‘I hereby declare that I have read this dissertation and found its content and form to meet acceptable presentation standards of scholarly work for the award of Bachelor of Mechanical Engineering (Thermal-Fluid)’

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Date	: …………………………………

THE PERFORMANCE OF THERMOELECTRIC POWER GENERATOR (TEG)

BASED HI-Z THERMOELECTRIC MODULES

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A report submitted in partial fulfillment of the

Requirement for the award of the degree of

Bachelor of Mechanical Engineering (Thermal-Fluid)

Faculty of Mechanical Engineering

Universiti Teknikal Malaysia Melaka

MAY 2010

I hereby, declare that this thesis entitled *"The performance of thermoelectric power generator (TEG) based Hi-Z thermoelectric modules"* is the result of my own research except as cited in the references.

Signature : ....

Name : MOHD HIDAYAD BIN ZULKIFLI

Date : 18/05/2010

Specially dedicated to My beloved father and mother who gives their endless love and support, family, friends and companion

ACKNOWLEDGEMENT

In the name of Allah, The Most Gracious, The Most Merciful. First and foremost, I thank to Allah for giving me this opportunity to complete my report successfully.

First of all, my heartiest appreciation to my final year project supervisor, Mr. Mohamad Firdaus Bin Sukri for his guidance, advice, support which have put me in the performance of thermoelectric power generator (TEG) based Hi-Z thermoelectric modules of this project. His idea, experience and knowledge had been aspiring to me abundantly.

I am also thankful to my other lecturers in Mechanical Faculty and fellow friends for sharing their valuable knowledge with me and not to forget my beloved family members for their endless support and encouragement.

ABSTRACT

Thermoelectric is a type of energy that created as resulting from power combination heat and electricity based on the necessary factors. Thermoelectric generator is a component that can change heat energy to electric power. Based on the study, thermoelectric generator is producing electrical energy from thermoelectric generator that has been installed on 1.3L 4G13 engine. This study is presenting production of electrical energy obtained by thermoelectric generator, based on Hi-Z thermoelectric module applied on 1.3L 4G13 engine. Before implementing the project, literature review is to study and identify the generator, module thermoelectric, heat transfer process, 1.3L 4G13 engine coolant system in vehicle and dynamometer. This study also required an analysis to choose the best location for thermoelectric generator before installing it on compartment of engine. Then, it is necessary to set up an experiment procedure which aiming to study and observe electrical energy generate which occur in thermoelectric generator when fitted in the 1.3L 4G13 engine. The production of electrical energy from this experiment was slightly less compared to theory result. Meanwhile, the engine efficiency would decrease and torque power and force become higher. This is because the coolant temperature that had emerged from thermoelectric generator.

ABSTRAK

Termoelektrik adalah suatu tenaga yang tercipta hasil dari gabungan kuasa haba dan kuasa elektrik mengikut beberape faktor yang diperlukan. Manakala Penjana kuasa termoelektik adalah sebuah komponen yang dapat mengubah tenaga haba kepada tenaga elektrik. Didalam kajian ini penjana kuasa termoelektrik menghasilkan tenaga elektrik dari penjana kuasa termoelektrik yang dipasang pada engine 4G13 1.3L. Kajian ini membentangkan penghasilan yang diperolehi oleh penjana kuasa termoelektrik. Kajian ini adalah untuk menentukan penghasilan yang berlaku oleh penjana kuasa termoelektrik berdasarkan modul termoelektrik Hi-Z termoelektrik apabila digunakan bersama enjin 4G13 1.3L. Sebelum kajian terhasil, kajian ilmiah dilakukan untuk mengkaji dan mengenalpasti mengenai penjana kuasa elektrik, modul termoelektrik, proses pemindahan haba, enjin 4G13 1.3L, sistem penyejukan pada kenderaan dan dinamometer. Kajian ini juga memerlukan analisis untuk memilih lokasi yang terbaik untuk penjana kuasa termoelektrik yang dipasang pada ruang enjin. Seterusnya, prosedur ujikaji dilakukan untuk mengetahui penghasilan yang terjadi pada penjana kuasa elektrik apabila dipasang terus pada enjin 4G13 1.3L tersebut. Penghasilan dari ujikaji dapat diketahui bahawa tenaga elektrik terhasil walaupun sedikit berbanding hasil teori. Kerja yang dilakukan pada enjin akan berkurang dan menghasilkan kuasa dan daya kilas yang tinggi ini disebabkan oleh suhu penyejuk yang keluar dari penjana kuasa elektrik..

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

DC	=	Direct Current
T	=	Temperature, ˚C
I	=	Current
ΔT	=	temperature difference, ˚C
Q_c	=	cooling power, W
V	=	voltage, V
α	=	coefficient
σ	=	electrical conductivity
k	=	thermal conductivity
R	=	resistance, ohm
G_{fh}	=	volume flow rate, m^2/s
ρ_{fh}	=	fluid density
C_{fh}	=	specific heat capacity.
Δt_{fh}	=	temperature drop
η	=	efficiency
Bi_2Te_3	=	Bismuth telluride
P	=	Electric Power
W	=	Power Output
Q	=	Heat Dissipate

LIST OF APPENDICES

CHAPTER I

INTRODUCTION

1.1 Introduction into General Topic

Many years ago, energy helps us to do things. It gives us light. It warms our bodies and homes. It bakes cakes and keeps milk cold. It runs our TVs and moves our cars. It makes us grow, move and think. Energy is the power to change things. It is the ability to do work.

The energy is used to produce heat and keeps our bodies warm. Sometimes, when run or work hard it can generate heat and feel really hot. In the winter, our jackets and blankets help to keep warm of the body. The energy is stored in plants and other things used to produce heat. The process of burning wood and natural gas to cook meals can make the house warm. Factories burn fuel to manufacture the products and also the power plant burn coals to produce electricity.

Energy runs machines; it takes energy to run TVs, computers and video games-energy in the form of electricity. Generate electricity by burning coal, oil, gas and even trash. Energy can produces from the sun, the wind, and falling water. Sometimes, the heat from inside the earth is used to generate electricity.

1.2 Thermal Energy

Thermal energy is generated and measured by heat. It is caused by the increased activity or velocity of molecules in a substance, which in turn causes temperature to rise accordingly. There are many natural sources of thermal energy on Earth, making it an important component of alternative energy.

The laws of thermodynamics explain that energy in the form of heat can be exchanged from one physical object to another. For instance, putting fire under a pot of water will cause the water to heat up as a result of the increased molecular movement. In that way, the heat, or thermal energy, of the fire, is partially transmitted to the water.

Understanding the principles of thermodynamics has allowed human beings to harness natural sources of heat to create thermal energy out of a variety of sources. The sun, ocean, and geothermal sources such as geysers and volcanoes, can all be sources of thermal energy. As humans attempt to turn to sustainable forms of alternative energy instead as fossil fuel resources become depleted, much attention has been focused on improving methods of harnessing thermal energy to power human activity.

1.3 Basic of Heat Transfer

In the simplest of terms, the discipline of heat transfer is concerned with only two things: temperature, and the flow of heat. Temperature represents the amount of thermal energy available, where as heat flow represents the movement of thermal energy from place to place.

On a microscopic scale, thermal energy is related to the kinetic energy of molecules. The greater a material's temperature and the greater the thermal agitation of its constituent molecules (manifested both in linear motion and vibrational modes). It is natural for regions containing greater molecular kinetic energy to pass this energy to regions with less kinetic energy.

Several material properties serve to modulate the heat transferred between two regions at differing temperatures. Examples include thermal conductivities, specific heats, material densities, fluid velocities, fluid viscosities, surface emissivities, and more. Taken together, these properties serve to make the solution of many heat transfer problems an involved process.

1.3.1 Heat Transfer Mechanisms

Heat transfer mechanisms can be grouped into 3 broad categories:

- Conduction
- Convection
- Radiation

1.4 Direct Energy Conversion

The energy conversion devices that have been in use for a long time are those that accept energy heat and produce mechanical work which is transformed into electrical power for distribution at last. Direct energy conversion device convert naturally available energy into electricity without an intermediate conversion into mechanical work. The energy source may be thermal, solar or chemical. Until now their uses have been confined to small scale special purpose applications, since the voltage output available with them is rather small.

The efficiencies of all modern-conventional thermal power generating systems between 35 to 42% as they have to reject large quantities of heat to the surroundings. In all conventional power plants (steam turbine, gas turbine, and diesel power plants), first the thermal energy is converted into mechanical work and then into electrical power.

Due to intermediate steps of conversion, efficiency is reduced to great extent. Great attempts have been made during the last two decades to convert thermal, electromagnetic or chemical energy directly into electrical energy raising the thermodynamic efficiency to 60 to 75%. Such systems are called direct energy converters.

1.5 Problem statement

More than 60% of the energy that goes into an automotive combustion cycle is lost, primarily to waste heat through the exhaust and radiator system. This is particularly true of automobiles, where two-thirds of the fuel is emitted unused in the form of heat. About 30 percents are lost through the engine block and a further 30 to 35 percents as exhaust fumes. It is clear that when a vehicle is loaded with a thermoelectric power generator (TEG), it is possible to generate electricity by using a “waste heat recovery” concept. Nevertheless, the installation of TEG will disturb the fundamental principle of the vehicle system operation itself. In other hand, the investigation of the performance of this TEG is very important to justify the suitability of the usage. By this reason a research has been proposed and will be conducted to investigate the performance of TEG when being used with 1.3L 4G13 engine.

1.6 Objectives of the Project

The objective of this project is to determine the performance of TEG based on Hi-Z thermoelectric modules when been using with 1.3L 4G13 engine.

1.7 Scopes of the Project

The scopes of this project are as follows:

1. Literature review on TEG, Thermoelectric Modules, heating transfer process etc.
2. Conduct analysis to choose the best location for TEG (used with selected compartments of engine).
3. Conduct experimental study on 1.3L 4G13 engine by using ready to use TEG.
4. Manipulate data collected from experimental study to determine the performance of the TEG.

CHAPTER II

LITERATURE REVIEW

2.1 Introduction

In this chapter there will be the literature review of this project. This chapter consist briefly the heat transfer process, basic of thermoelectric modules, studies about the TEG, 1.3L 4G13 engine, cooling system and Dynamometer.

2.2 Heat Transfer Process

Heat transfer is the transition of thermal energy from a hotter object to a cooler object ("object" in this sense designating a complex collection of particles which is capable of storing energy in many different ways) [4]. When an object or fluid is at a different temperature than its surroundings or another object, transfer of thermal energy, also known as heat transfer, or heat exchange, occurs in such a way that the body and the surroundings reach thermal equilibrium. Heat transfer always occurs from a higher-temperature object to a cooler temperature one as described by the second law of thermodynamics or the Clausius statement. Where there is a temperature difference between objects in proximity, heat transfer between them can never be stopped; it can only be slowed.

During processing, temperatures may change and therefore the rate of heat transfer will change. This is called unsteady state heat transfer, in contrast to steady state heat transfer when the temperatures do not change. An example of unsteady state heat transfer is the heating and cooling of cans in a retort to sterilize the contents. Unsteady state heat transfer is more complex since an additional variable, time, enters into the rate equations.

Heat can be transferred in three ways: by conduction, by radiation and by convection.

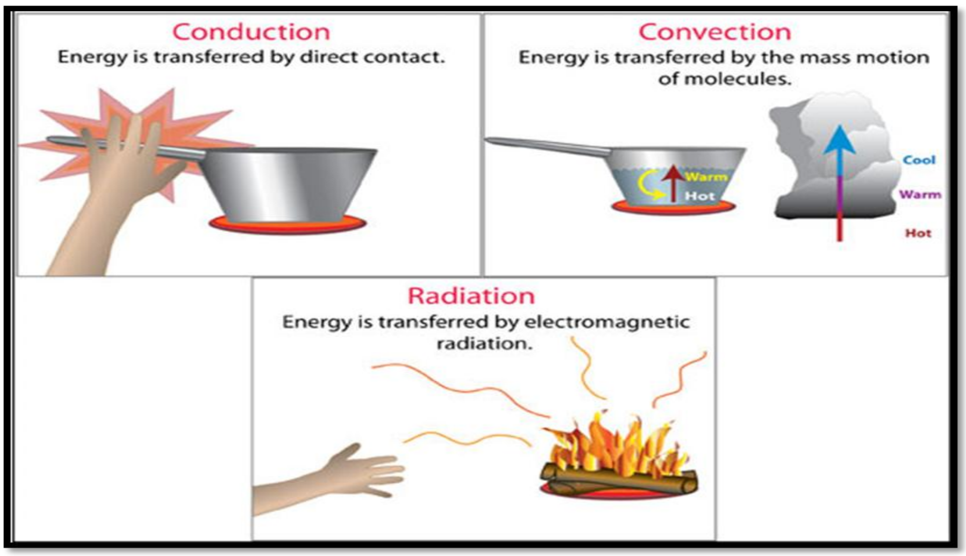

Figure 2.1: Conduction, convection and radiation (Source: Oklahoma Climatological Survey, (1996))

In general, heat is transferred in solids by conduction, in fluids by conduction and convection. Heat transfer by radiation occurs through open space, can often be neglected, and is most significant when temperature differences are substantial. In practice, the three types of heat transfer may occur together. For calculations it is often best to consider the mechanisms separately, and then to combine them where necessary.

2.2.1 Conduction

In heat transfer, conduction is the transfer of thermal energy between neighboring molecules in a substance due to a temperature gradient. It always takes place from a region of higher temperature to a region of lower temperature, and acts to equalize temperature differences [4]. Conduction takes place in all forms of matter, viz. solids, liquids, gases and plasmas, but does not require any bulk motion of matter. In solids, it is due to the combination of vibrations of the molecules in a lattice and the energy transport by free electrons. In gases and liquids, conduction is due to the collisions and diffusion of the molecules during their random motion. For example, a spoon in a cup of hot soup becomes warmer because the heat from the soup is conducted along the spoon. Conduction is most effective in solids-but it can happen in fluids. Conduction is one of the ways that energy is transferred from the earth's atmosphere to the air. Conduction is the process by which heat energy is transmitted through collisions between neighboring molecules [4].

That the energy is transferred by conduction and that the heat-transfer rate per unit area is proportional to the normal temperature gradient. When the proportionality constant is inserted,

$$\mathbf{q_x = -kA\frac{\partial T}{\partial x}} \qquad (1)$$

Where qx is the heat transfer rate, k is thermal conductivity and dT/dx is the temperature gradient in the direction of the heat flow.

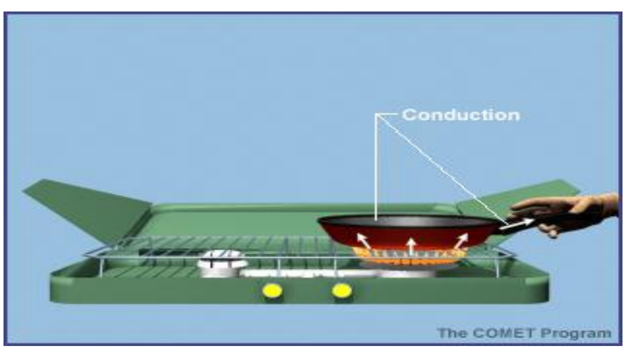

Figure 2.2: Frying pan set (Source: Physical Science, Transfer of Energy, (1998))