UNIVERSITI TEKNIKAL MALAYSIA MELAKA

STUDY ON THE IMPROVEMENT OF EFFICIENCY OF THERMAL ENERGY HARVESTER

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Engineering Technology (Mechanical)(Air Conditioning & Refrigeration System Hons.)

by

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ABSTRAK

Penuaian tenaga adalah satu proses penuaian tenaga yang dijana oleh sistem sekitar atau alam sekitar dan menukar kepada bekalan kuasa. Ia adalah satu topik yang menarik sebagai salah satu cara untuk membangunkan alat elektronik tanpa menggunakan mana-mana sumber semula jadi. Oleh itu, idea penuaian tenaga dikaji dalam kajian ini. Tujuan kajian ini adalah untuk mengira kecekapan penuai tenaga haba dengan menggunakan modul Peltier bagi meningkatkan kecekapan penuai tenaga haba. Selain itu, perbezaan suhu juga dianalisis dalam mencapai nilai terbaik kecerunan suhu. Suatu prototaip penuai tenaga haba telah dibangunkan untuk mencapai parameter. Parameter adalah suhu kedua-dua plat; plat sejuk dan panas serta voltan yang dijana oleh sistem. Semua data itu direkodkan dan dianalisis. Nilai perbezaan suhu modul Peltier itu telah diperoleh dan jumlah yang lebih tinggi daripada voltan diperolehi.

ABSTRACT

Energy harvesting is a process of harvesting energy generated by the surrounding system or the environment and converts is to available power supply. It is an interesting topic as one of a way to develop an electronic device without using any of natural sources. Hence, the idea of energy harvesting is studied in this research. The purpose of this study is to calculate the efficiency of thermal energy harvester by using a Peltier module in order in improving the efficiency of thermal energy harvester. Besides, the temperature difference is also analyzed in achieving the best value of temperature gradient. A prototype of thermal energy harvester (TEH) system was developed in order to achieve the parameters. The parameters are the temperature of both plates; cold and hot plates as well as the voltage generated by the system. All the data was recorded and analyzed. The value of temperature difference of the Peltier module was obtained as well the higher amount of voltage is obtained.

DEDICATION

I would like to dedicate this project to my beloved parents and family.

ACKNOWLEDGEMENT

I would like to thank my parents and family for all of their support. I am thankful for their constructive criticism and friendly advice during the project work. I express my warm to my supervisor, Mr Aludin bin Mohd Serah for his guidance in the making of this project. I would also like to thank to all of my friends for their support and helps for making this project successful.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

TEH	-	Thermal Energy Harvester
EH	-	Energy Harvesting
Δt	-	Temperature Difference

CHAPTER 1
INTRODUCTION

1.1 Project Background

Nowadays, natural sources such as fossil fuels as a sustainable supply of energy are decreasing while the demands in a sustainable energy are increasing. Hence, in order to deal with this problem many research have been conducted to find renewable energy in replacing the natural sources as a stable energy. This energy is very high demanding as it is act as a source of power generation. As implying the problem mention before, the idea of harvesting energy is generated within research.

Energy harvesting is the development in harvesting energy from the surrounding system or environment and converts it to available electricity. There are many sources in energy harvesting such as solar, thermal, mechanical and electromagnetic but in this project the focus is on thermal energy source. Usually, device that used thermal energy as a source is thermoelectric. Thermoelectric device employ the Seebeck effect, Peltier effect and Thompson effect. But, the Thompson effect generally will be neglected because of minimal effect on the thermoelectric module. The functions of thermoelectric module are used for both heating and cooling and

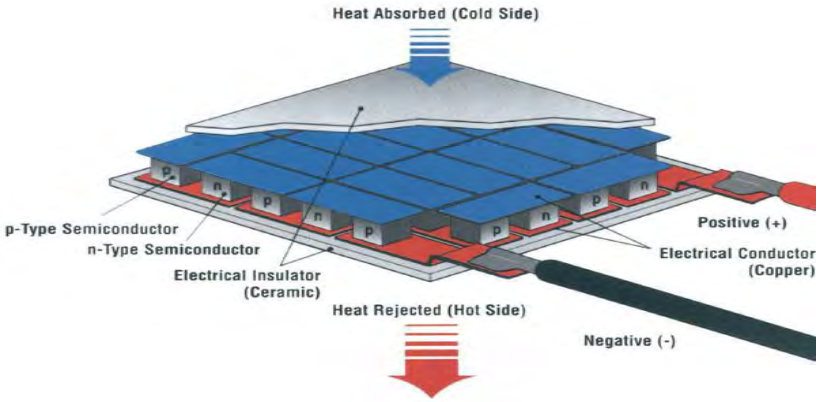
therefore it is applicable for precise temperature control application as well as for power generation.

Seebeck effect is found and invented by Thomas Seebeck in 1820. The theory can be best described as the current that is produced when two dissimilar metals undergoes temperature difference. Seebeck effect also may be defined as an electric potential will be develop in a thermocouple (closed circuit of two junctions of dissimilar metals) if these junctions are at different temperatures.

Few years later, a scientist discovered the opposite of Seebeck effect that works under a principal that if voltage is applies in a two thermocouple, one junction shall be heated and the other shall be cooled. The scientist's named Peltier and the effect called Peltier effect. In simple words, when there are temperature gradient is applied into the peltier, current electric is generated and can be stored in a purpose to power supply electronic circuits.

Peltier is a device that implies peltier effect to execute a function of a heat pump. A peltier consists of two plates that is one side for cooled and the other is for hot and between of the plates, there are several thermocouples. The thermocouples are connected to each other and two wires come out as in figure 1.1. Voltage is applied to both of the wires and the cool plate becomes cooled whereas hot plate becomes hot. This peltier device is called as heat pump because peltier do not generate heat nor cold, but heat transfer occurs from one plate to another. Peltier usually made of semiconductor materials.

Figure 1.1: Thermoelectric/ Peltier module.



The source to gain this temperature gradient is from a thermal energy - an energy that is generated within a system or an object. As the thermal energy is captures, it applies into the peltier module. Peltier module is made of two semiconductor pellets and connects to electrodes. One of the pellets will act as a hot surface while the other one is as a cold surface. Surface that absorbs heat becomes cold and a surface that release heat becomes hot. Hence, temperature gradient can be calculated by the temperature difference of the both pellets.

The significance of this project is to improve thermal energy harvester (TEH) efficiency in order to upgrade the performance of the energy harvester. This is because as the efficiency of energy harvester is increased, a sustainable energy may be supplied to more electronic devices without using natural sources. Even there are some electronic devices that used thermal energy harvester, but the application is still limited as to gain the high efficiency is still under study. Moreover, the wasted thermal energy may be used and it will not only waste without any purposes.

In order to improve efficiency of the thermal energy harvester (TEH), temperature gradient plays an important role. Temperature gradient must be achieved at the maximum point to generate a large amount of current. A way to increase the temperature gradient, variation of the composition of both pellets from hot to cold side was claimed in 1949 by A. F. Loffe. It was called “distributed Peltier effect”.

Energy harvesting gives numerous benefits and therefore it getting known widely. One of the advantages is eliminating the necessity of battery power. Harvesting energy may be reduce the needs in using battery as the device can be powered by only the harvester and depends on the energy storage. Besides, by energy harvesting the installation costs can be reduced. This is because it is easier to install even the self-powered device also need wires and conduits.

In addition, energy harvesting helps in reducing maintenance costs as it eliminates the possibility in servicing the batteries. Therefore, maintenance costs can be cut down and at the same time reducing the budget. Moreover, energy harvesting enables the possibility to continue provides sensing even under hazardous environment. This is beneficial to the owner as the device works in any under circumstances. The other advantage of energy harvesting is it provides long-term solutions. The energy harvesting device can functions without any problem as long as the ambient energy is available. One of the benefits from the energy harvesting is due to its environmental friendly characteristics, energy harvesting reduce the needs of using batteries as the device may only be powered from the ambient energy.

Furthermore, energy harvesting advantage is there are no moving parts. Hence, it is more stable and it functions at steady state operation. In addition, energy harvesting device used materials that do not need to be replenish. Therefore, costs can be reducing as well as the device may be used in a long term without maintenance

requirement. Energy harvesting device also provides benefit of heating and cooling process can be reversed. This is beneficial as only one device have the ability in heating and cooling. Thus, energy harvesting device helps in reducing space as well as reducing in costs because it ability in reversing heating and cooling process.

1.2 Problem Statement

Based on previous research, studies on thermal energy harvester are available. However, the efficiency of this thermal energy harvester is still at low rates. This is because thermoelectric energy conversion is still in a low efficiency. Hence, in this research it will be focus on investigation of the effect of temperature gradient of thermoelectric and the efficiency thermal energy harvester.

1.3 Objectives

i. To calculate efficiency of thermal energy harvester.
ii. To analyze the effect of temperature gradient of the hot and cold side of the peltier module.

1.4 Scope

In this project, the ambient energy is the energy generated by an iron that is a simulation of the condenser, one of the components is refrigeration system. The thermal energy will be captured with difference of time started when the iron is

running and after every minute. The temperature of the iron is neglected as the main purpose is only to capture amount of energy produce by the iron.

1.5 Summary

In this chapter 1, project background, problem statement, objectives and scope has been discussed. This chapter 1 will be essential for this project and work as a guidelines till the end of this project. Basically, this research's thesis consists of five chapters. Chapter 1 explained the introduction of this project that is what you have read in this chapter. Chapter 2 is literature review which discuss on other research based on the study. Chapter 3 is the methodology that explains all the methods in this thesis. Chapter 4 is on the report of the results and discussion of this project. Lastly, chapter 5 is on recommendation as well as conclusion.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

There are so much wasted energy generates by systems such as air conditioning system, electronic circuit and car system. Hence, in order to re-use the wasted energy, the idea of energy harvesting is created. In addition, in introducing energy harvesting there is theories need to be understood and studied as well as the application of the energy harvesting itself. Therefore, in this chapter there are a few key points will be reviewed and discussed. The key points are thermal energy harvesting, Peltier and effect of temperature gradient.

2.2 Thermal Energy Harvester

The main idea of this research is on the thermal energy harvesting and therefore understanding on the main idea is crucial. According U. Alvarado et. al (2012) energy harvesting is a process of harvesting energy that is generates from the environment or surrounding and converts it to power supply. In agreement, S. K. T. Ravindran et. al (2011) said energy harvester converts ambient energy that is in the

form of heat, vibrations, light, etc. to electrical energy. In summary, energy harvesting is a process of harvesting ambient energy in purpose of producing electrical current.

The idea of harvesting energy is as a replacement of the natural sources that is expected to be depleted in the near future. Yogesh K. Ramadass and Anatha P. Chandrakasan (2010) said harvesting heat energy is a convenient means to supply power to body-worn electronics and industrial sensors. They also stated that energy harvesting is an emerging technology with applications to handheld, portable and implantable electronics. This shows that energy harvester makes easier for developing an electronic device that is environmental friendly as well as easy to use and bring along.

2.3 Peltier

In this research, the main device used to complete this research is a Peltier module. The Peltier device is a heart for this research. Peltier or commonly known as thermoelectric module is developed by using the Seebeck effect and Peltier effect. S. Maharaj and P. Govender (n.d.) describe Seebeck effect as a thermocouple makes by a closed circuit of two junctions of dissimilar metals develops an electric potential if these junctions are at different temperatures. U. Alvarado et. al (2012) states that Seebeck effect is when the junction of two dissimilar metals undergoes a temperature difference and current is generated. Thus, the Seebeck effect can be concluded as when one of the junctions of a closed circuit that is made up by the two dissimilar metals is heated, a current is