FABRICATION AND PERFORMANCE TEST OF THE THERMOELECTRIC REFRIGERATOR

SUBMITTED BY

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Shaheen Ahmed	ID- BME-1902018057
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DEPARTMENT OF MECHANICAL ENGINEERING

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This thesis paper is submitted to Department of Mechanical Engineering, Sonargaon University of partial fulfillment in requirements for the degree of Bachelor of Science in Mechanical Engineering

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APPROVAL

This is to certify that the thesis submitted by Md. Arif Bapery, Shaheen Ahmed, Fazlarrabbi, Md. Sharif Hossain, Al-Mutakabbir "Department of Mechanical Engineering, Sonargaon University for the degree of Bachelor of Science in Mechanical Engineering" has been approved, in partial fulfillment of the requirements for the Bachelor of science in Mechanical Engineering.

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Head & Professor
Department of Mechanical Engineering
Sonargaon University (SU)

DECLARATION

We hereby declare that undergraduate research work reported in this thesis has been performed by us under the supervisor of Md. Mostofa Hossain and this work has not been submitted elsewhere for any purpose.

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DEDICATED

TO

OUR BELOVED PARENTS

ABSTRACT

Thermoelectric Devices are solid state devices which directly convert thermal energy to electrical energy and vice versa. In their recent past, a lot of effort has been made to improve the performance and also the power generated by a thermoelectric device. This is done by attaching heat sinks on either side of the device. Optimizing heat sinks improves the overall efficiency of it but on the other hand the device also has to be optimized. TECs are mostly used for electronic cooling where the heated electronic devices serve as target that needs to be cooled while air acts as a heat sink with natural convection. In this project, maximizing the cooling power of a TEC has been studied and its effect with respect to variations in the TE geometry has been discussed and using a 3D model of the same has been Sketch Up whose setup used has been explained in details. At low leg length of the TEC's, the cooling power can be improved but a lot of other parameters have to be taken into account to accurately model the system. The contact materials used to electrically connect the device and the resistance of the conductor plays a very important role while calculating the cooling power at low leg lengths and hence cannot be neglected. Results show that cooling power of the TEC can be dramatically improved at low leg lengths and with better heat sink material.

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Firstly, we want to express gratefulness and humbleness to Almighty Allah for his immense blessing upon us for the successfulness completion of this thesis work.

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Finally, we would like to express our sincere gratitude to our family who have given support to our study and prayed for our life.

TABLE OF CONTENTS

NOMENCLATURE

Symbol	Description	Unit
A_c	total fin surface area cold side heat sink	(mm^2)
A_e	cross-sectional area of thermoelement	(mm^2)
A_h	total fin surface area hot side heat sink	(mm^2)
A_M	base area of thermoelectric module	(mm^2)
COP	the coefficient of performance	
c_p	specific heat	(J/kg K)
G_e	thermocouple geometric ratio	
H	total height of thermoelectric air conditioner	(mm)
h	heat transfer coefficient of the fluid	(W/m^2K)
I	electric current	(A)
j	unit cell number	
L	total length of thermoelectric air conditioner	(mm)
k	thermoelement thermal conductivity	(W/m K)
K	thermal conductance	(W/K),
L_e	length of thermoelement	(mm)
n	the number of thermo couples	
no	the number of thermo couples	
out	outlet	
opt.	optimal quantity	
p	p-type element	
$*$	dimensionless	
∞	fluid	

Symbol	Description	Unit
N_I	dimensionless current,	N_I
P_{in}	input power	(W)
q_x	the rate of heat transfer around the differential element	
$\dot{Q}$	the rate of heat transfer	(W)
$\dot{Q}_c$	cooling capacity	(W)
$\dot{Q}_h$	heat rejection	
R_{Al}	thermal resistance of the aluminum block	
tal	thickness of the aluminum block	
T_c	cold junction temperature	(°C)
T_h	hot junction temperature	(°C)
$T_{\infty c}$	cold fluid temperature	(°C)
$T_{\infty h}$	hot fluid temperature	(°C)
$\dot{V}_c$	cold fluid volume flow rate	(CFM)
$\dot{V}_h$	hot fluid volume flow rate	(CFM)
W	total width of thermoelectric air conditioner	(mm)
$\dot{W}$	electrical power	
x	direction along the length of the element	
Z	the figure of merit	(1/K)
α	See beck coefficient	(Ω cm
ρ	electrical resistivity	(K/W)
φ	aluminum block thermal resistance	
η	fin efficiency of the heat sink	
γ	thermal resistances ratio between the heat sink and aluminum block	

CHAPTER I

INTRODUCTION

Thermoelectric is defined as the generation of electricity from a given temperature difference or vice versa. Solid state devices capable of producing power, these devices are environment friendly that come with low maintenance and reliability. They use a very simple concept of running on a temperature difference and as long as these criteria are being fulfilled, energy is produced. The concept of thermoelectricity can be classified into 2 parts. Thermoelectric Coolers (TEC) and Thermoelectric Generators (TEG). In order to run a TEC, a certain amount of current has to be input along with maintaining a temperature difference which gives a cooling power and the coefficient of performance of the device can then be measured. However, in a TEG, a load resistance is input along with maintaining a temperature difference and electricity is thus generated from these conditions. There have been quite a few numbers of applications in the recent past and the number of applications is increasing with time. Thermo electric has found its way into air conditioning systems, automobile applications, solar energy applications and many others.

1.1 Objective:

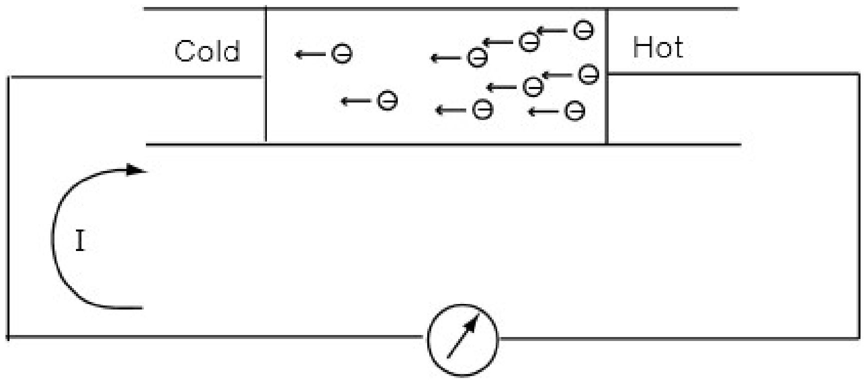
The objective of this thesis is-

(i) To Study about thermo electric effect
(ii) To Study about Peltier module
(iii) To test the performance of the system of the Thermoelectric refrigerator

1.2 History and Derivation of thermoelectric System:

Early years of 19th century, paved way for the discovery of the concept of Thermoelectricity. In 1821, Thomas See beck discovered that an electromotive force could be generated when a circuit was made out of two dissimilar materials and when the junction was heated [1]. The electro motive force that was generated was named the See beck Effect. A few years later, Jean Peltier discovered that this same Process could be reversed to produce heat when voltage was applied across the junction of two dissimilar materials. In short, when current is passed through a circuit, one junction increases in temperature while the other junction cools down. A thermoelectric module is formed when a number of dissimilar materials are connected thermally in series and electrically parallel to each other.

At the end of the 19th century, electrons were discovered. And that was when the concept of thermoelectricity came to be clearer to the people working on it. We now understand that electrons can be liberated from any source even at temperatures as low as the room temperature. This is the reason we have electrostatics everywhere. When a temperature difference is applied across a conductor, the hot region liberates more electrons and diffusion takes place from the hot side to the cold side. This distribution of electrons provokes the generation of an electric field which helps the electrons move from the hot side to the cold side due to Coulomb force. Therefore, an electromotive force (emf) is generated which causes the current to move in the direction opposite to the flow of temperature. The same can be said about the opposite criteria as well. The movement of electrons due to the application of a current result in the generation of temperature difference. This concept is shown in the following figure.



1.3 The See beck Effect:

When there is a temperature difference in a thermoelectric material, an electric current is created due to movement of holes and electrons in the semiconductor materials [2]. The effect that causes this behavior is called the See beck Effect.

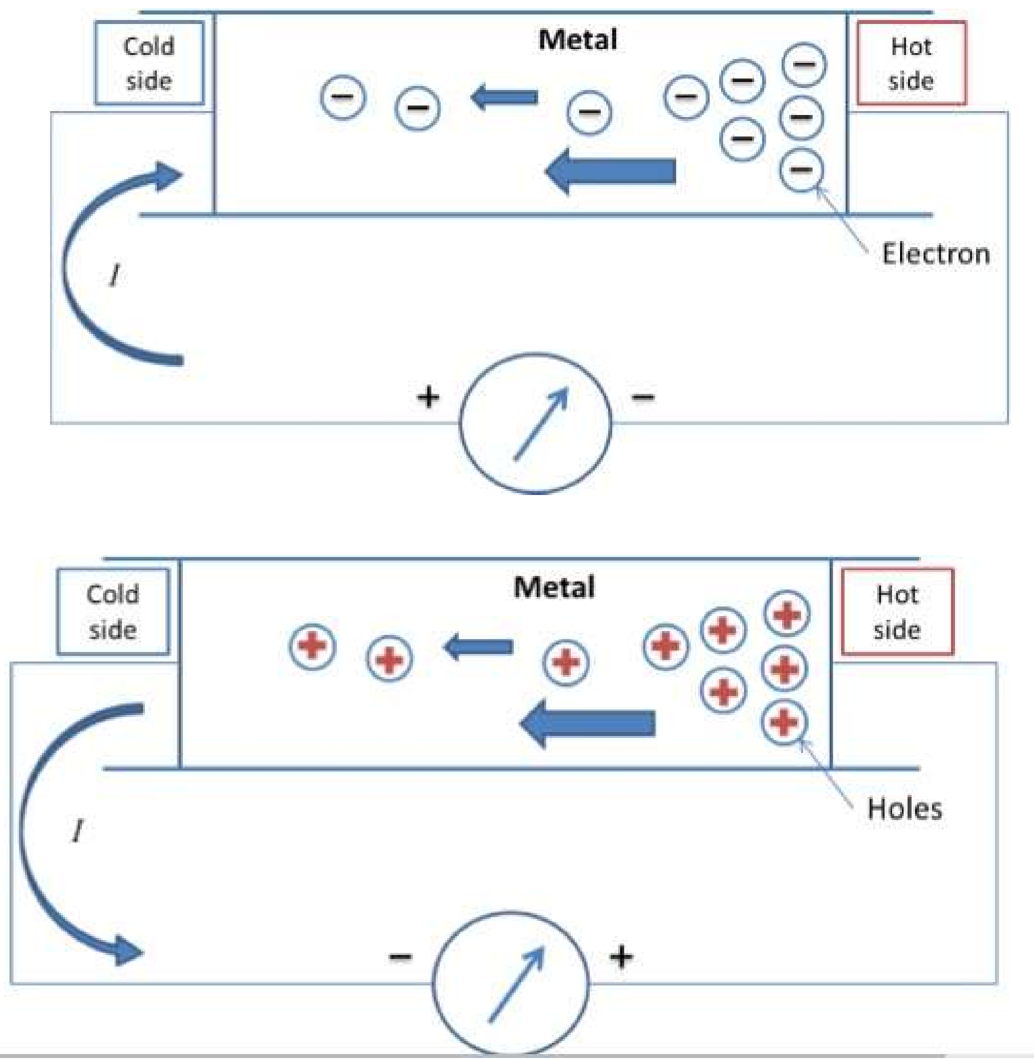


Fig. 1.3: The movement of (a) holes (b) electrons in the See beck Effect

A potential difference is developed when a voltmeter is placed in between the cold side and the hot side. This potential difference is proportional to the temperature difference between these sides. This relation is written as,

$$V = \alpha \Delta T$$

α is the See beck Coefficient while ΔT is the temperature difference between the two sides of the thermoelectric material. Hence, in a given thermoelectric module, α and ΔT are the factors that determine the voltage across it and depending on the resistance of the material and its geometry, the current can be determined.

1.4 The Peltier Effect:

Heat must be continuously added to or rejected from the body in order to keep the Junction temperatures constant when there is a current passing through it. The total Amount of heat added or rejected is proportional to the amount of current supplied. This phenomenon is called the

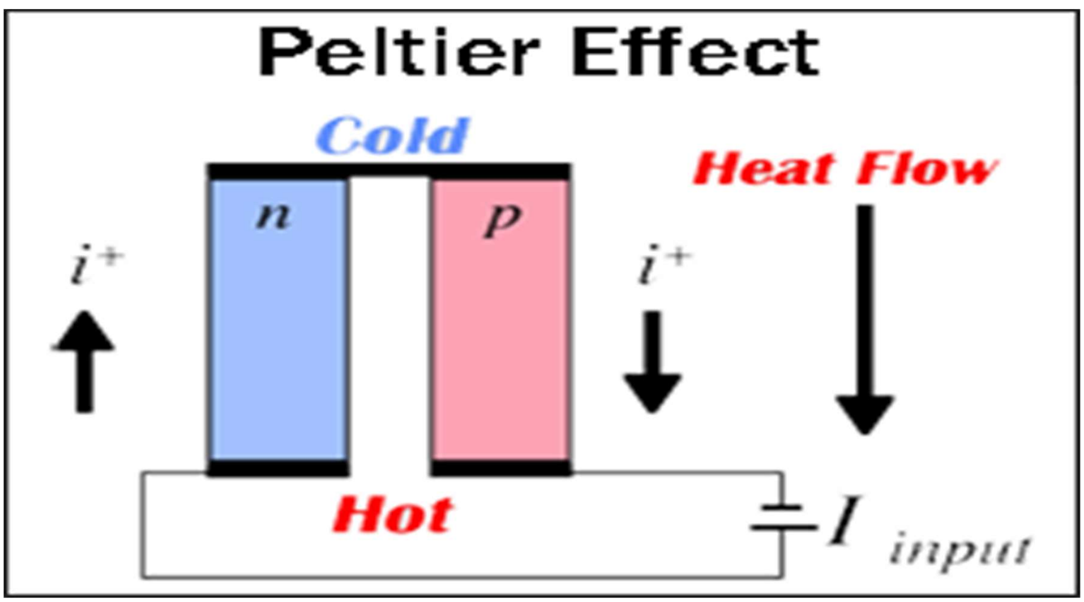


Fig.1.4: The Peltier Effect

Here, Π_{AB} is the Peltier coefficient, Peltier is the total heat added or rejected by the system and I is the current passing through the thermoelectric element

1.5 The Thomson Effect:

For the most part, the Thomson Effect is very similar to the Peltier Effect. Major difference between the two lies in the fact that the Thomson Effect requires a temperature gradient across the semi-conductor element along with the current supplied. This means that when current is supplied and when there is a temperature gradient along the length of the thermoelectric element, heat is either absorbed or rejected depending on the direction of the current supplied [3]. Hence, the Thomson Effect is proportional to the supplied current and the temperature gradient. It can be defined using the equation;

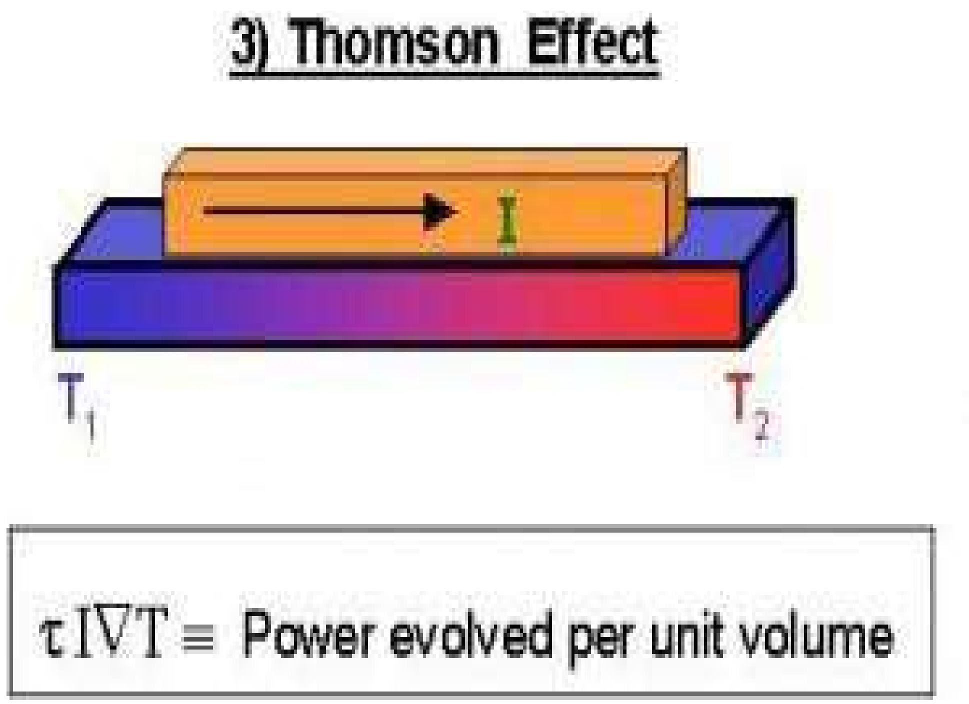


Fig. 1.5: The Thomson Effect

1.6 Figure of Merit:

Figure of merit is a term used to define the performance of a thermoelectric device. It can be calculated using the equation;

$$Z = \frac{\propto^2}{\rho\, k} = \frac{\propto^2 \sigma}{k}$$

where α is the see beck coefficient in (V/K), ρ is the electrical resistivity in (Ωm), k is the thermal conductivity in (W/mK) and σ is the electrical conductivity in (mK/W). The dimensionless figure of merit is defined as ZT where T is the absolute temperature [4]. For a long time, the value of Z Thad been constrained to1. But recent innovations have proven to have a ZT value greater than 1 that defines the performance of a thermoelectric system. The higher the value of ZT, higher the energy conversion efficiency of the device. From equation (1.4), the interdependence of the parameters is very evident. In order for the figure of merit to be high, the See beck coefficient α and the electrical conductivity σ must be high while the thermal conductivity k must be low. The values of these parameters are the defining points in the performance of a thermoelectric system and it has been very difficult to model a device that satisfies this inter dependence completely.

1.7 The Thermoelectric Module:

A thermoelectric pair consists of a p-type semiconductor, n-type semiconductor, and copper to connect the semiconductors. A module however, consists of a number of thermo electric pairs

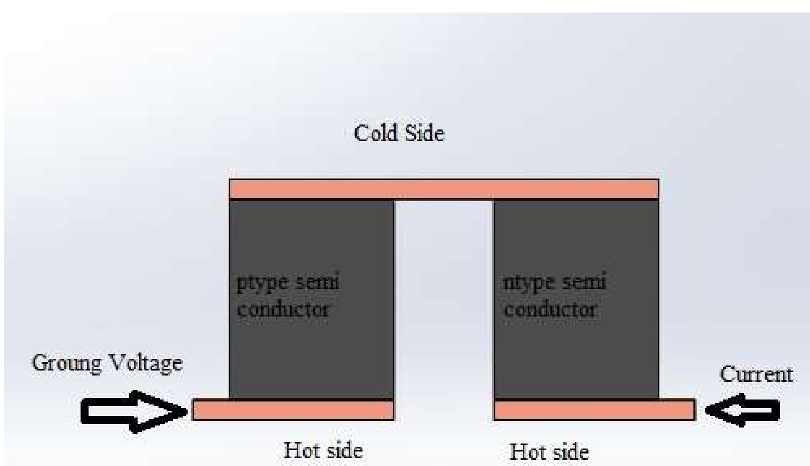


Fig.1.7: Thermocouple

depending on the application. The most widely used semiconductor is Bismuth Telluride. In the recent past however, materials better than Bismuth Telluride have been discovered. Materials like skitterier have proven to give better results under certain conditions. Depending on whether the module is a thermoelectric cooler or a generator, electric current is either supplied or generated from the system. In a thermoelectric cooler, the main focus of the current work, when an electric current is supplied to the n-type semiconductor, heat is absorbed and hence transported to the hot side. There by given an overall cooling effect. When current is applied in the opposite direction, an opposite effect is seen and the module gives a heating effect This concept holds an advantage of application over commercial refrigerators and heat pumps where these possess the advantage of direct energy conversion, high reliability, low maintenance, no refrigerants and all these advantages stand true mainly because the thermoelectric cooler is a solid-state device

CHAPTER II

THEORY

Some of the most recent applications in the concept of thermoelectric cooling is in vehicle air conditioning. Almost 10% of the annual consumption of fuel can be directed to the use of air conditioning. Most of these use refrigerants like R- 134a which has adverse effects on the environment being a major greenhouse gas. There is a lot of debate in the current day about banning all the environment depleting compounds and R-134a is definitely one of them. The U.S. Department of Energy (DOE) and the California Energy Commission funded a project to research an application involving thermoelectric heat ventilating and air conditioning system (TE HVAC) that promised to replace the traditional air conditioning systems in vehicles. Use of a thermo electric air conditioning system (TEAC) in place of the traditional air conditioning system has been proven to have benefits such as being able to produce a cooling effect without the use of environment depleting substance like the R-134 and also having a scope to select the areas needing heating or cooling instead of randomly cooling the whole area which in turn reduces the amount of fuel consumed considerably hence also reducing the exhaust.

2.1 Thermoelectric Today:

Al though the concept of thermo electric was observed centuries ago, the first model of its kind had come out only in the recent times. The first ever functioning device was developed in the late 1950s. These are also known as the first-generation thermoelectric devices. After a lot of questioning, answering and debating, many theories had been developed on various genres of this concept. Some of them included the study of thermoelectric properties with reduction in size. Early 90s saw the rise of experimental research that eventually gave several advances in the early 21^{st} century. Nano material have been discovered to have an effect on the value of the figure of merit that is worth noting. Due to an inverse relation between all the three parameters linking the figure.

2.2 Assumptions of thermoelectric ideal (standard) equations:

Consider two dissimilar semiconductor elements, which are sandwiched between copper conductive tabs, each element is called a thermoelectric leg or pellet, and is either p-type material (positive) or n-type material (negative). These elements are temperature independent with their material properties, which are See beck coefficient (α), electrical resistivity (ρ), and thermal conductivity (k).

The steady state heat balance at T_1 becomes

$$Q_1 = q_p + q_n$$

where q_p and q_n are the heat flows for p-type and n-type. The heat flows can be defined in terms of the Peltier heat and Fourier's law of conduction as [5]

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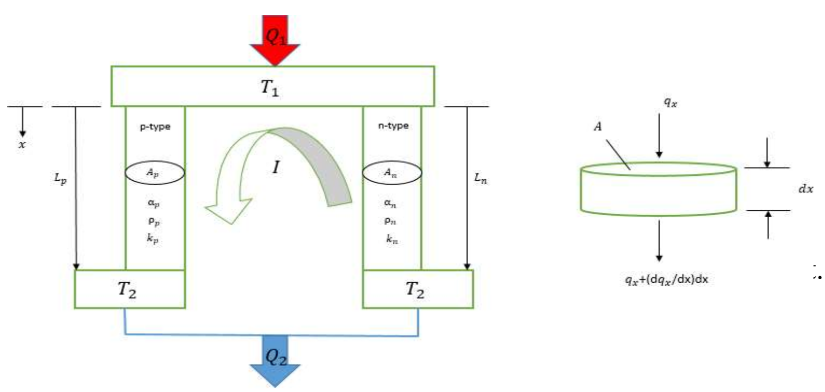


The steady state

(a) (b)

$$Q_1 = q_p + q_n$$

where q_p and q_n are the heat flows for p-type and n-type. The heat flows can be defined in terms of the Peltier heat and Fourier's law of conduction a Cooling and Heating side respectively which gives

$$Q_L = [\mathrm{SI}\ T_c - \frac{1}{2} I^2\ \mathrm{R} - \mathrm{K}\ (T_h - T_c)]$$

$$Q_h = [\mathrm{SI}\ T_h - \frac{1}{2} I^2\ \mathrm{R} - \mathrm{K}\ (T_h - T_c)]$$

$$\mathrm{W} = Q_h - Q_L$$

$$\mathrm{W} = \mathrm{SI}\ (T_h - T_c) + I^2\ \mathrm{R}$$

The coefficient of performance COP is similar to the thermal efficiency

$$\mathrm{COP} = \frac{QL}{W}$$

$$\mathrm{COP} = \frac{\mathrm{SI\ Tc} - \frac{1}{2}\mathrm{I}^2\ \mathrm{R} - \mathrm{K}\ (\mathrm{T_h} - \mathrm{T_c})}{\mathrm{SI}\left(\mathrm{T_h} - \mathrm{T_c}\right) + \mathrm{I}^2\mathrm{R}}$$

CHAPTER III

PROPOSED DESIGN

Fig. 3. Construction of Potable Refrigerator

3.1 Construction of Portable Refrigeration Unit:

Step 1:

A Unite is made according to 250mm x 165mm x 165mm size. Two holes are made on the both sides of the chamber according to Heat Sink Exhaust Fan. Four Peltier's are placed on the Heat Sink.

Step 2:

Two Exhaust fans are set up by on the Peltier module's hitting side i.e. outside of the chamber. Then 1 Cooling fans are set on the Peltier's cooling side i.e. outside the chamber.

Step 3:

Electrical connection is set up among the Peltier, cooling fans and exhaust fans. Then Peltier, cooling fan are connected with 12V DC, 50AM control drive. The driver is connected with a thermostat. And Exhaust Fans connected with 12v DC 5AM control drive.

3.2 Description of the component:

Component List-

- Peltier Module
- Cooling fan & Exhaust fan
- Digital thermostat
- 12V 50Amp DC power supply driver
- Heat sink
- 12V 5Amp DC power supply driver

3.2.1 Peltier Module:

TEC1-12706 THERMOMETRIC COOLER PELTIER MODULE Genuine 40x40mm Thermoelectric cooler Pettier plate module 12V 60W, We Test Each Peltier Module to Make Sure They Work.

Fig. 3.1: Peltier Module

Description Get ice cold in minutes or heat to boiling by simply reversing the polarity, used for numerous applications from CPU coolers to alternate power sources, or even for your own DIY project, what you can do with this Pettier module is limitless. Module consist primarily of semiconductor material sandwiched between ceramic plates and no moving parts. Connected to the 12-volt power supply cooling piece on both sides there will be difference in temperature, side cold side of the heat, do not long power cooler radiator, otherwise it will cause cooler internal overheating and burning.

The Peltier effect:

Thermoelectric coolers operate according to the Peltier effect. The effect creates a temperature difference by transferring heat between two electrical junctions. A voltage is applied across joined conductors to create an electric current. When the current flows through the junctions of the two conductors, heat is removed at one junction and cooling occurs. Heat is deposited at the other junction.

The main application of the Peltier effect is cooling. However, the Peltier effect can also be used for heating or control of temperature. In every case, a DC voltage is required.

Elements of thermoelectric cooler:

Thermo electric coolers from II-IV Marlow act as a solid-state heat pump. Each features an array of alternating n- and p- type semiconductors. The semiconductors of different type have complementary Peltier coefficients. The array of elements is soldered between two ceramic plates, electrically in series and thermally in parallel [6]. Solid solutions of bismuth telluride, antimony telluride, and bismuth selenide are the preferred materials for Peltier effect devices because they provide the best performance from 180to 400 K and can be made both n-type and p-type.

Fig. 3.2: Elements of thermoelectric cooler

The cooling effect of any unit using thermoelectric coolers is proportional to the number of coolers used. Typically, multiple thermoelectric coolers are connected side by side and then placed between two metal plates. II-VI Marlow features three different types of thermoelectric coolers including: Thermo cyclers, Single Stage, and Multi-Stage.

Heat absorption:

Cooling occurs when a current pass through one or more pairs of elements from n- to p-type; there is a decrease in temperature at the junction ("cold side"), resulting in the absorption of heat from the environment. The heat is carried along the elements by electron transport and released on the opposite ("hot") side as the electrons move from a high- to low-energy state.

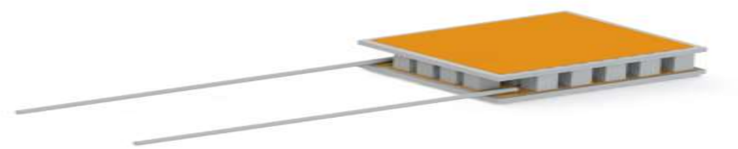


Fig. 3.3: Heat absorption

The Peltier heat absorption is given by Q = P (Peltier Coefficient) I (current) t (time). A single stage thermoelectric cooler can produce a maximum temperature difference of about 70 degrees Celsius. However, II-VI Marlow's Triton ICE Thermoelectric Cooler will chill electronics as much as 2 degrees Celsius below current market offerings.

Product Specification:

Model: TEC1-12706

Size 40x40x3.9mm (WxDxH), weight 27g

Imax 6.4A, Umax 15.4V, R = 1.98 ohm, 127 couples

TEC1-12706 max. = 68°C, Qmax 63.0W

Color: White

Operates from 0~15.2V and 0~6A

Operates Temperature: -30C to 70C

3.2.2 Cooling & Heat exhaust Fan:

Fig.3.4: Cooling Fan

Stands for "Heat Sink and Fan." Nearly all computers have heat sinks, which help keep the CPU cool and prevent it from overheating. ... This combination is creatively called. The fan moves cool air across the heat sink, pushing hot A heat sink is a device that incorporates either a fan or some other means to keep a hot component, such as a processor, cool. There are two heat sink types: active and passive. The picture to the right is an example of a heat sink that has both active and passive cooling mechanisms.ir away from the computer.

Material:
Aluminum alloys are the most common heat sink material. This is because aluminum costs less than copper. However, copper is used where higher levels of thermal conductivity are needed. Some heat sinks use a combination aluminum fins with a copper base.

Product details cooler fan:

- Supports all motherboards socket - (945, G31, G41, H61, H81)
- Dimension: (L/W/H) Approx. 65mm x 65mm x 65mm
- Speed: 2500±10% R.P.M
- Voltage: 12V DC
- Noise: 22 dBA
- Max. Wind: 34.6 CFM
- Net weight (One piece): Approx. 155g
- Usage lifetime: Approx. 30000 hours
- Material: Plastic

- **3.2.3 Digital Thermostat:**

Fig.3.5: Digital thermostat

Description: The is an incredibly low cost yet highly functional thermostat controller. With this module you can intelligently control power to most types of electrical device based on the temperature sensed by the included high accuracy NTC temperature sensor. Although this module has an embedded microcontroller no programming knowledge is required. 3 tactile switches allow for configuring various parameters including on & off trigger temperatures. The on-board relay can switch up to a maximum of 240V AC at 5A or at 10A. The current temperature is displayed in degrees Centigrade via its 3-digit seven segment display and the current relay state by an on-board LED.

Specification:

Temperature Control Range: -50 ~ 110 C Resolution at -9.9 to 99.9: 0.1 C Resolution at all other temperatures: 1 C Measurement Accuracy: 0.1 C Control Accuracy: 0.1 C Refresh Rate: 0.5 Seconds Input Power (DC): 12V Measuring Inputs: NTC (10K 0.5%) Waterproof Sensor: 0.5M Output: 1 Channel Relay Output, Capacity: 10A

Settings Chart Long press the “SET” button to activate the menu. Code Description Range Default Value P0 Heat C/H C P1 Backlash Set 0.1-15 2 P2 Upper Limit 110 110 P3 Lower Limit -50 -50 P4 Correction -7.0 ~ 7.0 0 P5 Delay Start Time 0-10 mins 0 P6 High Temperature Alarm 0-110 OFF Long pressing +- will reset all values to their default

Setting the cooling or heating parameter P0: The parameter P0 has two settings, C and H. When set to C (default) the relay will energize when the temperature is reached. Use this setting if connecting to an air-conditioning system. When set to H the relay will de-energise when the temperature is reached. Use this setting if controlling a heating device.

Setting the hysteresis parameter P1: This sets how much change in temperature must occur before the relay will change state. For example, if set to the default 2oC and the the trigger temperature has been set to 25oC, it will not deenergize until the temperature falls back below below 23oC. Setting this hysteresis helps stop the thermostat from continually triggering when the temperature drifts around the trip temperature.

Setting the upper limit of the thermostat parameter P2: This parameter limits the maximum trigger temperature that can be set. It can be used as a safety to stop an excessively high trigger temperature from accidentally being set by the user.

Setting the lower limit of the thermostat parameter:

This parameter limits the minimum trigger temperature that can be set. It can be used as a safety to stop an excessively low trigger temperature from accidentally being set by the user.

Setting temperature offset correction parameter Should you find there is a difference between the displayed temperature and the actual temperature (for instance if the temperature probe is on a long run of cable) you can make minor corrections to the temperature reading with this Parameter. Setting the trigger delay parameter This parameter allows for delaying switching of the relay when the trigger temperature has been reached. The parameter can be set in one-minute increments up to a maximum of 10 minutes. Setting the high temperature alarm parameter P6: Setting a value for this parameter will cause the relay to switch off when the the temperature reaches this setting. The seven-segment display will also show '---' to indicate an alarm condition. The relay will not re-energize until the temperature falls below this value. The default setting is OFF

3.2.4 12V 50Amp DC Power Supply Driver:

Fig.3.6: 12V 50Amp DC Power Supply Driver

Circuit Description:

Normally high-power factor LED drivers provide a regulated constant current output to drive a string of LEDs. In certain circumstances, the LED load may have a built in constant current LED driver so all that is need to drive the LED load is a power factor corrected constant voltage driver commonly referred to as an LED Power Supply. It is common for these supplies to generate 12 V, 24 V or even a higher voltage. The focus of this design note is the development of an isolated offline, high-power factor corrected single stage constant voltage supply which supports AC mains from 200−305 Vac. This addresses AC line voltages found in many parts of the world as well as the 277 Vac commercial input required for the United States. Specifically, this power supply is suitable for 12 V LED lamps used for retail, hotels, reception areas, art galleries, museums, and residential installations including landscape lighting. The constant output voltage with high power factor and compact size provides a driver solution suitable for many applications. An example 850 lumen LED lamp manufactured by Mega man is the AR111 which draws 15 W with a rated life of 25,000 hours. The narrow beam angle provides center beam illuminance of 5000 candela. Performance is comparable to a 75 W halogen lamp which typically provides only 1/10th the lifetime. Figure 1. AR111 − LED Lamp Shown below are the design guidelines for this driver: • Input Range: 200−305 Vac • Output Voltage: 12 V • Output Current: 1.5 A Continuous • Peak Current: 2.0 A • Efficiency: > 83% • Power Factor: > 0.95 http://onsemi.com DESIGN NOTE DN05050/D http://onsemi.com 2 • Isolated Output • Overload Protection the NCL30000LED3GEVB demonstration board serves as the basis for this application. This demo board was selected as it provides high input voltage covering 277 V applications with applicable tolerance. The low-profile design provides a compact solution. The high efficiency of this converter minimizes thermal issues. With a few modifications, this demo board will provide constant voltage control and exceed the performance objectives. Several component changes are required to optimize the demo board for constant voltage operation. Key changes are outlined below. The power transformer was designed with dual secondary windings. The demo board is shipped with the secondary windings connected in a series configuration to support higher output voltage [7]. Changing the windings to a parallel configuration optimizes the transformer for this 12 V application. The demo board readily supports this by relocating transformer lead “FL3” to PCB hole “H2” and lead “FL2” to hole “H5”. Higher transformer secondary current and lower voltage allows use of a Schottky rectifier which lowers power loss and improves efficiency. The ON Semiconductor is a good choice and can be fitted to the back of the demo board by forming leads to fit the pattern. High power factor single stage converters generally have no energy storage in the primary side circuit. As such, storage is required on the secondary side and typically in the form of capacitance in parallel with the load. Ripple voltage is nearly sinusoidal at twice the applied ac input frequency.

The ripple amplitude is inversely proportional to the total capacitance, thus increasing the filter capacitance will reduce ripple voltage. Output capacitors C11 and C12 are replaced with a lower voltage rating providing higher capacitance in the same size device reducing ripple for this higher output current application. The 1,500 F, 16 V capacitors are a direct fit on the board. On the original demo board, dual loop control is used to regulate a constant current. For this constant voltage application, the feedback will be modified to use one half of the dual op amp for voltage control and the other as current limit. A marked-up schematic is presented in Figure 2. This shows changes to the demo board in red. Component changes are listed below. Rework details are shown in Figures 3 and 4: • R26 = 0 • C14 = 1 F • R27 = 3.3 k • R28 = 160 • C15 = 100 pF • R29 = 0.05 (Stack Two 0.1 Resistors) • Remove R31. Scrape solder mask off PCB trace as shown in detail. Install R32 between scraped area and pad of R31 as shown in detail. • Place insulating tape over unused PCB pad for R31 as shown. Locate R31 = 6.2 k from uncovered pad of R31 to pad of R29 as shown in detail. The demo board includes over voltage protection which was originally set at ~57 V for high voltage LED applications. The threshold must be reduced to activate at a lower voltage. This protects the output capacitors. • D12 = 13 V Zener • R24 = 1 k On-time capacitor C9 controls the minimum ac line input voltage which will provide full output power. The peak transformer current must be reduced to operate the demo board transformer at this 12 V level to avoid saturation. Change C9 to 470 pF. In this example, the existing transformer on the demo board was used, if a new transformer was designed this would allow operation at 18 W for input voltages well below 200 Vac. It is possible to extend the input voltage down to 90 Vac. Converter startup time is controlled by the bias capacitor C8 and the startup resistors. For this application, the startup resistors R12 and R13 were increased in value to reduce dissipation and improve efficiency. This increases the converter startup time somewhat. Measured data shows the power factor exceeds the target value of 0.95 at 305 Vac and is above 0.97 for input voltage lower than 264 Vac. See Figure 5. Line voltage regulation and efficiency curves are shown in Figure 6. Note the tight voltage regulation and high efficiency exceeding 84% below 277 Vac input. A bill of materials is provided in Table 3. The highlighted components are those which must be changed relative to the standard demo board. Design Optimization There are some options to improve efficiency of this power supply. The standard demo board transformer was designed for applications higher than 12 V operation. Using the NCL30000 Design Worksheet, values specific to a particular application can be entered. Changing the turn's ratio and wire size can lower peak current which will improve efficiency. Another power saving option is reducing the losses due to the output rectifier. The Schottky rectifier suggested in this design note provides lower loss compared to a standard rectifier, however a synchronous rectifier approach similar to that outlined in DN05035/D could provide additional efficiency improvement.

3.2.5 Heat Sink:

Fig.3.7: Heat sink detailed dimension

A heat sink was designed and optimized using the optimization technique developed by Lee. An analysis was done on a system where one thermo electric module was included that consisted of 127couple sand an optimized heatsink. Heatsink was fixed on both sides of the thermoelectric module and an air duct was placed in order to input a mass flow rate for air. The input mass flow rate is 3.454g/s. the following figure shows a detailed sketch of the optimized heat sink that was used for this study.

3.2.6 : 12V 5Amp DC Power Supply Driver

Fig.3.8: 12V 5Amp AC to DC Power Supply Driver

Description:

Multipurpose 12V 50A DC Power Supply for large range of devices and applications.

Inbuilt Over load and short circuit protection.

Specification:

110-220 V AC Input +-15%12v 5A (Maximum) DC Output , 60W Power Output Terminal Board Design for Easy connections (5 Pin Terminal Board L,N, E, +V, -V)Short Circuit Protection Passive Cooling Design with Heat Sink Sturdy Steel Bod Adjustable output Voltage from (10V to 12.5V DC)

Dimensions'=16cm, B=10 cm, H=4.5 cm

Mounting Fitting: Screw mount via Bottom or Side Panel

Application:SMD Led Strip, Battery Charger, Toys, Lights, CCTV, Wall Clocks, Night Lamps, Door Bell, Water Overflow Tank, School and College Projects etc.

100% Quality control via in-house test facility with automating machine and experience technicians

Sales Package Content:1 x 12v 5A DC power Supply

CHAPTER IV

CONSTRUCTED PROJECT

FABRICATION AND PERFORMANCE TEST OF TE TERMOELECTRIC REFRIGERATOR

Fig.4:1 Construction of Potable Refrigerant Unit

Fig.4:2 Construction of Potable Refrigerant Unit

Fig. 4.3: Construction of Potable Refrigerant Unit

4.1 Working Principle:

There is one unit in the chamber. This is cooling unit. There is a thermostat to control the units. Cooling is controlled according to fixed temperature which is set on the thermostat. When we set 12 °C temperature on the thermostat it turns off. When there is 17 °C temperature inside the chamber then the thermostat on & the system will start.

CHAPTER V

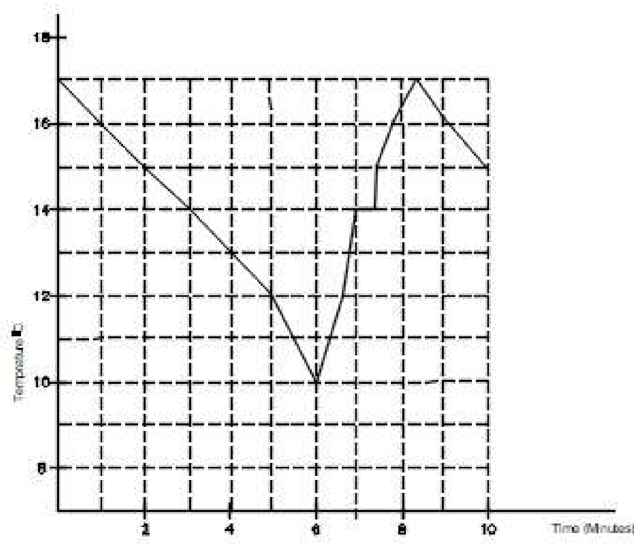
RESULTS AND DISCUSSIONS

5. Data Collection cooling chamber

Table 5.1 Data Collection of cooling chamber Temperature

SL No.	Cooling(T_c)
1	10°C
2	12°C
3	14°C
4	15°C
5	16°C
6	17°C
Average	=14°C

5.1.2 Table of the specification of TEC module



Performance curve of TEC module

5.2 Discussion:

Here table 5.1 represents cooling (T_c) rate according to the heating rate (T_h) after having calculation we find the heat absorption. Q_{Lh} is 54.56298 kj energy supplied (W) is 145.8435 kj and coefficient of performance (cop) is 0.37412 Here we find a decent of their different parameter which are defined earlier. The value identifies the acceptable range in terms of design and construction of cooling and heating chamber thermoelectric effect further more we can say the accomplishment of design and construction of cooling and heating chamber thermoelectric effect is successfully determined.

CHAPTER VI

FUTURE SCOPE

- Work can be done to improve the ceramic material property. One example of a better ceramic material is Aluminum Nitride with a thermal conductivity of 180W/m*K while the ceramic used in this work is Aluminum Oxide that has a thermal conductivity of 27W/m*K.
- This study can be extended to a system with number of modules. An application can be cited in thermoelectric air conditioning system that used more than one module. This is an expensive experiment and hence can be simulated using to get similar results. This kind of simulation however requires a high-end work station that comes with a full version.
- The analysis done in this project ignores a lot of physics as explained in the assumption of the ideal equations. Future work can be done including such physics like the temperature dependency of the material properties, radiation heat losses and also the transfer of heat in the longitudinal direction if a greater number of modules are included in a thermo electric system.

CHAPTER VII

CONCLUSION

This work was mainly aimed at validating analytical. A lot of discussion has also been made on the importance of electrical contact resistance and electrical copper resistance. It has been found that integrating CFD into thermal electric module during the simulation helps in deriving reliable results to validate the accuracy of the ideal equations. The discussion started off with explaining about the impact on a single module and then the same discussion was implemented on a complete module containing 36 modules. Miniature modules and macro modules were discussed and each of the parameters that impacted the overall cooling power of module was focused. The value of copper resistance and contact resistance is as such very low. But when the leg length is very low, the resistance values come in comparison with the value of the leg length. Hence, it starts impacting the cooling power and performance of the system. In higher leg lengths, however, the value of resistance is very low when compared to the value of the leg length. Hence, even though there is an impact on the cooling power, it is so insignificant that it can be neglected. optimized parameters depending on its input conditions. Modules ending up with very low leg length is very difficult to manufacture and sometimes need a new technology to build it. It is very difficult and also expensive to manufacture these kinds of modules. Hence the simulation acts as a supplement to an experimental analysis

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