UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF PORTABLE INTELLIGENT AIR CONDITIONING DEVICE USING PELTIER AND SEEBECK EFFECT

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electrical Engineering Technology (Industrial Automation & Robotics) with Honours

by

NURAINI BINTI SHAFIEI
B071210339
911216-08-6032

FACULTY OF ENGINEERING TECHNOLOGY
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This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Electrical Engineering Technology (Industrial Automation & Robotics) with honours. The member of the supervisory is as follow:

Signature **: ……**

Name **: MOHAMAD HANIFF BIN HARUN**

Date **: 12 JANUARY 2016**

ABSTRACT

The society bustle factor in this day and age, most people want to find equipment that is often used in everyday life in a small and light weight design. This is because people want convenience the daily running quickly and keep pace with the world moving fast nowadays. The purpose of this project is to develop portable air conditioning without using any gas. The system used thermoelectric heat pump as main device for producing cool air known as Peltier Effect. With additional source generated from temperature different from the device give the alternative to recharge the battery known as Seebeck Effect. This project could help to comply with the climate change whenever the user travel because it provide comfort by producing hot and cold air according to the needs of the user.

ABSTRAK

Faktor kesibukan individu pada masa kini, menyebabkan kebanyakan pengguna memerlukan peralatan yang boleh digunakan dalam kehidupan seharian dalam saiz yang kecil dan ringan. Ini adalah kerana pengguna memerlukaan kemudahan harian yang cepat dan seiring dengan dunia yang bergerak pantas pada masa kini. Tujuan projek ini adalah untuk menghasilkan penghawa dingin mudah alih tanpa perlu menggunakan sebarang gas. Sistem ini digunakan termoelektrik sebagai peranti utama untuk menghasilkan udara sejuk yang dikenali sebagai Kesan Peltier. Dengan sumber tambahan yang dihasilkan daripada suhu yang berbeza dari alat memberikan alternatif untuk mengecas bateri yang dikenali sebagai Kesan Seebeck. Projek ini boleh membantu untuk mematuhi perubahan iklim setiap kali perjalanan pengguna kerana ia memberi keselesaan dengan menghasilkan udara panas dan sejuk mengikut keperluan pengguna.

DEDICATIONS

To my dearly loved father and mother

To all lecturers and supervisor

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CHAPTER 1
INTRODUCTION

1.0 Introduction

Our new innovation is based on compilation of basic electronic principles of Seebeck, Thompson and Thermo-electric heat pump with the main application of thermoelectric heat pump. As the name being called, design and development of portable intelligent air conditioning device using Peltier and Seebeck Effect, it constitutes a small, lightweight and low cost consumption really inclined with the demands of developing community nowadays that needs convenience, conduciveness and simplicity. With these three concrete reasons, we have developed this project as from improvising from the current market product available. As from what we see, the main drawback of the product is the mechanism faulty and the waste of temperature difference concept plus the ignorance of sustaining the energy. So, to comply with the drawback we seen, an application of electronic principle in sustaining energy in an enclosed system is the most perfect way to solve this matter. We will be applying the thermoelectric heat pump which is a semiconductor that has two layers of hot and cold and it creates a gradient of temperature different to produce a variable voltage that can be used for an energy storage that can support the battery lifetime of our mini air conditioning device. In short, it acts as a dual temperate fan that have a property of power bank similar to the technology of power storage developed by China. As being said earlier, our research is based on the combination of devices that is available in market mainly China made devices that is power bank and portable mini cooler. In a nutshell, we would expect to see a dynamic and positive outcome from this research that is a mini portable air conditioning device that can store substantial amount of power. It is also able to comply with the climate change whenever the user travel because it provide comfort by producing hot and cold air according to the needs of the user.

1.1 Problem Statement

Society in the era of sophisticated information technology is now very busy with their daily operations. The society bustle factor in this day and age, most people want to find equipment that is often used in everyday life in a small and lightweight design. This is because people want convenience the daily running quickly and keep pace with the world moving fast nowadays. In addition, the equipment is small and light easy to carry along and can save you time, energy and money. Therefore, the equipment daily at the time of cutting-edge technology gives priority to small and lightweight components. We can see that in the China is ahead with this technology.

Technological advances now have to go hand in hand with environmental factors, particularly as the rise and decrease in temperature that occurs every day in our lives. As we all know, the weather plays a significant role in the ease of day. Such restructuring can adapt to any changes is very important. In business today, the use of technology such as laptops and computers in a long time cause electronic components are exposed to high temperatures applied. Fans radiation which had been built in it to accommodate the high capacity consumables result of high rates of use. This will burden the everyday affairs of man. For example in a factory and administrative offices from the point of production and productivity as required to provide additional funds for maintenance cost hardware to accommodate the high temperatures applied.

The second problem that arises in the private and public servants currently working long hours and exposure to cold air temperatures that allow workers to lose focus on the job they are doing. This is because when employees are in cold temperatures with long periods of time can cause to have been affected. But they have extreme temperatures or at room temperature in some time.

For adventurous travelers that love traveling in cold and hot country, they are vulnerable to abrupt climate change. For convenience, they required a device that capable of generating hot air and cold in neutralizing their body temperature.This is to avoid having health problems as a result of unpredictable climate change.

To solve this problem, the product must be produced to overcome the above must be appropriate. So we have designed a product that able to generate hot and cold air with additional of recharging system to expand the lifetime of this Mini Portable Air Conditioning Device.

1.2 Project Objectives

The objectives of the project are :

- To analyse the electrical performance characteristic compare to other portable air conditioning product
- To evaluate system robustness regardless location and climate change
- To fabricate fully prototype air conditioning that capable in produce cool and hot air with additional of recharging system

1.3 Project Scope

The scope of the project are :

- Production of cold and hot air, according to the weather which could have a significant impact in terms of comfort and convenience to the community by using Peltier which is having two layer hot and cold.
- This product will be using the heat sinks as a medium to spreading the hot and cold air produced by the Peltier.
- From the production of hot and cold air, the temperature difference is used to generate electricity that can charge the battery back to extend the useful life of this product without charge. This process called seebecks effect.

1.4 Research Background

We would like to highlight a product that is small, lightweight and inexpensive compared to other products that we review. To achieve the goal of this study is to use the component or mechanism other than the product that has been produced before.The product based mini - conditioning used wet sponge in the manufacture of mechanical structures of cold air . In general this is a mini cooling products were produced for cooling users but what we see is less effective products for use on the principle of using a mechanical fan and a wet sponge to cool the air . This causes the air produced by the mini cooli according to ambient temperature and it causes the user does not get the satisfaction they desire. Therefore, we have modified this mini cooli from using mechanical principles to electrical principles thatmore efficient in terms of producing energy. Modification of this product, the previous product to become a tool that not only can produce cold air but hot air for the comfort of the users according to their needs. The producing cool air can reach up to 9 ˚C and it's very positive impact on consumers when they are in an area of relatively high temperatures . Warm air can turn our state revenue through electrical principles used by this mini air cool. The hot air can reach up to 70 ˚C that able to provide comfort to the consumers when winter . This is provides a very positive impact on those who are working or in companies that have a very low temperature makes them less comfortable when doing work.

Termo-electric heat pump temperature difference is created by using a voltage between two electrodes connected to a sample of semiconductor material. This phenomenon can be useful when it is necessary to transfer heat from one medium to another at a small scale. Termo-electric heat pump technology has great potential. There is a large body of research that has been done to try and optimize the air conditioning through practical Termo-electric heat pump cooling or heating. When the temperature difference is used for certain different metals, an electric current results. This is called the Seebeck Effect. this effect is to use the current to hold the temperature difference is called the Termo-electric heat pump. Several devices are commercially available, but in general, this

method is inefficient, and thus lead to specific applications such as computer cooling and a small refrigerator.

1.5 Report Outline

This report is divided into three chapters. Chapter 1 is the introduction part which explains the project background, problem statement, project objectives and project scope. Chapter 2 which is literature review of the project is about references and understandings which are gained from various sources such a books, journal, internet and previous project. These materials are used as the main source for this project entire. Project methodology, methodology flowchart, hardware and software overview and process flow of the project are describe in chapter 3. The progress of FYP 1 and planning of FYP 2 have been started in chapter 4 which is preliminary result. Chapter 5 which is conclusion consists of discussion, suggestion and the conclusion of the project.

CHAPTER 2
THEORETICAL BACKGROUND

2.0 Introduction

This chapter will discuss mainly on the theory and current development in Peltier and Seebeck Effect. This chapter is divided into five parts, which is Peltier study, Seebeck Effect, thermoelectric study, heat sink and lastly energy consumption, environmental and user friendly.

2.1 Journal

Reference and understanding is gained from various source such as books, journals, internet references and previous project. These materials are used as the main source for this entire project. The core focus in this literature is about how Peltier function in cooling and heating process and another one is the Seebeck Effect from the heating and cooling process.

2.1.1 Peltier Study

According to this journal entitle as Optimization of Peltier Thermocouple Using Distributed Peltier Effect by (Belov et al., 1999) is focus on calculations of maximum temperature difference and coefficient of performance of double segment Peltier thermocouple. Distinction of thermoelectric properties of p- and n-type segments is taken into account. Obtained results are compared with measured characteristics of manufactured Peltier thermocouples. It is shown that efficiency of thermocouples using distributed Peltier Effect can be improved if optimized thermoelectric properties of segments

depending on temperature are used. In general our calculation results are in agreement with results of previous works under certain conditions AT and q values of double segment thermocouples are higher in comparison with ordinary Peltier thermocouples. Both AT max and q take a turn for the better when Z values of each segment and Seebeck coefficient difference Acx between the same type segments increase. In order to improve the characteristics of segmented Peltier thermocouples there is necessity of more accurate development of at least four sort thermoelectric materials (p, p2, n, and n2). In this materials Z must have a peak in needed temperature ranges. Due to the calculations above AT higher than 85 K can be obtained in this case. Thermoelectric properties of each material also must have small deviations from desired values in order to obtain high parameters of cooling devices. Finally it is also important to have a sufficiently simple method of manufacturing segmented thermo elements and assembling them into cooling modules.

The Peltier cooling system utilizing liquid heat transfer is used in small-sized refrigerators, wine cellars, and so forth by (Nishihata et al., 2002). This system has a heat-exchanger called a manifold in which a thermoelectric module contacts to liquid. Geometry of the channel inside the manifold was examined and it was showed that a labyrinthine-shaped turbulence promoter was effective in the enhancement of the heat transfer with the thermoelectric module and liquid. It was also shown experimentally that a heat transfer coefficient was more enhanced using the rotation of the impeller of the pump for the liquid circulation. Evaluation of the cooling performance of the heat exchanger, which combined the round thermoelectric module with the rotation of the above impeller experimentally, is also presented.

2.1.2 Seebeck Effect

Other than Peltier Effect, the other important things is seebecks effect which is integrated the technology of thermoelectric heat pump and phase-change thermal storage in experimental study on a New-type Thermoelectric Heat Pump Phase Change Thermal Energy Storage Device by (Xu et al., 2011), developed an active phase-change thermal storage/release device, which can retrieve and utilize low-quality energy (cryogenic

energy), and made experimental study on it. The experimental results show that: the device has obvious phase-change process and striking thermal storage effect. When storing heat, the highest heating coefficient of THP can come up to 2.2; when THP was used to supply heat for the part, the highest heating coefficient can come up to 5.6.The device overcame the uncontrollability of the heat transfer intensity and time, which usually occurred in the process of traditional passive heat storage/release, and greatly improved the efficiency of retrieving and utilizing low-temperature exhaust heat.

The other example of Seebeck Effect is the first approach is based on Seebeck's thermoelectric effect by Renewable and Sustainable Energy Replacement Sources ((Krinker and Goykadosh, 2010), which occurs when mobile charge carriers in liquids and solids are subjected to a temperature gradient. The proposed technical implementation of this approach can be done by placing one metal or semiconductor mesh a few meters deep in the soil, and another mesh made of a different metal close to the surface of the soil. This produces up to 50mV of photosynthesis electric potential between the roots and leaves (Voltree power). However, unlike the thermoelectric converters, plants have a much higher electric resistance.To make this approach feasible, two problems must be resolved: the reduction of the electric resistance of the plant's tissue and the organization of the collection of the energy (multiple electrode insertion). Even if just a portion of the solar energy will be converted into electricity, each square meter can produce tens of watts; thus 100x100 m area can produce 100-1000 kW of energy during sunny days, and larger forest are greater sources of energy.

The Seebeck Effect in carbon fiber-reinforced cement paste was found to involve electrons from the cement matrix and holes from the fibers introduce by (Wen and Chung, 1999). The two contributions were equal at the percolation threshold, with a fiber content between 0.5 and 1.0% by mass of cement. The whole contribution increased monotonically with increasing fiber content below and above the percolation threshold. The fiber addition increased the linearity and reversibility of the Seebeck Effect. Silica fume and latex as admixtures had minor influence on the Seebeck Effect.

In addition, Seebeck Effect is a thermoelectric effect that is the basis for thermocouples for temperature measurement. This effect involves charge carriers moving from a hot point to a cold point within a material, thereby resulting in a voltage difference between the two points. The Seebeck coefficient is the voltage difference per unit temperature difference between the two points. Negative carriers (electrons) make it more positive and positive carriers (holes) make it more negative. The Seebeck Effect in concrete is of interest because it gives the concrete the ability to sense its own temperature. No attached or embedded sensor is needed since the concrete itself is the sensor. This means low cost, high durability, large sensing volume, and absence of mechanical property degradation due to embedded sensors. As the temperature affects the performance and reliability of concrete, its detection is valuable. Seebeck behavior with and without fibers is expected to help understand the effect of carbon fibers on the electrical conduction. Therefore, one objective of this paper is to compare the Seebeck behavior under the presence and absence of carbon fibers.

2.1.3 Thermoelectric Study

In the study of Thermoelectric, the Thermo-electric (TE) materials transform heat energy to electric power using the Seeback effect by (Edwards et al., 2014). They are considered to be a reliable method without moving parts and have been deployed as part of the power generation in space applications for several decades. BiTe thermoelectric modules have been commercially available for some time and they can operate up to temperatures of around 300°C. Thermo-electric materials are also under investigation as waste heat recovery devices in industrial and automotive applications which sometimes require operation at higher temperatures. In addition to the TE-material itself, the properties of the interface and electrode materials in a TEM are important. If the joining and current-carrying materials do not have high thermal and electrical conductivities, the efficiency is decreased due to resistive losses. Sintered silver particles have recently gained attention in the field of power electronics due to the high thermal and electrical conductivity of the material. The nano silver paste used in this work has originally been developed for use as a die attach material in power applications, where these properties are important. The use of sintered silver particles as an alternative to other types of joining

materials for the electrical connection between thermoelectric materials and the substrate in thermoelectric modules (TEM) has been investigated.

The advancements made in semiconductor industry following Moore's law has resulted in products that have increased transistor density, and faster operating speeds by (Lakhkar et al., 2008). These features come at a price, higher chip power dissipation and heat fluxes. Roadmap projections for the high performance chip category suggest that the maximum chip power dissipation will exceed 300W and the maximum heat flux will exceed 150 W/cm2. The problem becomes more complex because of the fact that the increased power dissipation is also highly non-uniform in nature. Increase in chip temperature has a negative impact on the performance of chip and its reliability. Hence, an emphasis is given on new and advanced cooling techniques such as liquid cooling (immersion, jet and spray cooling), microchannel cold plate, and refrigeration cooling. Nevertheless, cost, reliability, volume and complexity of cooling equipment could restrict their use in electronic products. Solid state refrigerators could be an answer to this growing situation. Thermoelectric cooling has long been used in diverse applications, most often when efficiency of cooling solution is not a critical consideration. It has also been used extensively in applications that require tight thermal control such as in laser diodes. Thermoelectric coolers are now viewed as one of the potential solutions, for extending the ability of air-cooled heat sinks to handle the heat from ever increasing high density devices. However, low efficiency of these devices severely restricts their usage.

The next is, Thermoelectric heat pumps (TEHPs) have been applied to many electronic devices to create a steady, low temperature operating environment by (Cheng and Shih, 2007). The cooling capacity is the critical issue in the application consideration. This study uses a hybrid genetic algorithm (hGA) to maximize the cooling capacity of a two-stage TEHP under the condition that the amount of material being used is limited. For a two-stage TEHP with separate electrical currents, the design parameters of each stage the applied electrical current, the number of thermoelectric elements, and the ratio of area to length of the thermoelectric elements are optimized. The optimal parameter set of a two-stage TEHP is determined for various cold-side temperatures, and the cooling capacity is