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THE HOLDER OF THERMOELECTRIC POWER GENERATOR (TEG) BASED HI-Z THERMOELECTRIC MODULES

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

Signature : .....
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Date : ……

DEDICATION

Specially dedicated to my beloved family who gives their endless love and support, family, friends and companion

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ABSTRACT

Thermoelectric power generator (TEG) is a device that can convert heat directly to electricity. This project aims to produce the holder that can hold TEG in the decided position. In this research, the finding of the best location was done before designing the holder of TEG take place. There are few aspects which will be considered during choosing the best location of TEG. After deciding the location to place the holder, there are few conceptual design of TEG. One conceptual design was selected and detail drawing for the holder had been produced. The material for the holder will be analyzed to make sure the holder can hold the TEG safely. The material selection for the holder is based on the yield strength and tensile strength of the material. After the material for the holder has been selected, analysis of the holder using SolidWork will be done to get the value of maximum normal stress and minimum factor of safety. After the analysis in defining the maximum normal stress and minimum factor of safety has been done, the best material to fabricate the holder can be defined.

ABSTRAK

Penjana Kuasa Termoelektrik (PKT) ialah sebuah komponen yang dapat menukarkan tenaga haba kepada tenaga elektrik. Projek ini bertujuan untuk menghasilkan sebuah pemegang yang dapat memegang PKT pada tempat yang telah dipilih. Dalam projek penyelidikan ini, pemilihan tempat yang sesuai telah dilakukan sebelum mereka bentuk pemegang PKT dibuat. Terdapat beberapa aspek yang dititikberatkan di dalam pemilihan tempat yang terbaik untuk TEG. Selepas pemilihan tempat telah dibuat, terdapat beberapa konsep untuk dijadikan pemegang PKT telah direka dan lukisan secara terperinci pada pemegang telah dikeluarkan. Bahan yang akan untuk membuat pemegang akan dikaji untuk memastikan pemegang akan dapat memegang PKT dengan selamat. Pemilihan untuk membuat pemegang adalah berdasarkan kepada kekuatan tegangan dan kekuatan tekanan bahan tersebut. Selepas bahan yang akan digunakan untuk membuat pemegang dipilih, analisis pada pemegang menggunakan perisian SolidWork digunakan untuk mendapatkan nilai kekuatan tertinggi and tahap keselamatan pemegang tersebut. Selepas analisis untuk mendapatkan nilai kekuatan tertinggi and tahap keselamatan pemegang tersebut telah dapat, bahan yang terbaik untuk membuat pemegang dapat dicari.

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LIST OF SYMBOLS

F	=	Force, N
M	=	Moment, N.m
I	=	Moment of Inertia, m^4
c	=	Centroid of the Cross Secton, m
τ	=	Torsional Stress, N/m^2
T	=	Torsion, N.m
J	=	Polar Moment of Inertia, m^4
σ_1	=	Maximum Normal Stress, M/m^2
Q	=	Total Heat Transfer, kJ
q	=	Heat Transfer Rate, W
h	=	Convection Heat Transfer, $W/m^2.{}^oC$
T	=	Temperature, ^0C
A	=	Surface Area, m^2
x	=	Length, m
k	=	Thermal Conductivity, W/m. ^oC

CHAPTER I

INTRODUCTION

This research project had been carried out to produce a holder of thermoelectric power generator (TEG) based on the Hi-Z thermoelectric modules when using with 1.6L Campro engine. Through Seebeck effect, the TEG is used to recover heat loss from the coolant by converting to electricity.

1.1 Problem Statement

Study on thermoelectric power generator shows that the thermoelectric is the device can convert heat to electricity. In this project, the thermoelectric will be placed between engine and radiator. There are many position of TEG at the engine compartment but the best location must be choosen. The location of TEG is something critical since it can effect to the performance of the TEG. In other aspect, the holder is also considered in order to make sure this TEG can maintain the right position at any time without any problems. Therefore, this project is proposed to produce a conceptual design of holder for thermoelectric power generator (TEG).

1.2 Introduction into General Topic

Energy comes in difference forms such as heat (thermal), light (radiant), mechanical, electrical, chemical and nuclear energy. There are two type of energy such as stored energy is potential energy and moving energy is called kinetic energy. All forms of energy are stored in different ways, in the energy sources that we use every day. These sources are divided into two groups:

- Renewable
- Nonrenewable

Renewable is an energy source that can be replenished in a short period of time and nonrenewable is an energy source that we are using up and cannot recreate in a short period of time. Renewable and nonrenewable energy sources can be used to produce secondary energy sources including electricity and hydrogen.

The capability of thermoelectric module to convert automotive waste heat to electricity can be considered as a renewable energy. Thermoelectric conversion of heat to electricity has been used in various applications since the advent of semiconductor materials science enabled practical devices to be made.

1.2.1 Energy Transformation

In physics, the term energy describes the amount of work which may potentially be done by force within a system. Changes in energy in systems can only be accomplished by adding or subtracting energy from them, as energy is a quantity which is conserved. Energy in a system may be transformed so that it resides in a different state. Energy in many states may be used to do many varieties of physical work. Energy may be used in natural processes or machines, or else to provide some service to society For example, an internal combustion engine converts the potential chemical energy in gasoline and oxygen into heat, which is then transformed into the propulsive energy (kinetic energy that moves a vehicle. A solar cell converts solar radiation into electrical energy that can then be used to light a bulb or power a

computer. The generic name for a device which converts energy from one form to another is transducer.

1.2.1.1 Electricity

Electricity is a general term that encompasses a variety of phenomena resulting from the presence and flow of electric charge. These include many easily recognizable phenomena, such as lightning and static electricity, but in addition, less familiar concepts, such as the electromagnetic field and electromagnetic induction.

In general usage, the word "electricity" is adequate to refer to a number of physical effects. In scientific usage, however, the term is vague, and these related, but distinct, concepts are better identified by more precise terms:

- Electric charge – a property of some subatomic particles, which determines their electromagnetic interactions. Electrically charged matter is influenced by, and produces, electromagnetic fields.
- Electric current – a movement or flow of electrically charged particles, typically measured in amperes
- Electric field – an influence produced by an electric charge on other charges in its vicinity
- Electric potential – the capacity of an electric field to do work on an electric charge, typically measured in volts
- Electromagnetism – a fundamental interaction between the magnetic field and the presence and motion of an electric charge

Electrical phenomena have been studied since antiquity, though advances in the science were not made until the seventeenth and eighteenth centuries. Practical applications for electricity however remained few, and it would not be until the late nineteenth century that engineers were able to put it to industrial and residential use. The rapid expansion in electrical technology at this time transformed industry and society. Electricity's extraordinary versatility as a source of energy means it can be put to an almost limitless set of applications which include transport, heating,

communications, and computation. The backbone of modern industrial society is, and for the foreseeable future can be expected to remain, the use of electrical power (Source: www.Wikipedia, October (2009)).

1.3 Objectives

The objective of the project is to produce a conceptual design of holder for TEG based Hi-Z thermoelectric modules when using with 1.6L Campro engine.

1.4 Scopes

The scopes of the project are:

1. Literature review on related topics.
2. Conduct analysis to choose the best location for ready to used TEG.
3. Produce a conceptual design for the holder.
4. Conduct analytical study to determine the theoretical /expected forces/ load acting on the holder.

CHAPTER II

LITERATURE REVIEW

2.1 Brief History

Early 19th century scientists, Thomas Seebeck and Jean Peltier, first discovered the phenomena that are the basis for today's thermoelectric industry. Seebeck found that if temperature gradient placed across the junctions of two dissimilar conductors, electrical current would flow. Peltier, on the other hand, learned that passing current through two dissimilar electrical conductors, caused heat to be either emitted or absorbed at the junction of the materials.

It was only after mid-20th Century advancements in semiconductor technology, however, that practical applications for thermoelectric devices became feasible. With modern techniques, to produce thermoelectric "modules" that deliver efficient solid state heat-pumping for both cooling and heating; many of these units can also be used to generate DC power in special circumstances. New and often elegant uses for thermoelectrics continue to be developed each day.

Thomas Johann Seebeck initially believed this was due to magnetism induced by the temperature difference. However, it was quickly realized that it was an electrical current that is induced, which by Ampree's law deflects the magnet. More specifically, the temperature difference produces and electric potential (voltage) which can drive an electric current in a closed circuit. Today, this is known as the Seebeck effect. The voltage produced is proportional to the temperature difference between the two junctions. The proportionality constant is known as the Seebeck coefficient, and often referred to as the thermoelectric power or thermopower. The

Seebeck voltage does not depend on the distribution of temperature along the metals between the junctions. This is the physical basis for a thermocouple, which is used often for temperature measurement.

Jean Peltier found that an electrical current would produce heating or cooling at the junction of two dissimilar metals. Depend on the direction of current flow, heat could be either removed from a junction to freeze water into ice, or by reversing the current, heat can be generated to melt ice. The heat absorbed or created at the junction is proportional to the electrical current. The proportionality constant is known as the Peltier coefficient.

2.2 Introduction to Thermoelectric

Thermoelectric can convert thermal energy into electrical energy or use electrical energy to move heat. Thermoelectric conversion of heat to electricity has been used in various applications since the advent of semiconductor materials science enabled practical devices to be made. The widest use of the technology has been in applications to take advantage of the reliability and ruggedness that come from a high degree of solid stage function, for example in comparison to rotating machinery for electric generation. Thermoelectric generator (TEG) theoretically may offer many advantages such as being highly reliable, having no moving parts, and being environmentally friendly, when compared with conventional electric power generators.

Owing to these advantages, there have been considerable emphases on the development of the small TEGs for a variety of aerospace and military applications over the past years. More recently, there is a growing interest for waste heat recovery TEG, using various heat sources such as combustion of solid waste, geothermal energy, power plants, and other industrial heat-generating processes.

2.3 Heat Energy Converting to Electrical Energy

According to Daniel Jaiench (2009), for the most part, energy leaves automobiles unused in the form of waste heat through the exhaust pipe. The part of it could be recovered using thermoelectric modules. Although both effects always occur together, each can be used on its own with extreme precision. Depending on whether a temperature difference or an electric voltage is applied to thermoelectric materials, the respective counterpart is produced electric energy, heat or cold.

Daniel Jaiench (2009), state that the thermoelectric can help to secure mobility. Thermoelectric generators (TEGs) using the Seebeck effect convert heat directly into electric energy. As they use dissipated heat instead of mechanical energy, they generate electricity more or less for free and cut fuel consumption, CO2 emission and pollution. As a result, they significantly improve energy efficiency, environmental compatibility and the economy of forthcoming automobile generations.

As they work at even small temperature differences, they can adapt flexibly to operating conditions and temperatures with have no moving parts are robust with maintenance-free and scalable. Besides that, they can be employed in the vehicle for many different purposes such as for supplying the vehicle electrical system. However, the temperatures in the exhaust pipe can reach 700 degrees Celsius or more. Dr. Harald Bottner (2009) stated that the temperature difference between the exhaust pipe and a pipe carrying engine cooling fluid can thus be several hundred degrees Celsius.

At present, attention is centered on the geometric, mechanical and thermal aspects of integrating TEGs in the vehicle. One of the greatest challenges lies in integrating them into the heat flow. This has a major influence on the overall system's effectiveness. Prototypes and prototype testing in the laboratory (on test benches and in the vehicle) ensure that all requirements are met for example in relation to the repercussions on combustion engine and exhaust-gas after treatment as well as in terms of efficiency and operating reliability. Work will shortly begin on the task of integrating them in the vehicle from an electrical and functional point of view.

2.4 Thermoelectric Power Generator (TEG)

TEG is an electrical generator applied the Seebeck effect to recover lost heat in an internal combustion engine powered vehicle. Employing the effect which Seebeck observed, thermoelectric power generators convert heat energy to electricity. When a temperature gradient is created across the thermoelectric device, a DC voltage develops across the terminals. When a load is properly connected, electrical current flows.

The important parameters in thermoelectric power generator (TEG) can readily be derived by considering the simplest generator consisting of a single thermocouple with thermo elements fabricated from n-type and p-type semiconductors as shown (refer figure 2.1):

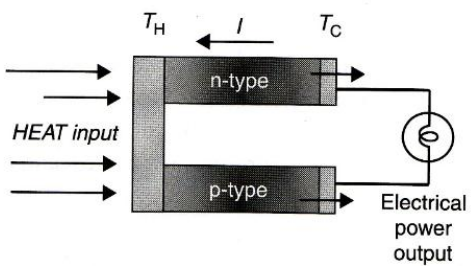

Figure 2.1: The Seebeck Effect (Source: Rowe (2006))

TEG consists of three main components, it is:

a. Hot-side heat exchanger
b. Cold-side heat exchanger
c. Thermoelectric materials (TEMs)

2.4.1 Hot-side Heat Exchanger

The function of hot-side heat exchanger is to extracting waste heat and delivering this heat to surface of TEM.

2.4.2 Cold-side Heat Exchanger

The cold-side heat exchanger is to dissipating heat from TEM to prevent damage on TEM due to high temperature, refer Figure 2.2 for schematic configuration of waste heat exchanger.

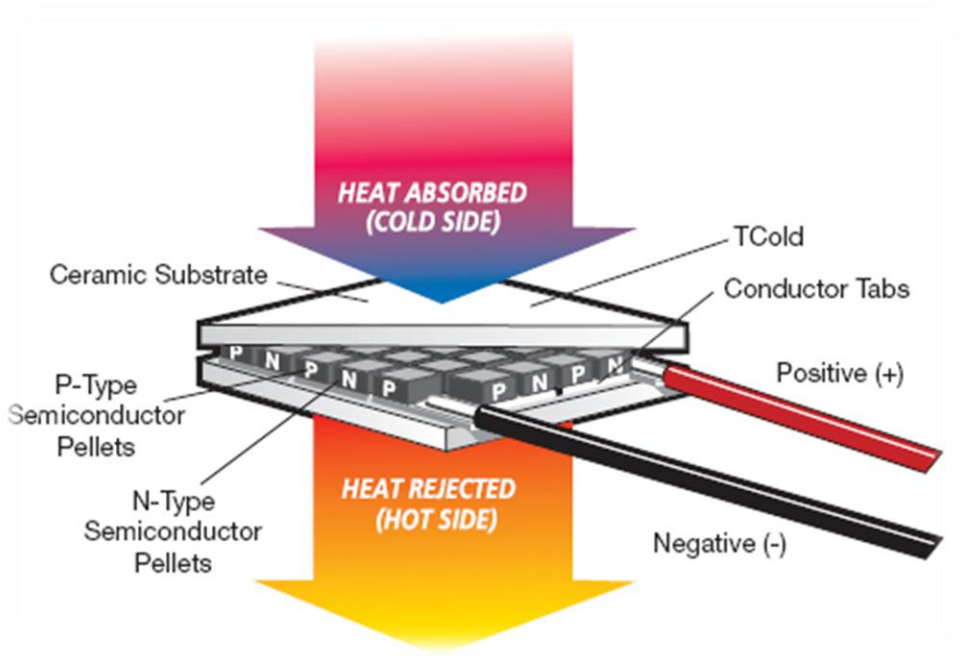

Figure 2.2: Schematic Construction of a Typical TEM (Source: www.tellurex.com (2009))

2.5 A Thermoelectric Application to Vehicles

According to Rowe (2006), in connection with the environment problems, a thermoelectric application to vehicles of interest in the automobiles industry for power generation from exhaust heat. The thermoelectric generator can be used for converting waste heat exhaust heat energy directly to electrical power, thereby decreasing fuel consumption. The specific characteristic of the thermoelectric generator is its ability to produce a large output current, which is adequate to charge a car battery. The generator, therefore, can replace the currently used shaft-driven