ANALYSIS ON VOLTAGE GENERATION AND THERMAL GRADIENT OF CAR WASTE HEAT USING THERMOELECTRIC GENERATOR

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For moms and dads

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ABSTRACT

This study is conducted to analyse the behaviour of voltage generation and thermal gradient of car waste heat when various conditions are applied; which consists of windows, brushless fan, sunshade, roofed car park, and air-conditioned, enclosed cabin. The analysis of these behaviours is made possible by utilising a set of three thermoelectric generators (TEGs) in each condition. Aside from those conditions, external load resistances are also introduced to the TEGs set to achieve the second objective of this study. The duration set to achieve the first objective is one hour whereas the duration for the second objective is ten minutes. At the end of the first objective, it is found that air-conditioned, enclosed cabin has the highest thermal gradient and thus voltage generation for both day and night time. On the other hand, at the end of the second objective, the optimise value of load resistance to match with the internal resistance of the TEGs set is around 100 to 500 Ω.

ABSTRAK

Kajian ini dijalankan bagi menganalisis tingkah laku generasi voltan dan kecerunan terma haba buangan kereta apabila pelbagai keadaan digunakan; yang terdiri daripada tingkap, kipas tanpa berus, pelindung matahari, tempat letak kereta berbumbung serta kabin tertutup berhawa dingin. Analisis tingkah laku ini dapat dilakukan dengan menggunakan set tiga dalam satu penjana termoelektrik (TEGs) dalam setiap keadaan. Selain daripada keadaan-keadaan tersebut, rintangan beban luaran juga diperkenalkan kepada TEGs untuk mencapai objektif kedua kajian ini. Tempoh yang ditetapkan untuk mencapai objektif pertama adalah satu jam manakala tempoh bagi objektif kedua adalah sepuluh minit. Di akhir objektif pertama, didapati bahawa kabin tertutup berhawa dingin mempunyai kecerunan terma yang paling tinggi dan generasi voltan untuk kedua-dua bacaan siang dan malam. Manakala, di akhir objektif kedua, nilai optimum rintangan beban yang sepadan dengan rintangan dalaman TEGs adalah sekitar 100 hingga 500 Ω.

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LIST OF ABBREVIATIONS

C	= Celsius
K	= Kelvin
k	= Kilo
m	= Mili
s	= Second
TEC	= Thermoelectric Cooler
TEG	= Thermoelectric Generator
TEM	= Thermoelectric Module
USB	= Universal Serial Bus
V	= Volt
W	= Watt
ZT	= Figure-of-Merit

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CHAPTER I

INTRODUCTION

This chapter shall explain in details regarding this study as well as the root factors of why it is conducted. Besides that, all the scope of works and general methodologies taken toward completing this study are also explained briefly in this chapter.

1.1 Introduction

When a car is parked in direct sunlight for long periods of time, it is never be a surprise to experience the dramatically increase of the temperature inside of the car. When there is always available initiative to slightly roll down the cars windows to reduce to temperature, there is always be some heat that is still trap inside. Thus, instead of sticking with the old mind set of complaining on the heat and let it gone by, it would be a far greater deed and more earth-friendly if the wasted heat is reuse in other beneficial applications.

Thermoelectric generators (TEGs) is used in this situation to convert thermal gradient produced in the car to electricity. From a previous study, it is found that the spots of where highest temperature is recorded are located near the glass windshields; specifically, on the dashboard and on the back surface near the rear windshield. The study is the proven again and the dashboard is chosen as the spot for completing both objectives of this study.

After that, a basic configuration is established consisted of a set of three TEGs and heatsink. By applying different conditions and ran through different time in a same day, the voltage generation and thermal gradient of the TEGs are analysed. Apart from that, the load dependent analysis is also characterized by introducing a load resistor to the TEGs.

1.2 Problem Statement

For a car parked and exposed under a direct sunlight, it is a normal occurrence for the car to trap in a lot of heat. In a way of supporting current uprising green campaign, a system which capable in converting the heat energy trapped in a car cabin into useful electrical energy for some low power application might be a good idea.

However, the output of those TEGs can never be predetermined as it is depending on the thermal gradient between both hot side and cold side of the TEGs. Thus, few conditions are set in order to study the behaviour of the voltage generated by the thermal gradient of each condition. Besides that, a load dependent analysis is needed to monitor the loading effect onto the voltage generation of the TEGs.

1.3 Objectives

1. To analyse the voltage generation and thermal gradient of car waste heat.
2. To characterize the load dependent analysis of car waste heat.

1.4 Scope of Work

This study is completed by achieving a few scope of works which consists of preliminary study on related information of TEG, study of thermal accumulation and distribution inside of car cabin, analysis on voltage generation and thermal gradient of car waste heat, and load dependent analysis of car waste heat.

The preliminary study on related information of TEG is basically only consisted of gathering information on basic concept of TEG, energy harvesting utilising TEG, as well as effects affecting the performance of TEG.

Study of thermal accumulation inside of a car cabin is done by measuring the open-voltage of one TEG directly using a digital multimeter. Ten data are collected at random time within one week duration which each consisted of outside temperature and measured (highest) voltage from each spot.

Analysis on voltage generation and thermal gradient of car waste heat can be further classified into two; which are the effect of different conditions and effect of different time of a day. To study the effect of different conditions, five other conditions are set aside from basic configuration where the thermal gradient and voltage generation from each condition are recorded. Meanwhile, to study the effect of different time of a day, the basic configuration is conducted in eight different time slots within 8.00 am to 6.00 am (of the next day); where the thermal gradient and voltage generation for each respective slot are also recorded.

Last but not least, load dependent analysis of car waste heat in done with ten different values of load resistance are being introduced to the basic configuration. For each value of load resistance, a total of 10 minutes duration is set and voltage generated by each load resistance is recorded.

1.5 Methodology Brief Explanation

Figure 1.1 shows the flow chart of the methodologies done for this study. This study is started with doing a lot of relevant literature review before proceeding to any

analysis. After that, the first part is done generally to determine which spot in a car cabin shall has the highest temperature and yield the highest voltage output. By applying the result from Part I, Part II and III shall be proceed only on the same spot determined. The second part is conducted in order to monitor the behaviour of voltage generation and thermal gradient of car waste heat when conducted in different conditions as well as different time. On the other hand, the third part is literally done to monitor the loading effect when a load resistor is introduced to the TEGs. From the result and observation gained in all parts, the study then proceeded with a thorough analysis on overall data collected.

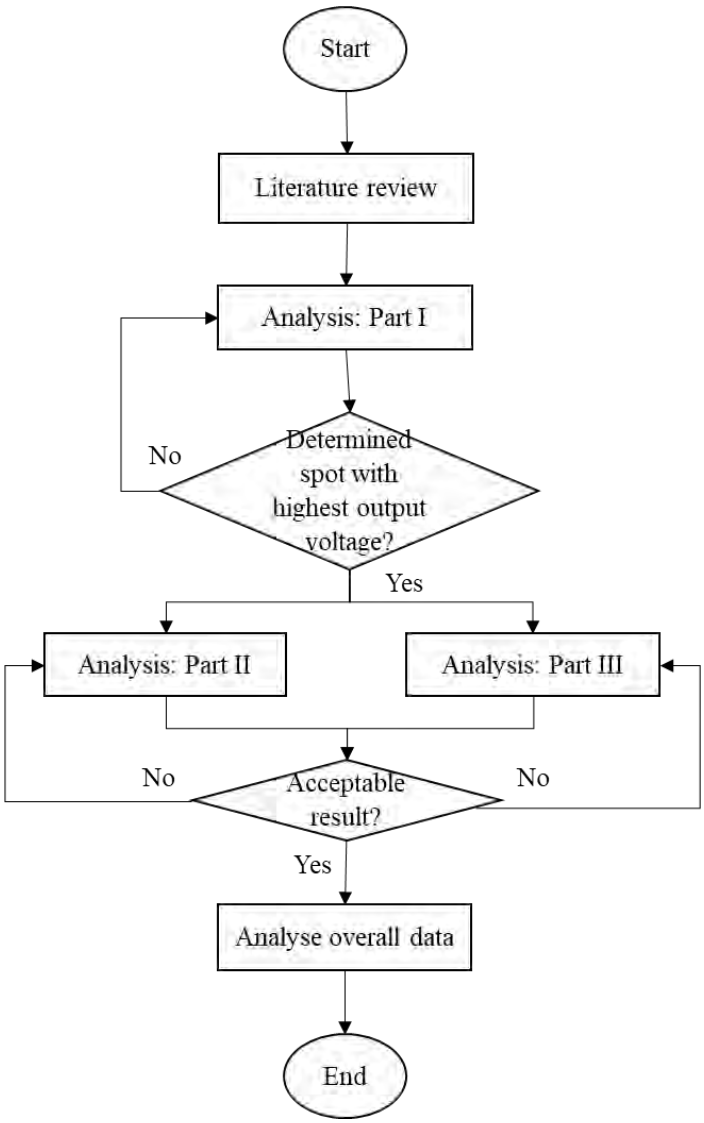

Figure 1.1: Flowchart of general methodology

1.6 Thesis Outline

This thesis consists of five main chapters as outlined in the table of contents. The summarisation of each chapter is as below:

Chapter 1 is regarding introduction. This chapter covered the introduction to the study. It represented the problem statement which leaded to this study, objectives needed to be achieved, scope of works, methodology and the thesis outline of this study.

Chapter 2 is consists of literature review. This chapter presented the brief explanation regarding thermoelectric generator which is the main component for this study. All the information in this chapter are derived either from published journals or books chapter.

Chapter 3 represented methodology. This chapter shows the detail explanation on how the study is conducted. It is divided into three parts, where each part may has difference methodology and carried a different purposed.

Chapter 4 is for result and discussion. This chapter shows all of the results obtained by conducting methodologies in Chapter 3. For each result, a detailed discussion is provided.

Last but not least, Chapter 5 is the all-around conclusion. This chapter contained the summarisation of the entire objectives, project achievements, as well as the recommendation for future work.

CHAPTER II

LITERATURE REVIEW

This chapter discussed all relevant information to this study in form of summarization from various trustworthy resources in forms of either published journals or books.

2.1 Introduction to Thermoelectric Generator

Thermoelectric module (TEM) is a device which converts thermal to electricity. The basic elements of a TEM are called thermoelements; where it's come in two types, p- and n- semiconductors as shown in Figure 2.1. These thermoelements are then connected electrically in series to increase the operating voltage and thermally in parallel to increase the thermal conductivity.

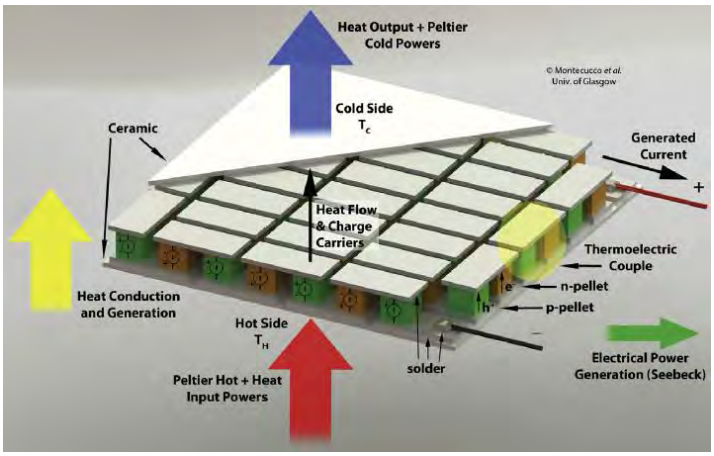

Figure 2.1: Thermoelectric generator [5]