UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF PORTABLE MINI THERMOELECTRIC GENERATOR FOR OUTDOOR ACTIVITIES AND EMERGENCY SITUATIONS BY USING EASILY AVAILABLE HEATING AND COOLING SOURCES

This report is submitted in accordance with the requirement of Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Mechanical Engineering Technology (Automotive Technology) with Honours

by

MUHAMMAD ALIF BIN ABDUL RAHMAN
B071210532
910715025037

FACULTY OF ENGINEERING TECHNOLOGY
2015

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **Development of Portable Mini Thermoelectric Generator for Outdoor Activities and Emergency Situations by Using Easily Available Heating and Cooling Sources**

SESI PENGAJIAN: **2015/16 Semester 2**

Saya **MUHAMMAD ALIF BIN ABDUL RAHMAN**

mengaku membenarkan Laporan PSM ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Sila tandakan (✓)

☐	SULIT	(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)
☐	TERHAD	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia sebagaimana yang termaktub dalam AKTA RAHSIA RASMI 1972)
☐	TIDAK TERHAD	

Disahkan oleh:

(_____)

(_____)

Alamat Tetap:

NO.65, Lorong Satu,

Taman Sungai Lalang,

08100 Bedong, Kedah.

Cop Rasmi:

** Jika Laporan PSM ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini perlu dikelaskan sebagai SULIT atau TERHAD.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

FAKULTI TEKNOLOGI KEJURUTERAAN

Tel : +606 234 6623 | Faks : +606 23406526

Rujukan Kami (Our Ref) :
Rujukan Tuan (Your Ref) :

25 JAN 2016

Pustakawan
Perpustakaan UTeM
Universiti Teknikal Malaysia Melaka
Hang Tuah Jaya,
76100 Durian Tunggal,
Melaka.

Tuan/Puan,

PENGKELASAN LAPORAN PSM SEBAGAI SULIT/TERHAD LAPORAN PROJEK SARJANA MUDA TEKNOLOGI KEJURUTERAAN (TEKNOLOGI AUTOMOTIF) (BETA): MUHAMMAD ALIF BIN ABDUL RAHMAN

Sukacita dimaklumkan bahawa Laporan PSM yang tersebut di atas bertajuk **"Development of Portable Mini Thermoelectric Generator for Outdoor Activities and Emergency Situations by Using Easily Available Heating and Cooling Sources"** mohon dikelaskan sebagai *SULIT / TERHAD untuk tempoh LIMA (5) tahun dari tarikh surat ini.

2. Hal ini adalah kerana IANYA MERUPAKAN PROJEK YANG DITAJA OLEH SYARIKAT LUAR DAN HASIL KAJIANNYA ADALAH SULIT.

Sekian dimaklumkan. Terima kasih.

Yang benar,

_____
Tandatangan dan Cop Penyelia

* Potong yang tidak berkenaan

NOTA: BORANG INI HANYA DIISI JIKA DIKLASIFIKASIKAN SEBAGAI SULIT DAN TERHAD. JIKA LAPORAN DIKELASKAN SEBAGAI **TIDAK TERHAD**, MAKA BORANG INI **TIDAK PERLU DISERTAKAN** DALAM LAPORAN PSM.

DECLARATION

I hereby, declared this report entitled “Development of Portable Mini Thermoelectric Generator for Outdoor Activities and Emergency Situations by Using Easily Available Heating and Cooling Sources” is the results of my own research except as cited in references.

Signature **: ……**

Name **: MUHAMMAD ALIF BIN ABDUL RAHMAN**

Date **: ……**

APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Mechanical Engineering Technology (Automotive Technology) (Hons.). The member of the supervisory is as follow:

…….

(ENCIK ALUDIN BIN MOHD SERAH)

ABSTRACT

Thermoelectric generator (TEG) is a device that converts heat into electrical energy through phenomenon known as Seebeck effect. The main component of TEG is thermoelectric module. When the temperature gradient created between the hot and cold sides of the thermoelectric module, electricity is generated. In this study, a prototype of portable mini thermoelectric generator was fabricated by applying this principles. This device is targeted to be used during outdoor activities and emergency situation such as flood and earthquake - the situations in which electrical supply cannot be accessed easily. Two prototypes of TEG were designed by using CATIA software. The TEG basically made of metal body, thermoelectric module, L-bracket (as body stand) and electrical wiring. Various sources of heating and cooling that were applied to the hot and cold side of the thermoelectric module such as candle flame, ice and cold packs. These heating and cooling sources were selected because they are easily available in such emergency situation and also low cost. The effectiveness of the TEG was evaluated through the measurement of charging rate of a power bank. The result shows that the amount of electricity generated was greatly influenced by the temperature difference between the hot and cold sides of the thermoelectric module. The charging rate of the power bank was the highest when candle flame and ice were used as heating and cooling sources, respectively. When candle flame and ice were used, it took about 10 hours to charge the power bank to 84 %. The efficiency of the TEG ranged between 0.9 to 1.9 %. With further improvement, this thermoelectric generator has great potential to become an attractive and practical device that can generate electricity during outdoor activities and emergency situations.

ABSTRAK

Penjana termoelektrik adalah peranti yang menukarkan haba kepada tenaga elektrik melalui fenomena yang dikenali sebagai kesan *Seebeck*. Komponen utama TEG adalah modul termoelektrik. Apabila kecerunan suhu diwujudkan antara kedua-dua belah panas dan sejuk modul termoelektrik, elektrik dihasilkan. Dalam kajian ini, prototaip mudah alih mini penjana termoelektrik telah difabrikasikan dengan menggunakan prinsip ini. Peranti ini disasarkan untuk kegunaan aktiviti luar dan dalam keadaan kecemasan seperti banjir dan gempa bumi, iaitu situasi yang menyebabkan bekalan elektrik tidak boleh diakses dengan mudah. Dua prototaip penjana termoelektrik telah direka dengan menggunakan perisian CATIA. Penjana termoelektrik pada asasnya diperbuat daripada logam badan, modul termoelektrik, kaki-L dan pendawaian elektrik. Pelbagai sumber pemanasan dan penyejukan yang digunakan untuk sebelah panas dan sejuk modul termoelektrik seperti api lilin, ais dan pek sejuk. Sumber pemanasan dan penyejukan ini telah dipilih kerana ia mudah didapati dalam keadaan kecemasan dan juga murah. Keberkesanan penjana termoelektrik ini dinilai melalui pengukuran kadar mengecas *power bank*. Hasil kajian menunjukkan bahawa jumlah penjanaan tenaga elektrik yang banyak dipengaruhi oleh perbezaan suhu di antara dua belah panas dan sejuk modul termoelektrik. Kadar caj *power bank* menunjukkan nilai yang tertinggi apabila api lilin dan ais telah digunakan sebagai sumber pemanasan dan penyejukan. Apabila api lilin dan ais telah digunakan, ia mengambil masa kira-kira 10 jam untuk mengecas *power bank* sebanyak 84 %. Kecekapan penjana termoelektrik ini adalah antara 0.9 hingga 1.9 %. Apabila melalui penambahbaikan yang selanjutnya, penjana termoelektrik ini berpotensi besar menjadi alat yang menarik serta praktikal yang boleh menjana elektrik semasa aktiviti luar dan kecemasan.

DEDICATIONS

To my beloved parents

Abdul Rahman Bin Md Issa

Aliah Binti Ibrahim.

Thanks for supported and loved.

ACKNOWLEDGMENTS

BISMILLAHIRRAHMANIRRAHIM

In the name of Allah, the most gracious and the most merciful

Alhamdulillah, I would like to thank to the Almighty Allah s.w.t. for His blessing, His power that give me the strength and His given that give me the idea to accomplish this final year project and thesis. There are so many people that stand by me, help and give me a guidance for every obstruction that stand in front of my way. Therefore, I would like to express my appreciation to those involved in this thesis.

Secondly, I would like to express my gratefulness towards my parents Abdul Rahman Bin Md Issa and Aliah Binti Ibrahim that always give me support and advice from start until I am completing my final year project.

Further, I would like to express my gratitude to Mr. Aludin Bin Mohd Serah for being my supervisor, his guidance and full support very valuable, and thanks for give me the knowledge and opinion to make this project complete successfully. I am also like to express my gratitude to Mr. Mohd Fauzi Bin Ab Rahman for being my co-supervisor, guider and supporter to make this project done.

Last but not least, I would like to express my sincere appreciation to all my friends about their encouragement to help me in the completion of this project in Universiti Teknikal Malaysia Melaka.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLE

LIST OF SYMBOLS AND ABBREVIATIONS

BTR	=	Best Temperature Range
CATIA	=	Computer Aided Three-dimensional Interactive Application
COP	=	Coefficient of Performance
CTEG	=	Concentrator Thermoelectric Generator
CSP	=	Concentrating Solar Power
EMF	=	Electromotive Force
MATLAB	=	Matrix Laboratory
TEG	=	Thermoelectric Generator
TEM	=	Thermoelectric Module
USB	=	Universal Serial Bus
ZT	=	Figure of Merit

CHAPTER 1

INTRODUCTION

1.0 Introduction

This chapter explains the project background, problem statement, objectives and scope in designing the portable mini thermoelectric generator.

1.1 Project Background

In recent years, mobile phones have become one of the most important devices in human life.

Figure 1.1: The Functions of Mobile Phones

This is because there is a lot of function provided by the mobile phones where the main function is to make the people contact between each other. Figure 1.1

shows the various functions of mobile phone. Mobile phone employs a multi-functional technologies that can be able to capture images, messages, compass direction, browsing the internet and others.

There are many functions of mobile phone that same as that of computer. Therefore, the mobile phones todays have been able to replace the function of the computer. Mobile phone has become an invention that can provide current information no matter when and where we are. Mobile phone has penetrated in everyone's lifestyle where everyone uses it almost all the times. However, the mobile phone is a device that requires electricity to enable it to be used.

Many outdoor activities that are extreme but yet attract many people to participate in such activities, for example, camping, jungle trekking, and hunting. The outdoor activities usually take place forest and people need a mobile phone to contact people at the outside in case of any emergency. However, if the electrical energy storage capacity in mobile phone's battery has fully discharged, the mobile phone cannot be used again until the battery is rechargeable. Figure 1.2 illustrate the problems during camping which create necessary to develop a device that can simply generate electricity to support camping's activities.

Figure 1.2: Necessity of Generating Electricity during Camping

Apart from that, there are many natural disasters that could happened today such as floods, earthquakes and tsunami. When this disaster strike, people are likely

experience difficulty in getting electricity. In such emergency situation, people must find alternative ways to generate electricity. Electrical source is importance to charge a mobile phone in the attempts to contact the people at outside area and request for assistance. A simple device that able to generate electricity in such situation must be developed. One of the most device that suit in this purpose is thermoelectric generator. This device is portable and small in size thus it suitable for outdoor activities and these kinds of emergency situations.

Thermoelectric generator is a device that can trap low-quality heat energy and then convert it into electricity. The main components of thermoelectric generator is thermoelectric module. A thermoelectric module consists of positive doped (P-doped) and negative doped (N-doped) semiconductors connected together in series to achieve a reasonably good output voltage. Pair of p-type and n-type semiconductor is called as thermoelectric module. Electric energy is generated due to temperature difference between the hot side and cold side when the both semiconductors solids joined together. Figure 1.3 shows that the schematic diagram of a thermoelectric module.

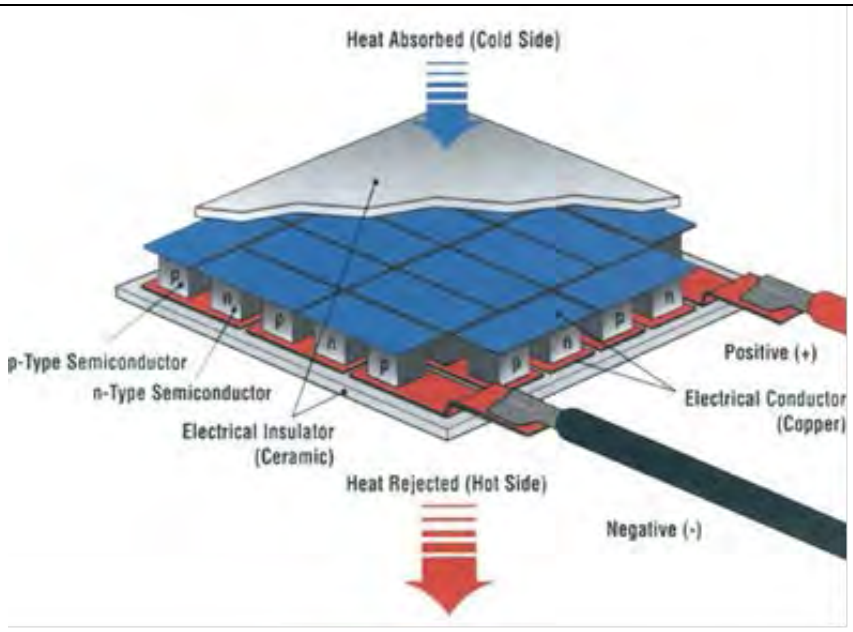

Figure 1.3: Schematic of a thermoelectric module (http://topmagneticgenerator.com/Blog/build-homemade-thermoelectric-generator.html)

When heat is applied to one surface of the thermoelectric generator, the electrons in the n-type semiconductor and the holes in the p-type semiconductor

move away from the heat source. This movement of electrons and holes gives rise to an electrical current. The direction of the current is opposite to the movement of the electrons, and in the same direction as the movement of the holes. By establishing appropriate electrical connections, the current of thermoelectric generator flows in a closed loop through the p-type semiconductor and n-type semiconductor. Both types of semiconductors form a thermocouple. This theory is based on Seebeck effect which was discovered by Thomas Seebeck in 1821. In this study, a prototype of thermoelectric generator was fabricated by applying various type of heating and cooling source to the hot and cold side of thermoelectric module.

1.1.1 Basic Principle of Thermoelectric Effect

Consider two wires that made from different metals joined at both ends (junctions), forms a closed circuit. Ordinarily nothing will happen. However, when one of the ends is heated, an electrical current flow continuously as shows in Figure 1.4.

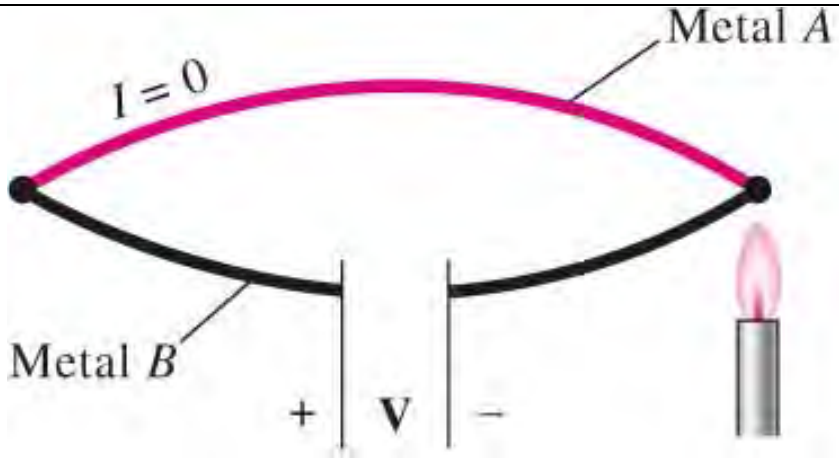

Figure 1.4: Basic Principle of Thermoelectric Effect (Garcia et al., 2007)

The Seebeck effect forms the basis of the development of thermoelectric generator.

1.1.2 Heating and Cooling Source

Heating and cooling sources are very vital in thermoelectric generator to create temperature difference between hot side and cold side of the thermoelectric module. The heating sources can be originated from various source such as vehicle's exhaust system, heat exchanger and even candle flames. This heating sources is applied to the hot side of thermoelectric module. The cooling sources can obtained from ice, cold water, and others. The temperature difference caused by both sources generates electricity.

1.2 Problem Statement

During camping, survival or in emergency situations such as flood and earthquakes, people need an electric generator to charge their electronic gadgets especially mobile phones. In this remote areas electrical is needed in order to charge mobile phones and others electrical accessories. Thermoelectric generator is one of the alternative device that can provide solution for these problems.

1.3 Objectives

In order for this study to be successfully conducted, the following objectives are set:

- To design and fabricate a prototype of portable mini thermoelectric generator for outdoor activities and emergency situations by using easily available heating and cooling sources such as candle flame, ice and cold packs
- To investigate the effectiveness of using the heating and cooling sources based on the charging rate of a power bank
- To calculate the thermal efficiency of the thermoelectric generator

1.4 Scope of Project

This project focuses about development the prototype of thermoelectric generator by using easily available heating and cooling sources. In this study, the development the prototype of thermoelectric generator focus on:

- Design a prototype of thermoelectric generator
- Selection of most suitable materials and components
- Fabrication of thermoelectric generator that use easily available heating and cooling sources

CHAPTER 2
LITERATURE REVIEW

2.0 Introduction

This section review some basic concepts of thermoelectric generator. It also introduces recent research and development of thermoelectric generator and its applications.

2.1 Thermoelectric Module (TEM)

Figure 2.1 shows the photo of thermoelectric module that available in the market. Thermoelectric module (TEM) is a semiconductor-based electronic component.

Figure 2.1: A Photo of Thermoelectric Module

This component can be used as the main component in thermoelectric heat pump that used for heating or thermoelectric cooler that used for cooling. TEM also can be used for electricity generation purposes. The components of TEM are consist of semiconductor, ceramic substrates, metal interconnects and external electrical connections. The size of TEM in general is 10-40 mm square and 3-6 mm thick.