'I hereby declared that I have read through this report and I found that it has comply the partial fulfillment for awarding the degree of Bachelor Mechanical Engineering (Structure and Material)'

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THERMAL ANALYSIS ON THERMOELECTRIC COOLING MODULE

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This dissertation is submitted as partial fulfillment of the requirement for the degree of bachelor of mechanical engineering (structure and material)

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ABSTRACT

Thermoelectric module is a device that converts electrical energy to cold and hot temperature and it is called Peltier effect. This cooling system used direct current (DC) as a power supply. The concept of thermoelectric module cooling system is used in various applications such as mobile refrigerator in car connected to automobile cigarette lighter. The main focus in this project is to determine the coefficient of performance and temperature distribution of the thermoelectric device during operation. This analysis method is by using the Solidworks 2005 modeling software combined with Finite element method MSC Nastran/Patran. This project has to compare the coefficient of performance between simulation analysis and previous experimental result. The current and voltage cannot be applied to the simulation. From the analysis results, the influence of heating load and input current can be shown. Thermoelectric module makes the aluminum block cooler. The behavior of Coefficient of performance graph for simulation analysis is showed and it is similar to experimental data. The coefficient of performance for the thermoelectric cooling module decrease with increasing of current, I for experiment and simulation analysis.

ABSTRAK

Modul penyejuk termoelektrik merupakan satu alat yang menukarkan tenaga elektrik kepada suhu sama ada panas mahupun sejuk. Keadaan ini dipanggil sebagai kesan Peltier. Sistem penyejukan ini menggunakan arus terus sebagai sumber kuasa. Prinsip modul termoelektrik ini dalam sistem penyejukan membolehkan ia digunakan dalam pelbagai aplikasi seperti peti sejuk mudah alih yang boleh dimuatkan di dalam kereta dan disambung pada palam pencucuh rokok. Perkara utama yang akan difokuskan didalam projek ini ialah untuk menentukan kapasiti termal dan serakan suhu untuk penyejuk termoelektrik semasa operasi. Analisis ini disiapkan dengan menggunakan software perisian "Solidworks 2005" dan digabungkan dengan "Finite element method iaitu MSC Nastran/Patran". Dalam projek ini, pekali prestasi ditentu dan seterusnya dibandingkn antara data experimen dan juga simulasi menggunakan perisian komputer. Arus dan voltan tidak boleh diaplikasi menggunakan perisian ini dan menyebabkan data tidak diperolehi dengan betul. Daripada analisis yang telah dibuat, pengaruh beban pemanasan dan arus elektrik dapat ditunjukkan. Penyejuk termoelektrik menyebabkan blok aluminium menyejuk. Graf pekali prestasi telah ditunjukkan dan dilihat mempunyai bentuk yang sama untuk simulasi dan analisis. Pekali prestasi untuk modul penyejuk termoelektrik berkurang dengan arus elektrik untuk simulasi dan experimen.

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T_H	=	Hot End Temperature
T_L	=	Cold End Temperature
ΔT	=	Temperature Difference
V	=	Voltage (V)
Q_L	=	cooling capacity (W)
P	=	Power
I	=	Current through the thermoelectric module (amp)
Kt	=	Thermal conductivity
T_S	=	surface temperature of aluminum block surface (^oC)
COP	=	coefficient of performance

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CHAPTER 1

INTRODUCTION

1.1 Background

Thermoelectric devices are solid-state devices that convert thermal energy fron temperature gradient into electrical energy or convert electrical energy into temperature gradient. The first application is used most notably in spacecraft pov generation systems and in thermocouples for temperature measurement, while t second application is largely used in specialized cooling applications. Conventioi cooling systems such as those used in refrigerators utilize a compressor and a worki fluid to transfer heat. `

Semiconductor thermoelectric coolers offer several advantages over conventioı systems. They are entirely solid-state devices, with no moving parts; this makes the rugged, reliable, and quiet. They use no ozone-depleting chlorofluorocarboı potentially offering a more environmentally responsible alternative to convention refrigeration. A thermoelectric cooling system incorporates a power source to provi the direct current through the electrical circuit, thermoelectric module with at least oı heat sink and at least one heat source, and a control assembly. The basic arrangement a thermoelectric module in a cooling system is shown in Figure 1.

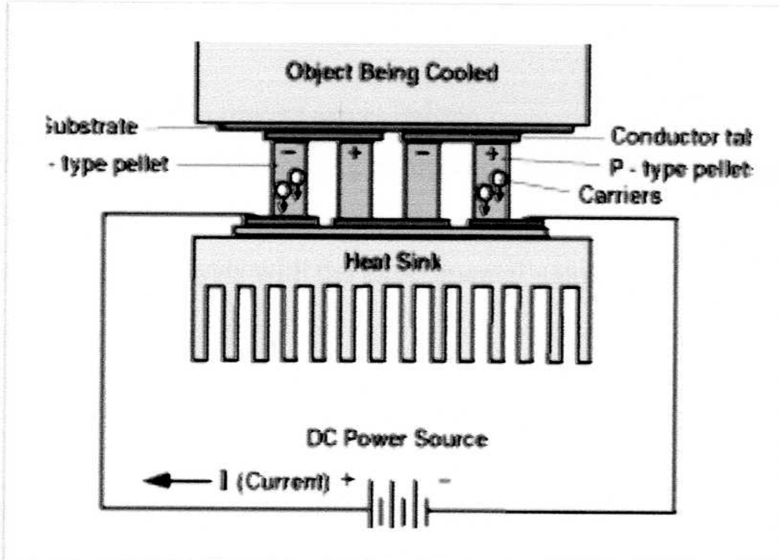


Figure 1: Application of thermoelectric cooling device.

1.2 Problem statement

Thermoelectric module is the device that widely used as cooling system in various industries. It is alternative device that have same function as air conditioner. This cooling system was created by many manufacturers and has different features and ability in cooling system suitable for industries. Thermoelectric is different compared to air conditioner. The advantages of the thermoelectric in the small system; thermoelectric modules can be the most economic because of the standard off-the-shelf components itself. The operating voltage used by thermoelectric contain series parallel electrical circuitry and this circuitry gives the best and flexible cooling power. Other than that the size of thermoelectric itself made it easy to install or attach to other device. The collaboration of heat exchangers with thermoelectric are widely used in the cooling systems. Simulation analysis is a cheapest and easy wy to predict result rather than experimental methods.

1.3 *Objectives*

The objectives of this project are as below:

1. To determine the coefficient of performance and temperature distribution of t thermoelectric device during operation.
2. To compare the analysis with the experimental value.

1.4 Scope

The scope that focus in this project are:

1. Design of the component using Solidworks 2005.
2. To perform thermal analysis for thermoelectric model using finite eleme analysis software, Nastran/Patran.
3. To perform a thermal analysis of thermoelectric cooling module system mod CP2-127-06L.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

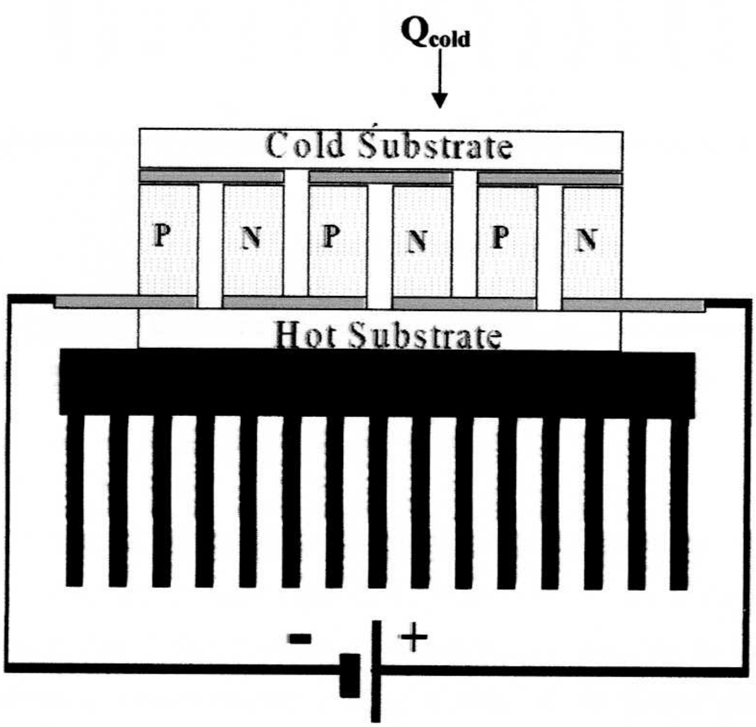
A literature review in this section is just a simple summary of the sources, such as journals and papers related to the thermoelectric cooling module. In this chapter, it is also discuss about the Thermoelectric Power Generator Design and Selection from TE Cooling Module Specifications, Thermodynamic optimization of heat/cold sink extenders in thermoelectric cooling assemblies, Theoretical evaluation of maximum temperature difference in segmented thermoelectric cooler and Demonstrations Using the Thermoelectric Cooling Module. All the research from the journal made by them involved here as a reference that really helpful to this project.

2.2 Thermoelectric Power Generator Design

According to the Richard J. Buist and Paul G. Lau (2006) from the "Thermoelectric Power Generator Design and Selection from TE Cooling Module Specifications" discuss about some of the unique features of these versatile devices together with some limitations and precautions.

Design curves are presented enabling one to design or select the TE module to convert heat flow to DC power with the highest level of performance thermoelectric can provide. Generation of electrical power via thermoelectric devices has been a subject of interest for decades.

Basically, thermoelectric power generation is a solid state means of converting heat flow directly into electrical power via the Seebeck effect. High temperature energy sources have historically been utilized because of the inherent higher efficiency at high temperature differences, ΔT's. However, there are many low level energy sources plentiful in nature which is candidates for thermoelectric conversion. A thermoelectric cooler consists of several N & P pellets connected electrically in series and thermally in parallel sandwiched between two ceramic plates as illustrated in Figure 2.



DC power supply.

Figure 2: Thermoelectric module in cooling mode

The same unit can be made into a thermoelectric power generator by simply replacing the DC source with the load, or item to receive power, and apply heat to the top surface of the TE modules as illustrated in Figure 3.

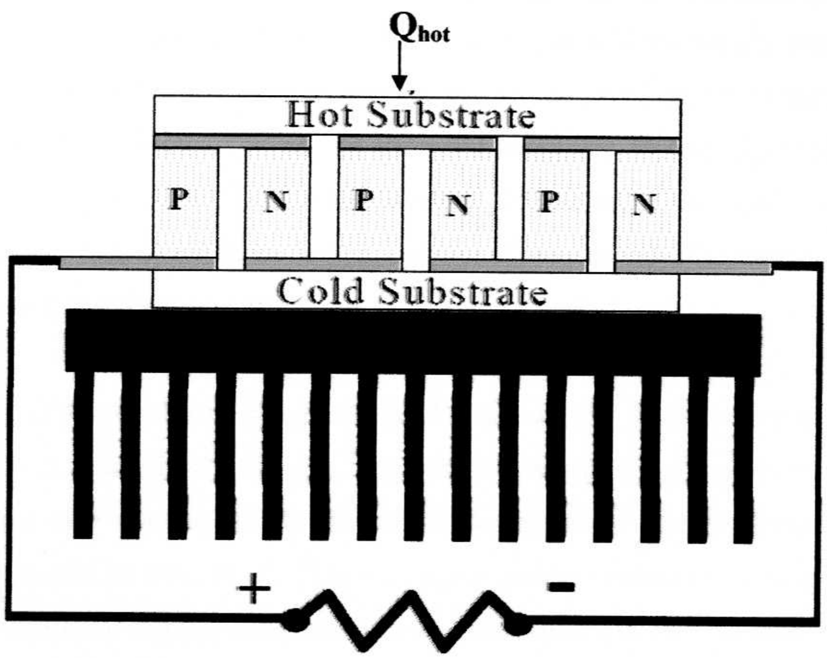


Figure 3: Thermoelectric module in power generation mode.

For Limitations and Precautions, the design curves presented in this paper enable the designer to define the ultimate capacity of thermoelectric for use as a low-intensity power generator and to define in detail the actual device required. In summary, if one expects to operate a Thermoelectric cooling module in the power generation mode, qualification testing should be done to assure long-term operation at the maximum expected operating temperature.

2.3 Thermodynamic optimization of heat/cold sink extenders

According to the Paul G. Lau et.al from the "Thermodynamic optimization of heat/cold sink extenders in thermoelectric cooling assemblies" the heat sink extender (HSE) is normally conceived of as a thermally conductive block which is mounted to a heat sink. The thermoelectric module is then, in turn, mounted on top of the footprint of the thermoelectric module. The use of heat sink extender or cold sink extender does decrease the plate-to-plate thermal conductance. However, a heat sink extender will increase the heat sink's resistance to heat transfer. Consequently, the thermoelectric will run at a higher hot-side temperature.

From this journal, it is best to use cold sink extender (CSE) rather than heat sink extender (CSE). Specifically, though, any given heat pumping condition needs to be evaluated on a case by case basis to determine if an optimum extender length exists or if an extender should be used at all. This evaluation can be especially important when the cold sink footprint is large in comparison to the thermoelectric module print.

2.4 Theoretical evaluation of maximum temperature difference in segmented TE cooler.

According to the L.N. Vikhor and L.I. Anatychuk (2005) from the "Theoretical evaluation of maximum temperature difference in segmented thermoelectric cooler" The methods of optimal control theory are used for the development of a sufficiently precise technique for a computerized design of segmented thermoelectric coolers. The optimal parameter values of BiTe-based material for thermoelectric coolers with single-, double- 'three-segmented legs are calculated in the paper.

The possibility of increasing maximum temperature difference of the double-, three-segmented thermoelectric coolers by 3-4 K as compared to Peltier device of optimally homogenous materials is demonstrated. The use of more than two segments is shown to be inadvisable owing to the parasitic effect of contact resistance between the segments. Based on this journal experiment, the results of the experimental research on such thermoelectric coolers made of BiTe-based material prove their improved characteristics as compared to conventional homogenous Peltier device.

2.5 Demonstrations Using the Thermoelectric Cooling Module

According to the Edmund J. Winder et.al (1996) from the "Thermoelectric Devices: Solid-State Refrigerators and Electrical Generators in the Classroom" Thermoelectric devices provide an engaging high-tech demonstration suitable for illustrating thermodynamic principles in the classroom. They also showcase an elegant solid-state method of refrigeration, heating, and power generation. Thermoelectric effects can be understood at a qualitative level through the familiar chemical concept of the kinetic molecular theory of gases. The materials used in thermoelectric devices and described herein can be used to introduce a variety of solid-state structures.

To demonstrate the Seebeck effect (in which a temperature gradient produces a potential), a small electrical device can be connected to the module in place of the power supply after the module has reached its maximum temperature gradient; power can be extracted from the module until the temperature gradient becomes too small. Other variations on this demonstration involve simply connecting a small motor or light bulb to the electrical leads and creating a temperature gradient by heating up or cooling down one side of the device.