UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF WASTE HEAT RECOVERY UNIT FOR PASSENGER CAR BY USING THERMOELECRIC GENERATOR

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

by

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BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

Tajuk: DEVELOPMENT OF WASTE HEAT RECOVERY UNIT FOR passenger CAR BY USING THERMOELECRIC GENERATOR

Sesi Pengajian: 2019

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Tarikh: 9 January 2020

Disahkan oleh penyelia:

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Cop Rasmi Penyelia

Tarikh: 9 January 2020

DECLARATION

I hereby, declared this report entitled DEVELOPMENT OF WASTE HEAT RECOVERY UNIT FOR passenger CAR BY USING THERMOELECRIC GENERATOR is the results of my own research except as cited in references.

Signature: ……

Author : MUHAMMAD HARITH AIZAD BIN ABDUL AMIN

Date: 9 January 2020

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 (Automotive) with Honours. The member of the supervisory is as follow:

Signature: …….

Supervisor : KHAIRUL AZRI BIN AZLAN

ABSTRAK

Dalam dunia moden sekarang, kita dikelilinigi oleh teknologi yang canggih dan hebat. Kita boleh melihat di sekeliling kita terdapat banyak peralatan yang sering kita gunakan di dalam kehidupan seharian yang kita tidak sedar akan kecanggihannya. Peralatan-peralatan ini dicipta untuk membantu manusia dalam menjalani kehidupan dengan lebih berkesan. Teknologi membantu untuk menjimatkan masa, untuk memberi keselesaan kepada mmanusia dan banyak lagi. Selari dengan itu, pada 180 tahun yang lalu, penjana thermoelectric telah dicipta dan sejak daripada itu ramai orang telah mencuba dan menjumpai kelebihan-kelebihan menggunakan penjana thermoelectric ini. Dari projek ini, objektif kertas ini adalah untuk menyiasat prestasi penjana termoelektrik (TEG) yang telah diletakkan di atas kereta. Kaedah ini dikaji secara eksperimen dengan menggunakan tenaga haba buangan yang dihasilkan oleh kereta ekzos. Sebuah kereta sedan 1.5 kereta kebangsaan digunakan dalam kajian ini di mana peranti TEG yang telah dibina telah diletakkan di paip ekzos selepas manifold ekzos. Kemudian suhu di tempat sejuk dan panas pada bahagian TEG, voltan dan arus diukur berdasarkan rpm kereta. Dari analisis dan pemerhatian, arus dan voltan yang dihasilkan meningkat apabila perbezaan suhu meningkat

ABSTRACT

In today's modern world, we are shaken by sophisticated and powerful technology. We can see around us there are many tools we often use in everyday life that we are not aware of the sophistication. These tools are designed to help people in their lives more effective. Technology helps to save time, to provide comfort to humans and more. In line with that, over the last 180 years, thermoelectric generators have been created and since then many people have tried and discovered the advantages of using this thermoelectric generator.From this project, the objective of this paper is to investigate the performance of thermoelectric generator (TEG) that had been placed on car. The method was experimentally studied by using waste heat energy produced by the exhaust's car. A 1.5 national sedan car was used in this study where the TEG prototype that had been built was been placed at the exhaust pipe after the exhaust manifold. Then the temperature at cold and hot side of TEG, voltage and current were measured based on the rpm of the car. From the analysis and observation, the current and voltage produced were increased as the temperature difference increased.

DEDICATION

To my beloved father and mother,

Abdul Amin Bin Othman and Halimah Binti Ahmad

The reasons of what I become today,

Thank you for all the supports, sacrifices, patience for me.

To my honoured supervisor and co-supervisor,

Khairul Azri Bin Azlan and Che Wan Mohd Faizal Bin Che Wan Mohd Zalani

And all UTeM lecturers and staff,

Thank you for always giving me guidance and

persistence helps to complete this project.

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All praise belongs to (SWT). Without the health, strength and perseverance He gave, I would not be able to complete this project thesis. I have taken efforts in this project and spend time wisely to complete this project. However, it would have not been possible without the kind support and help of many individuals. I want to thank to anyone that contributed in my project. They have encouraged me and giving me full thought during this project process. First, I would like to express the deepest appreciations to my supervisor, Khairul Azri Bin Azlan and my co-supervisor Che Wan Mohd Faizal Bin Che Wan Mohd Zalani for their patience and endless supports that continually teaching me throughout my project. Both of them gave me a proper suggestions and constant supervision as well as providing information regarding the project. Without their guidance and persistence help, this project would not complete successfully.

Besides that, my supervisor introduced me to this project, and he gave me a brilliant idea and thought about the project. By spending his valuable time, he shared his knowledge with his full attentions in carrying out this project. I also want to express my gratitude towards my beloved parents and families for their kind motivation to go through all the hard works and they give me support and positiveness while carrying out this project. In addition, I am very grateful for those who are giving me basic information and ideas for the project. My big appreciation also goes to the people who are directly and indirectly helped me in developing this project. Once again, thank you so much for all the supports.

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CHAPTER 1

INTRODUCTION

1.1 Background

Nowadays, the growth of technology is rapidly increasing, and it has advantages and disadvantages to it. One of the advantages is the work becomes faster, easier, more precise and saving time. But as the society are delighted with the development of more sophisticated technologies, there are drawbacks from it. The examples are pollution problems and energy demand. The pollution such as air pollution, noise pollution, and water pollution are getting worse day by day in every country in the world. The world needs to have the awareness about this. Even in daily life right know, the most common pollution is air pollution. One of the causes is from the waste of exhaust gas from the vehicles.

The number of vehicles moving on the road especially car increase year after year which makes the problem worse. A sustainable and green energy system is the most favorable approach in the fight against global warming. The development of this power supply system also can reduce consumer electricity since every year in Malaysia, electrical consumption has increased. The energy wasted from the car is heat and to not just let it be harmful to the environment, it needs to have reused them as renewable energy, so a new approach is needed. Thermoelectric generator (TEG) installed in cars is one such technology that can be used. More studies and research have been enhanced by the simple principle of converting heat energy from whatever source, including our bodies into acceptable energy.

Thermoelectric generator (TEG) has several distinct advantages over other technologies. This is because it is an environmentally friendly instrument, because it is reliable and because it has no mechanical part, it is less maintenance. It is also can be used at any time because it is not influence by the weather such as sunlight or wind. The aim of this project is therefore to implement the thermoelectric concept in order to produce electricity using waste heat from a common heat source in light weight vehicles.

1.2 Statement of the Purpose

The main objective of the proposed project are as follow:

1. To design a suitable TEG set to obtain maximum heat energy from the waste heat of the car.
2. To build a set of thermoelectric generators (TEG) prototype to be assemble with a place that provide the most heat energy sources from car.
3. To investigate the performance of the TEG that has been designed and built.

1.3 Problem Statement

The main problem with the design of a thermoelectric generator (TEG) is its very low efficiency. This thermoelectric module functions on the Seebeck impact that requires a minimum difference in temperature between two parties, named as cold and hot panels. The efficiency of the thermoelectric module improves, and a rated output voltage is achieved if the temperatures differ optimum. To this end, a cooling system consisting of a thermal sink and a fan or a water system to keep the temperature between the two sides of the thermoelectric module must be designed. It needs to control the voltage after that as the output module is not standardized and contains rips. Voltage regulator need to be used to solve this problem.

1.4 Scope of Study

The scope of this project is to study on the potential of seebeck in generating electricity using waste heat from car. The energy harvest technique is important for electricity production. Heat from the waste heat in a car is used through contact with the thermoelectric generator (TEG) which converts the heat into electric charges. But the velocity of the vehicle is the major factor in thermoelectric generator (TEG) power. The speed of the car should be increased to better performance of TEG. The higher temperature, the more energy for transformation into electrical energy is available. Temperature is significantly dependent upon the efficiency and power of thermoelectric generator (TEG).

Besides that, for the scope of study is to measure and maintain the voltage, power consumption, and electrical storage capacity of the system. The indicator for measuring power generation and system capacity in low power consumption devices will be these factors. The system proposed will also have an effective refrigeration system that maintains a low temperature on the cold side of the Thermoelectric Cooler to produce more energy from the car's waste heat. However, it is not possible for the system to power electrically consuming appliances like televisions, refrigerators, air conditions and other devices that required high level of power.

CHAPTER 2

LITERATURE REVIEW

This chapter will discuss about the review that will use to explodes the dominant themes include study and research of public material like journal, online library and technical document. Normally, the purposes of a literature review are to analyse critical segment of a publish body of knowledge through summary, classification and comparison of prior cases study, revere of literature and theoretical article. Further than that, this chapter will discuss topic that relate to thermoelectric generator

2.1 Introduction

Energy recovery techniques have long become significantly demanding due to the global energy crisis and environmental issues. Examples of energy recovery techniques include recycling water heat, ventilation for heat recovery, steam generators for heat recovery, and so on. Another attempt is to recover heat from waste by using thermoelectric power generators (TEGs). TEGs can convert thermal energy directly into electrical energy and have the benefits of light weight, no noise, and no mechanical vibration. In many applications, thermoelectric generator (TEG) have found their potential such as space, thermal energy sensors, textiles, etc. Automobiles waste heat is also considerable. Approximately, 40% of the fuel is generated from the exhaust pipe for a typical gasoline fuelled internal combustion engine and approximately 30% is lost in the coolant. Using these waste heat properly improves energy efficiency and saves money. The radiators and the exhaust system are the commonly used components in a vehicle to implement the thermoelectric generator (TEG). Hsiao established mathematical models

and performed experiments; by attaching TEGs to the exhaust system, they found better performance than the radiators. One way to go is to attach TEGs directly to the original exhaust s Alternatively, a heat exchanger can be built to extract heat from the exhaust pipe to the TEGs. system equipment, such as the catalytic converter, the muffler, the exhaust pipe, etc. (Weng & Huang, 2013)

2.2 Thermoelectric Generator (TEG)

2.2.1 Seebeck Effect

Thomas J. Seebeck discovered in 1821 that when one connection was heated, an electric force or potential difference could be generated through a circuit made of teo different wires. The Seebeck effect is known as. The SEececk effect creates electric current when different metals are exposed to temperature variance. Thermoelectric generator (TEG) or Seebeck generators that convert heat energy into electrical energy are the basis for applications for Seebeck's effects.

Thermoelectric generator (TEG) generates a voltage that corresponds to the temperature differences between the two metal connections. Thermoelectric generators (TEG) are the solid-state thermal engines consisting of p-type and n-type element pairs. The p-type elements are doped from semiconductor materials so that the load carriers are positive (holes) and the coefficient of Seebeck is positive. The elements of the n-type are doped from semiconductor material so that the charging carriers are negative (electrons) and the coefficient of Seebeck is negative.

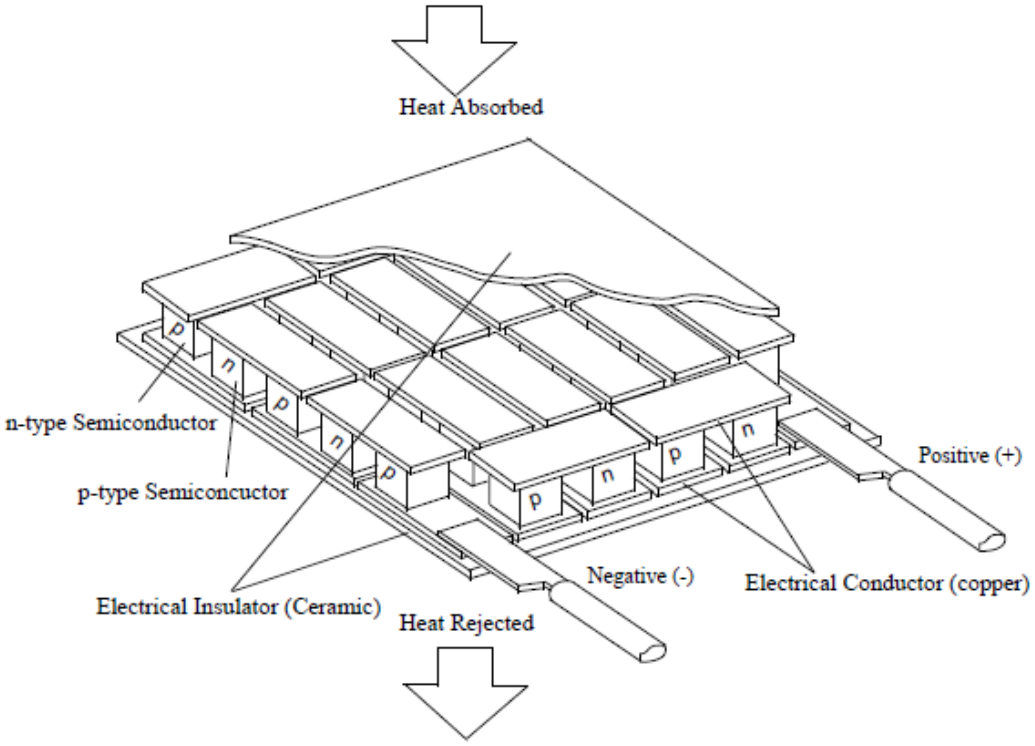

Figure 2.1 Cutaway of a thermoelectric generator module

2.2.2 Energy Generation

The mobile holes in the p-type element "see" the mobile electrons in the n-type element and migrate just to the other side of the junction when a p-type element connects electrically to the n-type element. For each hole migrating to the element n-type, an electron from the element n-type migrates to the element p-type. Soon, each hole and electron's switching sides are balanced and act as a block, preventing the migration of more electrons or holes. The area of degradation is known as this.

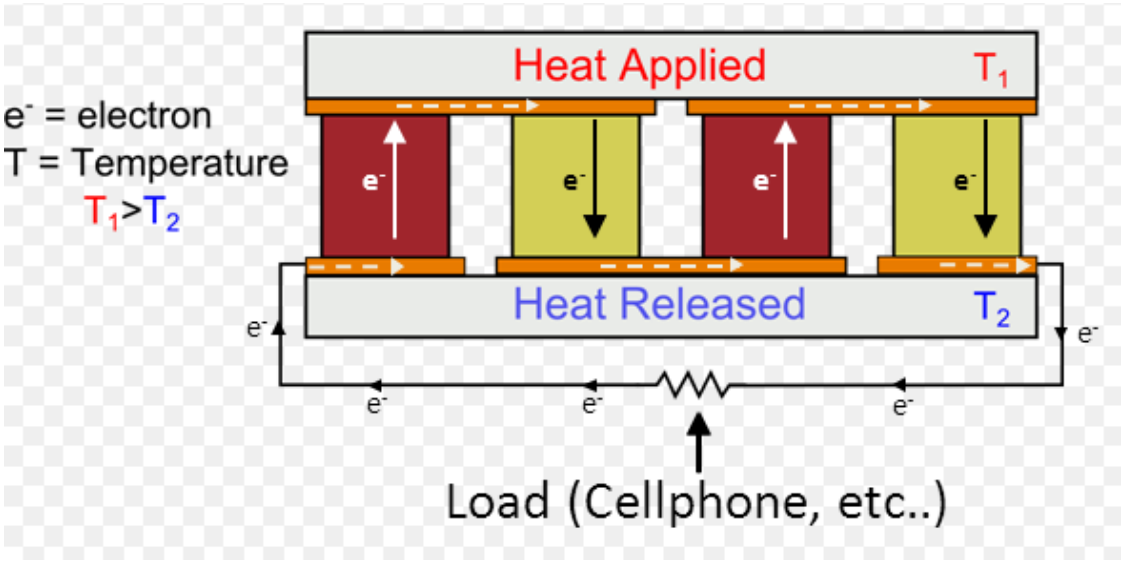

Figure 2.2 Inside Thermoelectric Generator

2.3 Potential of Car Exhaust Heat Recovery Using Thermoelectric Generator

Currently an internal combustion engine drives an overwhelming majority of cars. It was stated that the engine's thermal efficiency is about 25% on average. This means that as heat, 75% of the fuel's energy is wasted. 5% of friction and parasitic losses are wasted, 30% of engine coolant wasted and 40% of exhaust gas wasted. Although the engine's coolant contains a large proportion of waste heat, the coolant temperature should not exceed about 90 Celsius, which means the waste heat is lower. Recovering exhaust gas heat is therefore most viable as it is a higher grade / temperature. Thermoelectric generators might be used for the recovery of car exhaust heat. A study done by Bradly Orr and Aliakbar Akbarzadeh show the potential to be used on a car by the thermoelectric generator (TEG) exhaust heat recovery system.

Case study 1:

150 kW of mechanical power is produced by a car engine. The total energy input rate from the fuel can be calculated from equation 1a by using the above-mentioned energy distribution values of the engine. The heat energy rate in the exhaust gasses can be determined using equation 2a.

$$Q_{tot} = \frac{P_{eng}}{\eta_{eng}} \qquad (1a)$$

$$= \frac{150}{0.25}$$

$$= 600 \text{ kW}$$

$$Q_{exh} = \eta_{exh} Q_{tot} \qquad (2a)$$

$$= 0.4 \times 600$$

= 240 kW

Literature has listed a 24% thermal exchange efficiency and a 2.46% thermal efficiency for an exhaust heat recovery system. The heat recovery rate can be measured using equations 3a and the power generation potential can be calculated using equations 4a with these same values.(Orr & Akbarzadeh, 2017)

$Q_{rec} = \eta_{HX} Q_{exh}$ (3a)

= 0.24 x 240

= 57.6 kW

$P_{TEG} = \eta_{TEG}\, Q_{rec}$ (4a)

= 0.0246 x 57.6

= 1.4 kW

Nomenclature

P_{eng}	Engine power
P_{TEG}	TEG power
$\dot{Q}_{exh}$	Rate of heat energy in exhaust gases
$\dot{Q}_{rec}$	Rate of heat recovery
$\dot{Q}_{tot}$	Total rate of energy input from the fuel
η_{eng}	Engine efficiency
η_{exh}	Percentage of fuel energy in exhaust
η_{HX}	Heat exchanger effectiveness
η_{TEG}	TEG thermal efficiency