Learning	08/12/2020	09/12/2020	2
			Impact of Engineering Solutions	11/12/2020	12/12/2020	2
			Contemporary Issues Addressed	14/12/2020	15/12/2020	2
7	Conclusion & Recommendation	**Chapter (7)** Conclusion & Recommendation	Conclusion	14/12/2020	14/12/2020	1
			Future Recommendation	15/12/2020	15/12/2020	1
8	**Design of Prototype**			22/10/2020	31/10/2020	10
9	**Parts Purchase**			01/11/2020	05/11/2020	5
10	**Manufacturing**			02/11/2020	9/11/2020	8
11	**Testing**			19/11/2020	19/11/2020	1

Table (14) Assigned Members for Tasks

#	Task	Assigned Members
1	**Chapter (1)** Project allocation + Introduction	Abdulmohsen ALWayel
2	**Chapter (2)** Literature Review	Saad Al-Faris
3	**Chapter (3)** System Design	Abdullah ALSufayan & Hadi Al Harbi
4	**Chapter (4)** System Testing & Analysis	Abdullah ALSufayan
5	**Chapter (5)** Project Management	Saad Al-Faris & Abdullah M Alqahtani
6	**Chapter (6)** Project Analysis	Hadi Al Harbi
7	**Chapter (7)** Conclusion & Recommendation	Abdullah M Alqahtani
8	**Design of Prototype**	Abdullah ALSufayan & Hadi Al Harbi
9	**Parts Purchase**	Abdulmohsen ALWayel & Saad Al-Faris
10	**Manufacturing**	Everyone
11	**Testing**	Everyone

5.2 Contribution of Team Members

Team 06 members made a lot of effort in achieving the project requirements. Each member of Team 06 contributed in his effort and time depending on their work ability and efficiency. The table (15) below shows how much contribution each team member made.

Table (15) Contribution of Tasks

#	Tasks			Assigned Member	Contribution
1	Introduction	**Chapter (1)** Project allocation + Introduction	Project Definition	Abdulmohsen ALWayel	100%
			Project Objectives		
			Project Specifications		
			Applications		
2		**Chapter (2)** Literature Review	Project Background	Saad Al-Faris	100%
			Previous Work		
			Comparative Study		
3	System Design	**Chapter (3)** Design	Design Constraints & Design Methodology	Abdullah ALSufayan	75%
		Equipment & Material selection	Engineering Design Standards & Selected The Appropriate Items		
		Theory & Theoretical Calculations	Main Calculations Required Detailed Calculations To Your Design		
		Prototype assemble	System integration, describe , procedures and Implementation	Hadi Al Harbi	25%
4	System Testing & Analysis	**Chapter (4)** Testing & Analyses	Experimental Setup, Sensors and data acquisition system	Abdullah ALSufayan	100%
			Results, Analysis and Discussion		
5		**Chapter (5)**	Project Plan	Abdullah M Alqahtani	40%
			Contribution of Team Members		
			Project Execution Monitoring		

	Project Management & Project Analysis	Project Management	Challenges and Decision Making Project Bill of Materials and Budget	Saad Al-Faris	60%
6		**Chapter (6)** Project Analysis	Life-long Learning Impact of Engineering Solutions Contemporary Issues Addressed	Hadi Al Harbi	100%
7	Conclusion & Recommendation	**Chapter (7)** Conclusion & Recommendation	Conclusion Future Recommendation	Abdullah M Alqahtani	100%
8	**Design of Prototype**			Hadi Al Harbi	50%
				Abdullah ALSufayan	50%
9	**Parts Purchase**			Saad Al-Faris	50%
				Abdulmohsen ALWayel	50%
10	**Manufacturing**			Everyone	100%
11	**Testing**			Everyone	100%

5.3 Project Execution Monitoring

In order to improve and develop our project we had many activities related to maintaining the development of the project. These activities, including the important meetings and events related to the senior project in the fall 2020 - 2021, as shown in Table (16).

Table (16) Dates of Activities and Events

Activities/Events	**Time/Date**
Assessment Online Class	Once in week
Meeting with the group members Online by Zoom App	Bi-Weekly
Meeting with the Advisor Online by Zoom App	Weekly
First Finished Prototype	23^{th}October, 2020
Finishing Final Prototype	9^{th}November, 2020
First Test of System	10^{th}November, 2020
Midterm Presentation	12^{th}November, 2020
Test of the System	19^{th}November, 2020
Final Presentation	17^{th}December, 2020
Final Submission of Report	18^{th}December, 2020

5.4 Challenges and Decision Making

Working on the project is often a difficult task, but to get everything right you should faced the initial challenges were met by cooperation, listening to each other suggestions, and going back to the advisor. Also, with some internet and market research, so that decisions were made better. During the project phases, we faced some major challenges, which are equipment & devices problems, testing and safety issues and design problems.

5.4.1: Equipment and Device Problems

Digital Thermometer & Humidity

Figure (36) digital thermometer & humidity

Initially, the Digital Thermometer & Humidity did not give logical readings, which affected the calculations and results required of the project. Therefore, the problem was avoided by purchasing a new Digital Thermometer & Humidity and testing it and making sure of the readings by compared to other temperature sensors.

Water pump

We were surprised while operating the desert cooler to take the test readings, The water pump did not work and after looking inside the tank, we found that the intake hole in the pump was not implanted with water, and after increasing the amount of water in the tank until the entire pump was inside the water after that it worked.

Figure (37) Water pump

5.4.2: Testing and safety issues

We have taken every step to make the test extremely safe. The blower is installed correctly and stably to prevent vibration. Also an appropriate amount of water has been placed in the tank so that the water does not pose any danger to the motor.

5.4.3: Design Problems

In designing the project we addressed two main problems. The first is the material used in the manufacture of the body of the desert cooler, where at the beginning we decided to use aluminum, but the decision was changed to plastic after looking at the economic side, as plastic is cheaper than aluminum, and the performance is not a big difference. Second, the digital thermometer is next to the speed regulator, but when we actually wanted to do that, the decision was changed and we made it the same line but beyond away for better shape. Also, not to tangle of the speed regulator wires and the digital thermometer wires.

5.5 Project Bill of Materials and Budget

Money is one of the most important requirements of the project in addition to effort and time, so we spent money to purchase materials and parts for the constructions of the prototype. The table (17) shows the material prices and the total cost incurred in Saudi riyals.

Table (17): Project Bill

Materials	**Cost (SAR)**
Blower with motor	500
Evaporator pads	200
Water pump	60
Digital thermometer	30
Fabric selector switch	39
Cooler body	170.75
Power cable	50
Plug electric	30
Digital Thermometer & Humidity	75
White plastic Louvre Air Vent Grille	60.02
Manufacturing for prototype	300
Total	**1,514.**77

Chapter 6: Project Analysis

6.1 Life-Long Learning

The project solidified the scientific theories we learned at the university. Through the project, we learned a lot of knowledge and acquired important skills to complete our project to the fullest. We have succeeded in improving our skills in time management by working as a team and also communicating in an effective way. In this part we will discuss the skills that we learned in this project.

6.1.1: Software Skills

Through the project, we had to use Word, PowerPoint, and Solidwork to design the prototype of our project, but in an advanced way, and some skills are the first time we use it in the aforementioned programs. We learned to use montage software perfectly as we had to make a short video to market our project.

6.1.2: Hardware Skills

In our project it was necessary to perform a system performance test. Thus, we had to use some new devices that aim to collect data and give experiment readings. In this project, we used Digital Thermometer & Humidity to measure temperature and humidity, so we had experience in using temperature sensors and how to use them properly.

6.1.3: Time Management

The time management is one of the most important skills that have been acquired in this project, to reach our goals on time. We were helped by the Gantt chart, as it arranged the tasks for us and assigned each task a start and end date. In addition, we took advice from the advisor, which helped us achieve on time.

6.1.4: Project Management

The tasks were divided fairly among the team members. In addition, the tasks were distributed according to the experience of each team member in a specific area. In addition, we meet twice a week to collect work and tasks and discuss matters related to the tasks. In fact, the team members successfully accomplished the tasks assigned to them.

6.2 Impact of Engineering Solutions

6.2.1: Society

In this project, we took into account how it will serve the community, as we live in a desert environment, and our project, which is a desert cooler, is required in a society that abounds in events and camping in the desert, it is the customs and cultures of the community.

6.2.2: Economy

This project is very economical and differs from other cooler as the desert cooler has become the economic cooling the most important feature in its industry. The desert cooler works on the theory of evaporation. This method is cheap compared to the other. The project was expected to cost about 2000 Saudi Riyals, and after the completion of the project we found that it cost about 1,514.77 Saudi Riyals.

6.2.3: Environment

Our desert cooler project does not pose a threat to the environment as much as its operation because the desert cooler does not contain Freon. In addition, the work of the coolant depends on evaporation. Moreover, it is useful in hot and dry areas and is not effective in wet areas.

6.3 Contemporary Issues Addressed

There is global interest in global warming. In addition, conferences that take place annually to discuss climate change and how to preserve the atmosphere for the safety of the ozone hole and the absence of global warm. As well as one of the most important goals of these conferences is to recommend countries to reduce pollutants and gases polluting the atmosphere. From our team, everything mentioned has been taken into account in our project. The desert cooler does not contain Freon, which affects the atmosphere, but rather it depends on evaporative cooling. Our project contributes to reducing the contamination of the earth and thus preserving the safety of the planet, and this is what must be taken into account in any project.

Chapter 7: Conclusions and Future Recommendations

7.1 Conclusions

In short, our project is about the desert cooler. Desert cooler has proven to be a very effective method of cooling in hot and dry areas. For this purpose, this project aims to design a modern and economical desert cooler for hot and dry regions. The project tends to show the advantages of using the desert cooler, such as cooling in the indoors. In addition, desert cooler is very effective in hot and dry regions and not effective in high humidity areas. Moreover, depends of the desert cooler on evaporative cooling, which is more economical, easy to carry and does not contain Freon, which makes it not affect the environment. Simply, the hot air enters to desert cooler through the wet evaporator pads from the water pump, thus the air becomes less hot and then the air is outside the desert cooler by the blower. We learned how to use engineering theories correctly and how to apply them in our project. In addition, we learned how to use various devices such as sensors. Moreover, we improved our skills regarding to engineering software such as Solidwork. We learned how to plan and work in order to achieve our goals and how to work together to reach the goals in the fastest time.

7.2 Future Recommendations

Despite the difficulties we faced, we overcome all the difficulties and completed the project in a timely manner. For the recommendations after the completion of the project to help improve the project and make it work better. First, increasing the number of evaporator pads in the desert cooler and making them on three sides from the sides and back, and making the front side for the blower to give more coolness. As we know, the greater the number or thickness of the evaporator pads, the greater the cooling. Second, the weight of the blower with motor must be taken into account in relation to the body of the desert cooler so that the desert cooler is not affected. Finally, the data coming out of the temperature sensor must be checked so that the test data and results are correct. In general, the project was successful, but future recommendations should be taken into account in future.

7.3 References

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Appendix A: Progress Reports

	SDP – WEEKLY MEETING REPORT
	Department of Electrical Engineering **Prince Mohammad bin Fahd University**

SEMESTER:	FALL	ACADEMIC YEAR:	2020 - 2021
PROJECT TITLE	Design & Fabrication of a Desert Cooler		
SUPERVISORS	Prof. Waqar Ahmed Khan		

Month 1: Oct

ID Number	Member Name
Abdullah ALSufayan	201303801
Hadi Al Harbi	201303962
Saad Al-Faris	201500059
Abdulmohsen ALWayel	201301822
Abdullah M Alqahtani	201500337

List the tasks conducted this month and the team member assigned to conduct these tasks

#	Task description	Team member assigned	Progress 0%-100%	Delivery proof
1	**Work dividing & Researching & testing & Milestone(3): Chapter-3 System Design & Responsible for design in the workshop**	**Abdullah ALSufayan**	100%	
2	**Solid works Design & Chapter-3 System Design & Responsible for design in the workshop**	**Hadi Al Harbi**	100%	
3	**Chapter 1: Project allocation + Introduction & Responsible for design in the workshop**	**bdulmohsen ALWayel**	100%	
4	**Chapter 2: Literature Review & Responsible for design in the workshop**	**Saad Al-Faris**	100%	
5	**Responsible for design in the workshop & Researching for patrs**	**bdullah M Alqahtani**	100%	

List the tasks planned for the month of November and the team member/s assigned to conduct these tasks

#	Task description	Team member/s assigned
1	**Chick and Testing our equipment**	All Team
2	**Preparing for mid-term presentation**	All Team
3	**Prototype Completion**	All Team
4	**Working in Chapter 4: System Testing and analysis**	All Team
5	**Working in Chapters 5 and 6: Project Management and Project Analysis**	All Team

- **To be Filled by Project Supervisor and team leader:**
- **Please have your supervisor fill according to the criteria shown below**

Outcome MEEN4: an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts				
Criteria	**None (1)**	**Low (2)**	**Moderate (3)**	**High (4)**
MEEN4A. Demonstrate an understanding of engineering professional and ethical standards and their impact on engineering solutions in global, economic, environmental and societal context	Fails to demonstrate an understanding of engineering professional and ethical standards and their impact on engineering solutions in global, economic, environmental, and societal contexts	Shows limited and less than adequate understanding of engineering professional and ethical standards and their impact on engineering solutions in global, economic, environmental, and societal contexts	Demonstrates satisfactory understanding of engineering professional and ethical standards and their impact on engineering solutions in global, economic, environmental, and societal contexts	Understands appropriately and accurately the engineering professional and ethical standards and their impact on engineering solutions in global, economic, environmental, and societal contexts
Outcome MEEN5: an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet				

objectives				
Criteria	**None (1)**	**Low (2)**	**Moderate (3)**	**High (4)**
MEEN5A: Ability to develop team work plans and allocate resources and tasks	Fails to develop team work plans and allocate resources and tasks	Shows limited and less than adequate ability to develop team work plans and allocate resources and tasks	Demonstrates satisfactory ability to develop team work plans and allocate resources and tasks	Properly and efficently makes team work plans and allocate resources and tasks
MEEN5B: Ability to participate and function effectively in team work projects to meet objectives	Fails to participate and function effectively in team work projects to meet objectives	Shows limited and less than adequate ability to participate and function effectively in team work projects to meet objectives	Demonstrates satisfactory ability to participate and function effectively in team work projects to meet objectives	Function effectively in team work projects to meet objectives
MEEN5C: Ability to communicate effectively with team members	Fails to communicate effectively with team members	Shows limited and less than adequate ability to communicate effectively with team members	Demonstrates satisfactory ability to communicate effectively with team members	Communicates properly and effectively with team members

Indicate the extent to which you agree with the above statement, using a scale of 1-4 (1=None; 2=Low; 3=Moderate; 4=High)

#	Name	Criteria (MEEN4A)	Criteria (MEEN5A)	Criteria (MEEN5B)	Criteria (MEEN5C)
1	**Abdullah ALSufayan**	4	3	4	4
2	**Hadi Al Harbi**	4	4	4	3
3	**Saad Al-Faris**	3	4	4	4
4	**Abdulmohsen ALWayel**	3	4	4	4
5	**Abdullah M Alqahtani**	4	4	4	3

Comments on individual members

Name	Comments
Abdullah ALSufayan	I learned to convert the theoretical science to practical application. Be careful with the different parts names between scientific names and market names.

Hadi Al Harbi	We cannot design any project without SolidWork. But we must check the market before use SolidWork.
Saad Al-Faris	Literature Review is important to give an idea about the project.
Abdulmohsen ALWayel	The best solution if you encounter difficulties with Design System is asking the Advisor.
Abdullah M Alqahtani	Collective work was wonderful thanks for all the team.

	SDP – WEEKLY MEETING REPORT
	Department of Electrical Engineering **Prince Mohammad bin Fahd University**

SEMESTER:	**FALL**	**ACADEMIC YEAR:**	**2020 - 2021**
PROJECT TITLE	**Design & Fabrication of a Desert Cooler**		
SUPERVISORS	**Prof. Waqar Ahmed Khan**		

Month 2: November

ID Number	Member Name
Abdullah ALSufayan	201303801
Hadi Al Harbi	201303962
Saad Al-Faris	201500059
Abdulmohsen ALWayel	201301822
Abdullah M Alqahtani	201500337

List the tasks conducted this month and the team member assigned to conduct these tasks

#	Task description	Team member assigned	Progress 0%-100%	Delivery proof
1	**Chapter (4) System Testing & Analysis, Manufacturing, Prototype Completion**	**Abdullah ALSufayan**	100%	
2	**Chapter (6) Project Analysis, Manufacturing, Design of Prototype, Prototype Completion**	**Hadi Al Harbi**	100%	
3	**Chapter (5) Project Management ,Parts Purchase, Manufacturing, Prototype Completion**	**bdulmohsen ALWayel**	100%	
4	**Chapter (5) Project Management, Manufacturing, Prototype Completion**	**Saad Al-Faris**	100%	
5	**Chapter (5) Project Management,**	**bdullah M Alqahtani**	100%	

	Manufacturing, Prototype Completion			

List the tasks planned for the month of December and the team member/s assigned to conduct these tasks

#	Task description	Team member/s assigned
1	The prototype demo is going to be held in PMU on Wednesday Dec/16, between 12:00 pm – 01:00 pm.	All Team
2	practice for final presentation	All Team
3	The final presentation is going to be held online on the next day (Thursday Dec/17)	All Team
4	Upload your final presentation PowerPoint	Leader
5	Upload your final report as Word document here	Leader
6	Upload a softcopy of your brochure and banner	Leader
7	Please assess your teammates and upload your assessment here	All Team
8	Upload a proof of finishing your online course here.	All Team
9	Finish the Mechanical Engineering Exit survey before Sunday Dec/20.	All Team

- **To be Filled by Project Supervisor and team leader:**
- **Please have your supervisor fill according to the criteria shown below**

Outcome MEEN4: an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts				
Criteria	**None (1)**	**Low (2)**	**Moderate (3)**	**High (4)**
MEEN4A. Demonstrate an understanding of engineering professional and ethical standards and their impact on engineering solutions in global, economic, environmental and societal context	Fails to demonstrate an understanding of engineering professional and ethical standards and their impact on engineering solutions in global, economic, environmental, and societal contexts	Shows limited and less than adequate understanding of engineering professional and ethical standards and their impact on engineering solutions in global, economic, environmental, and societal contexts	Demonstrates satisfactory understanding of engineering professional and ethical standards and their impact on engineering solutions in global, economic, environmental, and societal contexts	Understands appropriately and accurately the engineering professional and ethical standards and their impact on engineering solutions in global, economic, environmental, and societal contexts

Outcome MEEN5: an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives				
Criteria	**None (1)**	**Low (2)**	**Moderate (3)**	**High (4)**
MEEN5A: Ability to develop team work plans and allocate resources and tasks	Fails to develop team work plans and allocate resources and tasks	Shows limited and less than adequate ability to develop team work plans and allocate resources and tasks	Demonstrates satisfactory ability to develop team work plans and allocate resources and tasks	Properly and efficently makes team work plans and allocate resources and tasks
MEEN5B: Ability to participate and function effectively in team work projects to meet objectives	Fails to participate and function effectively in team work projects to meet objectives	Shows limited and less than adequate ability to participate and function effectively in team work projects to meet objectives	Demonstrates satisfactory ability to participate and function effectively in team work projects to meet objectives	Function effectively in team work projects to meet objectives
MEEN5C: Ability to communicate effectively with team members	Fails to communicate effectively with team members	Shows limited and less than adequate ability to communicate effectively with team members	Demonstrates satisfactory ability to communicate effectively with team members	Communicates properly and effectively with team members

Indicate the extent to which you agree with the above statement, using a scale of 1-4 (1=None; 2=Low; 3=Moderate; 4=High)

#	Name	Criteria (MEEN4A)	Criteria (MEEN5A)	Criteria (MEEN5B)	Criteria (MEEN5C)
1	**Abdullah ALSufayan**	4	4	4	4
2	**Hadi Al Harbi**	4	3	4	4
3	**Saad Al-Faris**	4	4	3	4
4	**Abdulmohsen ALWayel**	4	4	4	3
5	**Abdullah M Alqahtani**	3	4	4	4

Comments on individual members

Name	Comments
Abdullah ALSufayan	It was an experience rich with theoretical and practical information and skills learned.
Hadi Al Harbi	Through the project, we had to use Solidwork to design the prototype of your project, but in an advanced way which is great for our skills.
Saad Al-Faris	Project Plan is very important to complete the tasks assigned to us to achieve excellent project results.
Abdulmohsen ALWayel	The Gantt chart was an important factor in facilitating the correct distribution of tasks.
Abdullah M Alqahtani	It was wonderful cooperation between team members which made the tasks easier for us

Appendix B: Engineering standards (Local and International)

- The motor uses the standard IEC 60034-1.
- The Evaporating Cooling Pad (ECP), made of cellulose paper.
- The cooler body we choose plastic. This material that we choose is high density of Polypropylene (PP) from polymers.

Various of Standards	
ASME	American Society of Mechanical Engineers
ISO	International Organization for Standardization
ASTM	American Society for Testing and Materials
IEC	International standard of the International Electrotechnical Commission for rotating electrical machinery

Appendix C: CAD drawings and Bill of Materials

3.5.1 Blower Motor by Solidwork

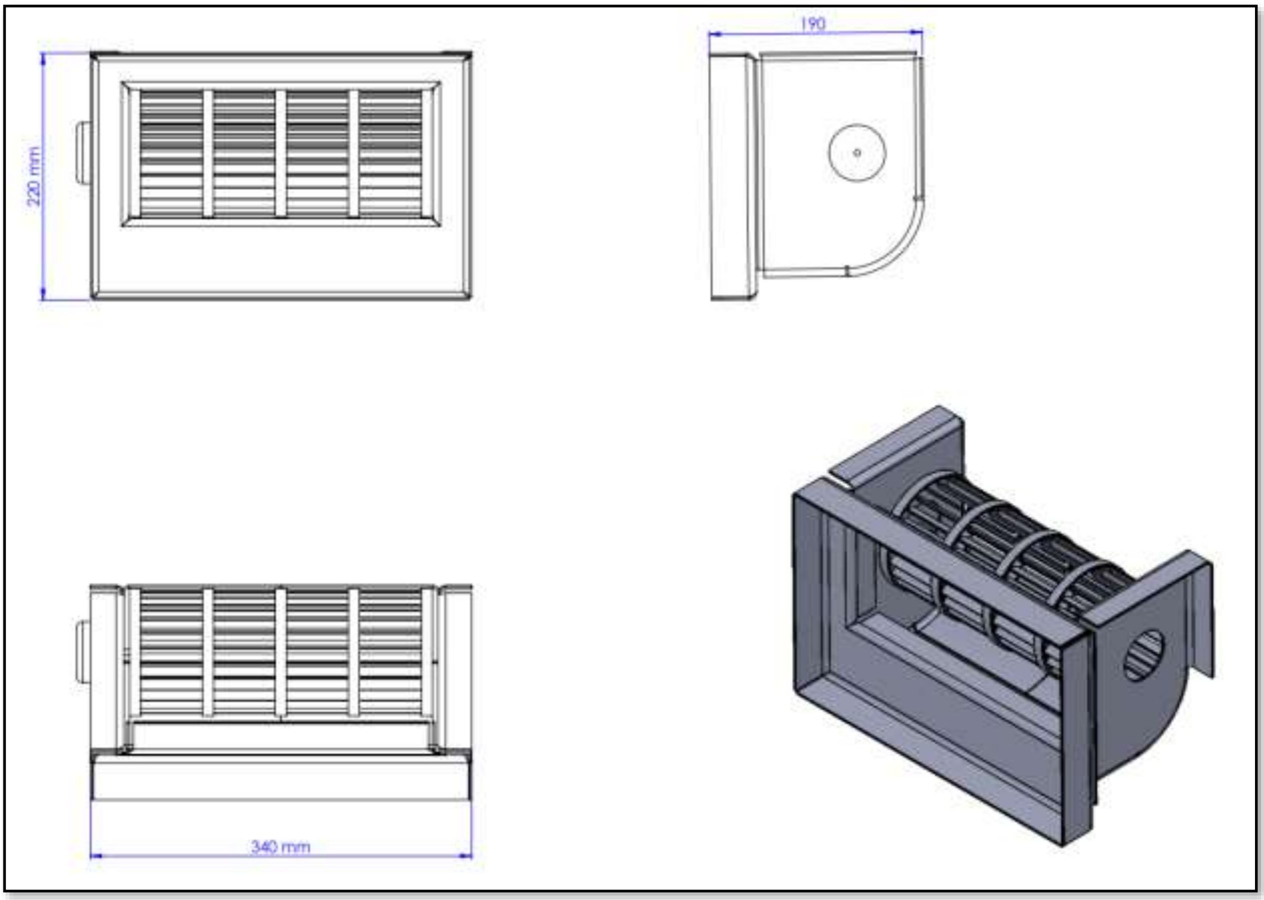


Figure (17) Blower with Motor by Solidwork

3.5.2 Evaporator pads by Solidwork

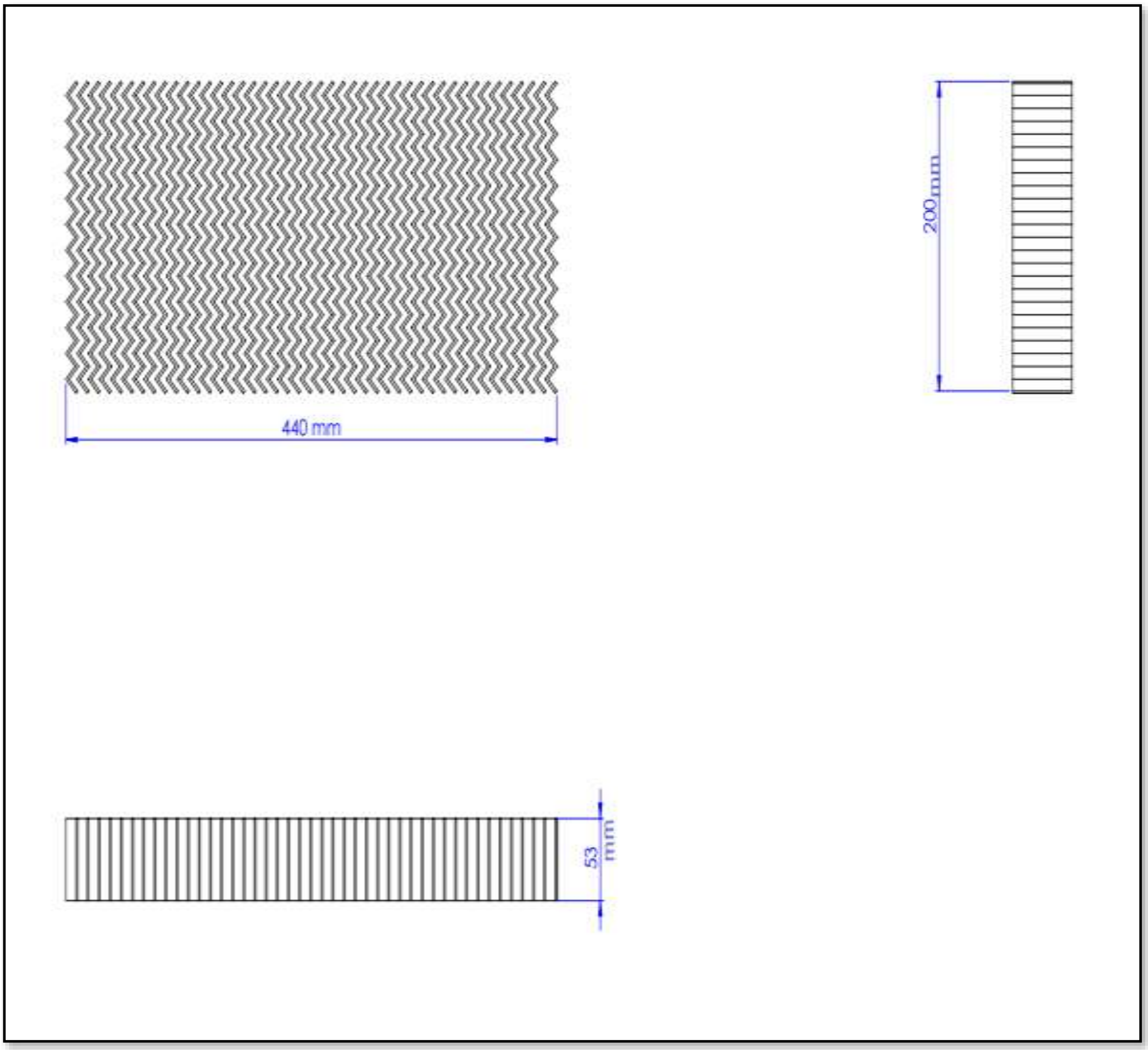


Figure (18) Evaporator pads by Solidwork

3.5.3 Water pump by Solidwork

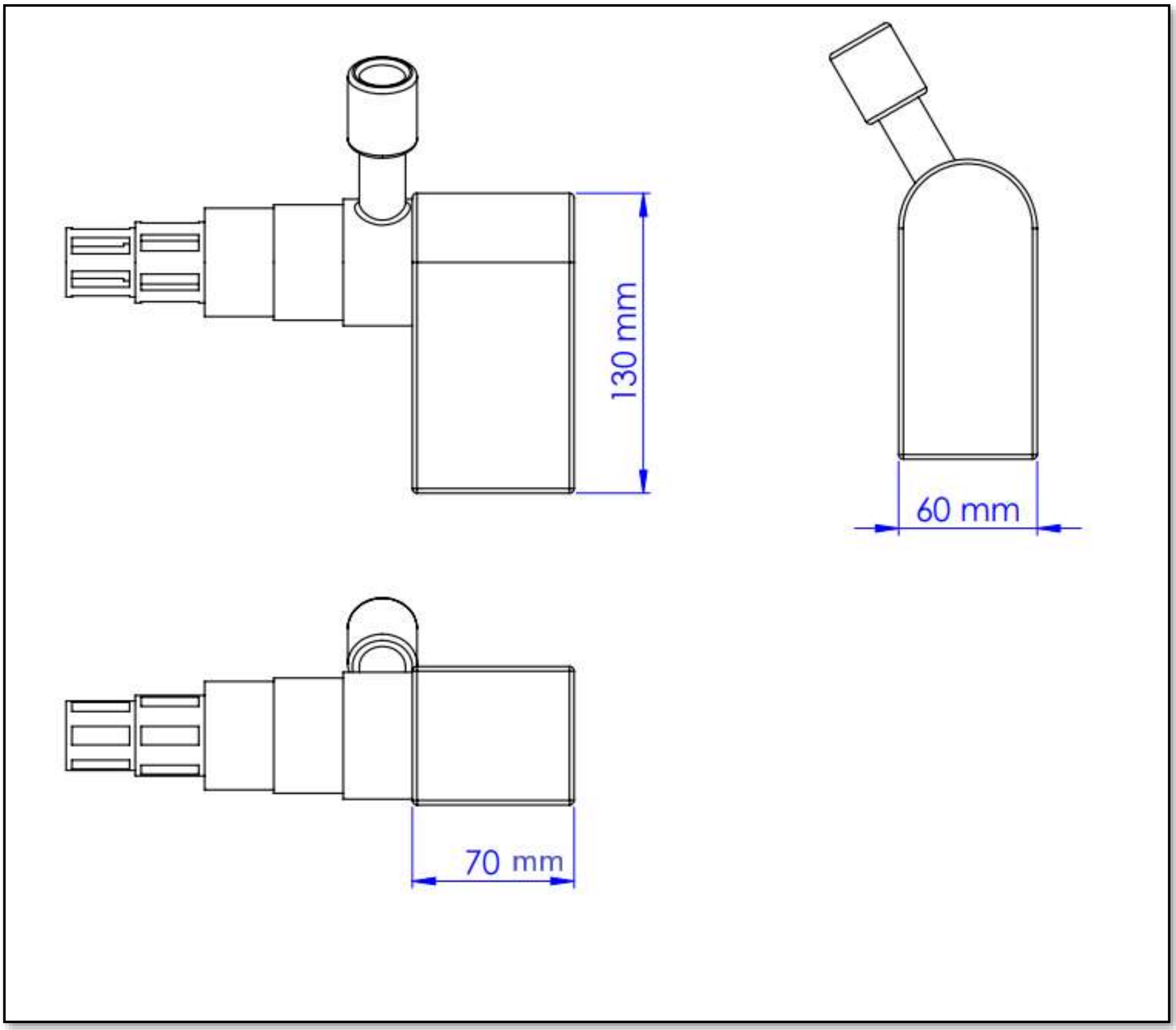


Figure (19) Water pump by Solidwork

3.5.4 Digital Thermometer by Solidwork

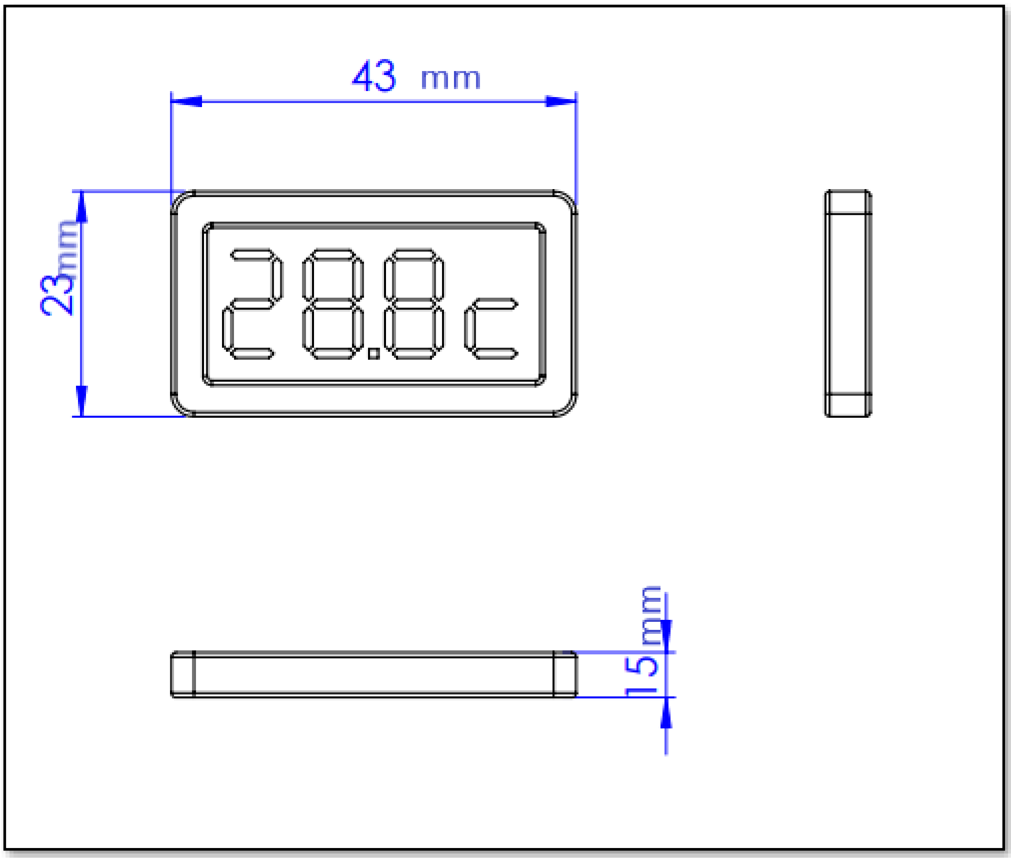


Figure (20) Digital Thermometer by Solidwork

3.5.5 Cooler body by Solidwork

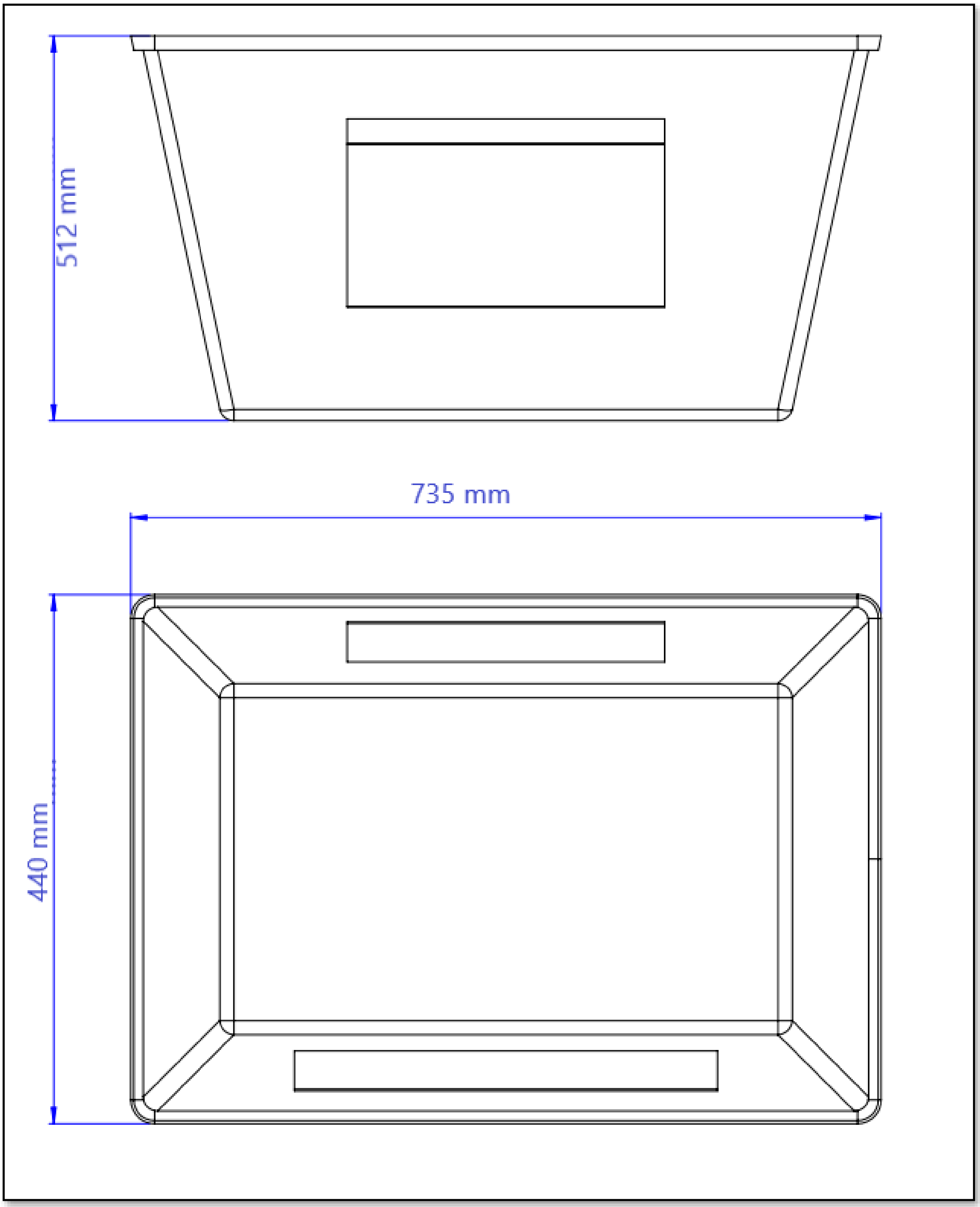


Figure (21) Table Cooler body by Solidwork

3.5.6 Assembly of Desert Cooler by Solidwork

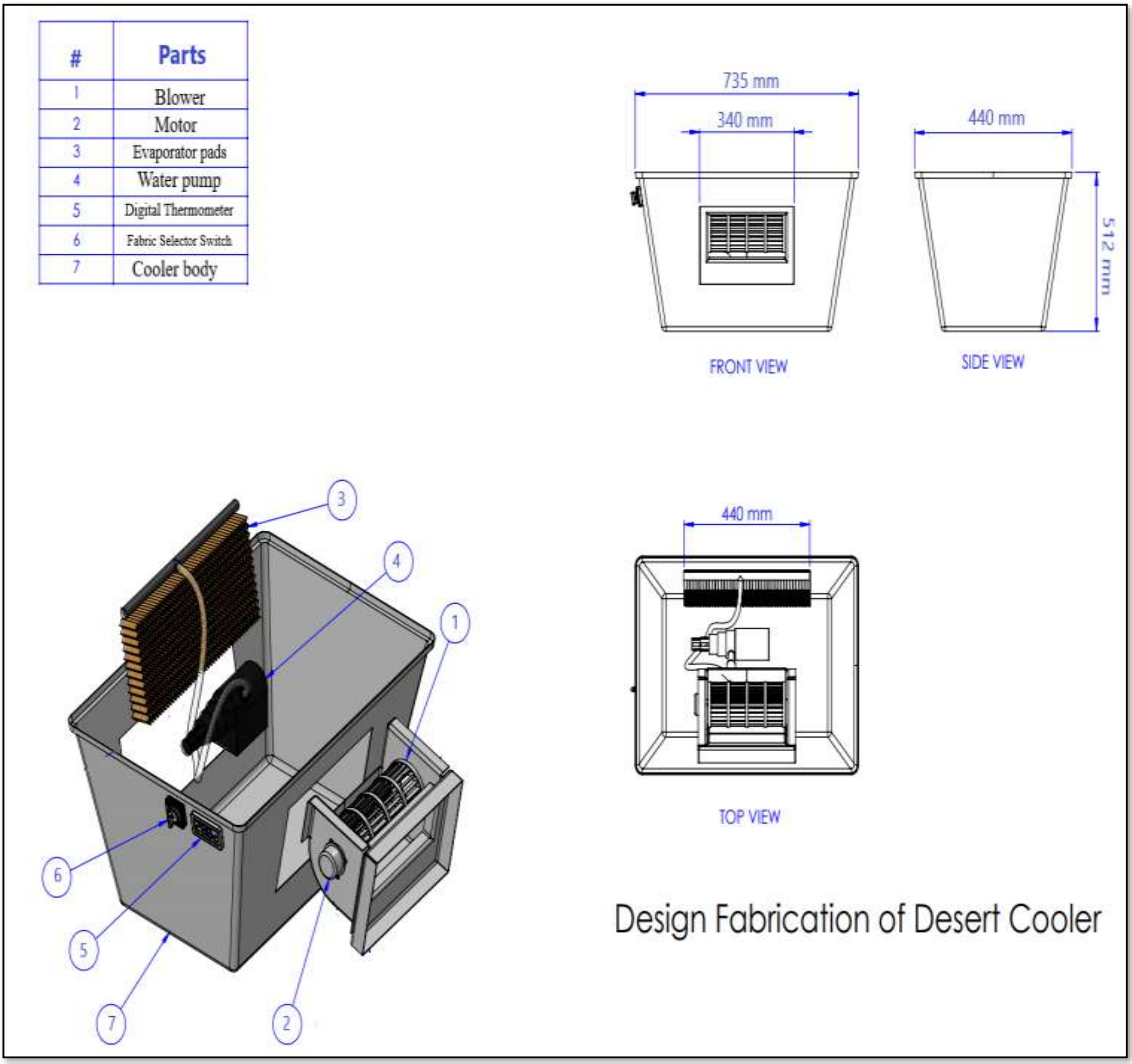
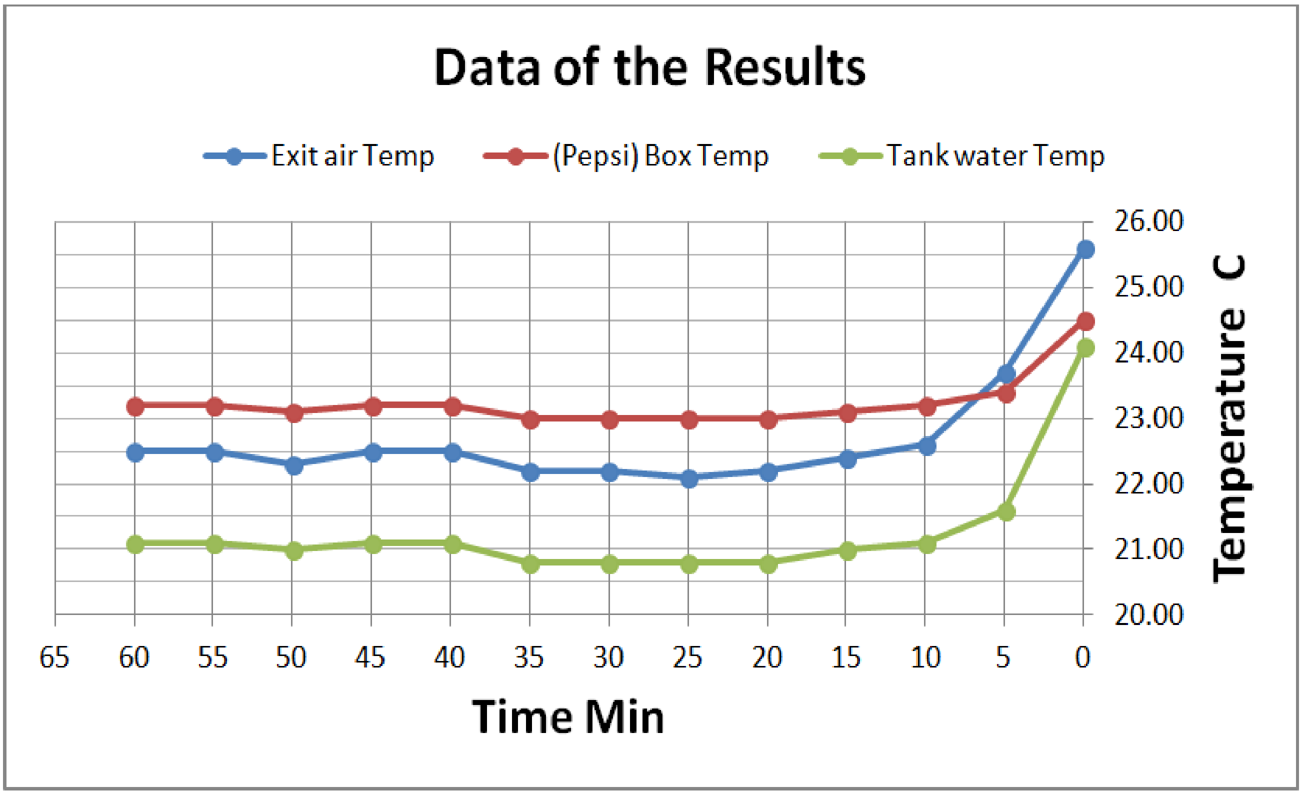


Figure (22) Assembly of Desert Cooler by Solidwork

Appendix D: Datasheets

Table (6) Data of the Results

Time (Minutes)	(Pepsi) Box Temp	Tank water Temp	Exit air Temp	Humidity
0	24.5	24.1	25.6	66%
5	23.4	21.6	23.7	67%
10	23.2	21.1	22.6	66%
15	23.1	21.0	22.4	67%
20	23.0	20.8	22.2	67%
25	23.0	20.8	22.1	67%
30	23.0	20.8	22.2	67%
35	23.0	20.8	22.2	67%
40	23.2	21.1	22.5	67%
45	23.2	21.1	22.5	67%
50	23.1	21.0	22.3	67%
55	23.2	21.1	22.5	67%
60	23.2	21.1	22.5	67%



Data of the Results
Exit air Temp
(Pepsi) Box Temp
Tank water Temp
26.00
25.00
24.00
23.00
22.00
21.00
20.00
Temperature C
65
60
55
50
45
40
35
30
25
20
15
10
5
0
Time Min

Appendix E: Operation Manual

OPERATION INSTRUCTION

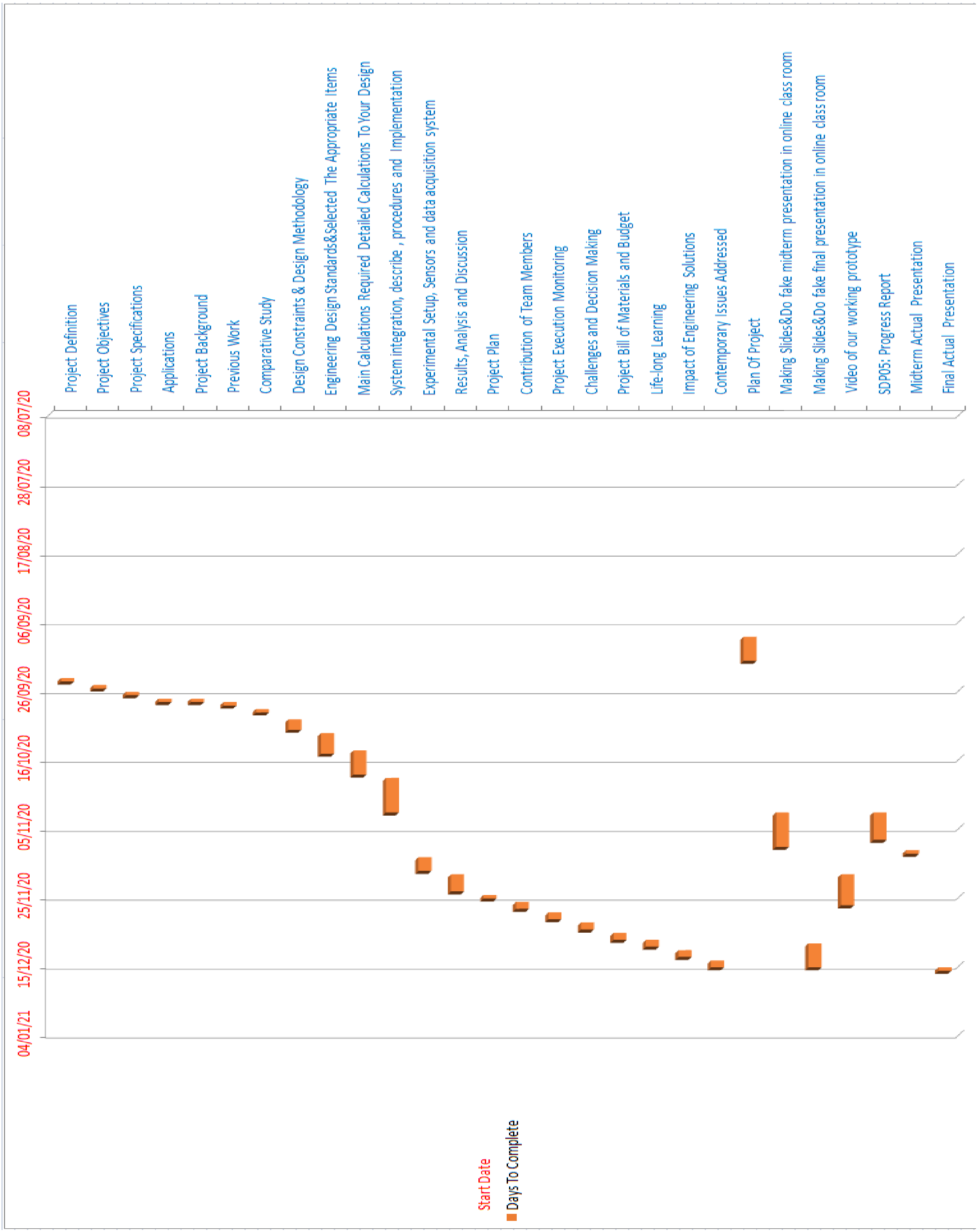
Cooling Operation

1. Put the water in the water tank.
2. Put the frozen crystals into the water tank.
3. Add clean water into the water tank and ensure the water level is between the “Min” and the “Max”level.
4. Turn the button to turn on the appliance.

Appendix F: Gantt Chart

#	Tasks			Start	End	Duration
1	Introduction	**Chapter (1)** Project allocation + Introduction	Project Definition	23/09/2020	23/09/2020	1
			Project Objectives	25/09/2020	25/09/2020	1
			Project Specifications	27/09/2020	27/09/2020	1
			Applications	29/09/2020	29/09/2020	1
2		**Chapter (2)** Literature Review	Project Background	29/09/2020	29/09/2020	1
			Previous Work	30/09/2020	30/09/2020	1
			Comparative Study	02/10/2020	02/10/2020	1
3	System Design	**Chapter (3)** Design	Design Constraints & Design Methodology	05/10/2020	07/10/2020	3
		Equipment & Material selection	Engineering Design Standards & Selected The Appropriate Items	09/10/2020	14/10/2020	6
		Theory & Theoretical Calculations	Main Calculations Required Detailed Calculations To Your Design	14/10/2020	20/10/2020	7
		Prototype assemble	System integration, describe , procedures and Implementation	22/10/2020	31/10/2020	10
4	System Testing & Analysis	**Chapter (4)** Testing & Analyses	Experimental Setup, Sensors and data acquisition system	14/11/2020	17/11/2020	4
			Results, Analysis and Discussion	19/11/2020	23/11/2020	5
5	Project Management	**Chapter (5)** Project Management	Project Plan	25/11/2020	25/11/2020	1
			Contribution of Team Members	27/11/2020	26/11/2020	2
			Project Execution Monitoring	30/11/2020	01/12/2020	2
			Challenges and Decision Making	03/12/2020	04/12/2020	2

	& Project Analysis		Project Bill of Materials and Budget	06/12/2020	07/12/2020	2
6		**Chapter (6)** Project Analysis	Life-long Learning	08/12/2020	09/12/2020	2
			Impact of Engineering Solutions	11/12/2020	12/12/2020	2
			Contemporary Issues Addressed	14/12/2020	15/12/2020	2
7	Conclusion & Recommendation	**Chapter (7)** Conclusion & Recommendation	Conclusion	14/12/2020	14/12/2020	1
			Future Recommendation	15/12/2020	15/12/2020	1
8	**Design of Prototype**			22/10/2020	31/10/2020	10
9	**Parts Purchase**			01/11/2020	05/11/2020	5
10	**Manufacturing**			02/11/2020	9/11/2020	8
11	**Testing**			19/11/2020	19/11/2020	1


Project Definition
Project Objectives
Project Specifications
Applications
Project Background
Previous Work
Comparative Study
Design Constraints & Design Methodology
Engineering Design Standards&Selected The Appropriate Items
Main Calculations Required Detailed Calculations To Your Design
System integration, describe , procedures and Implementation
Experimental Setup, Sensors and data acquisition system
Results, Analysis and Discussion
Project Plan
Contribution of Team Members
Project Execution Monitoring
Challenges and Decision Making
Project Bill of Materials and Budget
Life-long Learning
Impact of Engineering Solutions
Contemporary Issues Addressed
Plan Of Project
Making Slides&Do fake midterm presentation in online class room
Making Slides&Do fake final presentation in online class room
Video of our working prototype
SDP05: Progress Report
Midterm Actual Presentation
Final Actual Presentation
08/07/20
28/07/20
17/08/20
06/09/20
26/09/20
16/10/20
05/11/20
25/11/20
15/12/20
04/01/21
Start Date
Days To Complete