DEVELOPMENT OF THERMOELECTRIC COOLER

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‘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 (Thermal-Fluid)’

Signature :.....................................

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Date :...18/5/09..........

Dedication

This book is especially dedicated to my supervisor, all respective UTeM staffs and friends for their undivided help and guidance in enabling me to gain experience and knowledge in making my final year project a success.

"I declare that this report is done by my own exclude the citation with the mentioned references for each"

Signature:…………………………................

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ABSTRACT

A thermoelectric cooler is a solid state heat pump that uses the Peltier effect, and works in conjunction with a heat sink to remove heat from a system. Most applications that require cooling do not employ thermoelectrics because of the low values of efficiency that are inherent in thermoelectric coolers. Thermoelectric module is a simple device that can be used as a cooling element. This system has the merits of being light, reliable, noiseless and low cost compare to the refrigerant as a heat carrier in the refrigeration system. The main objective of this research is fabricate thermoelectric cooler and study of thermoelectric cooling module system and to run some experimental procedures to determine the performance of temperature using thermoelectric device. This thermoelectric cooler are using the thermoelectric device CP2-127-06L from the Melcor company. In this experiment, three different boxes are use to determine the performance of thermoelectric and in order to check the corresponding respond of the cooler box to the cooling load, some water (1000ml) been put to the cooler box. Experiment results demonstrate that the unit maintain the temperature in the box around 10^0C to 12^0C and have a COP about 0.3.It is expected that the cooler box would be potential for food stuff and drink in remote area, or outdoor applications where electric power supply is absent just using the battery.

ABSTRAK

Penyejuk Termoelektrik adalah satu fungsi pam yang menggunakan efek Peltier dan berfungsi dengan penyingkiran haba dalam satu system yang lengkap. Kebanyakan aplikasi yang menggunakan penyejukan tidak menggunakan termoelektrik disebabkan efisiensi yang rendah dalam penyejuk termoelektrik. Termoelektrik adalah satu benda ringkas yang ringan, sistem yang tidak mengeluarkan bunyi yang bisisng, dan lebih murah jika dibandingkan dengan peti sejuk yang menggunakan kompresor sebagai sistem utamanya. Tujuan utama projek ini dibuat adalah untuk merekabentuk satu termoelektrik yang ringkas dan mempelajari sistem termoelektrik yang menggunakan prinsip Seebeck, Peltier, dan Thomson efek dalam sistemnya. Tujuan kedua projek ini di buat adalah untuk mengkaji prestasi termoelektrik apabila lengkap fabrikasinya. Hasil daripada eksperimen menunjukkan unit kotak penyejuk termoelektrik dapat mencapai suhu pada 10^0C hingga 12^0C dan nilai COP pada 0.3. Dijangkakan, kotak penyejuk termoelektrik ini, mampu untuk menyejukkan makanan dan minuman. Juga dapat di aplikasi menggunakan bateri untuk kegunaan luar rumah seperti berkelah dan kegunaan di dalam kereta.

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LIST OF ABBREVIATION

COP	=	coefficient of performance
I	=	current through the thermoelectric module (amp)
K_t	=	total thermal conductivity of thermoelectric module, (W°C^{-1})
Q_C	=	cooling load (W)
P	=	electric power supplied to the thermoelectric module (W)
R	=	total electrical resistance of thermoelectric module (ohm)
T_H	=	hot-end temperature of the thermoelectric module (K)
T_C	=	cold-end temperature of the thermoelectric module (K)
V	=	voltage to the thermoelectric module (volt)
α	=	Seeback coefficient of thermoelectric module ($V°C^{-1}$)
ΔT	=	temperature difference

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CHAPTER 1

INTRODUCTION

1.1.1 Background research

According to the Brooks Samuel Mann, (2006), a thermoelectric device is a solid state heat pump that uses the Peltier effect, and works in conjunction with a heat sink to remove heat from a system. Most applications that require cooling do not employ thermoelectric because of the low values of efficiency that are inherent in thermoelectric cooler. A thermoelectric requires relatively large amounts of electrical power in order to produce a cooling effect. In fact, more conventional systems such as vapor compression refrigeration cycles have as much as a 3 to 1 advantage in efficiency over thermoelectric. However, thermoelectric can be useful in certain applications where the advantages outweigh the disadvantages. Thermoelectric device are solid state, and so they produce no noise and require little to no maintenance. They also are quite small when compared to other systems, and so can be useful when there is a limited amount of space in a system

Due to that, there are studies made specifically to focus on fabricate the thermoelectric cooler and also investigate the performance of thermoelectric cooler. In order to know the performance of thermoelectric cooler, coefficient of performance

(COP) been calculated using the formulae and the value of heat pumped of thermoelectric can be known from the graph that manufacturer given according the value of temperature difference get from the experiment.

Figure 1.1 shows the thermoelectric that will be use on fabrication the thermoelectric cooler made by Marlow company. The table 1.1 shows completely specification of this thermoelectric given by manufacturer. Despite their small size, these devices can all create temperature differences of around 67 °C . They can also be stacked on top of each other to create even larger temperature differences. From the data that company given when buying this thermoelectric, can know that the maximum power of this thermoelectric can achieve is 120W.The maximum current and voltage is 14 Ampere and 15 Volts.Also known that the number of couples N is 127.

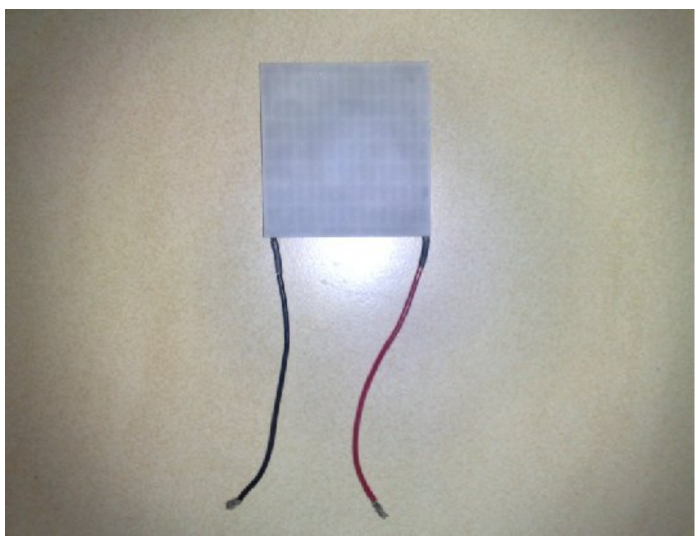

Figure 1.1: Thermoelectric device CP2-127-06L

Table 1.1 Specification of thermoelectric device CP2-127-06L

Type	**Value**
Maximum Power	120W
Delta T Max	67°C
Maximum Current	14A
Maximum Temperature	85°C
Dimensions (LxWxH)	62x62x4.6mm
Maximum Voltage	15V
Number of couples N	127

The current applications of thermoelectric besides cooler are minimal because of the low efficiency values associated with them. Besides to make a cooler box, there are some lists are possible uses of thermoelectric as a temperature stabilization of bolometers and ferroelectric detectors, uses to cold the computer processor, using in laser diode arrays in fiber optic systems, and maintaining constant viscosity in ink jet printers.(Scott T. Huxtable 1996)

1.2 Problem statement

Thermoelectric module is a simple device that can be used as a cooling element. This system has the merits of being light, reliable, noiseless and low cost compare to the refrigerant as a heat carrier in the refrigeration system. From those reason of being light, reliable and noiseless can get an idea to fabricate the thermoelectric cooler. The problem that will be examined in this research is about the performance of temperature using thermoelectric device can be cooled in three different boxes with different size. In this research, the problem is whether the thermoelectric device can make sure the box that been made about is enough to make the box been cooled around 10℃. To generate this thermoelectric cooler, the following systems parameters of cold side temperature, hot side temperature, and amount of heat absorbed at cold surface to maintain cold side must be known. The surface of hot side temperature determined by two major parameter, the temperature of the environment which heat rejected and efficiency of the heat exchanger which are using the aluminum heat sink with the fan to rejected heat to environment. The thermal greese is important think to make sure the heat been rejected smoothly. The temperature difference are been used in graph from the manufacturer to determine the heat pumped by the model with different value of current and voltage. With this value of heat pump, the coefficient of performance (COP) of thermoelectric cooler can be determined using the formulae. The graph can be plotted to show the performance of thermoelectric.

1.3 Objective

There are 2 main objective of this project that have been set as a project goals in order to accomplish this thesis are:

1. Fabricate thermoelectric cooler.
2. Investigate the performance of thermoelectric cooler box after fabrication based on graph from the manufacturer and run some experimental test.

1.4 Scope

In order to complete this project in the particularly time, it demand a lot of time consuming and resources from every types of medium such as journals, text book and other references that related to thermoelectric study field. In generally, the scope of study that consisted in this thesis accomplishment is:

1. Literature review and study on thermoelectric device system
2. Student need to fabricate a simple thermoelectric cooler with three different boxes
   A: 47cmx45cmx32cm
   B: 48cmx45cmx32cm
   C: 60cmx45cmx32cm
3. Run some experimental procedures to determine the performance of thermoelectric cooler.
4. Choose the suitable box for this thermoelectric device 120W that can reach temperature to 10^0C.
5. Check the corresponding response of cooler box to a cooling load.

CHAPTER 2

LITERATURE REVIEW

2.1 Thermoelectric background history.

According to Brooks Samuel Mann in the year 2006, the study of thermoelectric began in 1822 when Thomas Johann Seebeck, a German physicist, noticed that two dissimilar metals in a closed loop caused a compass needle to deflect when the two metals were held at different temperatures. This meant that an electric field was created between the two metals, thus inducing a magnetic field to deflect the needle. Seebeck later discovered that some metals were able to create stronger fields with the same temperature difference, and that the amount of deflection in the needle was proportional to the temperature difference between the two conducting metals. These principles make up the foundations of thermoelectric, and for his discoveries the Seebeck coefficient (the voltage produced between two points of a conductor where a uniform temperature difference of 1K exists between those two points) was named after the founding father of thermoelectric.

In 1834 a French watchmaker named Jean Charles Athanase Peltier discovered that thermoelectric materials could also work in reverse. That is, an applied voltage could create a temperature difference between the two dissimilar metals. Although Peltier is generally credited with the discovery of thermoelectric cooling, he did not fully understand the physics of the phenomenon. The full explanation was given four years later by Emil Lenz, who showed that a drop of water on a bismuth-antimony junction would freeze when electrical current was applied one way, and melt again when the current was reversed. (Brooks Samuel Mann 2006)

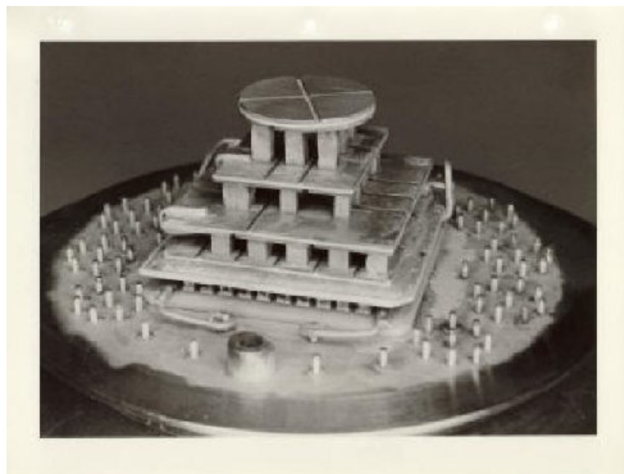

Figure 2.1:The first idea of thermoelectric device.
(http://thermoelectric.com/2005/old/photo-3.htm)

Figure 2.1.1: The first thermoelectric cooler been made
(http://thermoelectric.com/2005/old/photo-3.htm)

2.2 Thermoelectric Theory

Thermoelectric phenomenon describes the relationship between the flow of heat and electricity. These are the Seebeck effect, the Peltier effect, and the Thomson effect . The thermoelectric properties of a material are measurable and are bulk properties of a given material just like electrical or thermal conductivity. The Seebeck, Peltier, and Thomson relations are commonly used to characterize materials that exhibit thermoelectric properties. (Elaine P. Scott)

2.3 How Thermoelectric coolers work.

Thermoelectric coolers are solid state heat pumps that operate on the Peltier effect, the theory that there is a heating or cooling effect when electric current passes through two conductors. A voltage applied to the free ends of two dissimilar materials creates a temperature difference. With this temperature difference, Peltier cooling will cause heat to move from one end to the other. A typical thermoelectric cooler will consist of an array of p- and n- type semiconductor elements that act as the two dissimilar conductors. The array of elements is soldered between two ceramic plates, electrically in series and thermally in parallel. As a dc current passes through one or more pairs of elements from n- to p-, there is a decrease in temperature at the junction ("cold side") resulting in the absorption of heat from the environment. The heat is carried through the cooler by electron transport and released on the opposite ("hot") side as the electrons move from a high to low energy state. The heat pumping capacity of a cooler is proportional to the current and the number of pairs of n- and p- type elements (or couples).

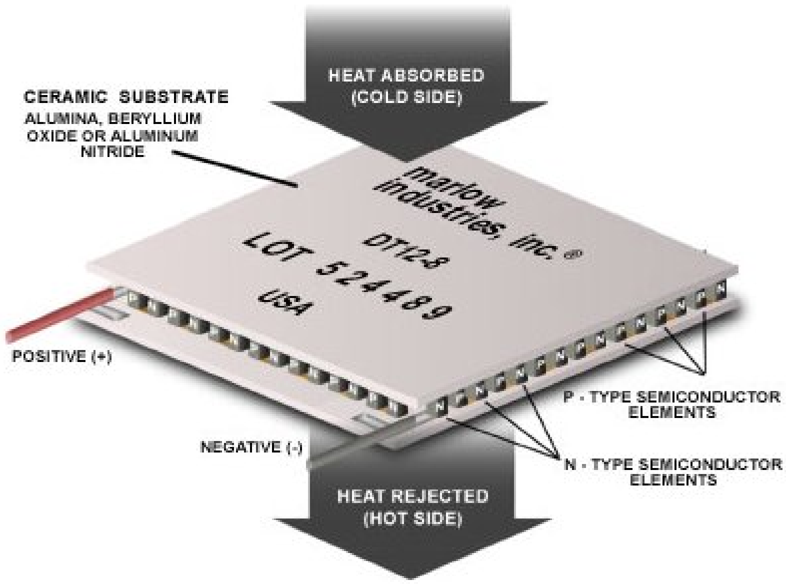

Figure 2.3.1 - Diagram of a typical thermoelectric cooler

N and P type semiconductors (usually Bismuth Telluride) are the preferred materials used to achieve the Peltier effect because they can be easily optimized for pumping heat and due to the ability to control the type of charge carrier within the conductor.

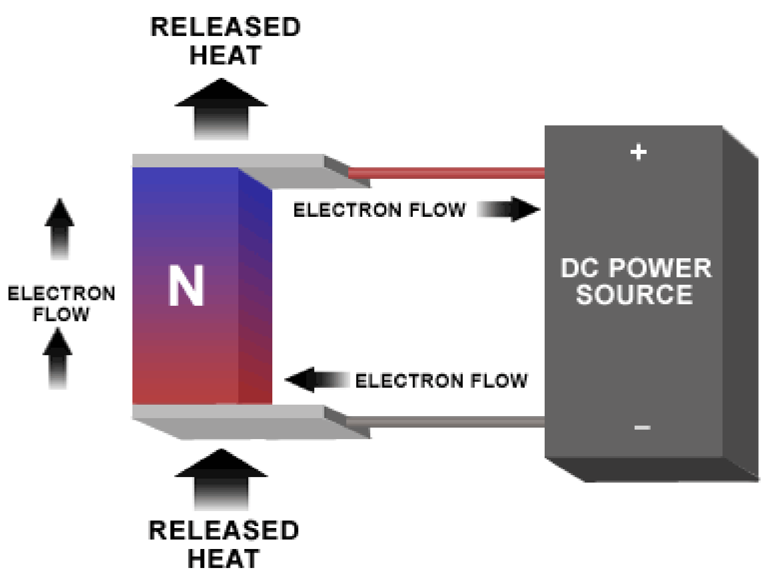

Figure 2.3.2; Illustrates an "N-type" semiconductor element utilized to facilitate the Peltier effect.