UNIVERSITI TEKNIKAL MALAYSIA MELAKA

POWER GENERATION THROUGH HEAT ENERGY HARVESTING AT DOMESTIC AREA

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

by

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APPROVAL

This report is submitted to the Faculty of Mechanical and Manufacturing Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfilment of the requirements for the degree of Bachelor of Mechanical Engineering Technology (Industrial Power) with Honours. The member of the supervisory is as follow:

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ABSTRAK

Berdasarkan sejarah termoelektrik yang telah ditemui sejak 160 tahun yang lepas mempunyai suatu kelebihan dalam penukaran haba dimana ianya mempunyai ketahanan dan jangka hayat yang baik. Kini, termoelektrik telah menjadi antara bahan yang hangat dibincangkan oleh para saintis dan pengkaji dalam menyiasat kebolehan termoelektrik. Dengan pembangunan yang sangat pesat di dunia ini, pengkaji terdahulu dan sekarang telah lebih fokus dalam menemukan bahan yang terbaik untuk digunakan pada termoelektrik sebagai tenaga yang boleh diperbaharui. Dari segi aplikasi untuk termoelektrik, ianya telah digunakan pada pelbagai sektor seperti pengangkutan, perubatan, industri dan alam sekitar tetapi tiada lagi penggunaan yang luas di sektor domestik. Dalam kajian ini, cadangan telah diajukan dengan menggunakan konsep termoeletrik untuk memperluaskan penggunaan sisa haba dari segi persekitaran yang dapat menghasilkan penjanaan untuk aplikasi elektrik di kawasan domestik. Selanjutnya, reka bentuk prototaip akan dihasilkan berdasarkan keadaan yang boleh dijadikan sebagai satu sumber penggunaan sisa haba. Antara kawasan yang boleh dilaksanakan ialah pada perkakas rumah akan digunakan untuk menuai tenaga haba daripadanya. Fokus utama dalam kertas ini adalah untuk menghasilkan ujian prestasi dan analisis terhadap reka bentuk prototaip termoelektrik dari segi perbezaan suhu yang boleh dihasilkan dan kecekapan untuk menjana aplikasi elektrik di kawasan domestik.

ABSTRACT

Based on the thermoelectric background discovered over the last 160 years, it has a strong longevity and reliability in the heat transfer. Thermoelectric became one of the most common materials for thermoelectric technology researchers and scientists today. Researchers from past and present have concentrated on discovering the right resources for thermal energy as clean energy for the exponential growth of this planet. It has been used in different sectors as regards appliances for energy, such as transportation, medical, the industry and the environment but is no longer commonly used in the domestic sector. In this study, suggestions were made about the use of thermoelectric concepts to expand the application of heat residues to create energy for domestic applications. The prototype design will also be developed based on the conditions that can be used as a residual heat source. Some areas on the home appliances can be used to harvest heat energy from it. This paper focuses primarily on the performance test and analysis of the thermoelectric prototype design in terms of the variation in temperature that can be obtained and the reliability of domestic applications.

DEDICATION

My dedication especially to my beloved parents and ALLAH S.W.T that gave me the strength to prepare this report in the same way it provided. Besides, my mother was perseverance, support me and often prays for success to me. For my father, he was a hard worker, assists me a lot in my studies.

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Along to conclude my report, I have served with the aid of my family and my supervisor from the outset to the date of submission of this project in drafting this research. Besides that, they also contributed to the concept of streamlining the project in compliance with the directions given. Further, thanks to all of them. In addition, several thanks to friends for their support and motivation in helping me complete my project and report. From that, I know something more about to complete this report.

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LIST OF SYMBOLS

A	-	Ampere
V	-	Voltage
Δ□,□□	-	Temperature Difference
□	-	Seebeck Coefficient
P, □□	-	Electric Power
□	-	Efficiency
□	-	Converted Heat
□□	-	Hot Temperature
□□, □□	-	Cold Temperature
ZT	-	Figure of Merit
□	-	Electrical Resistivity
□	-	Thermal Conductivity
T	-	Temperature
E	-	Charge
R	-	Resistance
I	-	Current

LIST OF ABBREVIATIONS

AC	Alternating Current
DC	Direct Current
TEG	Thermoelectric Generator
COP	Coefficient of Performance
HVAC	Heating, Ventilation, and Air Conditioning
UPC	Universal Power Converter
WSN	Wireless Sensor Network
Bi2Te3	Bismuth Telluride
LiFePO4	Lithium Iron Phosphate
Pmax	Maximum Power
TEM	Thermoelectric Module
Voc	Open Circuit Voltage

CHAPTER 1

INTRODUCTION

1.1 Background

Power generation is important to generate electricity in this world. Most used in power generation to produce electricity are coal, gas, renewable energy, oil, biomass, and heat. China contributed nearly 60% of global growth in power generation followed by Indian, Japan, South Korea, and Indonesia in the global generation 2018. Since 2000 renewable power generation has been increasing that comes from near wind and solar capacity in Europe. Norway is a country that has been using renewable energy compared to other countries (Anon. 2020a). The use of renewable energy that is used by the country by 98% and non-renewable energy is only 2% on the global generation 2018 (Anon. 2020a).

Nowadays, the world is required renewable energy that has a friendly environment, mostly in industrial, utility, and commercial. These area aims for green energy harvesting to supply electricity system or different energy sources that environmentally present without grid connection or battery use and to reduce their monthly bills (Fajardo et al. 2016). According to the changes of technology today, there are a few inventions in energy conversion from waste heat energy to power. Waste heat energy has been created by a hundred studies on how to recover the energy into better use were all over the countries using thermoelectric devices. Heat reusing is quite popular in Europe when Denmark receives half the electricity from reused heat followed by Finland 39%, Russia 31% while the US only 12% (He et al. 2016).

The temperature gradient is the ambient energy source that can relate to a thermoelectric device and the effect of the thermoelectric device. A well-researched approach for converting waste heat to power is the use of a thermoelectric module (TEM) (Julaihie et al. 2019). The thermoelectric device contains a simple thermocouple that can convert either electrical energy into heat energy for heating and cooling (Peltier effect) or convert heat energy into electrical energy for power generation application in low electrical energy and medium electrical energy (Seebeck effect). Application for low electrical energy is the low power that can support the application such as battery charger, waste heat energy and electrical of rural homes (Crane and Jackson 2004). Besides that, as power sources, the application for medium electrical energy is more used in industries such as to measure the station's oil and natural gas facilities.

TEMs employ a thermoelectric generator (TEG), which is a solid-state device which transforms the temperature difference into dc sources of energy directly. Also, TEG offers some advantages such as the ability to operate without any moving part, simple design, long service life, easy maintenance and no chemical product included (Jaziri et al. 2019). One of the studies, there are some important parameters of the module that affect the TEG to get better performance with height, length, area, gap, and heat transfer materials (Omer et al. 2020). The basic concept of TEG is a thermocouple that is made up of one P-type and one N-type semiconductor, also known as pellets (Anon. 2020b).

TEGs are based on the Seebeck effect exist because of the movement of charger carriers inside the semiconductor. There are two separate P-type and N-type chargers in the semiconductor when the P-type disables, the charging carriers are holes and the energy become electrons whereas the N-type disables. This charge carrier diffused away from the hot side of the semiconductor. This diffusion causes an expansion of charge carriers to one end. This expansion of charge can create a voltage that is directly proportional to the temperature difference at the semiconductor Figure 1.1 (Siouane et al. 2017). Seebeck coefficient of the thermoelectric materials and the temperature differential is relative to the generated voltage and power. Seebeck is also referred to as thermopower, thermoelectric energy and thermoelectric sensitivity. Material is a measure of the size of the thermoelectric voltage caused by the Seebeck effect in reaction to the temperature differential over that material (Bhushan 2012).

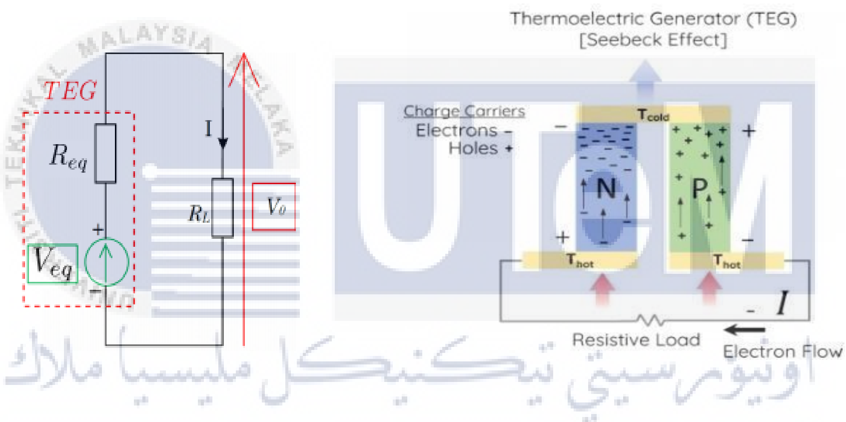

Figure 1.1: Thermoelectric charge carrier and equivalent electrical circuit (Siouane, Jovanović and Poure, 2017).

The thermoelectric generator includes an assembly of very small and thin thermocouple in a unique configuration that can utilise a small >2℃ temperature fluctuations which occur naturally in applications such as ground-to-air, air to air water or air to air skin interfaces. Depending on the temperature range, a TEG electric output can be changed from microwatt to milliwatt or more by customising the design. This TEG application can cover many sectors, including Automobile performance monitoring, home, military security monitoring, biomedicine and farm management. The documented that the thermoelectric generator may be relevant for many other stand-alone, low- power applications depending on the environment applied (Id et al. 2014).

Domestic area each residential area has heat energy generated from electrical equipment such as air conditioners, heating water and refrigerator. Among electrical equipment that produces heat energy is air conditioners. The study has shown since 2011, air conditioning has become increasingly popular as requested by many residents of a residential area, and the new housing area is now constructed including air conditioning (Kubota et al. 2011). This air conditioning has an indoor and outdoor unit for full system operation. The indoor unit serves as a cooling unit where the outdoor unit will function to remove heat in a space, and indirectly the heat removed from the outdoor unit can be reused as renewable energy sources through the harvesting.

1.2 Problem Statement

Today the demand for energy is rising tremendously, but the electricity available is limited in availability. Energy is an essential requirement for human life and its development. Commercial energy sources are generally fossil fuels (coal, oil, and natural), hydroelectric and nuclear power plants that meet a country's energy needs that cause global warming. Given such problems linked to traditional energy sources are now focused on the conversation and efficient utilisation of energy. The average energy use of air conditioners has risen as provide a consistent means of cooling zoned room a residential and commercial building. Therefore, it will produce more waste heat energy from the outdoor air conditioners unit. From consideration to domestic area, energy losses or heat waste emitted from the cooking stove, outdoor air-conditioners unit or refrigerator is wasted to the environment and not being utilised. In view of that problem, by creating a device that can convert waste heat harvest energy and can bring many benefits to humanity. In addition, the aim of this system is also green energy to save our climate. Furthermore, the growing energy prices today may adversely affect the cost of living for consumers. This initiative will provide both residents with renewable electricity resources and secondary resources, such that electric power use from the grid can be that. In addition, the design of such a device should be proposed to not only optimize the operation of the device but also to hinder any drawback towards the performance of the applications.