Faculty Of Mechanical And Manufacturing EngineeringTechnology

PERFORMANCE ENHANCEMENT OF MINI THERMOELECTRIC REFRIGERATOR BY USING THERMOELECTRIC MODULE COOLED WITH PARAFFIN PHASE CHANGE MATERIAL (PCM) HEAT SINK

MUHAMMAD HAZIM BIN MANSOR

B091910476

Bachelor of Mechanical Engineering Technology (Refrigeration and Air-Conditioning Systems) with Honours

2023

DECLARATION

I declare that this choose an item entitled "performance enhancement of mini thermoelectric refrigerator by using thermoelectric module cooled with paraffin phase change material (PCM) heat sink" is the result of my own research except as cited in the references. The choose an item has not been accepted for any degreeand is not concurrently submitted in candidature of any other degree.

Signature :

Name : Muhammad Hazim bin Mansor

Date : 11 / 1 / 2023

APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Mechanical Engineering Technology (Refrigeration And Air-Conditioning Systems) with Honours.

Signature : ....

Supervisor Name : ALUDIN BIN MOHD SERAH
Pensyarah
Jabatan Teknologi Kejuruteraan Mekanikal
Fakulti Teknologi Kejuruteraan Mekanikal dan Pembuatan
Universiti Teknikal Malaysia Melaka

Date : 11 / 1 / 2023

DEDICATION

This study is wholeheartedly dedicated to my beloved parents, who have been my source of inspiration and gave the strength when I thought of giving up, continually provided the moral, spiritual, emotional and financial support.

To my beloved brother, sisters, friends, mentor and classmate always share the words of advice and encouragement to finish my study.

ACKNOWLEDGEMENTS

In the Name of Allah, the Most Gracious, the Most Merciful

First and foremost, I would like to thank and praise Allah the Almighty, my Creator, my Sustainer, for everything I received since the beginning of my life. I would like to extend my appreciation to the Universiti Teknikal Malaysia Melaka (UTeM) for providing the research platform.

My most appreciation goes to my main supervisor, Mr Aludin bin Mat Serah,Universiti Teknikal Malaysia Melaka (UTeM) for all his support, advice and inspiration. Herconstant patience for guiding and providing priceless insights will forever be remembered. Also, special thanks go to all assistant engineer laboratory, Universiti Teknikal Malaysia Melaka (UTeM) who constantly supported my journey.

Last but not least, from the bottom of my heart a gratitude to my beloved parents for their endless support, love and prayers. Finally, thank you to all the individu who had provided me the assistance, support, and inspiration to embark on my study.

ABSTRACT

The release of refrigerants particularly chlorofluorocarbons (CFC) and hydrofluorocarbons (HCFC) by human activities from vapor compression refrigeration systems has had a negative influence on the environment. This problem necessitates the development of more environmentally friendly and energy-efficient air-conditioning and refrigeration technologies. One of the most promising solutions to meet this need is by developing efficient thermoelectric refrigerators. Thermoelectric modules were used as the major components in this study to create a mini thermoelectric refrigerator. When electric current is supplied to a thermoelectric module, one side of the thermoelectric module becomes hot and the other side is cold. The cold side can be utilized for cooling purposes. However, the hot side of the module tends to become so hot that it requires a heat sink to efficiently dissipate the heat to the surrounding environment. The study aims to evaluate the best design of heat sink with phase change material (PCM) to reduce the hot side temperature of the module to achieve a lower cooling temperature and increase the coefficient of performance (COP) of the mini thermoelectric refrigerator. Paraffin PCM is an organic PCM that used in this study has melty temperature of 59.1 ˚C and heat of fussion (ΔH) of 127.3 kJ/kg. This thermal energy storage materials melts when the heat sink temperature of the hot side of the thermoelectric module exceeds its melty temperature. The thermoelectric module was also impacted by the type of heat sink selected. To ascertain which form of heat sink can enhance the heat rejection of a hot-side thermoelectric module, this study uses two different types of heat sinks: a copper plate heat sink and a fin heat sink. The fin heat sink can reduce the cold temperature of the thermoelectric unit better. Hence, it was chosen for this study. The data for this study and research was gathered in 1 minute interval for 10 minutes. The temperature of the cold side and hot side when copper plate PCM heat sink was used were 39.2 ˚C and 108.8 ˚C respectively. However, when fin PCM heat sink was used, the temperature of cold and hot side of thermoelectric module were 6.4 ˚C and 29.9 ˚C respectively. It become that fin PCM heat sink is a better cooling medium. The PCM was macro encapsulated in aluminium foil and the attached to the fin heat sink on the hot side of the thermoelectric module to increased the heat rejection. Therefore, a mini thermoelectric refrigerator with fin PCM heat sink was employe for future investigation superior heat rejection capability. The effectiveness of PCM as a cooling medium has was proved with experiment evidence that without PCM, the hot side temperature of the module is 29. 0 ˚C where with PCM the temperature was 27.6 ˚C. The thermoelectric refrigerator cooling space temperature also can reduce with increasing mass of PCM. When 3 gram of PCM were applied, the cooling space drops to 11.9 ˚C and achieve lower 11.0 ˚C when 6 gram of PCM was utilized. Depending on the mass of PCM, various cooling space temperature can be achieved. The coefficient of performance for a thermoelectric unit using copper plate heat is 18.22 %. On top of that, the coefficient of performance of a thermoelectric unit using a fin heat sink is 7.49 %. The use of PCM raises the thermoelectric unit's coefficient of performance to 8.34 %. Based on the results, it is possible to draw a conclusion that PCM heat sink is an efficient cooling medium of the hot side of thermoelectric module. Thus enable the mini thermoelectric refrigerator to achieve lower cooling space temperature.

ABSTRAK

Pembebasan bahan pendingin khususnya klorofluorokarbon (CFC) dan hidrofluorokarbon (HCFC) oleh aktiviti manusia daripada sistem penyejukan mampatan wap telah memberi pengaruh negatif terhadap alam sekitar. Masalah ini memerlukan pembangunan teknologi penyaman udara dan penyejukan yang lebih mesra alam dan cekap tenaga. Salah satu penyelesaian yang paling menjanjikan untuk memenuhi keperluan ini ialah dengan membangunkan peti sejuk termoelektrik yang cekap. Modul termoelektrik digunakan sebagai komponen utama dalam kajian ini untuk mencipta peti sejuk termoelektrik mini. Apabila arus elektrik dibekalkan kepada modul termoelektrik, satu bahagian modul termoelektrik menjadi panas dan sebelah lagi sejuk. Bahagian sejuk boleh digunakan untuk tujuan penyejukan. Walau bagaimanapun, bahagian panas modul cenderung menjadi sangat panas sehingga memerlukan sink haba untuk menghilangkan haba dengan cekap ke persekitaran sekeliling. Kajian ini bertujuan untuk menilai reka bentuk terbaik sink haba dengan bahan perubahan fasa (PCM) untuk mengurangkan suhu sisi panas modul untuk mencapai suhu penyejukan yang lebih rendah dan meningkatkan pekali prestasi (COP) peti sejuk termoelektrik mini. PCM parafin ialah PCM organik yang digunakan dalam kajian ini mempunyai suhu lebur 59.1 ˚C dan haba peleburan (ΔH) sebanyak 127.3 kJ/kg. Bahan simpanan tenaga haba ini cair apabila suhu sink haba bahagian panas modul termoelektrik melebihi suhu cairnya. Modul termoelektrik juga dipengaruhi oleh jenis sink haba yang dipilih. Untuk memastikan bentuk sink haba yang boleh meningkatkan penolakan haba modul termoelektrik sisi panas, kajian ini menggunakan dua jenis sink haba yang berbeza iaitu sink haba plat kuprum dan sink haba sirip. Sinki haba sirip boleh mengurangkan suhu sejuk unit termoelektrik dengan lebih baik. Oleh itu, ia dipilih untuk kajian ini. Data untuk kajian dan penyelidikan ini dikumpul dalam selang 1 minit selama 10 minit. Suhu bahagian sejuk dan bahagian panas semasa sink haba PCM plat kuprum digunakan ialah 39.2 ˚C dan 108.8 ˚C masing-masing. Walau bagaimanapun, apabila sink haba PCM sirip digunakan, suhu bahagian sejuk dan panas modul termoelektrik ialah 6.4 ˚C dan 29.9 ˚C masing-masing. Ia menjadi sink haba PCM sirip adalah medium penyejukan yang lebih baik. PCM dikapsulkan secara makro dalam kerajang aluminium dan dilekatkan pada sink haba sirip pada bahagian panas modul termoelektrik untuk meningkatkan penolakan haba. Oleh itu, peti sejuk termoelektrik mini dengan sink haba PCM sirip digunakan untuk penyiasatan masa depan keupayaan penolakan haba yang unggul. Keberkesanan PCM sebagai medium penyejukan telah dibuktikan dengan bukti eksperimen bahawa tanpa PCM, suhu sisi panas modul ialah 29. 0 ˚C di mana dengan PCM suhu adalah 27.6 ˚C. Suhu ruang penyejukan peti sejuk termoelektrik juga boleh berkurangan dengan peningkatan jisim PCM. Apabila 3 gram PCM digunakan, ruang penyejukan turun kepada 11.9 ˚C dan mencapai minimum 11.0 ˚C apabila 6 gram PCM digunakan. Bergantung pada jisim PCM, pelbagai suhu ruang penyejukan boleh dicapai. Pekali prestasi untuk unit termoelektrik menggunakan haba plat kuprum ialah 18.22 %. Selain itu, pekali prestasi unit termoelektrik menggunakan sink haba sirip ialah 7.49 %. Penggunaan PCM meningkatkan pekali prestasi unit termoelektrik kepada 8.34 %. Berdasarkan keputusan, adalah mungkin untuk membuat kesimpulan bahawa sink haba PCM adalah medium penyejukan yang cekap bagi bahagian panas modul termoelektrik. Oleh itu membolehkan peti sejuk termoelektrik mini mencapai suhu ruang penyejukan yang lebih rendah.

TABLE OF CONTENTS

		PAGE
DECLARATION		
APPROVAL		
DEDICATION		
ABSTRACT		
ACKNOWLEDGEMENTS		
TABLE OF CONTENTS		
CHAPTER 1	**INTRODUCTION**	
1.0	Introduction	1
1.1	Background	1
1.2	Problem Statement	6
1.3	Research Objective	7
1.4	Scope of Research	7
CHAPTER 2	**LITERATURE REVIEW**	
2.0	Introduction	9
2.1	The Effect of Convensional Vapor Compression Refrigerator System	9
2.2	Thermoelectric Refrigerator	11
2.3	Thermoelectric Effect	11
2.4	Heat sink	16
	2.4.1 Type of Heat Sink	17
2.5	Phase Change Materials (PCM)	20
	2.5.1 Type of Phase Change Materials (PCM)	21
	2.5.2 Advantages and Disadvantages	24
	2.5.3 Applications of PCM	25
2.6	Cooling Fan	28
2.7	Components of Thermoelectric Refrigerator	28
	2.7.1 Thermoelectric Module	29
	2.7.2 Heat Sink	29
	2.7.3 Computer Fan	30
2.8	Design of Refrigerator	30

2.9 Determination of Coefficient of Performance (COP) 31

CHAPTER 3 METHODOLOGY

3.0 Introduction 33
3.1 Flow of Project 33
3.2 Selection of Materials and Specifications 35
3.2.1 Thermoelectric Module 35
3.2.2 Insulation Cotton Washer 36
3.2.3 Digital Thermometer 37
3.2.4 Phase Change Material (PCM) Paraffin Wax 38
3.2.5 Styrofoam Box 39
3.2.6 Thermal Sheet 41
3.2.7 Thermal Paste 42
3.2.8 Copper Plate 44
3.2.9 Heat Sink (Finned) 45
3.2.10 Cooling Fan 46
3.3 Electrical Connection of Peltier Module 47
3.4 Calculation Coefficient of Performance (COP) 48
3.5 Design and Procedure 49
3.5.1 Fabrication of Thermoelectric Unit 49
3.5.2 Design of Thermoelectric Unit 55
3.5.3 Exploded View 56
3.6 Testing Procedure 57
3.6.1 Electric Current Ampere 58
3.6.2 Temperature 58
3.7 List of Material 59
3.8 Gantt Chart 60

CHAPTER 4 RESULTS & DISCUSSION

4.0 Introduction 61
4.1 Temperature of Peltier Module with various Current Quality 61
4.2 Effect of Copper Plate Heat Sink 64
4.3 Effect of Fin Heat Sink 66
4.4 Effect of Mass PCM 69

CHAPTER 5 CONCLUSION & RECOMMENDATIONS FOR FUTURE RESEARCH

5.0 Summary of Research 73

5.1 Achievement of Research Objective 75
5.2 Significant of Research 76
5.3 Problem during Research 76
5.4 Suggestion for Future Work 76

REFERENCES 79

LIST OF TABLES

TABLE	TITTLE	PAGE
Table 2.1	Salt Hydrate PCM	23
Table 3.1	General Specification of Peltier Module	36
Table 3.2	Specification of Insulation Cotton Washer	37
Table 3.3	Specification of Digital Thermometer	38
Table 3.4	Specification of Paraffin Wax	39
Table 3.5	Specification of Styrofoam Box	40
Table 3.6	Specification of Thermal Sheet	42
Table 3.7	Specification of Thermal Paste	43
Table 3.8	Specification of Copper Plate	44
Table 3.9	Specification of Cooling Fan	47
Table 3.10	Procedure of Paraffin Wax	50
Table 3.11	Procedure of Copper Plate Heat Sink	51
Table 3.12	Procedure of Fin Heat Sink	54
Table 3.13	List of Equipment used	59

LIST OF FIGURES

FIGURE	TITTLE	PAGE
Figure 1.1	The Configuration of The Thermoelectric Cooler	3
Figure 1.2	Thermoelectric Effect	4
Figure 1.3	Seebeck Effect	4
Figure 2.1	Green House Effect	10
Figure 2.2	N-Type and P-Type	12
Figure 2.3	P and N Junction of Thermoelectric Module	13
Figure 2.4	Seebeck Coefficient and Measurement Custom Set-Up	15
Figure 2.5	Seebeck, Peltier and Thomson Effect	15
Figure 2.6	Heat Sink	16
Figure 2.7	Copper Stamped Heat Sink	18
Figure 2.8	Extrusion Aluminium Heat Sink	18
Figure 2.9	Bonded-Fin Heat Sink	19
Figure 2.10	Folded-Fin Heat Sink	20
Figure 2.11	Melting and Solidification Process	21
Figure 2.12	Application of PCM	26
Figure 2.13	Application of PCM at Truck	27
Figure 2.14	Schematic Refrigerator	31
Figure 3.1	Flowchart of Project	32
Figure 3.2	Thermoelectric Module	35
Figure 3.3	Insulation Cotton Washer	36
Figure 3.4	Digital Thermometer	37
Figure 3.5	Paraffin Wax	39
Figure 3.6	Styrofoam Box	40
Figure 3.7	Thermal Sheet	41
Figure 3.8	Thermal Paste	43
Figure 3.9	Copper Plate	44
Figure 3.10	Finned Heat Sink	45
Figure 3.11	Cooling Fan	46
Figure 3.12	Circuit Diagram Thermoelectric Unit	47
Figure 3.13	Thermoelectric Module	49

Figure 3.14	Thermoelectric Design	56
Figure 3.15	Exploded View of Thermoelectric Unit	57
Figure 4.1	Thermoelectric Module Testing	61
Figure 4.2	Effect Ampere to Peltier Module	63
Figure 4.3	Heat Sink Copper Plate	64
Figure 4.4	Effect of Copper Plate Heat Sink with Various Current	66
Figure 4.5	Mini Thermoelectric Refrigerator with Fin Heat Sink	67
Figure 4.6	Temperature of Fin Heat Sink with Various Current	65
Figure 4.7	Effect of Mass PCM	67
Figure 5.1	Effect of PCM	75
Figure 5.2	Design of 2 Thermoelectric Module	77
Figure 5.3	Recommended location of PCM elements	77
Figure 5.4	Principle of PCM	78

LIST OF SYMBOLS

A	-	Ampere
˚C	-	Celsius
CFC	-	Chlorofluorocarbon
CFM	-	Cubic per Minute
COP	-	Coefficient of Performance
CPU	-	Central Processing Unit
DC	-	Direct Current
g/cc	-	Gram per Cubic Centimetre
G	-	Gram
GPU	-	Graphics Processing Unit
HCFC	-	Hydrofluorocarbon
HFC	-	Hydrofluorocarbon
K	-	Kelvin
KG	-	Kilogram
kJ/Kg	-	Kilojoules per Kilogram
M	-	Meter
m	-	Minute
MM	-	Millimetre
PCM	-	Phase Change Material
PV	-	Photovoltaics
RAM	-	Random-Access Memory
SEG	-	Solar Electricity Generating System
SI	-	System International
TEC	-	Thermoelectric Cooler
TEG	-	Thermoelectric Generator
TES	-	Thermal Energy Storage
TEM	-	Thermoelectric Module
TER	-	Thermoelectric Refrigerator
TE	-	Thermoelectric
USB	-	Universal Serial Bus
V	-	Voltage
W	-	Watt
W/mk	-	Watts per Meter-Kelvin

ΔT	-	Different Temperature
ΔV	-	Different Voltage

CHAPTER 1

INTRODUCTION

1.0 Introduction

Refrigeration is a process that involves transferring heat from a cold medium to hot medium. Mechanical effort powers the heat transfer process. A thermoelectric refrigerator works similarly to a traditional compressor refrigerator. Due to the compressor is high energy consumption and negative environmental impact, the thermoelectric device offers a possible alternative refrigerator system. The Peltier module, also known as the thermoelectric module is used to operate the thermoelectric refrigerator. It functions as a solid state active heat pump, transferring heat from one side to the other with the use of electrical energy and depending on the current direction.

1.1 Background

The Peltier effect is used in thermoelectric cooling to produce a heat flux at the intersection of two distinct types of materials. A Peltier cooler, heater, or thermoelectric heat pump is a solid state active heat pump that transfers heat from one side of the device to the other while using electrical energy. Peltier devices, Peltier heat pumps, solid state refrigerators, thermoelectric cooler (TEC), and thermoelectric batteries are various names for the same device. It may be used for both heating and cooling, however cooling is the most common application. It may also be used as heating or temperature cooling control.

This method is used for refrigeration significantly less frequently than vapor compression refrigeration. When compared to a vapor compression refrigerator, the thermoelectric cooler has the following advantages: no moving components or circulating liquid, extremely long life, leak resistance, mini size, and flexible shape. It is primary drawbacks are it is high cost per cooling capacity and it is low power efficiency (a low COP).

Jean Peltier discovered that sending an electric current through the intersection of two different metals produces a heating or cooling effect in 1834. A running current over one function of metal absorbs heat while rejecting heat due to a differential in the thermal energy transferred by charge carriers. This phenomenon is known as the Peltier effect or thermoelectric effect. In other word, the variation in the average energy of the carriers in two dissimilar material able to generate electricity (Sadeq et al., 2021).

Thermoelectric cooler have a hot side and cold side. Each side have a heat sink and fan to enchange the heat transfer rate. However, the hot side of the thermoelectric module tends to become very hot. Because of that, thermoelectric cooler can not achieve the maximum cooling temperature and coefficient of performance. Phase change material (PCM) been attach to the heat sink of the hot side thermoelectric module to increase the heat rejection. At the same time, PCM help to improve the performance of the mini thermoelectric refrigerator based on reduce of the hot side temperature. Figure 1.1 shown a thermoelectric cooler component arrangement.

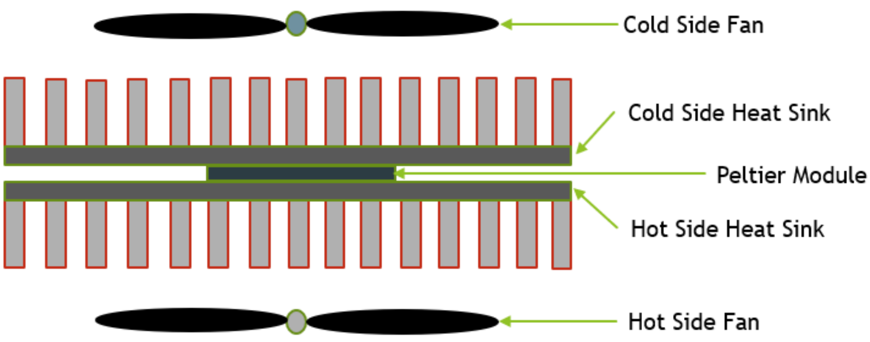

Figure 1.1 : The Configuration of The Thermoelectric Cooler

One heat sinks is used on the hot side and one on the cold side of a thermoelectric cooler. The thermoelectric module will be flanked by hot and cold heat sinks. A small fan is used on either side to help with heat transfer.

In thermoelectric cooler there area three phenomena effect by thermoelectric module such as Thermoelectric effect, Seebeck effect and Thompson effect. A thermocouple convert temperature variations into electric voltage and vice versa. When the temperature on both sides of a thermoelectric device differs, a voltage. Heat is transported from one side to the other when a voltage is applied to it, resulting in a temperature differential.

An imposed temperature gradient causes charge carriers in a material to diffuse from the hot side to the cold side at the atomic level. This phenomenon can be utilised to create power, measure temperature, or alter item temperatures. The applied voltage affects the direction of heating and cooling, hence thermoelectric devices can be employed as temperature controls. Figure 1.2 show the effect of thermoelectric.

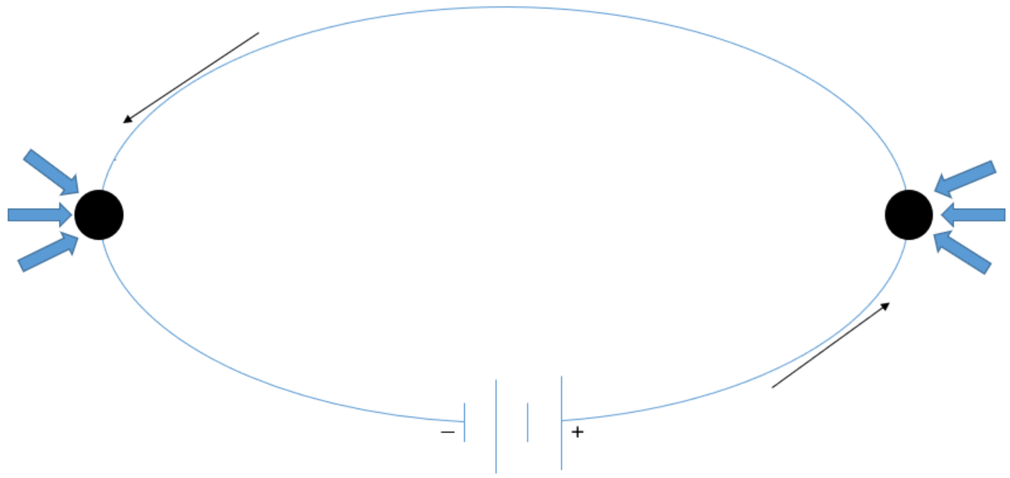

Figure 1.2 : Thermoelectric Effect

The thermoelectric effect functions as a heat pump, transferring heat from one side to the other. When it transfers heat, it uses electrical energy and is also dependent on the direction of the current. The Seebeck effect occurs when a temperature differential between two dissimilar electrical conductors or semiconductors results in a voltage difference between them. The Seebeck coefficient is measured using a custom built device that heats one end of the sample as shown in Figure 1.3 while leaving the other at room temperature to produce a temperature gradient and induce thermovoltage via the Seebeck effect.

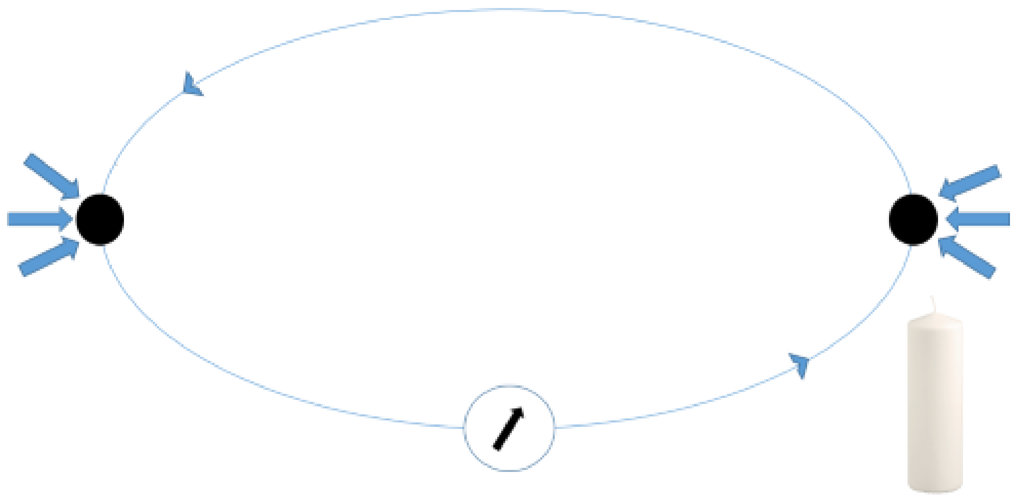

Figure 1.3 : Seebeck Effect

A temperature differential between two dissimilar electrical conductors or semiconductors causes the Seebeck effect, which results in a voltage difference between the two substances.

William Thomson is a British scientist, discovered the Thomson effect in 1854. When an electric current runs through a circuit comprised of a single material with a temperature variation throughout its length, the Thomson effect occurs. This heat transmission is placed atop the normal heat generation related with conductor electrical resistance to currents. Heat is absorbed from the copper as the conventional current approaches the hot point, and heat is delivered to the copper just beyond the hot point if a copper wire carrying a continuous electric current is exposed to external heating at a small segment while the remainder stay colder.

In thermoelectric module there are three type of cooling medium. The first cooling medium is using air. This medium usually using the fan for create or supply the air to cooling the thermoelectric module. Second medium is using water. This type usually more efficiency than air medium because the water can carry more heat load. The last cooling medium in thermoelectric module is using the phase change material (PCM).

Mini refrigerator are small in size, that they can be kept anywhere without consume large space. They are most suitable for usage in small office, dorm rooms and bedrooms. The constant in space often result in replacing a full fledged bulking refrigerator with a mini refrigerator.

Phase change material (PCM) are extremely attractive materials for thermal management solutions. This is because PCM absorb and release latent heat during the process of melting and freezing changing from one phase to another. When such a PCM freezes, it release figure large amount of energy in the form of latent heat. Conversely, when the material is melted, an equal amount of energy is absorbed from the surrounding enviroment as it changes from solid to liquid. Phase PCM can be utilized numerous ways particularly as thermal energy storage (TES) whereby heat or cool energy can be stored from one process over period of time and use the energy in different time or location. PCM are also very useful in providing thermal barriers or insulation for example, in temperature controlled materials for thermal comfort in building.

1.2 Problem Statement

Convensional vapour compression systems are used in a broad variety of applications. Their pricing, however, as well as environmental issues like as refrigerant leakage and CO2 emissions from fossil fuel energy used to power compressor and fans contribute to pollution and global warming. These issues are harmful to the environment and can have a direct impact on human health, prompting researchers to hunt for more energy efficient and environmentally friendly technology. Besides, nowday portability devices also important for the convience and smoothness of daily activies especially in the medical field. In medical field, portable refrigerator important because there are some of equipment need to be maintained their cool temperature to maintain the quality of equipment and compoents such as internal organs of human body.

Portable refrigerator also help because easy to access where ever need a cool food especially when camping. In response to the aforementioned challenges, thermoelectric (TE) technology is an appealing improvement. It may be used for cooling that requires electricity, or it can be utilised to generate energy by collecting waste heat from existing systems (Abderezzak et al., 2019).

However, the hot side of the thermoelectric module tends to become very hot that it requires a heat sink to efficiently dissipate the heat to the surrounding. As a result, the mini thermoelectric refrigerator's coefficient of performance (COP) struggles to attain lower cooling temperature. In this study, PCM was encased in an aluminium heat sink and then attached to the heat sink of the thermoelectric module's hot side to maximise heat rejection and obtain the lowest cooling temperature possible.

1.3 Research Objective

The main aim of this research is to fabricate a mini thermoelectric refrigerator by using phase change material (PCM)-cooled thermoelectric module. Specifically, the objectives are as follows:

a) To design and fabricate a mini thermoelectric refrigerator using thermoelectric module that with phase change material (PCM) – cooled heat sink.

b) To investigate the design of PCM heat sink to the thermal performance of the mini thermoelctric refrigerator.

c) To evaluate the thermal performance of the mini thermoelectric refrigerator based on the minimum cooling temperature achieved and the coefficient of performance (COP).

1.4 Scope of Research

a) Design and fabricate of a mini thermoelectric refrigerator using (PCM) cooled thermoelectric module.

b) Data collection the effect of thermoelectric module, PCM, fan, geometries and their arrangement to the performance of mini thermoelectric refrigerator.

c) Comparison of thermal performance improvement of mini thermoelectric refrigerator based cooling temperature achieved the coefficient of performance (COP).

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

In this chapter will introduce of the past and current research work related to thermoelectric refrigerator. Main focus in this chapter is to review, compare, and select the best material and design for prototype of mini thermoelectric refrigerator using phase change material (PCM) as a cooling module for thermoelectric module.

2.1 The Effect of Convensional Vapor Compression Refrigeration System

In absorption cooling and refrigeration cycles, refrigerants such as chlorofluorocarbon (CFC), hydrochlorofluorocarbon (HCFC), and hydrofluorocarbon (HFC) are utilised (Wei et al., 2017). The activity of releasing clorochlorofluorocarbons (CFC) and hydrochlorofluorocarbons (HCFC) to the atmosphere from the vapor compression refrigeration systems has raised the awareness towards environment. Chlorofluorocarbon (CFC) are harmful to the atmosphere and caused the green house house effect. Green house gases prevent heat from escaping into space causing over warming at earth. Figure 2.1 show the effect of green house.