POLITEKNIK
MALAYSIA
MUKAH

AN ALTERNATIVE FOR VAPOR COMPRESSION REFRIGERATOR BY USING PELTIER ELEMENT

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DEPARTMENT OF MECHANICAL ENGINEERING
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AN ALTERNATIVE FOR VAPOR COMPRESSION REFRIGERATOR BY USING PELTIER ELEMENT

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PROJECT REPORT VERIFICATION

This report entitled **An Alternative for Vapor Compression Refrigerator by Using Peltier Element** has been submitted and reviewed as to meet the conditions and requirements of project writing.

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"We declare that this report is our own work except each piece that we have explained the source"

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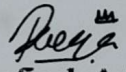
2. **Signature** : 
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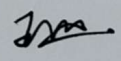
3. **Signature** : 
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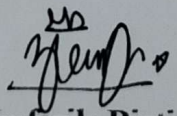
5. **Signature** : 
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Thanks for all your encouragement.

ABSTRACT

An alternative for vapor compression refrigerator by using Peltier element is another alternative that can help students to store their food especially food such as fresh milk and fruit in the hostel. This research is produced to build a refrigerator by using Peltier element and to design a device that can keep food for a longer period than the room temperature. By using an alternative for vapor compression refrigerator by using Peltier element could save much energy usage and it also can be powered by a DC current. The method that had been used to build this device are fabrication process and analysis the temperature that can be achieved by the Peltier element. As for the result for this research it has achieve the objective by producing a refrigerator by using Peltier element. The minimum temperature that can be achieved by using Peltier element is 11°C within 45 minutes.

(Keywords: Vapor compression refrigerator, thermoelectric cooling, Peltier effect, thermoelectric refrigeration)

ABSTRAK

An alternative for vapor compression refrigerator by using Peltier element adalah salah satu pendekatan yang dapat menbantu para pelajar untuk menimpan makanan seperti buah-buahan dan minuman di asrama. Kajian ini adalah untuk membina peti sejuk yang menggunakan Peltier element dan mencipta satu alat yang dapat menyimpan makanan dan minuman untuk jangka yang agak lama berbanding dengan penyimpanan di suhu persekitaran. Selain itu, dengan menggunakan an alternative for vapor compression refrigerator by using Peltier element dapat menjimatkan penggunaan tenaga dan ia juga dapat dihidupkan dengan menggunakan arus DC. Proses yang digunakan dalam penghasilan projek ini adalah dengan menggunnakan kaedah fabrikasi dan analisis suhu yang dapat dicapai oleh Peltier element. Hasil daripada kajian ini telah mencapai objektif dengan terhasilnya sebuah peti sejuk dengan menggunakan Peltier element. Suhu minimum yang dapat dicapai oleh Peltier element ialah 11°C dalam masa 45 minit.

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

This chapter will explain the introduction of the project that has been done at Politeknik Mukah's Department of Mechanical Engineering on An Alternative for Vapor Compression by using Peltier Element. The problem statement is stated to give a clear objective of the project.

1.2 PROBLEM STATEMENT

For students they had some difficulty in keeping food for a longer period especially food such as fresh milk and fruit. As we know student needs more fresh milk and fruit to keep them healthy. The fresh milk and fruit usually has their own limitation time to store them or to keep its freshness. The food such as fresh milk usually can be keep at least 4 hours after it had been open. Meanwhile, the food such as fruit usually can last for 2 until 3 days depends on the type of the fruit. So that the student should finish up the food before it get spoilt or rotten because it is hard to keep this type of fruit at the room temperature. Every type of the food has its own ideal temperature that help them to be keep for a longer period than in the room temperature. For student who life in the hostel it is hard for them to bring electric device with a high energy usage such as conventional refrigerator. This is because the conventional refrigerator needs a lot of energy to activate the component such as compressor, evaporator, expansion valve and condenser.

1.3 OBJECTIVES

The objective for this project are:

i. To build a refrigerator by using Peltier element that can be powered by DC current

ii. To design a device that can keep the fresh milk and fruits for a longer period than at the room temperature.

1.4 SCOPE

This project only for keeping the foods freshness and keeping them for a longer period than the food at the room temperature. The temperature inside the box can reach till 11°C within 45 minutes. The optimum temperature for keeping the fruit freshness is 11°C. This project is use to keep fresh milk and fruit only because it is not suitable to keep other food such as fish, chicken and meat because this device do not reach to it freezing point. This is because this device does not build to reach the freezing point.

1.5 IMPORTANT OF THE PROJECT

This project would give a big effect in a refrigeration system. This project would help many student to store food which has a limited time to store such as fresh milk and fruit. This type of food is important for them to keep them healthy. Besides that, as we know the conventional refrigerator used large amount of energy usage so that the student could not bring the conventional refrigerator to their hostel. By using an alternative for vapor compression refrigeration by using Peltier element device it would help to minimized the energy usage.

CHAPTER 2
LITERATURE REVIEW

2.1 INTRODUCTION

This chapter will explain the main theory use to produce this project and the previous research that has relation in this project.

2.2 REFRIGERATION SYSTEM

Refrigeration is a process of reducing and maintaining the temperature of a body below the temperature of its surrounding. There are many types of refrigeration such as ice refrigeration, evaporative refrigeration, air expansion refrigeration, throttling refrigeration, stem-jet refrigeration, thermoelectric refrigeration and the vapor compression system.

Vapor compression refrigeration system is the most common system in the conventional refrigeration. It can be define as the reverse heat engine (heat pump). Reverse heat engine is a thermodynamic system operating in a thermodynamic cycle which removed heat from a low temperature to a high temperature.

In the second law of thermodynamic state that it is impossible to construct a device that operates in a cycle that transfer heat from a lower temperature to a high temperature without no effect.

2.2.1 Refrigerator component

In vapor compression process it is important to raise the temperature of the refrigerant. There are four basic component that involves in vapor compression refrigeration system. They are metering devices, evaporator, compressor and condenser.

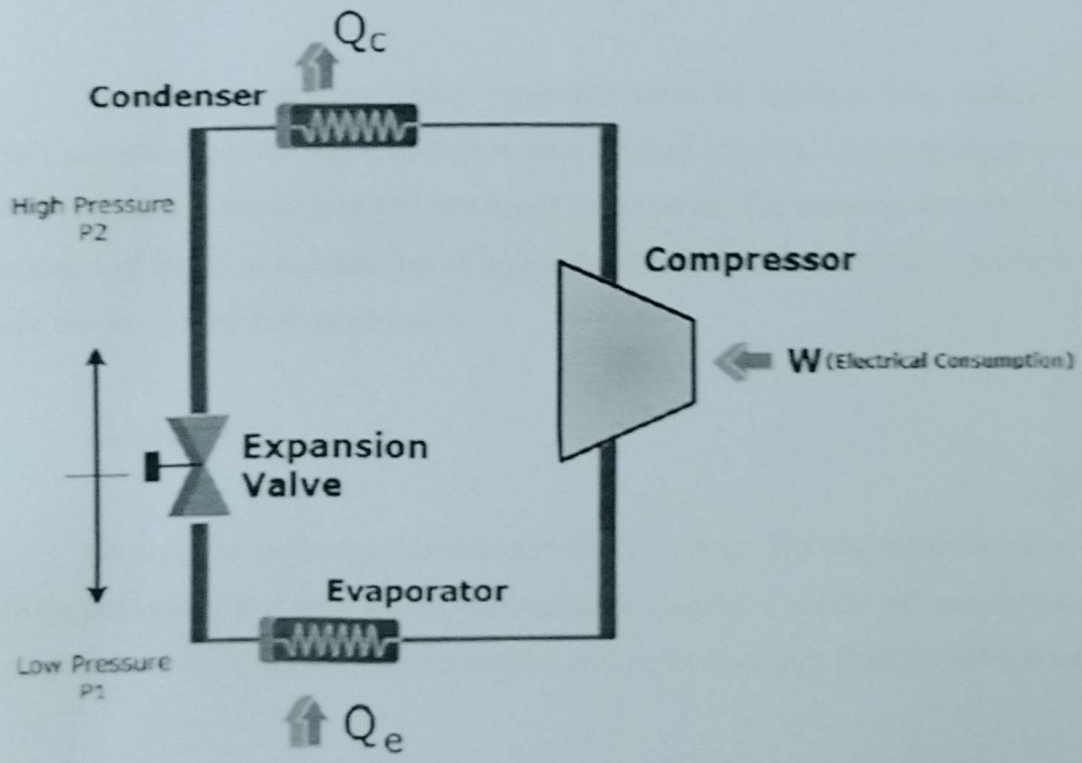


Figure 1: Basic component in the vapor compression system

i. Compressor

The heat is exposed to relative cooler in the surrounding temperature so that the heat in the refrigerant can be removed. Since the air outside is higher, the refrigerant temperature should be rise much higher. The compressor can increased the refrigerant temperature by using its pressure. When the hotter the air outside, the higher the compressor pressure could be.

ii. Condenser

Instate of absorbing heat as the evaporator, it released the heat to the surrounding. The heat is released as a vapor condenses into a liquid within the condenser.

iii. Metering devices/ expansion valve/capillary tube

The metering devices, either expansion valve or capillary tube, reduces the liquid pressure from forcing it through nozzle or small opening. Lowering the pressure of the refrigerator allows it to boil at a lower temperature. The metering devices change the steam of liquid to a dense fog of liquid droplets before it enters the evaporator to make the refrigerant boil more easily.

iv. Evaporator

The warm air in the space is blown to the evaporator. The heat in the air is absorb into the refrigerant as it boils within the evaporation tubing. The heat will remain inside the refrigerant while the air flows to another area to be discharge from the refrigerant.

2.2.3 Merit and demerit of the conventional refrigerator

Merit of the conventional refrigerator

i. Can reach freezing temperature
ii. Has various design and size
iii. Can store food for a longer period

Demerit of the conventional refrigerator

i. High energy usage
ii. Not environmental friendly

iii. High maintenance cost

iv. Not a portable device

2.3 PELTIER ELEMENT

2.3.1 Introduction

Thermoelectric are based on Peltier effect that had discover by the French physicist, Jean Charles Athanase Peltier in the year of 1834. He found that an electric current flow through the two dissimilar semiconductor it will cause the temperature different. The Peltier element is one of the three thermoelectric effect, while the other two known as Seebeck effect and Thomson effect. This three thermoelectric effect is connected to each other by a simple relationship.

The common thermoelectric module is manufactured by using two thin ceramic wafers with a series of P-type and N-type doped bismuth-telluride semiconductor material. On the both side of the thermoelectric adds the necessary electrical insulation such as ceramic material. The n-type has an excess of electron meanwhile the p-type has a deficit of electron. The thermoelectric coupes are electrically in series and thermally in parallel. Thermoelectric module can be contain one to several hundred couples.

As the electron moves from the p-type electron to n-type electron will absorbing the thermal energy and it will be a cold side. Meanwhile, the hot side will occur when the n-type electron move to the p-type electron. This thermoelectric can be used to heat or to cool by depending on the direction of the current that had been supply.

2.3.2 What is Peltier?

Peltier element is used to create the heat flux between the two junctions of dissimilar semiconductor materials. The Peltier element is a solid-state active heat pump that transfer heat from the other side to the another side by depending on the direction

of the current that had been supply to the Peltier element. Peltier element are used as a cooling or heating element, a temperature controller and a thermoelectric generator. Peltier element has two dissimilar semiconductor material that would produce heating or cooling. When there is a current flow through the Peltier element, one side of the semiconductor material will bring the heat from the other side to another. This will cause one side of the Peltier element to be hot while the other side will be cool.

2.3.3 Construction

The Peltier module is manufactured using two tiny ceramic plate with a series of p-type and n-type of unique semiconductors materials. This type of semiconductor is used because they had different electron densities. A couple of thermoelectric is made of one p-type and one n-type and this two semiconductor is placed in thermally parallel to each other and electrically in series. A thermoelectric module can contain of many thermoelectric couple. The n-type material has an excess of an electron while the p-type deficit electron. As the electrons move from p-type to the n-type through the electric current, the electron increase to a higher energy state that absorbing the thermal energy. Then, the electron from n-type flow to the p-type through an electric current and it caused a drop of energy state and released energy as heat to the heat sink. When the energy is released to the heat sink, it will remain at ambient temperature, while the cooled side will goes below room temperature. The thermoelectric can be used to heat or cool by depending on the direction of the current supplied onto it.

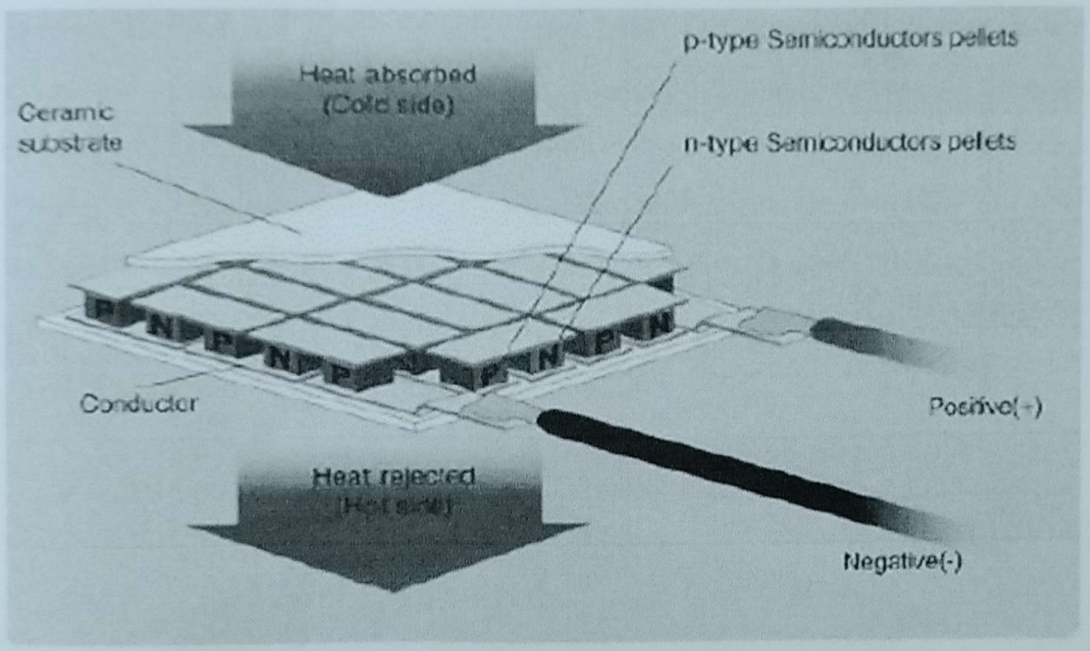


Figure 2: The Peltier element

2.3.4 Structure and function

Since the thermodynamic cooling system and conventional system are usually compared. The best way to show the different between thermodynamic cooling and conventional system is to describe the system themselves. In a conventional system contain 3 main part such as an evaporator, compressor and condenser.

A thermoelectric cooling has a similar part. The heat is absorb by the electrons as they pass from low energy level to a higher energy level at the cold junction. The p-type semiconductor element has low energy level, while the n-type has the higher energy level. When the power is supply to the Peltier it will cause the electron to move through the system. The heat is removed to the heat sink at the hot junction. The heat is removed as the electron move from high energy level (n-type) to the lower energy level (p-type).

2.3.5 Commercial Peltier device

A single Peltier element can be used as an electrical power or as a pump heat. The power output of a single Peltier element is not sufficient for realistic situation either

used as an electrical power or as a pump heat. The commercial Peltier device are composed of many n-type and p-type semiconductor that used to increase the power of the Peltier element. The element are connected in series for the individual element byusing the metallic junction. In a Peltier device, the individual element are arranged so that the n-type and the p-type so that the heat flow in the same direction.

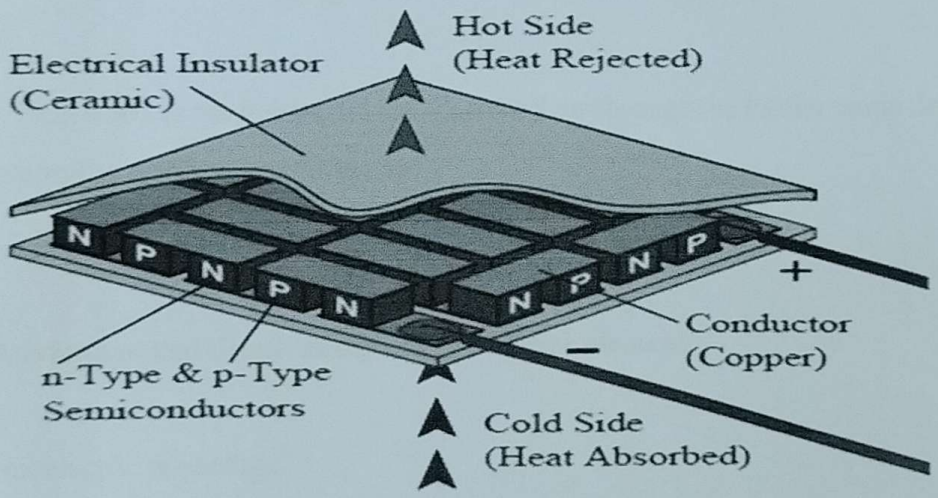


Figure 3: The design of a commercial Peltier device. When current supply to the Peltier device, heat is transfer from one side to another side.

A complete Peltier device architecture consist of two electrically insulating ceramic plates sandwiching a series a series of p-type and n-type pairs joins by a copper. This design provides a large surface area improving the heat transfer for cooling and heating applications.

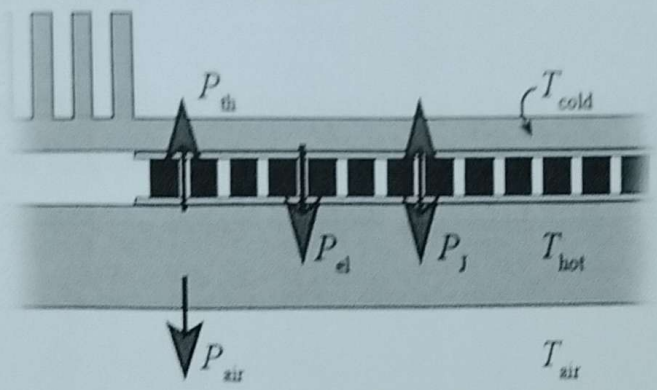


Figure 4: Heat flows in the Peltier device. Current flow through the Peltier pump devices and generates the temperature difference.

2.3.6 Advantage and disadvantage of the Peltier element

The thermoelectric advantage:

i. Does not has a moving parts so less maintenance required
ii. Does not released chlorofluorocarbons (CFC) gases
iii. Has flexible shape
iv. Has solid state construction

The thermoelectric disadvantage:

i. Only a limited amount of flux can be dissipated
ii. Heat sink is needed for heat transfer
iii. Not as efficient in terms of coefficient of performance

2.4 MODES OF HEAT TRANSFER

Heat transfer is defined as the transmission of heat energy from one region to another due to the temperature difference between two regions. Heat can be transfer in three (3) types of method. The three method of heat transfer are conduction, convection and radiation.

Conduction

Conduction is a process of heat transfer from one particle of the body to another in direction of fall temperature. The particle will remain in fixed position relative to each other.

Convection

Convection occur when there is an upward and downward movement of a gas or fluid. When a fluid is heated, it will expand and move upward. This occur because the fluid became less compact then before it had been heated. While a cold fluid became more compact and it will move downward. If the fluid move upward and downward motion there will be a flow of heat transfer call convection. Convection is the heat transfer due to flowing fluid and it can be occur in two form either gas or fluid.

Radiation

Radiation is a transmission energy through space without presence of matter or object. Radiation is an electromagnet wave move in the empty space.

2.4.1 Laws of Heat Transfer

Newton's law of cooling

Newton's law of cooling states that "heat transfer from a hot object to a cold object is directly proportional to the surface area and difference of temperature between the two objects".

$$Q = hA(T2 - T1)$$

Where,

Q= amount of heat transfer

h= coefficient of heat

A= surface area of heat flow

T1= initial temperature

T2= final temperature

Fourier's law of heat conduction

This law is an important law in heat conduction, which is represented by equation,

$$Q = kA\frac{dT}{dx}$$

Where,

Q = amount of heat flow through the object in unit time

A = surface area of heat flow

dT = temperature difference of the two faces of the object

dx = thickness of the object through the heat flows

k = thermal conductivity of the body

Table 1: Thermal conductivity for typical solid materials

Material	Thermal conductivity, k [W/m K]
Copper	350
Aluminum	236
Mild steel	50
Polyethylene	0.5
Face brick	1.0
Glass	0.9
Fireclay brick	1.7
Dense concrete	1.4
Common brick	0.6
Medium concrete block	0.5
Dense plaster	0.5
Stainless steel	14
Nylon, Rubber	0.25
Aerated concrete	0.15
Wood, Plywood	0.15
Wood-wool slab	0.10
Mineral wool expanded	0.04
Expanded polystyrene	0.035

2.5 HEAT SINK

2.5.1 Introduction

Heat sink is an electric device that used to transfer heat from a hot surface into the surrounding and cools the device/component. This is to avoid the premature failure to the component.

2.5.2 Heat sink principle

In Fourier's law of heat conduction, the heat transfer from high temperature to low temperature. This process allow the high temperature to cool down while the low temperature part help to release the heat to the surrounding.

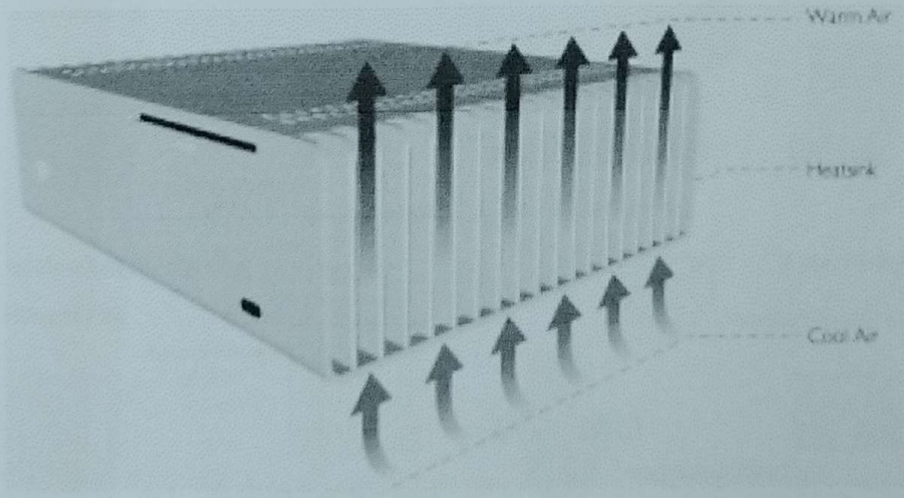


Figure 5: The principle of heat sink

Conduction took place when the two object with different temperature contact with each other. The particle of the object will transfer heat to another in direction of fall temperature. The moving particle of the high temperature object transfers thermal energy to the low temperature object and this is termed as thermal conductivity.

It is similar to the heat sink. Heat sink transfer the heat or thermal energy from a high temperature component to the other medium such as water, air and oil. Usually air is used to transfer the medium temperature, while water and oil usually used to transfer the high temperature.

2.5.3 Heat sink type

Heat sink can be classified into different categories based on its own criteria. There are two type of heat sink that are active and passive heat sinks.

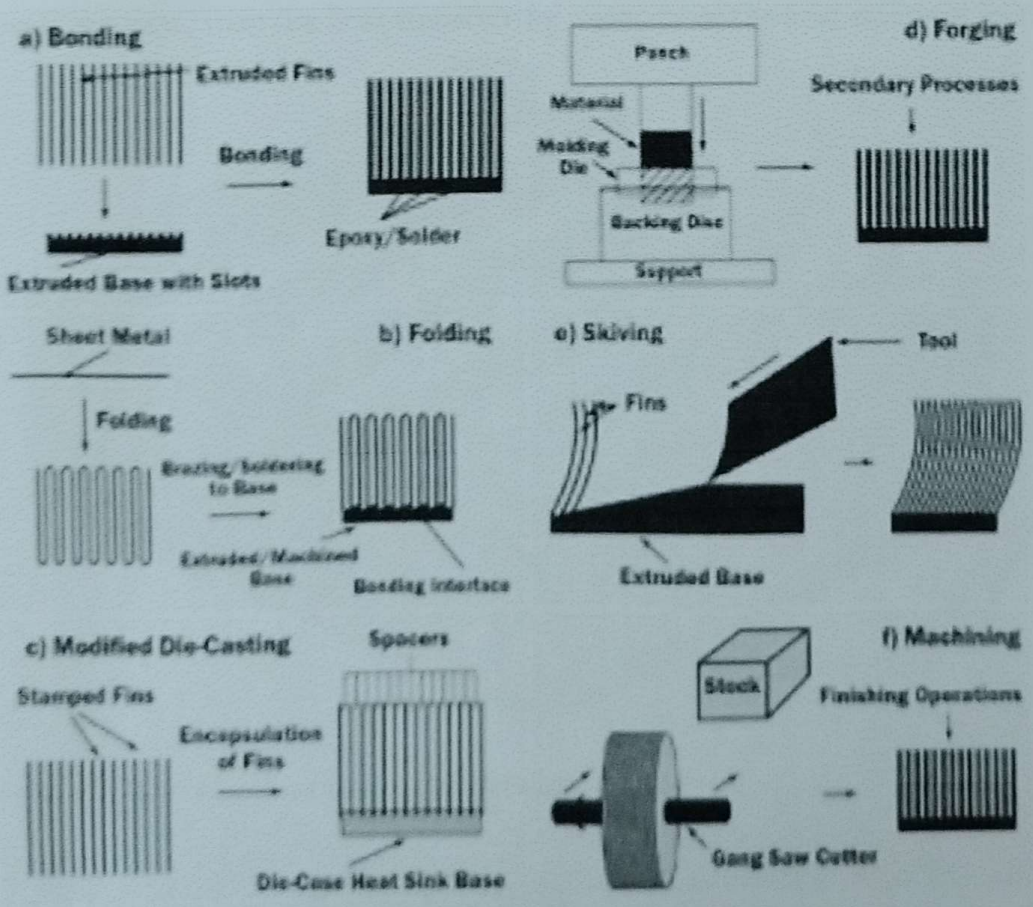


Figure 6: The type of heat sink

Active Heat Sinks

Active heat sink is a fan type and utilize power for cooling purposed. It also called as heat fan. This type of heat sink is has an excellent performance, but not for long term application as they consist of moving part.

Passive Heat Sink

Passive heat sink are made of aluminum finned radiator that transfer heat or thermal energy by using the convection process. These type are recommended to maintain the heat or thermal energy transfer in the system. If the conductivity of the metal increase, then the heat transferring capacity of the heat sink will increase.

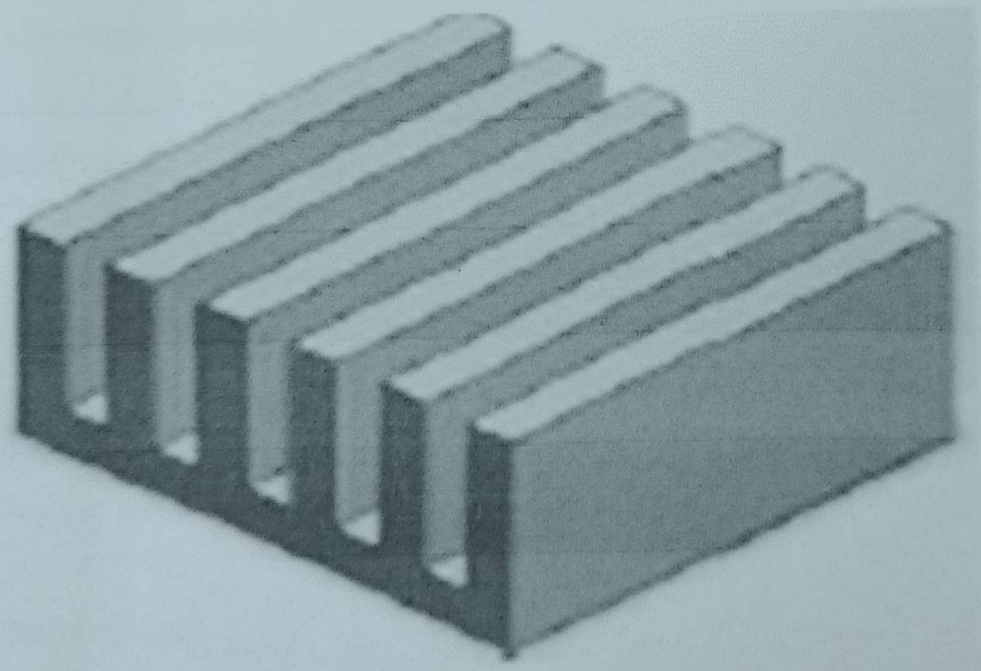


Figure 7: The aluminum type of heat sink

2.5.4 Design factor for the heat sink

There are many factor that need to be concern to produce a good thermal energy transfer such as material, fin efficiency and fin arrangement.

Material

The most common material used are aluminum alloys. This is because aluminum alloy has the higher thermal conductivity. The values of the thermal conductivity depend on the temper of the alloy.

The excellent heat sink properties in terms of its thermal conductivity and corrosion resistance such as copper. Copper has twice thermal connectivity from the aluminum. It also transfer thermal energy and more efficient heat absorption than the aluminum. But copper are three dense and more expensive than the aluminum. Copper heat sink are machined and skived while the aluminum heat sink can be extruded, but the less ductile copper cannot.

Fin efficiency

Fin efficiency is the one of the factor that makes a higher thermal conductivity. A flat plate with the heat flowing on the other side and being dissipated into the surrounding fluid as it travels to other is the consideration for the fin of a heat sink. As the heat flows through the fin, the thermal energy will dissipated to the surrounding by using air, water or oil to cool down the heat sink.

Fin arrangement

Every heat sink has the pin that extend from its base. The pin can be cylindrical, elliptical or square. There are two common fin arrangement on the market that are a pin and straight fin. The more the surface area of the heat sink has, the more efficiency it is. However, it is not always true. The concept of a pin heat sink is try to fill as much the surface area into a given volume. Kordyban has compared the performance of the pin fin and the straight fin of the heat sink with a similar dimension.

Table 2: Comparison of a pin and straight fin heat sink of similar dimensions (Adapted from data of Kordyban)

Heat sink fin type	Width (cm)	Length (cm)	Height (cm)	Surface area (cm^2)	Volume (cm^3)	Temperature difference (°C)
Straight	2.5	2.5	3.2	58	20	44
Pin	3.8	3.8	1.7	194	24	51

Another configuration is the flared fin heat sink. For this type of heat sink the fin are not parallel to each other. Flaring fin decreases flow resistance and make more air can go through the fins channel.

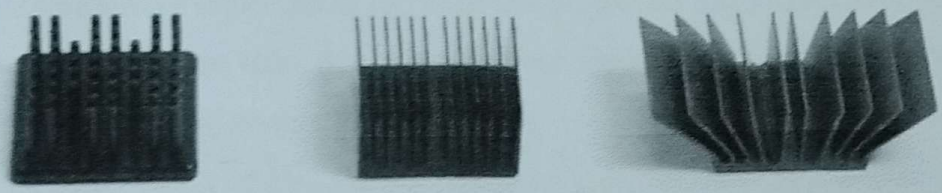


Figure 8: Pin, straight and flared fin type

2.5.5 Important of heat sink

Heat sink helps to maintain the thermal energy stability for every electrical and electronic component of any circuit. The component of electronic devices required heat sink for cooling. To preventing the premature failure of the component and improving its reliability of the component the heat generated by the component should be dissipated to the surrounding.

The performance of the heat sink depends on the choice of the material surface treatment and the air velocity. If the heat sink are not provide for an electronic circuit, then the increased chance of failure to the component. Heat sink also help to avoid the overheating of the device or component.

CHAPTER 3
METHRODOLOGY

3.1 INTRODUCTION

Methodology is the method and the procedure that had been used for this project in details. This chapter consist of introduction, project design, project planning, material used, budged of the project, fabrication process and data analysis method. This procedure is very important in carry out this project till this project to be succeed in the given period. Other than that there is some method to test the effectiveness of the evaporative cooling system for this project.

In producing a project, there are some method that should be done before it is finished. These steps should be done with conscientiously to produce a success project.

3.2 PROJECT DESIGN

Design are the one important thing to do when creating a project. In this project it had 3 design. From the three design we agree to choose design 3 as our final design.

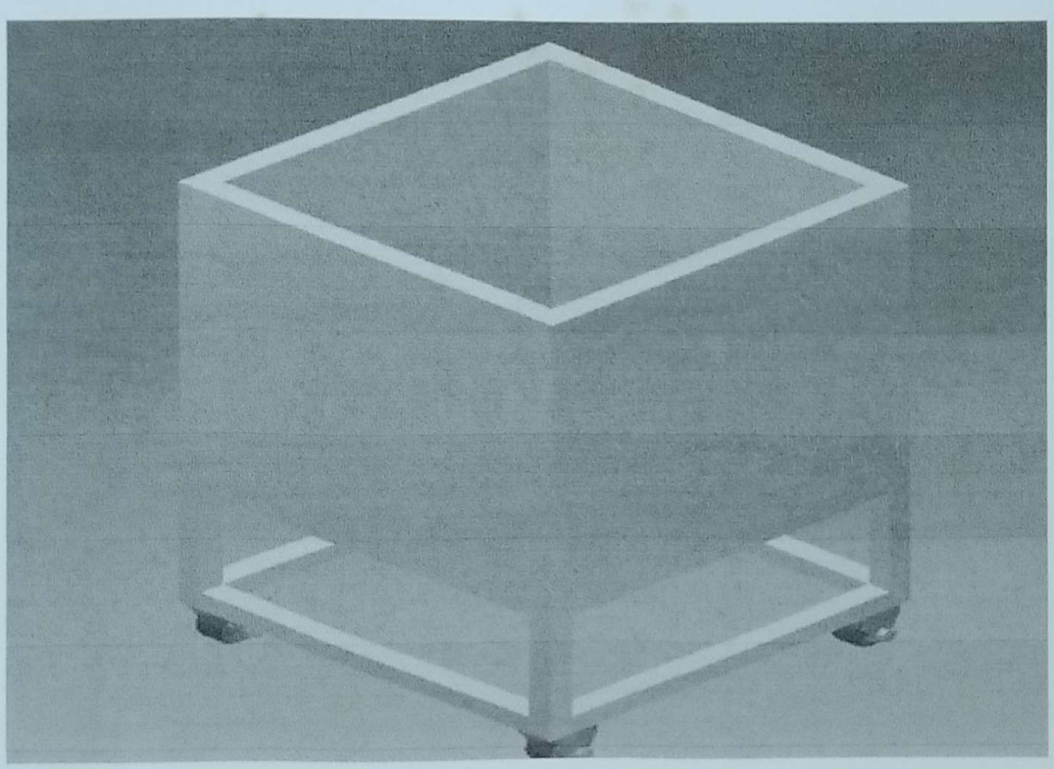


Figure 9: Design 1 of the project

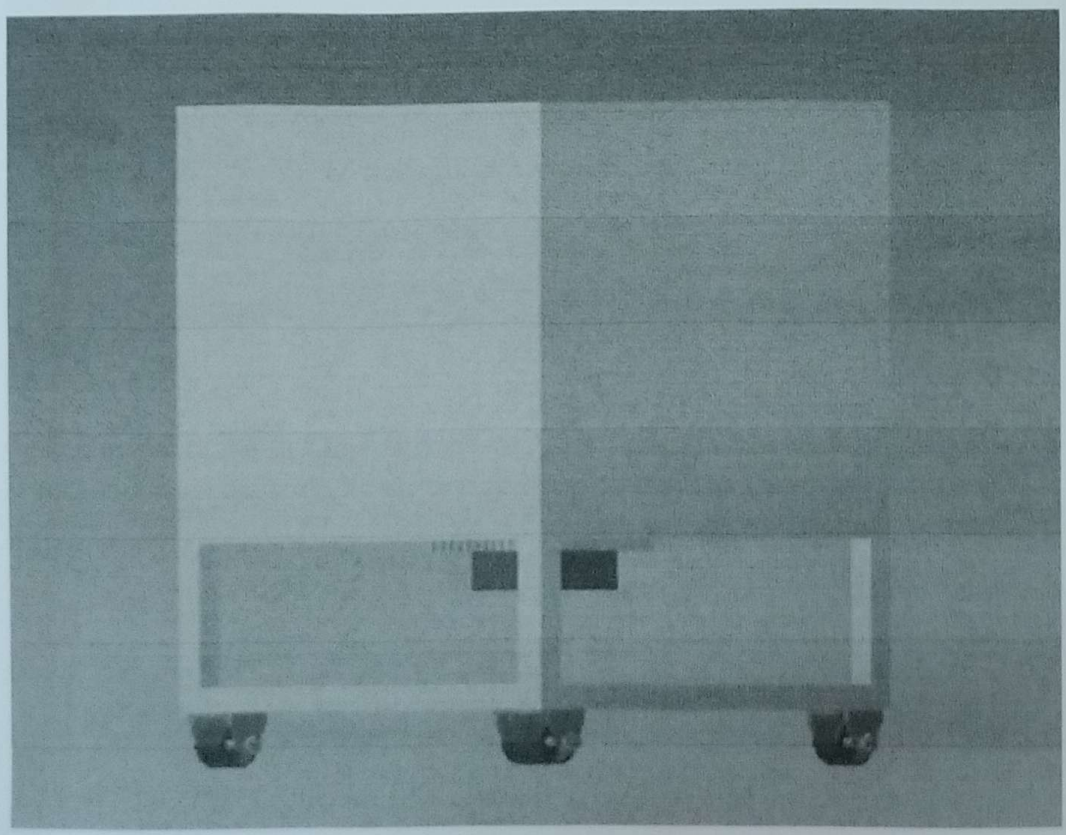


Figure 10: The side view of Design 1

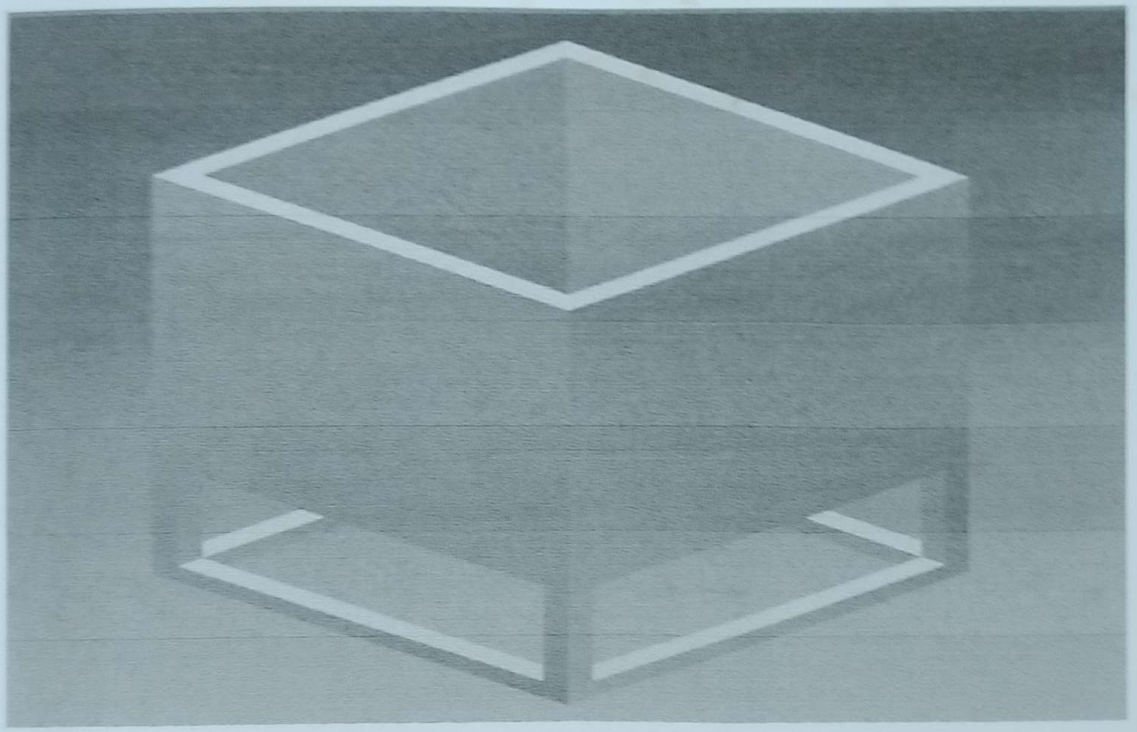


Figure 11: Design 2

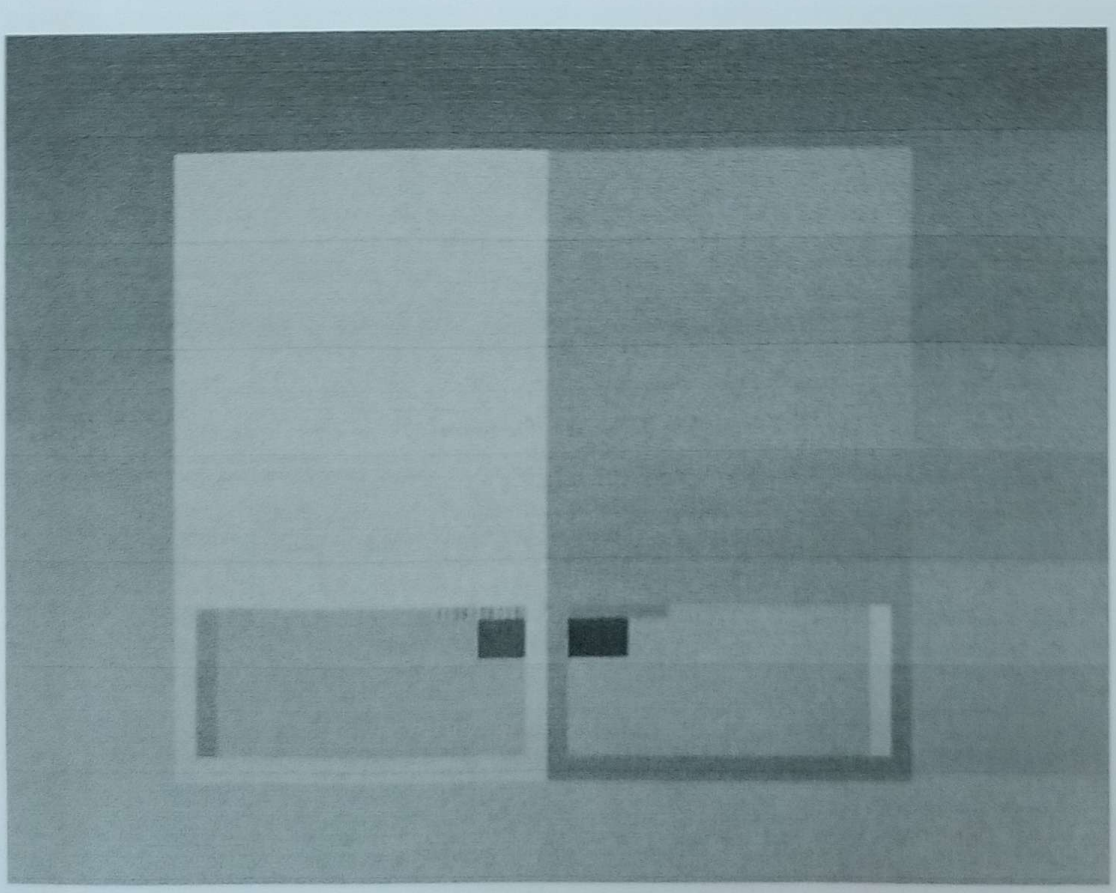


Figure 12: The side view of Design 2

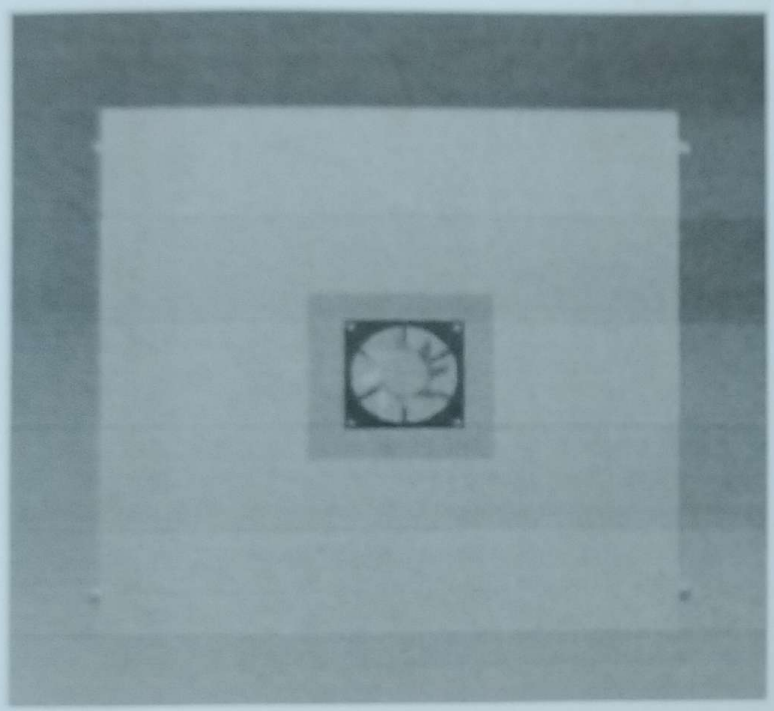


Figure 13: The top view for Design 1 & Design 2

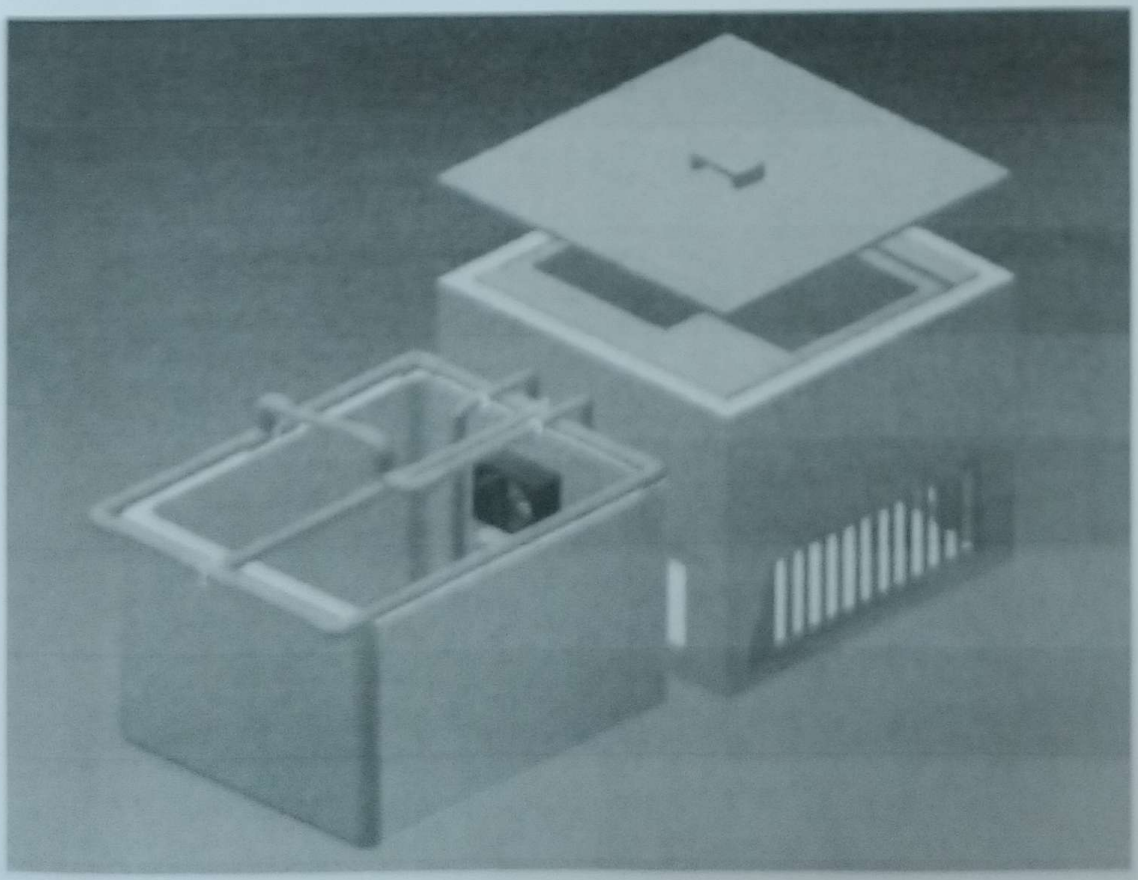


Figure 14: Design 3

Final design

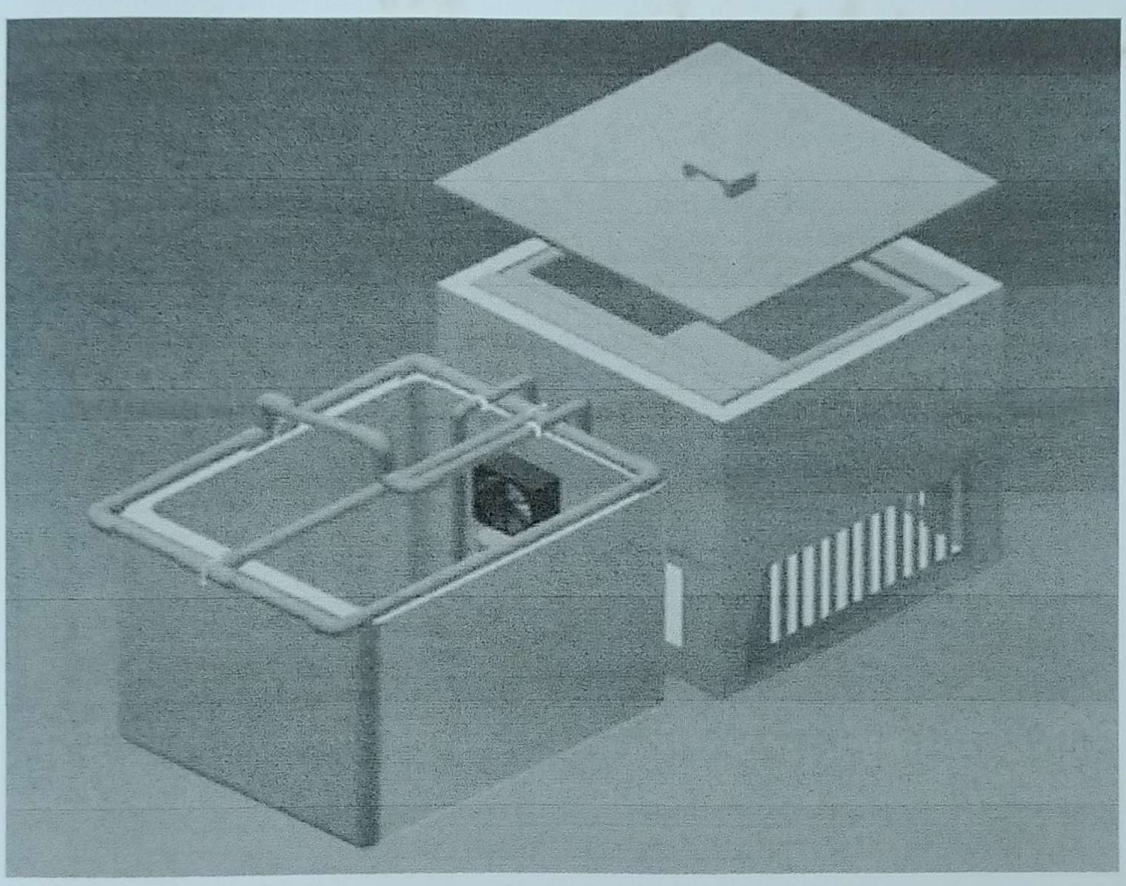


Figure 15: Final design

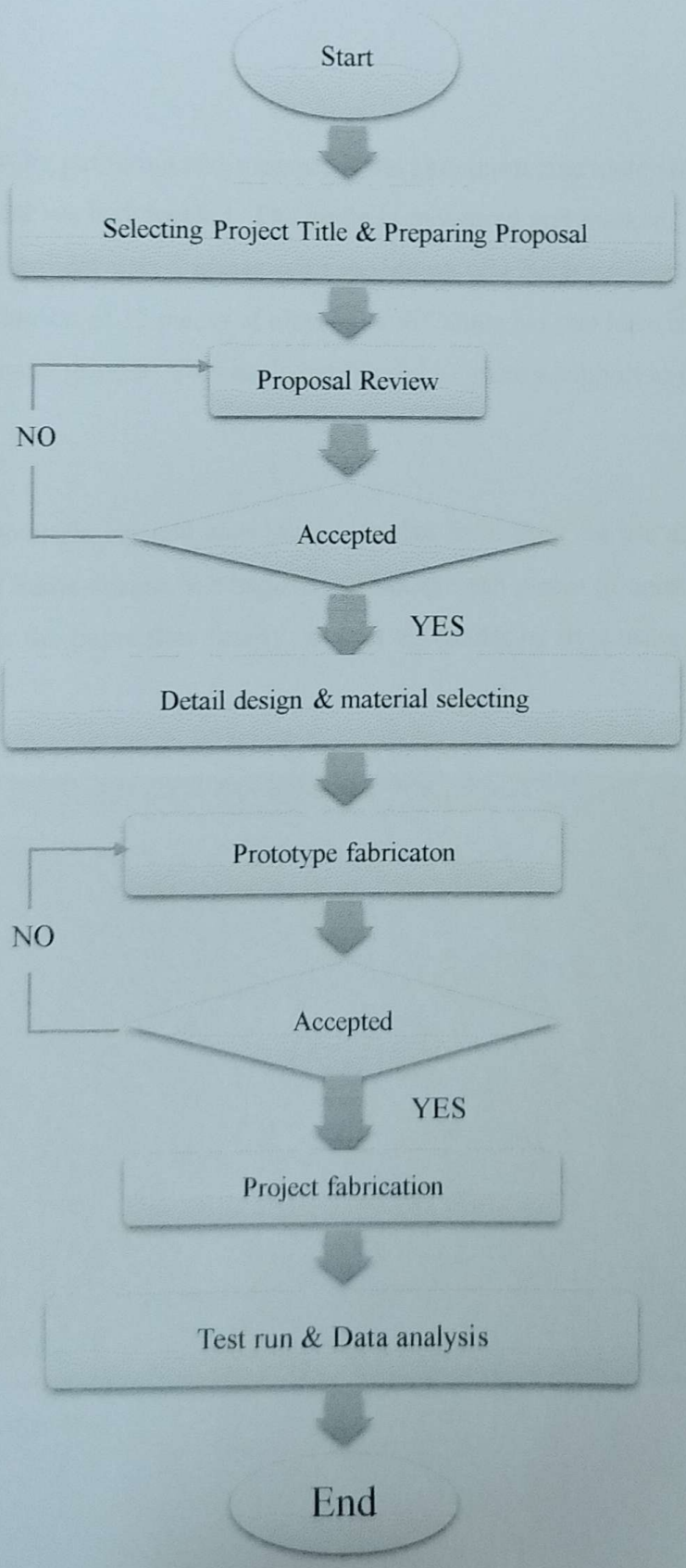
Main box

The main material that we use for our final design is polystyrene. This is because polystyrene is more vacuum than other material.

Water container

We use larger container to keep water supply because to ensure that the water did not get warm faster. We use also pipes as a chiller so that the heat transfer faster than usual.

3.3 PROJECT PLAINNING



3.4 PROJECT FABRICATION PROCESS

Outer box

i. We begin by gathering and measuring the aluminum zinc material according to the dimension that we had decided. The angle is measured and marked. Then it is cut by using a hand grinder into 5 pieces with the length of 17inch x 17inch each for the outer box. An addition of 12 pieces of aluminum 90° angle bar that have been measured and cut using a hand grinder. This angle bar is used to make a support to the aluminum zinc.

ii. All of the angle bar and aluminum zinc that have been cut are attach together according to the frame design. We begin by grinding the 5 pieces of outer box together and 12 pieces for the frame then finally connect altogether by rivet using the riveter as shown in figure.

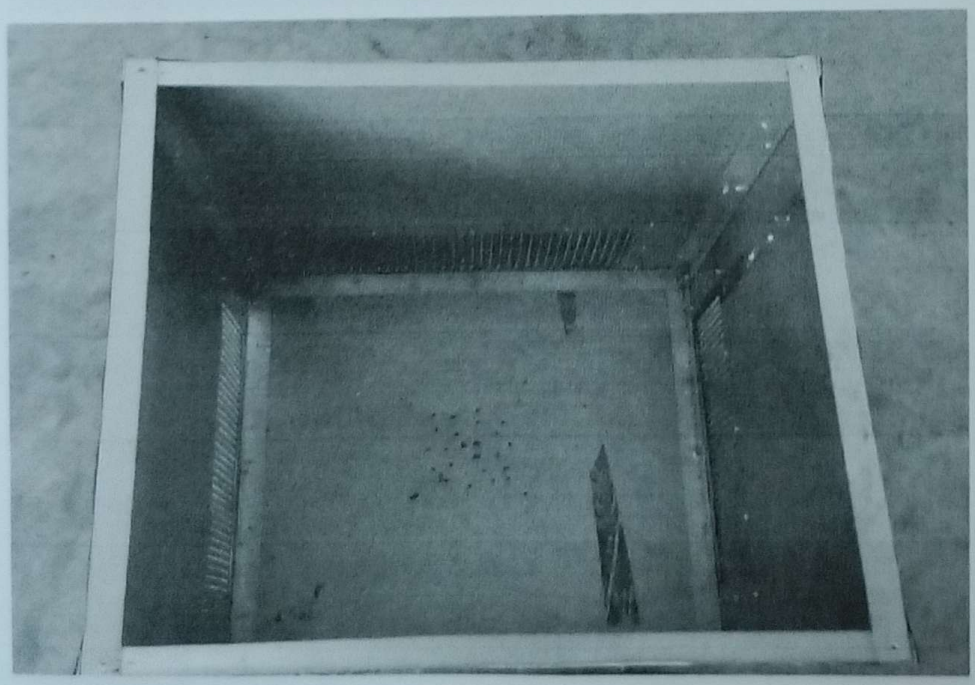


Figure 16: The outer box

ii. After that, we make the base inside the box. We use the aluminum 90 ° angle bars and Perspex then cut using hand grinder. Finally before we connect altogether by using riveter and paint the Perspex using spray, we make a hole for the fan at the Perspex.

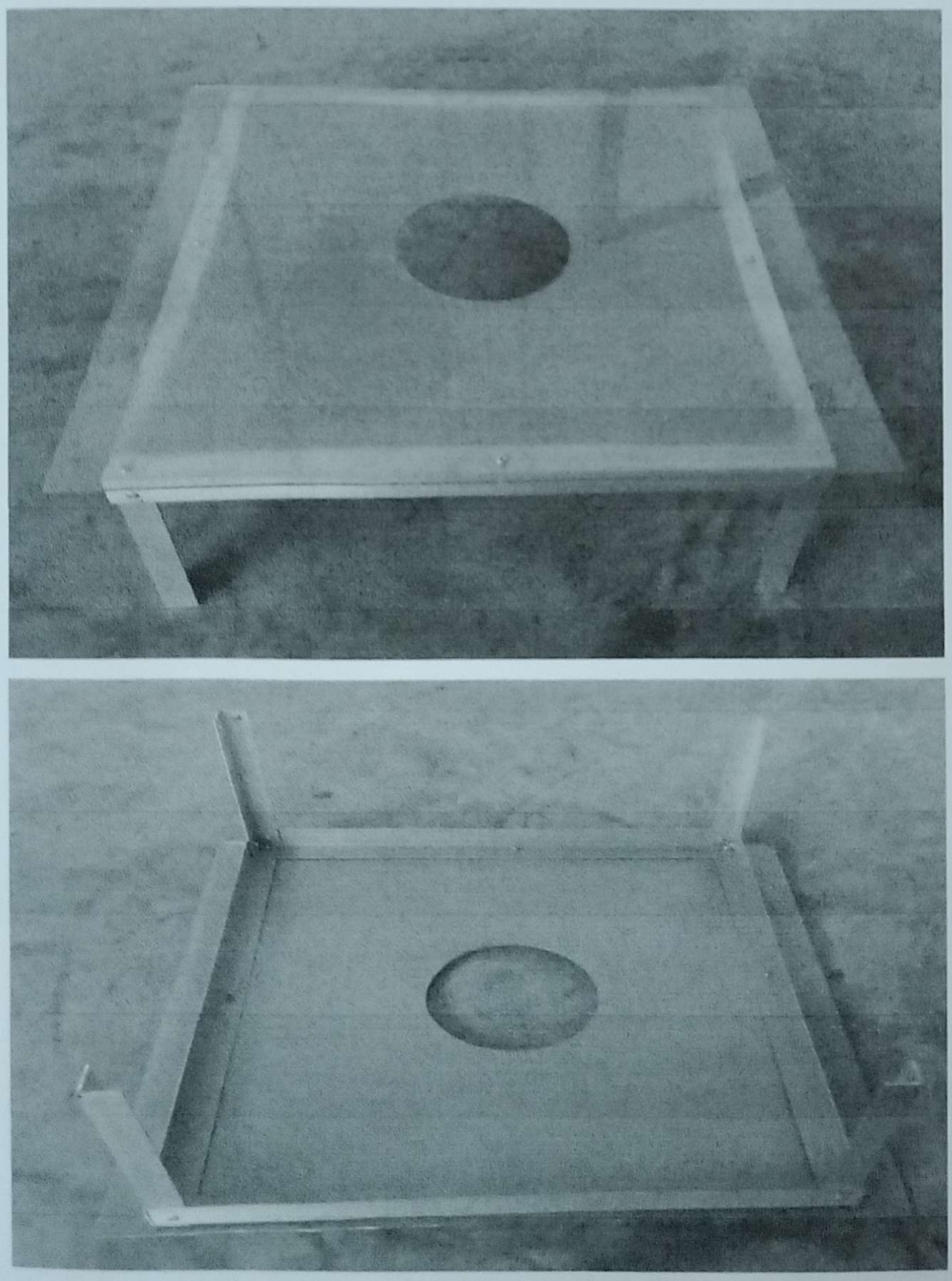


Figure 18: The base inside the box

Base inside the box

i. Base inside the box are the main component for this project. Components that we use are Peltier element, fan, aluminum heat sink, stainless steel heat sink, power supply and battery. First of all, drill two holes at the stainless steel heat sink. Second, insert hose at the first hole. Third, stick 4 Peltier elements on top the stainless steel using thermal paste. Forth, put aluminum heat sink on top the Peltier elements. Fifth, put the fan on top the aluminum heat sink. Sixth, connect the wire for Peltier elements to the power supply and connect the fan's wire to the portable connector then to the switch.

Stainless steel heat sink

i. We begin with mark the dimensions for material of stainless steel size 8cm x 8cm x 2cm. Then, we cut the metal into 6 pieces using hand grinder.

ii. After finish cutting the stainless steel, put altogether the stainless steel and joint it using Tungsten Inert Gas (TIG) welding.

iii. Finally, to make it more look good and clean, we use metal polish as the finishing for the stainless steel heat sink

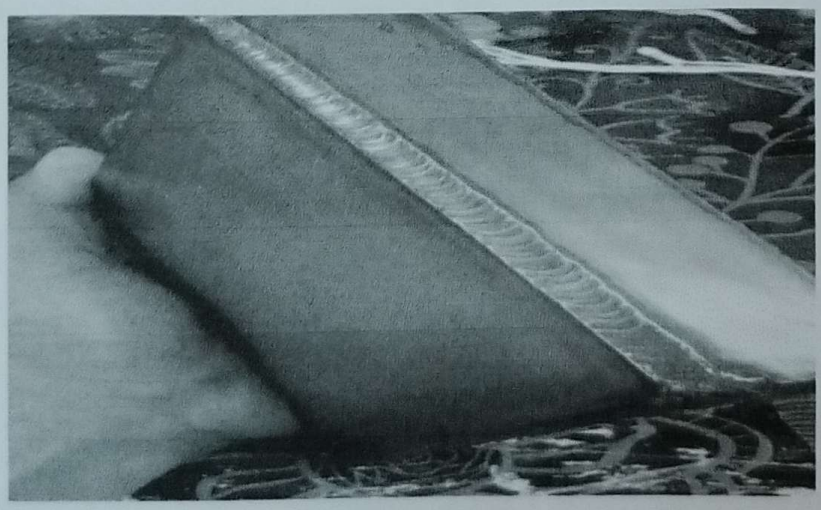


Figure 19: The stainless steel type of heat sink

Assembly

Finally, assembly the main components and a test run is made; check the temperature and the data of the test are recorded.

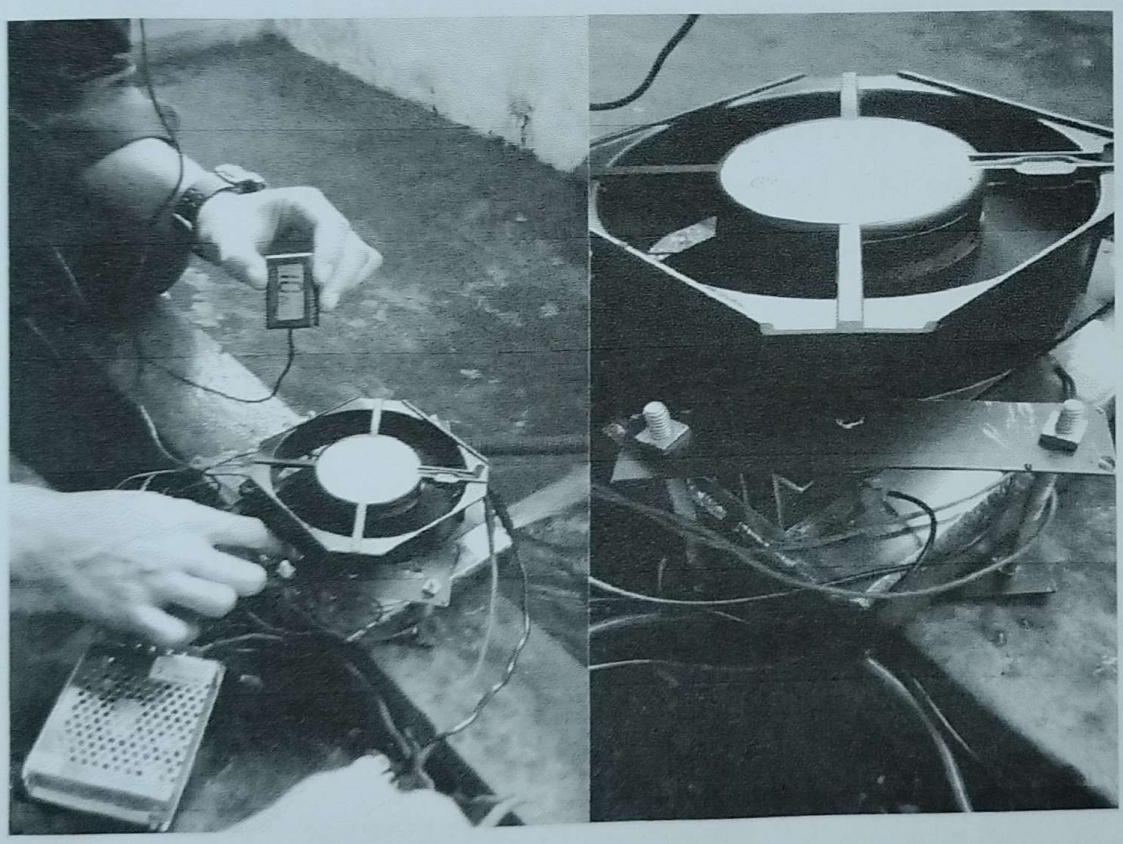


Figure 20: The assembly of the main component

3.6 DATA ANALYSIS TECHNIQUE

3.6.1 Comparison of the food

This process is used to identify which system can keep the food for a longer period either using an alternative for vapor compression refrigerator by using Peltier element or the food at the room temperature. The impact of the project is immediately realized as shelf life for the most produce is extended by 2 to 10 times more longer then the food at the room temperature without an alternative for vapor compression refrigerator by using Peltier element.

3.6.2 Experimental

Other than that, we also have conduct a simple experiment in order to know how much time needed for the Peltier element to reach 15°C. In this experiment we also want to know the duration for Peltier could maintain its temperature for 15°C.

Figure 21: The experimental technique

CHAPTER 4
RESULT & ANALYSIS

4.1 RESULT

Experimental result

From the experiment, the alternative for vapor compression refrigerator by using Peltier element that had been build the device can reach 15-19°C while the surrounding temperature is 32°C. The device can obtain 15-19°C within 45 minutes. When we used a battery as the power supply the battery only can last for 2 days.

Comparison of the food result

As for the result, we found that the tomatoes can be keep 2 days at the room temperature, while when we used the alternative for vapor compression refrigerator by using the Peltier element the tomatoes can be keep 4 days. In the surrounding temperature about 30°C the fresh milk only can be keep for 2-4 hours after the milk has been open. When, we keep the milk inside the alternative for vapor compression we found that the fresh milk could be keep for 1 days. For an apple it would last for 3 days at a room temperature. Meanwhile, the apple would last for 5 days in the alternative for vapor compression refrigerator by using Peltier element. The impact of the project is immediately realized as shelf life for the most produce is extended by more longer then the food at the room temperature with an alternative for vapor compression refrigerator by using Peltier element.

4.2 ANALYSIS

From the experiment we can conclude that the project has been achieve the objective which is to create a refrigerator by using Peltier element this can be proved when the device can reach 19°C till 15°C within 45 minutes. The temperature also can be deficient till 0°C by using proper thermal conductivity material. The second objective is to design a device that can keep the fresh milk and fruits for a longer period than at the room temperature also had been achieved when it can store food longer than at the room temperature.

CHAPTER 5

CONCLUSION

In conclusion, we can conclude that this project did achieve the objective that is to build a refrigerator by using Peltier element and to design a device that can keep the fresh milk and fruit for a longer period than the room temperature. For the future research, we suggest that to use a chiller to ensure the water do not get warm faster. It also important to choose the good thermal conductivity material so that the heat can be transfer freely so the Peltier can obtain the minimum temperature.

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ENCLOUSURE

A. Grant chart

POLITEKNIK MALAYSIA MUKAH

Grant chart

Supervisor's name: Mr. Ahmad Amin Bin Abdul Rahman

Title: An alternative for vapor compression refrigerator by using Peltier element

TASK NAME	DURATION(WEEK)	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13	Week 14
Course registration	1														
Project briefing	1														
Prototype fabrication	4														
a. Tools obtain	2														
b. Prototype assembly	2														
c. Prototype run out and analysis	1														
Project fabrication	9														
a. Project tools obtain	3														
b. Project assembly	5														
c. Project run out and analysis	2														
Thesis writing	14														
Final presentation	1														

B. Budget of project

Name of equipment	Quantity	Cost per unit Including GST	Total cost Including GST
Peltier element	4	RM 16.20	RM64.80
Aluminum Heat sink	1	RM 108.00	RM108.00
Aluminum (0.30 mm)	55 inch	RM 0.35 per inch	RM 19.50
Aluminum 90° angle bar	12	RM 1.95	RM 23.40
CPU Fan	1	RM 60.00	RM 60.00
Water Pump	1	RM 25.00	RM 25.00
Thermal Paste	1	RM 10.00	RM 10.00
Metal Polish	1	RM 10.80	RM 10.80
Battery	1	RM 158.00	RM 158.00
Isolator	1	RM 29.00	RM29.00
Perspex	1	RM 90.00	RM90.00
TOTAL AMOUNT			RM 598.50

ENCLOUSURE

A. Grant chart

POLITEKNIK MALAYSIA
MUKAH

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Final presentation	1														