UNIVERSITI TEKNIKAL MALAYSIA MELAKA

A STUDY ON THE POTENTIAL OF PELTIER IN GENERATING ELECTRICITY USING HEAT LOSS

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electrical Engineering Technology (Industrial Power) with Honours.

by

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FACULTY OF ENGINEERING TECHNOLOGY

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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 Engineering Technology (Industrial Power) (Hons.). The member of the supervisory is as follow:

MOHAMAD HANIFF BIN HARUN

(Project Supervisor)

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ABSTRACT

In the era of globalisation, the electrical energy usage is the main priority in order to do our job and daily activity. Unfortunately, limited power supply for the electrical energy usage makes it hard to continuously provide electrical energy for 24 hours. By using peltier device, it is possible to develop a portable generating system using heat loss in machines and vehicles. The generating system theoretically can recycle the heat loss to produce additional electricity for other usage. Generally, the objective of the generating system is to study on the potential of peltier device to generate usefull electricity for additional power supply using heat loss. This generating system can be applied on many types of machines and other type of mechanism such as vehicle that release heat loss. Therefore, the result will be obtain in term of voltage can be generated by the generating system.

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ABSTRAK

Dalam era globalisasi, penggunaan tenaga elektrik memainkan peranan penting untuk melakukan pekerjaan dan aktiviti seharian kita. Namun, bekalan elektrik yang terhad menjadikan keadaan sukar untuk membekalkan tenaga elektrik selama 24 jam. Dengan menggunakan peranti peltier, ada kemungkinan besar untuk mencipta sistem penjanaan mudah alih dengan menggunakan tenaga haba yang terbazir dalam mesin dan kereta. Secara teori, sistem penjanaan ini boleh menggunakan semula haba yang terbazir untuk menjana elektrik untuk kegunaan lain. Secara am, objektif penjanaan elektrik ini adalah untuk menjalankan kajian tentang kebolehan peranti peltier untuk menjana elektrik dengan menggunakan tenaga haba yang terbazir untuk kegunaan lain. Sistem penjanaan ini boleh digunakan pada pelbagai jenis mekanisme seperti pelbagai jenis mesin dan kereta yang mengeluarkan haba terbazir. Sehubungan itu, hasil kajian akan di ambil dalam bentuk voltan yang dihasilkan oleh sistem penjanaan tersebut.

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DEDICATIONS

To my beloved parents, Shalsam bin Ibrahim and Rosni binti Waini, thanks for continuously giving me support and always pushing me to do well in this project. To my siblings, i would like to thank them for the support and inspired me to manage my project work. They have been supporting me in funds and moral value for the whole time.

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LIST OF SYMBOLS AND ABBREVIATIONS

SBM	=	Shape-Based Matching
T_H		High-temperature
T_L		Low-temperature
T_C		Temperature cold
T_H		Temperature hot
P		Power output
V		Voltage
ICE		Internal combustion engine
Bi2Te3		Bismuth Telluride
TEG		Thermoelectric generator
CMO		Calcium Manganese Oxide
PbTe		Led Telluride
DC		Direct current
$Z\bar{T}$		Figure of merit
$\bar{T}$		Average absolute temperature of hot
α		Seebeck coefficient
η		Maximum efficiency
Rth		Thermal resistance
$\bar{x}V$		Average voltage generated
$\bar{x}T$		Average temperature difference

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CHAPTER 1
INTRODUCTION

1.0 BACKGROUND

Generally, a peltier device is an intelligence device that can operate for cooling system by supplying voltage to the device to eject hot and cold air. The cold air will be used for cooling system. Reversely, the device can generate electricity by absorbing heat without supplying any voltage to power up the peltier device based on W. Thomson in 1851 rewrite Thomas Johann Seebeck foundation on "Seebeck effect" in 1821. In Seebeck effect theory, the electrons in the semiconductor act as transferring agent to transfer the heat from one medium to another medium according to the law of thermodynamics. In this case, the application where the energy conversion system applied is on vehicle engines and exhaust system. Based on Electrical Energy Conversion (E2C) past research at the KTH School of Electrical Engineering 2011, all machines are not working 100% effectively, most appears to work only 70% to 80% effectively as shown in Figure 1.1. Meanwhile, the other 30% to 20% are released into energy loss in term of heat. In order to recover the heat loss, this project will design a portable generating system using peltier device to produce electricity by absorbing heat loss.

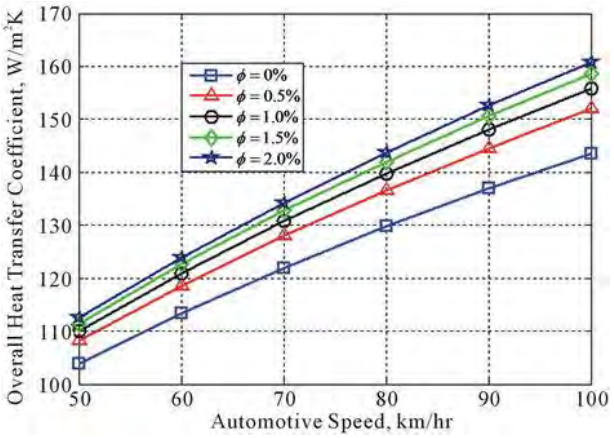

Figure 1.1 : Heat loss in car engine

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The basic operations for the device have been discovered for many years by Thomas Seebeck in 1821 where the temperature difference is established between hot and cold npn junction type semiconductors. Heat loss will be absorb on the hot side and leaving to the cold side of the peltier device as shown in Figure 1.2. During the process, the electrons in the npn semiconductor will active and vibrate due to heat then collides with each other in order to release the heat to the cold side. The result is voltage will be produced due to Seebeck effect.

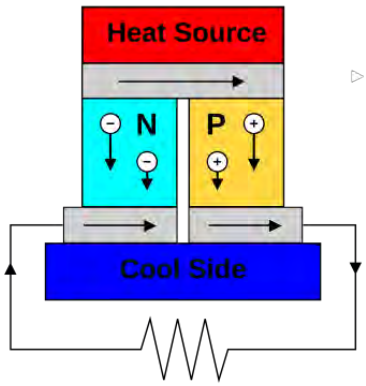

Figure 1.2 : Heat transfer from hot to cold side

The hot side absorbs heat loss at rate of T_H high temperature ejected by the system and transfer the heat to the cold side to be released at a rate of T_L low temperature. By referring to Seebeck effect, the heat loss absorbed at the hot junction causes electrons to be active and electric current then flow in the npn semiconductor and electrical energy is generated. Using the thermodynamics first law energy conservation principle, the difference between T_H and T_L will generate the electrical energy output power, W_e. The heat released then enter cooling agent which is to maximize the efficiency or the output voltage generated by the device in order to achieve higher temperature gradient between both hot and cold side. The increasing temperature difference between two junctions will increase voltage generation. The generated voltage will flow to the control circuit to provide 12V ouput voltage to charge battery for other usage.

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As stated by Mohd Izam Abd Jalil and Jahariah Sampe, 2013, the advantages of using peltier as generating system are:

- Easy to install the generating system
- No maintenance required
- Small size, compact and easy to use
- Environmental friendly

The portable generating system can be uses in car engine system and exhaust system which has the highest heat loss produced in vehicle parts.

1.1 PROBLEM STATEMENT

The main issue is the lack of electrical power supply for our daily usage forced us to create a generating system for a backup electrical supply for other usage. Therefore, electrical energy can be harvest by heat loss in the car system. In fact, a car only burn 15% of gasoline in the tank in order to move the car. The other 75% are lost in engine system, driveline ineffectively, and idling. Unfortunately, 70% of heat losses are released at the surrounding of the engine system. This factor is caused many types element in the internal combustion engine (ICE) and driveline. Thus, ICE is not a very effective working machine to convert gasoline into mechanical energy, the frictional force between the piston and block in the engine part create heat loss that released to the engine surface. In this case, the efficiency of the internal combustion engine (ICE) can be increase by recycling the heat loss produced in the ICE to generate electricity. The project will study on the potential of peltier device in generating electricity using heat loss in car.

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1.2 OBJECTIVE

The objectives of the project are:

- To study on the potential of peltier device to generate electricity using heat loss.
- Develop a generating system by using peltier device to generate 12V electricity at vehicle parts.
- To analyse the data measured in order to define the potential of peltier in generating electricity in term of voltage.

1.3 SCOPE

The work scope of this project is to study on the potential of peltier device to generate electricity using heat loss. The project also to develop a generating system that will be experiment on two vehicle parts which has the highest heat loss. Those two parts will be tested due to easy to install generating system and data collecting. Data will be record in term of voltage generated for a temperature difference over time.

Two vehicle parts that has the highest heat loss:

- Exhaust system
- Engine system

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CHAPTER 2
THEORETICAL BACKGROUND

2.0 INTRODUCTION

Literature reviews of the project cover and describe comparison from the journals on the internet, paper proceedings and past research. The literature review is done to investigate cases of the peltier device and other generating system parts. The literature review provides a great knowledge on the fundamentals of project.

2.1 PELTIER DEVICE (THERMOELECTRIC MODULE)

In this research, peltier is a device used to generate electricity by absorbs heat from the hot side then release heat to the cold side of the device. According to A.Jacks delightus peter's, Balaji.D, D.Gowrishankar, 2013, thermoelectric power generator is a TEG type peltier device that generate electricity based on "Seebeck effect" due to temperature difference between the TEG. The research constructs a TEG peltier using different type of material such as Bi2Te3- Bismuth Telluride (TEC1-12706) with thermal conductivity, k = 1.5 Wm^{-1} K^{-1}, PbTe-Led Telluride and CMO- Calcium Manganese Oxide. The maximum efficiency of TEC1-12706 calculated are 6%. Analyzing and gathering information on the thermoelectric property of the module material is very important. Thus, 200-300μV/K is the peltier material range for a good Seebeck property. Material thermoelectric material figure-of-merit property must be around 3×10-3 for a better conducting material. The result is 2.6 V is generated using 200 modules at temperature difference 260 ºC which means a module able to generate 13mV. This TEG is used to convert the waste heat released from Jet Engine and IC Engines as shown in Figure 2.1.

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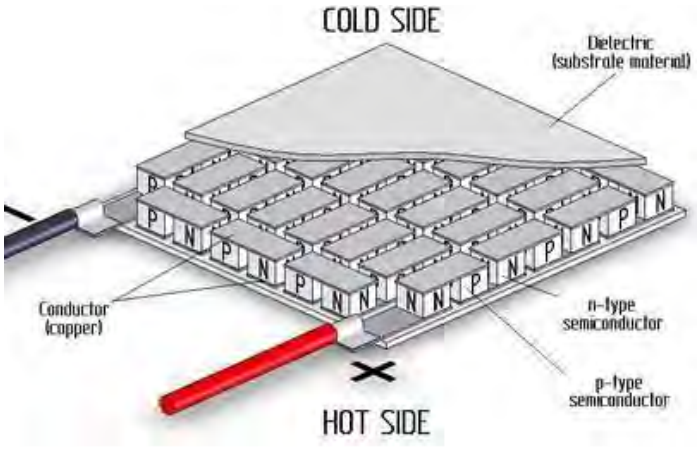

Figure 2.1 : Peltier material

Meanwhile, Martin Ozallapins, Aivars Kakitis, 2012 says when the heat transferring from hot to cold side occur, the electrons in the npn-semiconductor are also carried to the cold side. The resulting voltage is directly proportional to the temperature difference by Seebeck coefficient. The thermoelectric generator will generate DC electrical energy as long as there is a temperature difference across the peltier module. Two units of thermoelectric generators TEP1-1264-1.5 were used as shown in Figure 2.2. The peltier used is a module consisting of 126 Bi2Te3 p-type and n-type semi-conductor. By connecting the peltiers in series, higher voltage is produced that can be deliver through a load. The voltage generated for open circuit voltage for one TEP1-1264-1.5 at temperature difference 267.0 ºC in current system is 19.8 V. The module has a flat plane surface with dimensions 40x40 mm and height 3.5 mm. Maximum working temperature on hot side is 280 ºC and 380 ºC. For cold side it can't be more than 180 ºC. Otherwise the generated voltage will be low. Heat flux across one module is about 140 W.

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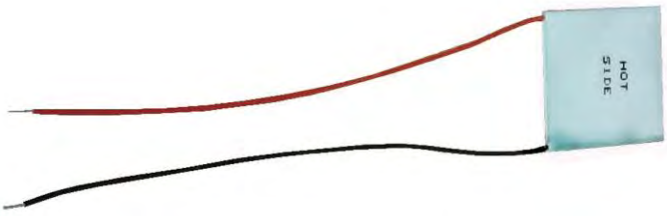

Figure 2.2 : TEP1-1264-1.5

Thermoelectric materials are determined by their figure of merit to represents their standard of performance, or efficiency defined by:

$$Z = \frac{\alpha}{kR} \qquad \text{Equation 1}$$

Where

α = the Seebeck coefficient

k = thermal conductivity constant (1.5)

R = electrical resistivity

The efficiency of a peltier material can be measured by calculating the Seebeck coefficient. Seebeck coefficient is directly proportional to the voltage generated by the peltier. In order to achieve high figure of merit, the material of peltier must have low electrical resistivity and thermal conductivity.

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The figure of merit can be calculated based to the electrical conductivity as shown below:

$$Z\bar{T} = \frac{\alpha^2 \bar{T}}{kR} \quad \text{Equation 2}$$

$$\bar{T} = \frac{T_H + T_L}{2} \quad \text{Equation 3}$$

Where,

T_H = Temperature high

T_L = Temperature low

The maximum efficiency, η of a peltier device can be defined using the figure of merit, temperatures of the hot side and cold side.

$$N = n_{carnot} \left[\frac{\sqrt{1+Z\bar{T}} - 1}{\sqrt{1+Z\bar{T}} + \frac{T_L}{T_H}} \right] \quad \text{Equation 4}$$

The value of carnot efficiency can be calculate by,

$$n_{carnot} = 1 - \frac{Temperature\ low}{Temperature\ high} \quad \text{Equation 5}$$

By referring to peltier electric generating calculation, the potential electricity generated by the peltier device can be calculated by,

$$V = \alpha(T_h - T_c) \quad \text{Equation 6}$$

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Where

V = the thermoelectric material figure of merit

α = the seebeck coefficient

T_h = temperature at hot side

T_c = temperature at cold side

The Seebeck coefficient can be calculated by,

$$\alpha = \frac{\bar{x}V}{\bar{x}T} \qquad \text{Equation 7}$$

Where,

$\bar{x}V$ = average voltage generated

$\bar{x}T$ = average temperature difference

The magnitudes of voltage generated are affected by the temperature difference 1 ºC across the peltier device, as stated the Seebeck effect. Material with high Seebeck effect is the main factor to increase the effeciency of the peltier device.

Based on John John Therampilly, 2012, there are 3 different types of energy generating system and one of the generating system are using peltier device. The generating system are using peltier TEC1-12706 module then the voltage generated increased by using boost converter to change small dc input to large dc output. The output voltage generated by the peltier TEC1-12706 is approximately 3.3V can reach to 9V for 75 ºC temperature difference for a single peltier used due to the boost converter used in the system.

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