BEHAVIORAL ANALYSIS OF THERMOELECTRIC MODULE UNDER DIFFERENT CONFIGURATIONS AND TEMPERATURE GRADIENT

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FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

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PROJEK SARJANA MUDA II

Tajuk Projek : BEHAVIORAL ANALYSIS OF THERMOELECTRIC MODULE UNDER DIFFERENT CONFIGURATIONS AND TEMPERATURE GRADIENT

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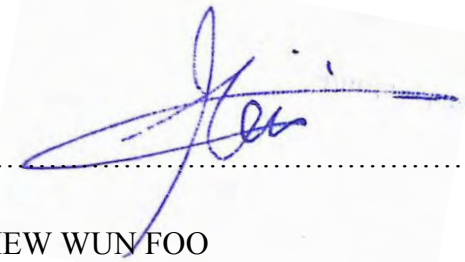
Signature : 

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"I acknowledge that I have read this report and in my opinion this report is sufficient in term of scope and quality for the award of Bachelor of Electronic Engineering (Industrial Electronics) with Honors."

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A very special dedication for my beloved family especially to my parents,

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ABSTRACT

Thermoelectric technology is one of the greatest inventions in the field of green technology. It is because thermoelectric technology capable to convert heat energy directly into electrical energy without required external conversion circuit. Also, thermoelectric technology is eco-friendly and it does not emit any polluted substances or gases in its application. There is the only issue that facing by the thermoelectric technology which is its low power generation. Nowadays, applications that use this type of technology are less and limited due to its low power generation. With its low efficiency of power generation, thermoelectric technology is only capable to supply power to low power electronic devices and some niche applications. Therefore, an analysis project is proposed to provide an engineering solution which capable to enhance the efficiency of thermoelectric technology in terms of temperature gradient and output voltage generated. In this paper, an analysis is carried out to analyse the behaviour of thermoelectric module under several arrangements of thermoelectric module. Also, a tested is carried out by using different types of heat sinks in terms of sizes for thermoelectric module to analyse the effect corresponding to its output voltage. It is important to study the relationship between temperature gradient and output voltage of thermoelectric module in order to come out an alternative solution to improve its efficiency of power generation.

In the summary of the analysis results, thermally connected in parallel and electrically connected in series (TPES) configuration showing the best results in terms of temperature gradient and output voltage. Heat sink with large contact surface and high height design shows the best cooling performance because it capable to maintain a huge temperature gradient between both sides of thermoelectric module.

ABSTRAK

Teknologi termoelektrik adalah salah satu ciptaan yang paling hebat dalam bidang teknologi hijau. Ia adalah kerana teknologi termoelektrik mampu untuk menukarkan tenaga haba terus kepada tenaga elektrik tanpa memerlukan litar penukaran. Selain itu, teknologi termoelektrik adalah mesra alam dan ia tidak mengeluarkan apa-apa bahan-bahan tercemar atau gas dalam aplikasinya. Terdapat satu-satunya isu yang dihadapi oleh teknologi termoelektrik, ia itu penjanaan kuasa yang rendah. Pada masa kini, aplikasi yang menggunakan jenis teknologi ini kurang dan terhad kerana penjanaan kuasa yang rendah. Dengan menghadapi masalah penjanan kuasa yang rendah, teknologi termoelektrik hanya mampu untuk membekalkan kuasa kepada peranti elektronik yang berkuasa rendah dan beberapa aplikasi am. Oleh itu, projek analisis adalah dicadangkan untuk menyediakan penyelesaian kejuruteraan yang mampu untuk meningkatkan kecekapan teknologi termoelektrik dari segi kecerunan suhu dan voltan output yang dihasilkan. Dalam kertas ini, analisis akan dijalankan untuk menganalisis kelakuan modul termoelektrik dalam beberapa perkiraan modul termoelektrik. Di samping itu, eksperimen telah dijalankan dengan menggunakan pelbagai jenis sinki haba dari segi saiz kepada modul termoelektrik untuk menganalisis kesan yang sepadan dengan voltan output. Adalah penting untuk mengkaji hubungan antara kecerunan suhu dan output voltan modul termoelektrik tujuan untuk mengeluarkan penyelesaian alternatif bagi meningkatkan kecekapan penjanaan kuasa.

Dalam kesimpulan keputusan analisis, haba bersambung secara selari dan elektrik bersambung secara siri (TPES) konfigurasi menunjukkan hasil yang terbaik dari segi kecerunan suhu dan voltan output. Sink haba dengan permukaan sentuhan besar dan reka bentuk ketinggian yang tinggi menunjukkan prestasi penyejukan yang terbaik kerana ia mampu untuk mengekalkan kecerunan suhu yang besar antara kedua-dua belah modul termoelektrik.

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TES	-	Thermoelectric System
TEG	-	Thermoelectric Generator
TEM	-	Thermoelectric Module
DC	-	Direct Current
SC-TES	-	TES Thermally and Electrically Connected in Series
PSC-TES	-	TES Thermally and Electrically Connected in Parallel
SSC-TES	-	Parallel Thermally and Series Electrical Connection
ICE	-	Internal Combustion Engine
TSES	-	Thermally and Electrically Connected in Series
TPEP	-	Thermally and Electrically Connected in Parallel
TPES	-	Thermally Connected in Parallel and Electrically Connected in Series
TSEP	-	Thermally Connected in Series and Electrically Connected in Parallel

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CHAPTER I

INTRODUCTION

This chapter will discuss the introduction of the analysis project. There are some sub-topics that will be discusses regarding to the analysis, which is the introduction of the project, problem statement, objective of the analysis, scope of work, project methodology and thesis outline.

1.1 Introduction

Thermoelectric is one of the greatest inventions in green technology. One of the useful features in thermoelectric technology is that the electrical energy is converted directly from heat energy through thermoelectric device without required external electronic devices in the conversion process. Although thermoelectric technology is convenient to use but still the applications using this type of technology are very limited due to its low voltage and low power generated. Therefore, an analysis was carried out to study the behaviour of thermoelectric module under different configuration and temperature gradient in order to obtain the high output voltage and high power generation. Also, an analysis was carried out to study the effect of different types of heat sinks on the output voltage of thermoelectric module.

1.2 Problem Statement

Thermoelectric technology is easy and convenient to use in designing an electronic application due to its low fabrication cost. In the presence of heat energy, thermoelectric device can converted heat energy directly into electrical energy without external conversion circuits or electronic devices. In terms of sustainable, thermoelectric technology is out of the question due to its low output voltage and low power generation. The applications which are using this kind of technology are less

and limited in the market because the output voltage and output power generated by thermoelectric device is significantly low and unsustainable. The low output voltage and output power generated by the thermoelectric device is sufficient to supply only to low power electronic devices. In order to widely implement thermoelectric technology in high power electronic devices, an analysis must be carried out to investigate the best way to generate high output voltage and output power as well as high sustainable voltage supplied.

1.3 Objectives

The objectives of the analysis are:

a. To analyse the behaviour of thermoelectric module in several arrangements of thermoelectric module configuration.

b. To analyse the effect of different types of heat sinks on the output voltage of thermoelectric module.

c. To analyse the relationship between the temperature gradient and its corresponding output voltage of thermoelectric module.

1.4 Scope of Work

This project consists of two parts of analysis: first part is to analyse the behaviour of thermoelectric module in several arrangements of thermoelectric module configuration; second part is to analyse the effect of different types of heat sinks on the output voltage of thermoelectric module.

In the first part of the analysis, the behaviour of thermoelectric module is tested in four different arrangements of configuration and analysis is made based on its temperature gradient and output voltage. The four different arrangements of configuration are thermally and electrically connected in series; thermally and electrically connected in parallel; thermally connected in parallel and electrically connected in series; thermally connected in series and electrically connected in parallel. The test is carried out using two thermoelectric modules and four thermoelectric modules which test separately for each four of the different

arrangements of configuration. The heat energy is generated from the hot plate as the heat source for thermoelectric module to generate output voltage with temperature of 100°C within 30 minutes. Due to the limitation operation temperature of the thermoelectric module, the analysis is carried out with temperature of the hot plate set to 100°C for four different arrangements of configuration in order to avoid the malfunction of thermoelectric module.

In the second part of the analysis, total of five types of heat sinks are used to analyse the effect of different types of heat sinks on the output voltage of thermoelectric module. Based on the result of the analysis in the first part, the best thermoelectric configuration is chosen to carry on into the second part of analysis. The analysis is carried out with temperature of the hot plate set to 100°C within 15 minutes for all five types of heat sinks. The minimum time taken for thermoelectric module to achieve equilibrium is around 15 minutes. Therefore, the time taken for this analysis is only set to 15 minutes in order to analyse the different temperature gradient obtained from the different types of heat sinks.

1.5 Project Methodology

An analysis is carried out to study which is the best thermoelectric module configurations in terms of temperature gradient and output voltage. The four types of thermoelectric module configurations are thermally and electrically connected in series; thermally and electrically connected in parallel; thermally connected in parallel and electrically connected in series; thermally connected in series and electrically connected in parallel. A hot plate was used which act as a heat source to supply heat energy for thermoelectric modules to convert it into electrical energy. The temperature was set to 100°C and sample was recorded within 30 minutes for all four types of thermoelectric module configurations. For the analysis of the effect of different types of heat sinks on the output voltage of thermoelectric module, the temperature of hot plate is set to 100°C and sample is recorded within 15 minutes for all five types of heat sinks.

A PicoTech TC-08 Thermocouple data logger is used to measure the temperature at hot side and cold side of the thermoelectric module. Using PicoLog Recorder software, the temperature gradient between hot side and cold side of