“DESIGN AND FABRICATION OF MINI ECO-FRIENDLY REFRIGERATOR”

A Project Report

Submitted in partial fulfillment for the

Award of the degree of

BACHELOR OF TECHONOLOGY

IN

MECHANICAL ENGINEERING

Submitted by

AMIT CHOUDHARY **(1264540013)**

PIYUSHKANT PATHAK **(1264540051)**

RAJAT KUMAR **(1264540060)**

TUSHAR BSIHNOI **(1264540076)**

VAIBHAV CHOUDHARY **(1264540077)**

UNDER THE SUPERVISION OF

Mr. M. K. PODDAR
(Assistant Professor)

IDEAL INSTITUTE OF MANAGEMENT & TECHNOLOGY, GHAZIABAD
Dr. A. P. J. ABDUL KALAM TECHNICAL UNIVERSITY, LUCKNOW

(2015-2016)

<u>DECLARATION</u>

We hereby declare that we are **Student of Mechanical Engineering, IIMT, Ghaziabad.** We are working on project under the guidance of **Mr. M. K.PODDAR** Further, this work has been submitted in full to obtained degree of the Bachelor of Technology that the studies described in this report entitled "**DESIGN & FABRICATION OF MINI ECOFRIENDLY REFRIGERATOR"** in subject Mechanical engineering is carried out by us.

NAME	ROLL NO.	SIGNATURE
AMIT CHOUDHARY	1264540013	
PIYUSHKANT PATHAK	1264540051	
RAJAT KUMAR	1264540060	
TUSHAR BISHNOI	1264540076	
VAIBHAV CHOUDHARY	1264540077	

Date:

IDEAL INSTITUTE OF MANAGEMENT & TECHNOLOGY, GHAZIABAD
Dr. A. P. J. ABDUL KALAM TECHNICAL UNIVERSITY, LUCKNOW
(An ISO 9001:2008 Certified Institution)
Phone:- 0120-2767816, 0120-2767818, Fax:- 0120-2767352
Email:- info@idealinstitute.ac.in Website:- www.idealinstitute.ac.in

CERTIFICATE

This is to certify that project report entitled "**DESIGN & FABRICATION OF MINI ECO-FRIENDLY REFRIGERATOR"** which is being submitted by **Amit Choudhary, Piyushkant Pathak , Rajat Kumar , Tushar Bishnoi** ,**Vaibhav Choudhary** in partial fulfilment for the requirement for the award of the degree of Bachelor of Technology in department of Mechanical Engineering of Ideal Institute of Management and Technology, Ghaziabad under Dr. A. P. J. Abdul Kalam Technical University, Lucknow. They have worked under the guidance of Mr **M. K. PODDAR** (Asst. Professor, Department of Mechanical Engineering, IIMT, GZB) and have fulfilled the requirement for the submission of the project. The matter embodied in this thesis is original and has not been submitted for the award of any other degree.

Signature of Supervisor	*Signature of HOD*	*Signature of External Examiner*
Mr. Manoj Kumar Poddar	**Mr. Krishan Kumar Gupta**	
Assistant Professor	Assistant Professor	
Deptt of Mech. Engg.	Deptt of Mech. Engg.	

Date

ACKNOWLEDGEMENT

We express our deep sense of gratitude and indebtedness to **HOD Mr. K. K. GUPTA,** Lucknow for giving us opportunity to carry out this project. With immense pleasure we express our deep sense of gratitude and respectful to **Mr. M. K. PODDAR (Assistant Professor)** who was guiding us by giving his valuable suggestions, constructive criticism and encouragement, which helped us to keep our spirits high and to deal with problems. His meticulous methodology, critical assessment and warm encouragement made it possible for me to bring the work in its present shape.

We are sincerely thankful to all other members of FACULTY OF MECHANICAL, IIMT for giving us time to time support in doing this project. We express a word of thanks to our friends for their constant support, suggestions and encouragement during preparation of this project. Finally, we thank God for giving us the loving siblings and affectionate parents, who blessed us with everything all throughout our life. Our gratitude to them cannot be expressed in words. To them we owe our wonderful today and a dream filled tomorrow.

Name	Roll No.	Signature
AMIT CHOUDHARY	**(1264540013)**	
PIYUSHKANT PATHAK	**(1264540051)**	
RAJAT KUMAR	**(1264540063)**	
TUSHAR BSIHNOI	**(1264540076)**	
VAIBHAV CHOUDHARY	**(1264540077)**	

Date:

ABSTRACT

The objective of this project work is to develop portable thermoelectric refrigeration system capable of maintaining vaccine temperatures between 8 °C and 13 °C. The main system consisted of thermoelectric module as cooling generator along with insulated cabin, battery and charging unit. Thermoelectric elements perform the same cooling function as Freon-based vapor compression or absorption refrigerators. To ensure the success of this project several criteria's are to be satisfied such as portability, size and cost of the system. The design of the preservation is based on the principles of thermoelectric module (i.e. Peltier effect) to create a hot side and a cold side. The cold side of the thermoelectric module is used for refrigeration purposes; provide cooling to the vaccine chamber. On the other hand, the heat from the hot side of the module is rejected to the surroundings with the help of heat sinks and fans. After gathering experimental data's and necessary guidelines from research papers on the thermoelectric refrigeration systems, the initial design of the model was made. Based on the heat load calculations, the thermoelectric module is selected. The system was fabricated and was experimentally tested for the cooling purpose. The capability of the system to maintain the required temperature and the time for reaching the same were analyzed. The results showed that the system can maintain the vaccine storage temperature at 8°C and 13 °C under ambient temperature up to 30 °C with minimum power consumption of 64 Watt. The proposed thermoelectric module, to maintain the vaccine storage temperature, satisfied the design criteria. Coefficient of performance of the vaccine preservation (COPR) was calculated and found to be about 0.106.

TABLE OF CONTENTS

LIST OF TABLE

LIST OF FIGURES

CHAPTER 1: INTRODUCTION

1.1THEORY:

The conventional cooling systems are used now a days are requires the refrigerant whose phase change takes place in heat exchanging and compressor are required for the compression of the refrigerant. The compressor required more power and space. The refrigerant is also not eco-friendly and increases the global warming and the major cause of ozone layer depletion.

The mini Eco-friendly refrigerator is based on the PELTIER EFFECT and a thermoelectric device called Peltier device is used for the cooling purpose. In the MEF-Refrigerator there is no need of compressor and refrigerant. Semiconductor thermoelectric coolers (also known as Peltier coolers) off temperature control ($< \pm 0.1$ °C) can be achieved with Peltier coolers. However, their efficiency is low compared to conventional refrigerators. Thus, they are used in niche applications where their unique advantages outweigh their low efficiency. Although some large-scale applications have been considered (on submarines and surface vessels), Peltier coolers are generally used in applications where small size is needed and the cooling demands are not too great, such as for cooling electronic components.

1.2 INNOVATION:

Conventional cooling systems such as those used in refrigerators utilize a compressor and a working fluid to transfer heat. Thermal energy is absorbed and released as the working Fluid undergoes expansion and compression and changes phase from liquid to vapor and back, respectively. Semiconductor thermoelectric coolers (also known as peltier coolers) offer several advantages over conventional systems. They are entirely solid-state devices, with no moving parts, reliable, and quiet. They use no ozone depleting chlorofluorocarbons, potentially offering a more environmentally responsible alternative to conventional refrigeration. They can be extremely compact, much more so than compressor-based systems. The applications of thermoelectric coolers are increasing with an ever increasing demand of cooling in every sector for the past forty years. The TE coolers convert electrical energy into a temperature gradient which is also known as peltier effect. Although the physical principles upon which modern thermoelectric coolers function actually discovered in early 1800s but commercial thermoelectric modules were made available in the year 1960.In 1821, the first important discovery relating to thermoelectricity occurred by German scientist Thomas See beck who found that an electric current would flow Continuously in a closed circuit made up of two dissimilar metals, provided that the junctions of the metals were maintained at two different temperatures. Later, in 1834, while investigating the See beck Effect, a French watchmaker and part-time physicist, Jean Peltier found that there was an opposite phenomenon where by thermal energy could be absorbed at one dissimilar metal junction and discharged at the other junction when an electric current flows within the closed circuit. After studying some of the earlier thermoelectric work, Russian scientists in 1930s, inspired the development of practical thermoelectric modules based on modern semiconductor technology by replacing dissimilar metals with doped semiconductor material used in early experiments. The See beck, Peltier and Thomson effects, together with several other phenomena, form the basis of functional thermoelectric modules. Its applications are found in military, aerospace, telecommunication, electronic systems, laser diodes and medical sector. Recently TE coolers are also finding applications for cooling in high powered components such as microprocessors in both manufacturing test processes and user conditions. High cooling capacity TE coolers, in combination of air cooling or liquid cooling techniques, are being pursued to extend the conventional air cooling limits for high power dissipating microprocessors. Compact in size and silent in operation, the TE cooler is easy to be integrated into a system in comparison with the vapor compression cooling technology.

The variety of TE products is quite large and is ever increasing with the imaginations of design engineers for heating and cooling applications. However, TE cooling is specifically the abstraction of heat from electronic components. Over the past four decades, improvement in the conversion efficiency has been marginal. The challenge has been the improvement in the performance of the thermocouple materials, which could lead to a breakthrough in terms of the efficiency of the TE device. TE cooling is specifically the abstraction of heat from electronic components. Over the past four decades, improvement in the conversion efficiency has been marginal. The challenge has been the improvement in the performance of the thermocouple materials, which could lead to a breakthrough in terms of the efficiency of the TE device. An increasing surge in the demand of refrigeration has been noticed e.g. air-conditioning, food preservation, vaccine storages, medical services, and cooling of electronic devices, led to an increase in the consumption of electricity which is a contributing factor for global warming and climate change. TE refrigeration is a beneficial alternative as it can use waste electricity for further cooling applications and meeting our present energy challenges. Further, these are entirely solid-state devices and absence of moving parts makes them rugged, reliable, and quiet. In addition to this, these use no ozone depleting chlorofluorocarbons, potentially offering a more environmental friendly alternative to conventional refrigeration.

However, their efficiency is low compared to conventional refrigerators. Objective of this project is to design thermoelectric Refrigerator to control the temperature in the range 5 °C to 25 °C.

1.3 EASE OF USE:

The thermoelectric refrigerator is easy to use and maintained because it has no moving parts it is completely a solid state heat pump. There are very less components in thermoelectric refrigerator due to which it is portable and can be carried outside easily. It also consume less electricity.

An increasing surge in the demand of refrigeration has been noticed e.g. air-conditioning, food preservation, vaccine storages, medical services, and cooling of electronic devices, led to an increase in the consumption of electricity which is a contributing factor for global warming and climate change. TE refrigeration is a beneficial alternative as it can use waste electricity for further cooling applications and meeting our present energy challenges. Further, these are entirely solid-state devices and absence of moving parts makes them rugged, reliable, and quiet. In addition to this, these use no ozone depleting chlorofluorocarbons, potentially offering a more environmental friendly alternative to conventional refrigeration.

1.4 NEED:

Peltier cooler refrigerator are generally used as: -

For a Cold Storage of

- Foods & Beverages.
- Medicine.
- Beauty care Products.

The system comprising of

1. PELTIER device that uses the thermo couple to transfer the heat one to another side with consumption of electricity.

2. HEAT sink is used both side for transfer of heat.

3. FAN is used for flowing air over the heat sink.

Fig 1.1: Thermoelectric refrigerator

1.5HISTORY AND DEVELOPMENT

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 thefoundations 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 AthanasePeltier 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 Peltiergenerally 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

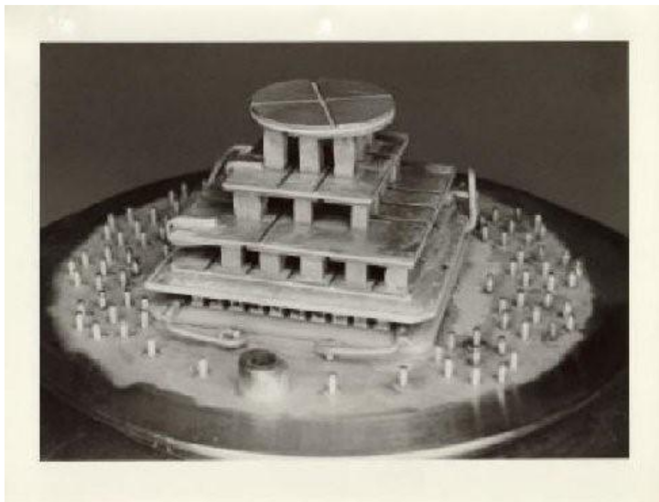


Figure1.2: The first idea of thermoelectric device

Figure1.3: The first thermoelectric cooler been made

1.6 THERMOELECTRIC REFRIGERATOR

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).

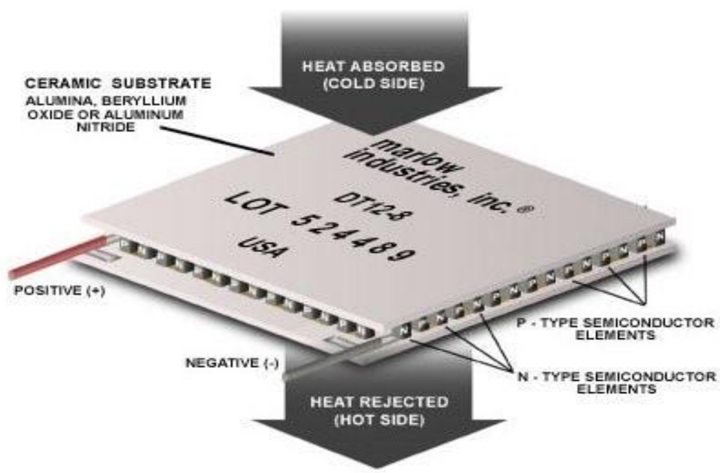


Figure1.4: Diagram of a typical thermoelectric cooler

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.

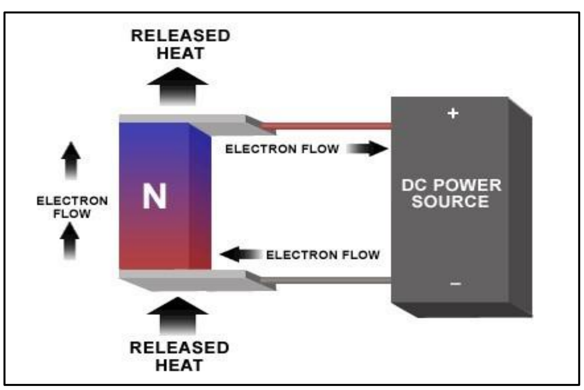


Figure1.5: Illustrates an "N-type" semiconductor element utilized to facilitate the Peltier effect

1.6.1. ADVANTAGES OF THERMOELECTRIC REFRIGERATION

COMPACT SIZE: Very little space is required by the cooling system. The thermoelectric module is the size of a matchbook.

LIGHTWEIGHT*:* 36 qt. capacity unit weighs only 17 lbs. PORTABLE: Carries with one hand and is unaffected by motion

LOWER PRICE*:* 20% to 40% less expensive than compressor or absorption units.

LOW BATTERY*:* Averages approximately 4.5 amps - less than your cars headlights.

PERFORMANCE: Thermoelectrics coolers maintain "cool" temperatures in ambients up to 90 degrees F.

HEATING OPTION*:* Thermoelectric can be operated in heating mode for a short period.

SAFETY*:* No open flames, propane, or toxic refrigerants used.

RELIABILITY*:* Thermoelectrics have a 40 year proven track record in military, aerospace, laboratory, and no of consumer applications.

EASY SERVICE*:* Most parts are easily replaced by the end-user with a screw driver.

LOWMAINTENANCE: The only maintenance required with any thermoelectric unit is periodic "dusting" and Vacuuming to ensure good heat dissipation.

1.6.2. COMPARISON OF THERMOELECTRIC REFRIGERATION AND OTHER METHODS OF REFRIGERATION

THERMOELECTRIC*:* Cooling is achieved electronically using the "Peltier" effect - heat is pumped with electrical energy.

COMPRESSOR: Cooling is achieved by vaporising a refrigerant (such as freon) inside the refrigerator heat is absorbed by the refrigerant through the principle of the "latent heat of vaporisation" and released outside the refrigerator where the vapour is condensed and compressed into a liquid again. Uses mechanical energy.

ABSORPTION: Cooling is achieved by vaporising a refrigerant (ammonia gas) inside the refrigerator by "boiling" it out of a water ammonia solution with a heat source (electric or propan e).
Uses the principle of "latent heat of vaporisation". The vapour is condensed and re-absorbed by t he ammonia solution outside the refrigerator. Uses heat energy. s.

1.6.3. COMPARISON OF THE FEATURES OF ALL THREE SYSTEMS:

COMPACTNESS*:* Koolatron thermoelectrics are the most compact because of the small size of the cooling components - cooling module / heat sink / cold sink

WEIGHT: Koolatron units weigh 1/3 to 1/2 as much as the other units because of the lightweigh t cooling system - no heavy compressor.

PORTABILITY: Koolatrons are the most portable because they are light enough to carry with o nehand and are not affected by motion or tilting. Compressor models are quite heavy and the absorption models must be kept level within 2 - 3 degrees.

PRICE: Koolatron coolers cost 20% - 40% less than the equivalent sized compressor or absorpti on units available for recreational use.

BATTERY DRAIN: Thermoelectrics have a maximum current drain on 12 volts of 4.5 amps. Compressor portables draw slightly more current when running but may average slightly less depending on thermostatic control settings. Absorption portables draw 6.5 to 7.5 amps when run ning and may average about 5 amps draw.

BATTERY PROTECTION: Consider the "Battery Saver" option as discussed in the previous section.

COOLING PERFORMANCE: Compressor systems are potentially the most efficient in hot weather. Some models will perform as a portable freezer and will refrigerate in ambient temperatures of up to 110 degrees F.thermoelectricunits will refrigerate in sustained ambient temperatures of up to 95 degrees F. If they are kept full, they will refrigerate satisfactorily even if peak daytime temperatures reach 110 degrees F because the contents temperature will lag behind ambient. The food will be just starting to warm up when the air cools off in the evening which br ing the food temperature back down to normal. Absorption type refrigerators provide almost sam e cooling performance as Thermoelectrics portables but are less efficient at high ambients.

FREEZING ICE CUBES: Compressor systems will usually make a quantity of small ice cubes except in very hot weather. Gas absorption systems can do the same except in hot weather. therm oelectric units do not make ice cubes but can preserve them in a plastic container for 2 - 3 days which is often adequate for most applications.

SAFETY: Koolatron systems are completely safe because they use no gases or open flames and runon just 12 volts. Compressor systems can leak freon which can be extremely dangerous if heated. Absorption systems may use propane which can be extremely dangerous in the event of a leak.

RELIABILITY: Thermoelectric modules do not wear out or deteriorate with use. They have been used for military and aerospace applications for years because of their reliability and u nique features. Compressors and their motors are both subject to wear and freon-filled coils are subject to leakage and costly repairs. Absorption units are somewhat temperamental and may req uire expert servicing from time to time, especially if jarred when travelling.

EASE OF SERVICING AND MAINTENANCE: Thermoelectric units have only one moving part, asmall fan (and 12 volt motor) which can easily be replaced with only a screw driver. Most parts can be easily replaced. Compressor and absorption units both require trained (expensive) mechanics and special service equipment to service them.

CHAPTER 2: LITERATURE SURVEY

2.1LITERATURE REVIEW OF MEF-REFRIGERATOR

1. Jonathan Michael Schoenfeld et at [1] in his thesis submitted on integration of a thermoelectric sub cooler in 2008.

There are two general research areas focused on increasing TEC performance; materials Researchon thermoelectric semiconductors and system level assembly and heat dissipation techniques. The former is focused on developing advanced thermoelectric materials with superior thermoelectric properties. The most important parameter of a thermoelectric semiconductor is the figure of merit, Z, which is given by α2/ (kρe). Each of these properties is temperature dependent so often the of merit will be given at a particular temperature in the dimensionless form, ZT. Increasing the figure of merit directly results in an increase in the optimum COP of a TEC. The most common thermoelectric semiconductor in today's TECs is Bismuth Telluride (Bi 2Te 3), which has a ZT of ~0.9 at 300 K.

(2)Bass et al. (2004) [2] investigated the use of multi-layer quantum well (MLQW) thermo electrics in a cooling application. MLQW thermoelectric material is a composite of thin layers of alternating semiconductor material with differing electronic band gaps deposited on a substrate. In this way, the thermal and electrical conductivity of the material can be decoupled. The non-dimensional figure of merit of such composite materials has been determined experimentally to be as high as 3 or 4.

Theoretical analysis predicted COPs as high as 5 at a ΔTm of 20 K. A TEC utilizing MLQW thermoelectric material is still under development. It can be expected that the additional manufacturing costs of such a module would be substantial.

Besides the obvious increase in optimum COP provided by such an improvement in thermoelectric properties, it has also been recognized that Tellurium, a main component in Bismuth Telluride, is becoming increasingly rare and expensive, which will eventually lead to a necessary replacement for thermoelectric materials. Further research is still required to develop nanotechnology thermo electrics, with the ultimate hurdle being the fabrication of a scaled up module with an applicable cooling capacity.

(3) Chain and Chen et al.(2005) [3] investigated the use of a micro channel heat sink on a TE module used to cool a water tank. The micro channels were etched into a silicon wafer with a glass cover plate. Four micro channel heat exchangers were fabricated with a differing number of ports and hydraulic diameters (D h), from 89 ports at a D h of 65 µm to 44 ports at a D h of 150 µm.

Water was pumped at flow rates ranging from 289 – 10,702 ml/h to remove the heat from the hot side of the module. The micro channel was placed on top of a 4 cm x 4 cm TE module. The lowest measured thermal resistance for the heat sink was 1.68 K/W. The authors suggested that the thermal resistance could be reduced to 0.5 K/W by increasing 6 the aspect ratio of the micro channel ports and by using a more conductive material like copper.

(4)Webb et al. (1998) [4]investigated the use of a thermo syphon as the heat sink of a TE module used for electronics cooling. A porous aluminum surface was employed to enhance the boiling heat transfer in the evaporator. The condenser was constructed with internal micro fins to enhance condensation. An experimental study was conducted with simulated heat loads typical of a thermoelectric module heat rejection. At 75 W a thermal resistance of 0.0505 K/W was calculated for a 45 mm square enhanced boiling surface.

The authors also recognized that the thermal resistance decreased slightly with increasing heat flux. As the figure of merit continues to increase through a continued research effort, the use of thermo electrics for air cooling has become more feasible.

(5)Riff at and Qiu et al. (2005) [5] investigated TE air conditioning systems with an air and water cooled heat sink. A cylindrical heat sink was designed through the optimization of the interior fin length and pitch as well as fluid velocity. The cylindrical design was capable of reducing heat exchanger volume and thermal resistance. An evaporative water “condenser” was suggested as the outdoor unit, which would cool the circulated water down close to the wet bulb temperature through convective and evaporative cooling. It was shown that the thermal resistance of a water cooled heat sink was significantly lower than an air cooled heat sink, with values reported as low as 4.75 x 10-4 K/W for a cylinder with an outer surface area of 0.23 m 2. An ideal COP of 1.8 was reported at a ΔTm of 20 K of merit of Z = 3.0 x 10 -3 K -1. Although possible, it would be difficult to fabricate a TE module on a curved surface as suggested.

(6) Muhammad Khazratul development of small D.C. thermoelectric refrigerator et al [6]

The refrigerator is one of the most innovative and important inventions of the twentieth century. The basic function of a domestic refrigerator is to preserve the quality of perishable food products. Several studies have shown that the quality of food products directly depends on temperature and air distribution inside the storage chambers. Hence, unsuitable temperatures and air velocities may cause food to undergo a premature deterioration. Even if the average temperature inside the refrigerator cabinet is adequate, uncontrolled rise or fall in local temperatures may affect the quality of food products.

A device described as a "refrigerator" maintains a temperature a few degrees above the freezing point of water; a similar device which maintains a temperature below the freezing point of water is called a "freezer". The refrigerator is a relatively modern invention amongst kitchen appliances. It replaced the common icebox which had been placed outside for almost a century and a half prior, and is sometimes still called by the original name "icebox".

A typical household refrigerator is actually a combination refrigerator-freezer since it has a freezer compartment to make ice and to store frozen food. Today's refrigerators use much less energy as a result of using smaller and higher-efficiency motors and compressor, better insulation materials, larger coil surface areas, and better door seals.

2.2 PROJECT OBJECTIVES

The tittle of project work is "Design and fabrication of Mini Eco-Friendly Refrigerator"(MEF). The objectives of the present work are:

- ❖ Study on Refrigeration machine on the basis of performance, economy and applications.
- ❖ Design and construct a working unit of MEF- Refrigeration machine.

- ❖ Cost analysis of MEF Refrigeration Machine.
- ❖ Environment friendly to save ozone layer depletion.

CHAPTER 3: DESIGN AND CONSTRUCTION

3.1COMPONENTS AND TECHNICAL FEATURES

In thus chapter we have discussed about the various components that are required in the design and fabrication of mini eco-friendly refrigerator .This chapter is divided into many sub-chapters.

3.1.1Module Selection:

DESIGNS Selection of the proper thermoelectric module for a specific application requires an evaluation of the total system in which the refrigeration will be used. For most applications, it should be possible to use one of the standard module configurations while in certain cases a special design may be needed to meet stringent electrical, mechanical or other requirement. The overall cooling system is dynamic in nature and system performance is a function of several interrelated parameters. Before starting the actual thermoelectric module selection process, under listed questions must be answered. At what temperature must the cooled object be maintained? How much heat must be removed from the cold object? Is thermal response time important? What is the expected ambient temperature? What is the extraneous heat input (heat leak) into the system? How much space is available for the module and heat sink? What power is available? What is the expected approximate temperature of the heat sink during operation?

3.1.2THERMOELECTRIC COOLING MATERIAL:

Although the principle of thermoelectricity dates back to the discovery of the Peltier effect, there was little practical application of the phenomenon until the middle 1950‟s. prior to then, the poor thermoelectric properties materials made them unsuitable for use in a practical refrigerating device. According to Nolas et al , from the middle 1950s to the present the major thermoelectric material design approach was that introduced by A.V. Ioffe, leading to semi-conducting compounds such as Bi_2Te_3, which is currently used in thermoelectric refrigerators. In recent years there has been increased interest in the application of thermoelectric to electronic cooling, accompanied by efforts to improve their performance through the development of new bulk materials and thin film micro coolers.

The usefulness of thermoelectric materials for refrigeration is often characterized by the dimensionless product, ZT, of the thermoelectric figure of merit Z and temperature T. The expression for the thermoelectric figure of merit is given by:

Where is the See beck coefficient?

$$Z = \frac{\alpha}{\rho k}$$

Where ρ is the electrical resistivity.

K is the thermal conductivity.

Low electrical resistivity and thermal conductivity are required for high figure of merit. These values are temperature dependent therefore, the figure of merit is temperature dependent. P and N type material have different figures of merit and are averaged to determine a materials overall quality.

Semiconductors are the optimum choice of material to sandwich between two metal conductors because of the ability to control the semiconductors' charge carriers, as well as, increase the heat pumping ability.

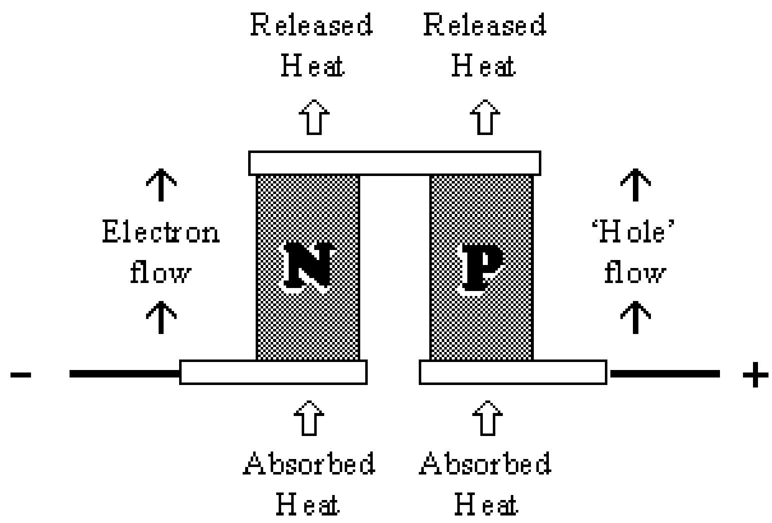


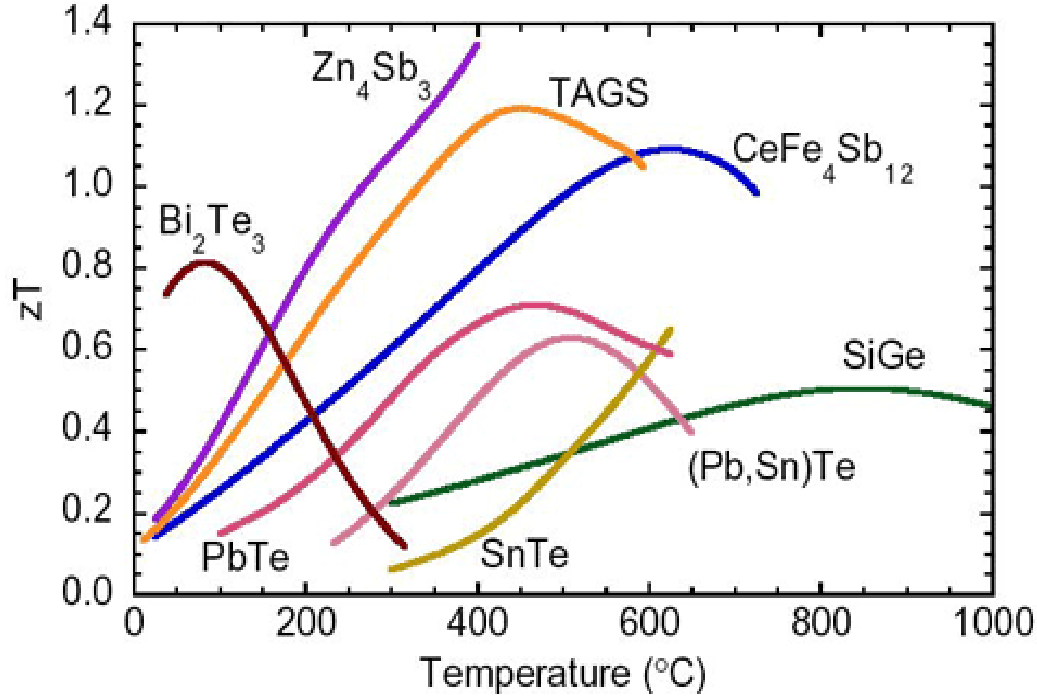
Fig3.1:Heat flow in semiconductor

The most commonly used semiconductor for electronics cooling applications is Bi_2Te_3 because of its relatively high figure of merit. However, the performance of this material is still relatively low and alternate materials are being investigated with possibly better performance.

Alternative materials include:

I. Alternating thin film layers of Sb_2Te_3 and Bi_2Te_3.
II. Lead telluride and its alloys
III. SiGe
IV. Materials based on nanotechnology

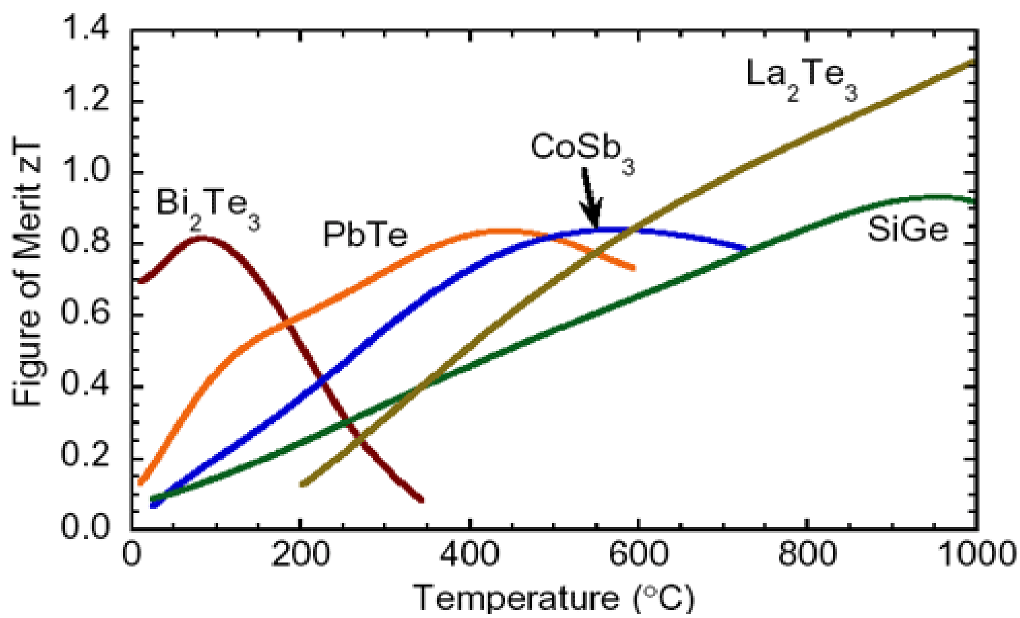
A plot of various p-type semiconductor figures of merit time's temperature vs. temperature is shown. Within the temperature ranges concerned in electronics cooling (0-200°C) Bi_2Te_3 performs the best



.

Fig3.2: ZT for p-type thermoelectric materials

Similar results are shown for n-type semiconductors



***zT* for n-type thermoelectric materials**

Fig3.3: Z*t* for n-type thermoelectric matetial

Metals are used to sandwich the semiconductor. Because the TE performance is also dependent on these materials, an optimal material must be chosen, usually copper.

3.1.3COMPONENTS DESCRIPTION OF MEF-REFRIGERATOR

The Thermoelectric Module: The thermoelectric module consists of pairs of P-type and N-type semi-conductor thermo element forming thermocouple which are connected electrically in series and thermally in parallel. The modules are considered to be highly reliable components due to their solid state construction. For most application they will provide long, trouble free service. In cooling application, an electrical current is supplied to the module, heat is pumped from one side to the other, and the result is that one side of the module becomes cold and the other side hot.

The thermoelectric cooler module material chosen is Bismuth telluride.The properties of a 127 couple, 6 A Bismuth Telluride module.

Thermoelectric module is a Direct Current (D.C) device. Specified thermoelectric module performance is valid if a Direct Current (D.C) power supply is used. Actual D.C power supply hasa rippled output. This D. C. component is detrimental [7]. Degradation of thermoelectric module performance due to the ripple can be approximated by

$$\frac{\Delta T'_{MAX}}{\Delta T_{MAX}} = \frac{1}{1+\frac{N^2}{2}}$$

Figure3.4: Peltier module

Heat Sink: The heat sink usually made of aluminum, is in contact with the hot side of a thermoelectric module. When the positive and negative module leads are connected to the respective positive and negative terminals of a Direct Current (D.C) power source, heat will be rejected by the modules hot side, the heat sink expedites the removal of heat. Heat sink typically is intermediates stages in the heat removal process whereby heat flows into a heat sink and then is transferred to an external medium. Common heat sinks include free convection, forced convection and fluid cooled, depending on the size of the refrigerator.

Cold Side: The cold side also made of aluminum is in contact with the cold side of a thermoelectric module, when the positive and negative module leads are connected to the respective positive and negative terminals of a direct current (D.C) power source, heat will be absorbed by the modules cold side. The hot side of a thermoelectric module is normally placed in contact with the object being cold.

Spacer Block: The spacer block though optional in water chillers is used to ensure sufficient air gap between the heat sink and the object being cooled.

FAN:A Fan is a device which is used to carry the heat from one side to another. It cools the particular area by taking away the hot air away from that particular area. In thermo electric refrigeration process the fan is used on both sides i.e. cold and hot side. The hot side fan takes away the heat from the hot side and discharges it to the surroundings by the assistance of cold side fan. In thermoelectric refrigeration fins are also attached to the fans for more efficient cooling. Basically the fans used are similar to use in CPU of computer. The power consumption of each fan is 2.5 watt.

Fig3.5: Cooling Fan

FIN: Fins are surfaces that extend from an object to increase the rate of heat transfer to surroundings by increasing convection. Adding a fin to an object increase the surface area and is an economical solution to heat transfer problems. The shape of the fins must be optimized such that the heat transfer density is maximized when the space and the material s used for the finned surface are constraints. The rate of cooling depends on the surface area of fin exposed to surroundings. In the thermoelectric refrigerator the fins are used on cold side as well as hot side. Fins are used with the cooling fan so that more heat will be drawn from the cold side to the hot side. The fin on the hot side is used to increase the surface area of the fan so that overheating can be reduced and the device will work efficiently.

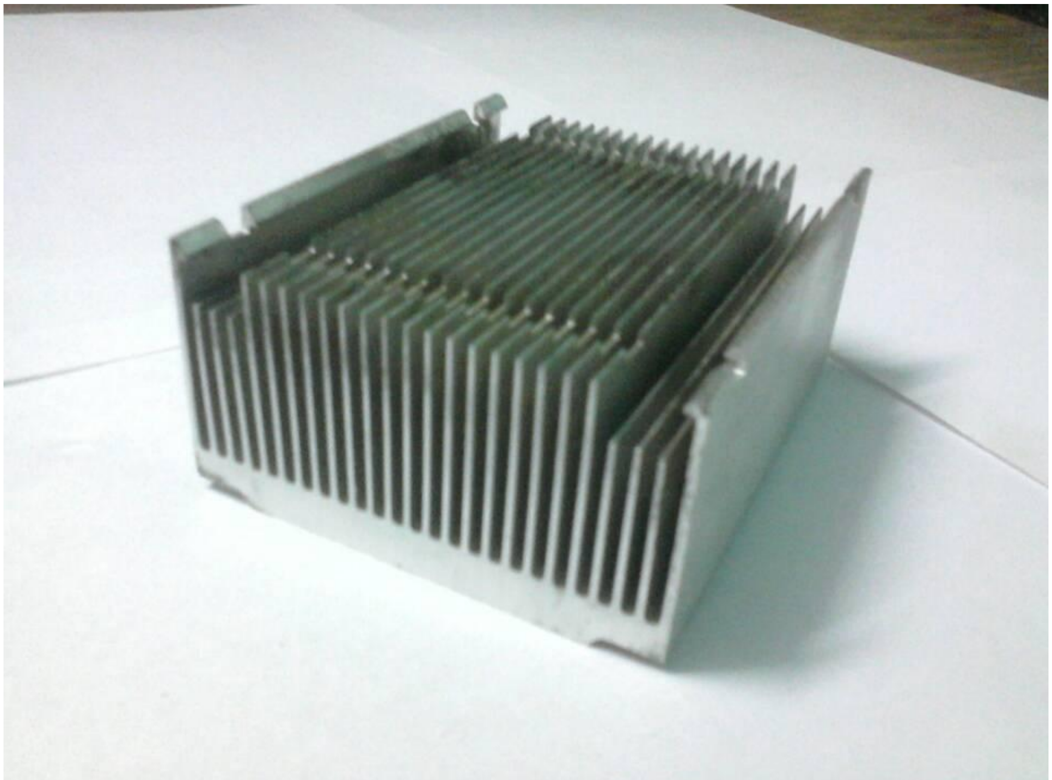


Fig3.6: Cooling Fin

CIRCUIT CONTROLLER: Controller is a device which works as a power supply. It converts A.C. to D.C. which helps to decrease the temp of the chamber by controlling the palter device and cooling fans.

Fig3.7: Circuit controller

REFRIGERATION BOX: It is just like a normal box which helps to make a cooling chamber. Basically the refrigeration box is made of thermion which is insulated from inside with the aluminum and from outside with the wooden ply. It also makes to hold to screw on it. It is useful for us because it is more cheaply than other refrigeration box. The dimensions of the refrigeration box that we have used are 285*225*300mm.

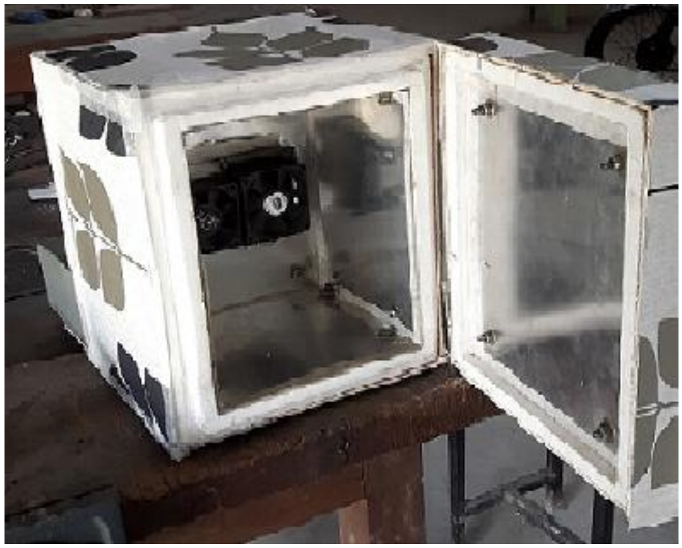


Fig 3.8: Refrigeration box

Temperature Sensor: The temperature sensor is a device which is used to sense the temperature of the refrigeration box and give us the accurate data about the rate of cooling of the box. It is an important device which is gives us the information about the cooling rate of the box and it also helps us to calculate the efficiency of the device i.e. thermoelectric refrigerator.

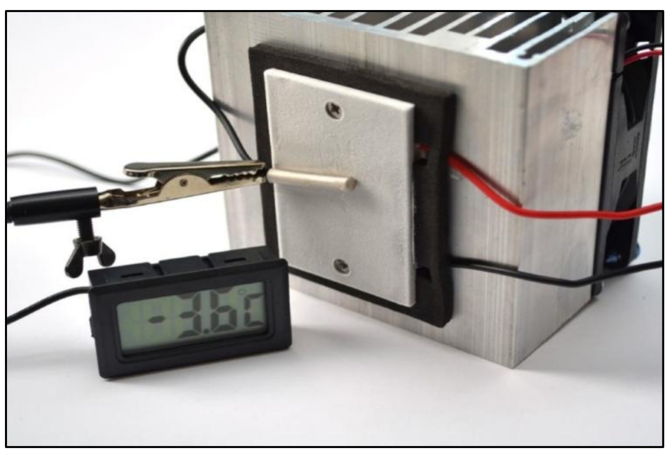


Fig3.9: Temperature sensor

Exterior Casing:

The design of the exterior casing was changed to accommodate for the change in fan type as well as avoid some of the difficulty associated with creating the complex shape of the original casing design. The new casing includes separate fan heat-sink shrouds which are also used to mount the exterior fans in place over the exterior heat-sinks.

Lid:

Originally the lid was designed with hinges. It was later determined that the hinges were not necessary and so a free lid is now used.

Input:

In order for the user to set the temperature of the device three buttons are now used. While using these buttons is not quite as intuitive as the knob that was initially in the planning, they were much easier incorporate into the micro-controller programming.

Additional features and improvements:

In this section there are some additional features and improvements that could be added to the device. Some of these are beyond the scope of the original project, however they could be used as ideas for a continuation of the project.

3.2BASIC LAYOUT:

In basic layout we are discussing about the layout and construction of the MEF. The layout of the MEF consists of a simple Thermacol box which is used as a Cooling chamber. The inner part of box is covered with the aluminum sheet of thickness 1mm and thermal conductivity. The outer side of box is insulated with wooden sheet of thickness 4mm and thermal conductivity.

The block diagram of the MEF is given below

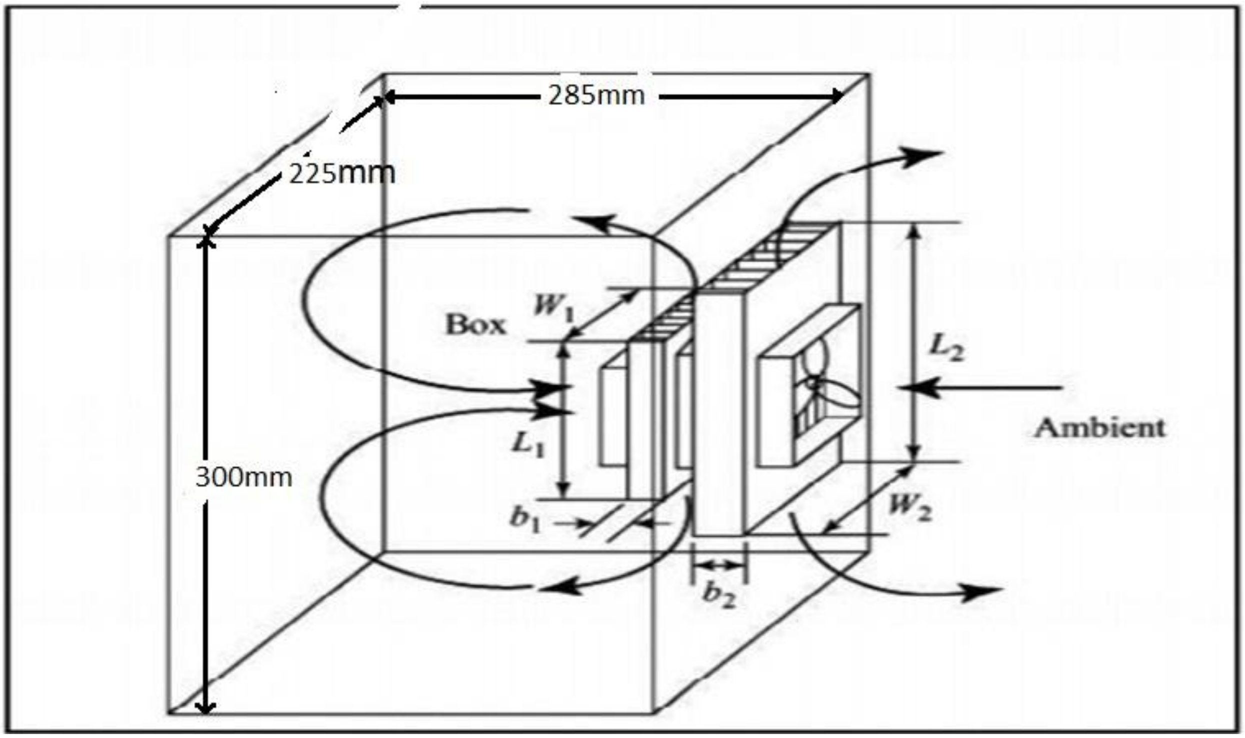


Fig3.10: Block Diagram

The dimensions of the MEF Refrigerator have been described in the above figure. The dimensions are 285*225*300 mm. On the back of the refrigerator is the fin fan assembly which is the basis of cooling in thermoelectric refrigerator. There are two fin fan assembly one at the hot side and other at the cold side as shown in figure. Between the both fin-fan assembly there is a peltier device which is the cooling device of our thermoelectric refrigerator.

The peltier device is connected to the circuit controller which acts as dc power supplier. As a result of peltier effect one side of the peltier device becomes cool and others becomes cool. This is deeply described in circuit diagram shown below.

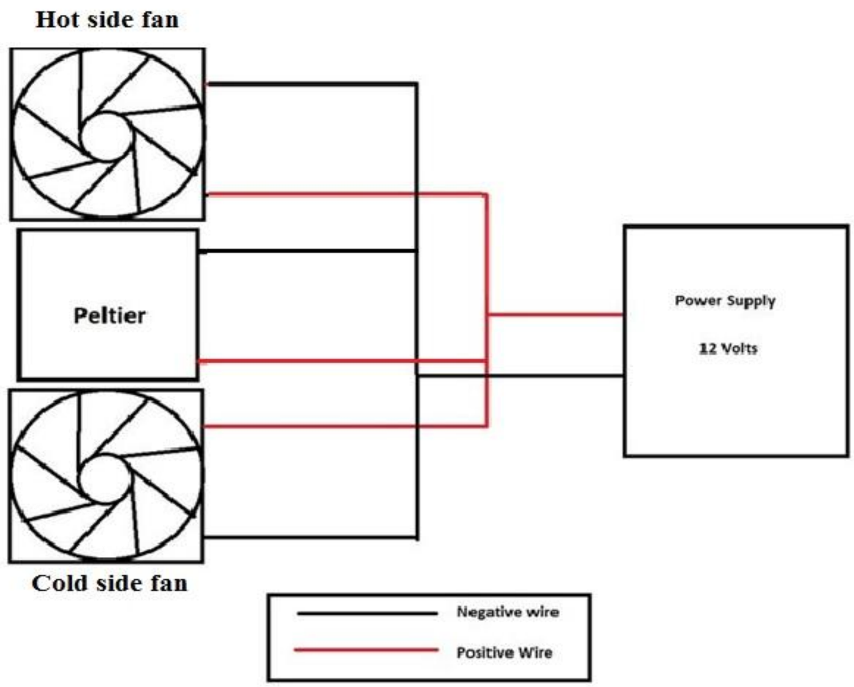


Fig3.11: Circuit Diagram

In circuit diagram we can see that the peltier is placed between the hot side fan and the cold side fan. Both the peltier device and the fans are connected to the 12V power supply. Here the power supply is direct current (D.C.) because the peltier device is a semiconductor device. The red wire is positive and the black is negative. As the peltier gets the power supply its one end gets hot and the other gets cold which is the basis of the working of our thermoelectric refrigerator.

3.3WORKING PRINCIPLE

In MEF-Refrigerator the peltier device is used which works on peltier effect

PELTIER EFFECT: The Peltier effect occurs whenever electrical current flows through two dissimilar conductors, depending on the direction of current flow, the junction of the two conductors will either absorb or release heat.

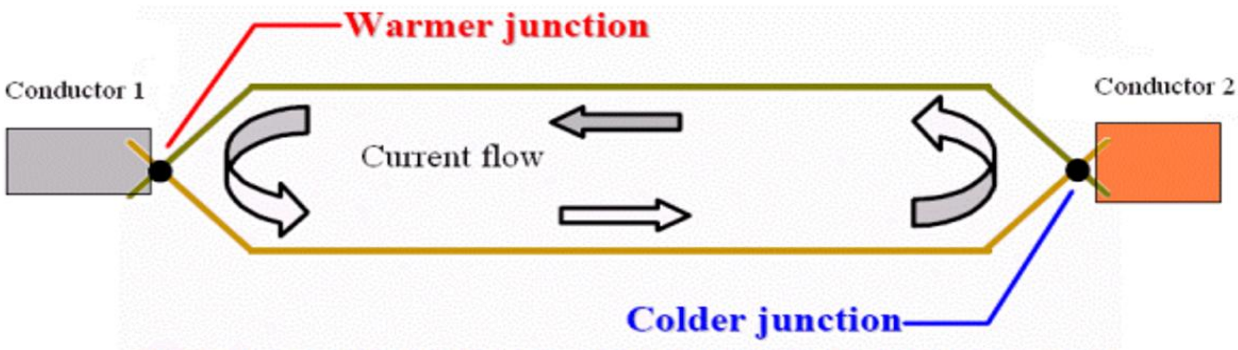


Fig 3.12: peltier effect

The Seebeck Effect- is the reverse of the Peltier Effect. By applying heat to two different conductors a current can be generated. The Seebeck Coefficient is given by:

$$\alpha = \frac{\varepsilon_x}{dT / dx}$$

Where is the electric field?

A typical thermoelectric cooling component is shown. Bismuth telluride (a semiconductor), is sandwiched between two conductors, usually copper. A semiconductor (called a pellet) is used because they can be optimized for pumping heat and because the type of charge carriers within them can be chosen. The semiconductor in this examples N type (doped with electrons) therefore, the electrons move towards the positive end of the battery

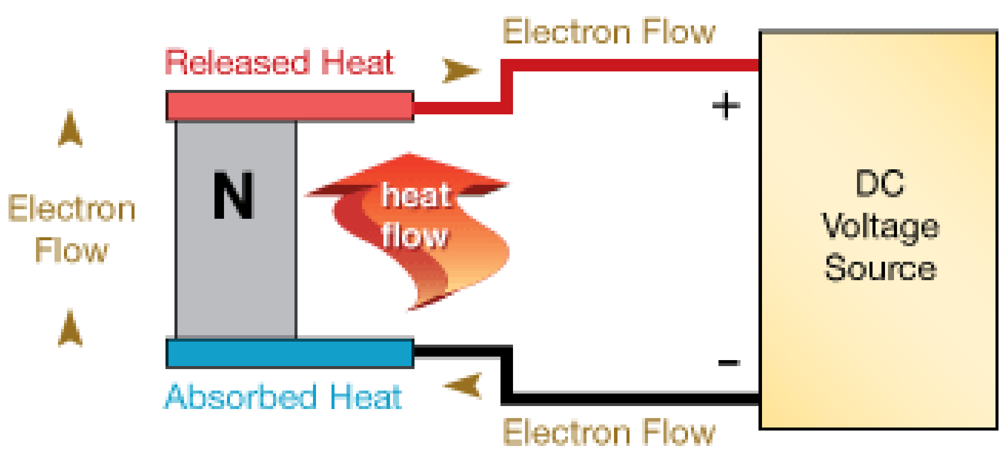


Fig 3.13: Heat Transfer In "N" type

The semiconductor is soldered to two conductive materials, like copper. When the voltage is applied heat is transported in the direction of current flow.

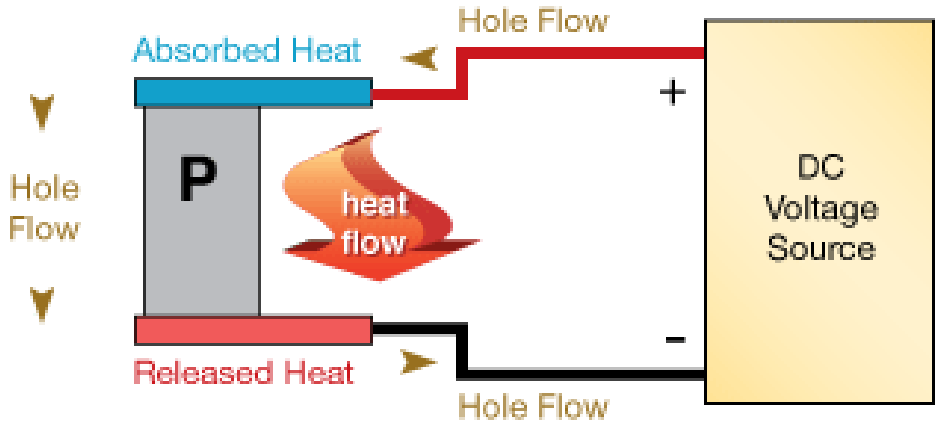


Fig. 3.14: Heat Transfer in "p" Type

When a P type semiconductor (doped with holes) is used instead, the holes move in a direction opposite the current flow. The heat is also transported in a direction opposite the current flow and in the direction of the holes. Essentially, the charge carriers dictate the direction of heat flow

Method of Heat Transport:

Electrons can travel freely in the copper conductors but not so freely in the semiconductor. As the electrons leave the copper and enter the hot-side of the p-type, they must fill a "hole" in order to move through the p-type. When the electrons fill a hole, they drop down to a lower energy level and release heat in the process. Then, as the electrons move from the p-type into the copper conductor on the cold side, the electrons are bumped back to a higher energy level and absorb heat in the process.

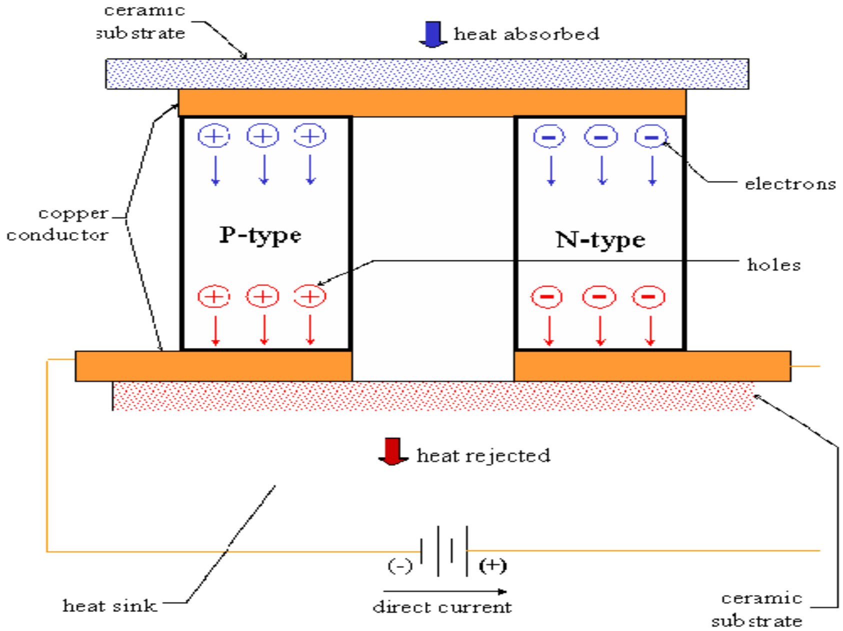


Fig.3.15: Heat Transfer Through Peltier

Next, the electrons move freely through the copper until they reach the cold side of the n-type semiconductor. When the electrons move into the n-type, they must bump up an energy level in order to move through the semiconductor. Heat is absorbed when this occurs. Finally, when the electrons leave the hot-side of the n-type, they can move freely in the copper. They drop down to a lower energy level and release heat in the process.

The TE components can be put in series but the heat transport abilities are diminished because the interconnecting's between the semiconductors creates thermal shorting.

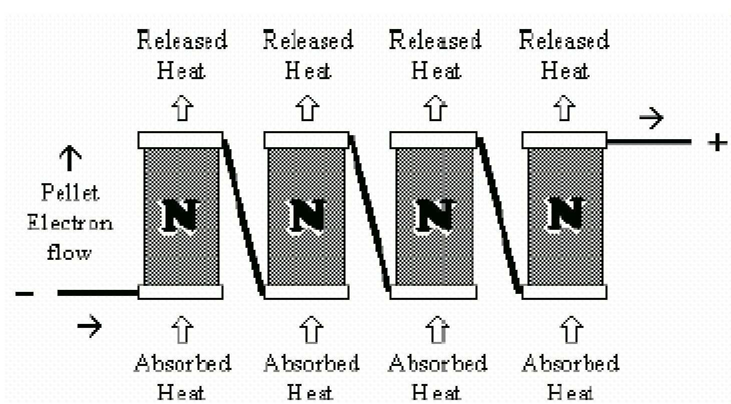


Fig3.16: Heat transfer in N type Combination

The most efficient configuration is where a p and n TE component is put electrically in series but ther3.13mally in parallel. The device to the right is called a couple. One side is attached to a heat source and the other a heat sink that connects the heat away. The side facing the heat source is considered the cold side and the side facing the heat sink the hot side.

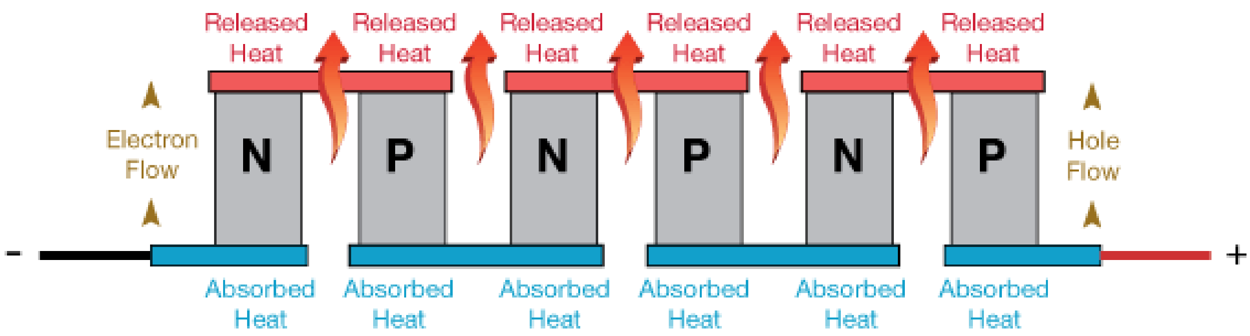


Fig3.17: Heat transfer in N-P Combination

Between the heats generating device and the conductor must be an electrical insulator to prevent an electrical short circuit between the module and the heat source. The electrical insulator must also have a high thermal conductivity so that the temperature gradient between the source and the conductor is small. Ceramics like alumina are generally used for this purp.

3.4 CALCULATIONS

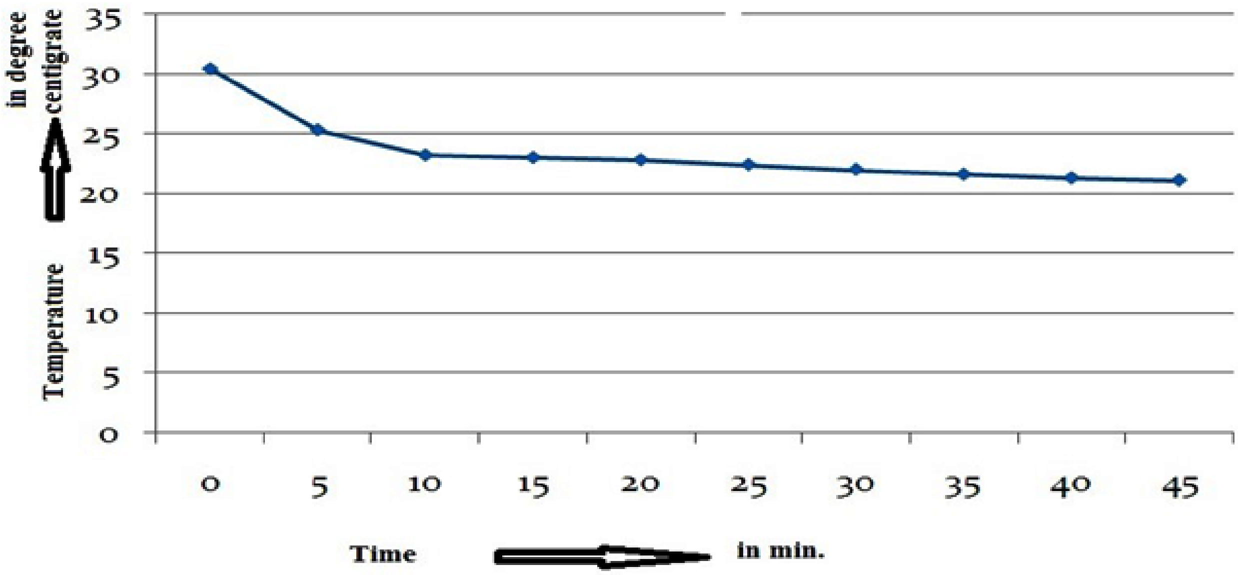
3.4.1 TEMP V/S TIME TABLE

The table of time v/s temp is given below. As shown in the table the initial temperature of the refrigeration box is 30.4 degree Celsius. We have observed the cooling rate for about 45 minutes and after 45 minutes we have observed that the temperature of the refrigeration box has declined from 30.4 degree Celsius to 21.1 degree Celsius. Thus the temperature has fall 9.3 degree Celsius in 45 minutes.

3.4.1 TEMP V/S TIME GRAPH

Now we are plotting the temp v/s time graph of the above table which is given below.

TIME	TEMPERATURE(°C)
Starting	30.4
5 min	25.3
10 min	23.2
15 min	23
20 min	22.8
25 min	22.4
30 min	22
35 min	21.6
40 min	21.3
45 min	21.1



3.5 ASSEMBLY

In this section we will discuss about the various design procedures that we have followed in the fabrication of the thermoelectric refrigerator.

Step 1: MAKING OF REFRIGERATION BOX

The first step is to make the refrigeration box. Firstly we have taken the thermacol box for the purpose of refrigeration. After that the insulation is done on the both side. On the outer side the insulation is done with the wooden ply of thickness 4mm and on the outer side the insulation is done with the aluminum sheet of thickness 1mm. The insulation is done to ensure that the ox wil remain cool properly and there is no loss of heat to the surroundings.

Step 2: CUTTING PROCESS

After the box has been made the back side of the box is cut in the proper dimensions to fit the fin-fan assembly in it.

Step 3: DRILLING:

Drilling is done on both the fins i.e. hot and cold side fins. The drilling is done to hold the both fins together tightly. The drilling is done by holding the both fins in a clamp tightly and after that the drilling is done on the drilling machine very precisely.

Step 4: MOUNTING OF THERMOELECTRIC MODULE

Mounting of module has to be done with utter most care. The surface of the fin, to be attached to the Peltier Module is wiped free off dirt and grease using alcohol or similar and thin film of thermally conductive silicon grease on the suitable surfaces. The thermoelectric module is then attached to the fin with the help of glue.

Step 5: TIGHTENING OF SCREWS

After the thermoelectric module is sandwiched between the fins both fins are tightened together with the help of screws in the holes which are drilled previously. The screws are tightened precisely and the excess part of the screw is cut.

Step 6: MOUNTING OF FIN-FAN ASSEMBLY

After the fins are tightened together the fans are attached to them and the whole assembly is mounted on the back side of the refrigeration box. The assembly is mounted in such a way that the cold side fin is inside the box and hot side fin is outside the box. The peltier module is between the both fins.

Step 7: SELECTION OF POWER SUPPLY

Now the circuit controller is mounted on the backside of box. The circuit controller is used as a power supply source. Both the fans and the peltier module is attached to the circuit controller with the help of wires. The black wire is positive and red is negative. Here we have used the 12V dc power supply.

Fig3.18: Power supply system

CHAPTER 4: COST ESTIMATION

4.1 COST ESTIMATION

To ensure sustained and healthy growth of refrigerator production Sector, it is necessary to rationally evaluate the cost of production of refrigerator and to determine a selling rate which should be acceptable to consumers and attractive for investors.

EXPENDITURE TABLE

S.NO	COMPONENT NAME	QUANTITY	MATERIAL	PRICE
1	PELTIER DEVICE	2	Pb-Bi	2000
2	HOT SIDE FAN	2	plastic	500
3	COLD SIDE FAN	2	plastic	500
4	HOT SIDE FIN	2	Al	200
5	COLD SIDE FIN	2	Al	200
6	REFRIGERATION BOX	1	wood	1500
7	CIRCUIT CONTROLLER	1		1000
8	OTHER EXPENDITURE			500
9	**TOTAL COST**			6400

LABOUR COST: DRILLING, GRINDING, HACKSAW,SCREW TIGHTNING,SHEET CUTTING,FINISHING :

Cost = Rs. 1600

OVERHEAD CHARGES: The overhead charges are arrived by "Manufacturing cost"

Manufacturing Cost = (Material Cost + Labour cost)

= Rs. (6400 + 1600)

= Rs. 8000

Overhead Charges = 10% of the manufacturing cost

= Rs. 800

TOTAL COST:

Total cost = (Material Cost + Labour cost + Overhead Charges)

= Rs. (6400 + 1600 + 800)

Total cost for this project = **Rs. 8800**

CHAPTER 5: CONCLUSION

We have been successful in designing a system that fulfils the proposed goals. However we do realize the limitations of this system. The present design can be used only for maintaining a particular temperature. The system is unable to handle fluctuations in load. Extensive modifications need to be incorporated before it can be released for efficient field use. Thermoelectric refrigeration is one of the key areas where researchers have a keen interest. Some of the recent advancements in the area surpass some of the inherent demerits like adverse COP. Cascaded module architecture has defined new limits for its application. Moreover recent breakthrough in organic molecules as a thermoelectric material promises a bright future for TER. With more and more countries showing interest in Montreal and Kyoto protocol, TER is gaining more attention as an affordable, reliable and a green refrigeration alternative.

There are several different types of cooling devices available to remove the heat from industrial enclosures, but as the technology advances,thermoelectric cooling is emerging as a truly viable method that can be advantageous in the handling of certain small-to-medium applications. As the efficiency and effectiveness of thermoelectric cooling steadily increases, the benefits that it provides including self-contained, solid-state construction that eliminates the need for refrigerants or connections to chilled water supplies, superior flexibility and reduced maintenance costs through higher reliability will increase as well.

After conducting tests on designed cold storage plant of cascade refrigeration system with and without phase change material(PCM), following conclusions are drawn. From the experimentation it is observed that in Cascade (Binary) refrigeration system the refrigeration effect can be increased by 27.7% as compared to single system for producing -200C in the cold storage. By using cascade system the actual work can be reduced by 33.3% as compared single system for producing -200C in the cold storage. Experimental results show that the coefficient of performance (COP) of cascade refrigeration system is higher than single refrigeration system. Experimental results shows that for fall of temperature from -200C to 00C without phase change material, takes 5.5 hours time whereas the same by using phase change material it takes 14.5 hours time.

FUTURE DEVELOPMENTS:

The two main issues in thermoelectric refrigeration are the development of new materials with stronger Peltier effects and the application of these materials to real engineering problems such as refrigeration and control of process heat. The former issue is primarily the domain of physicists and materials scientists who test a large number of materials looking for crystalline structures which combine high electrical conductivity with low thermal conductivity as well as a strong thermoelectric characteristic. The latter issue is of greatestconcern to mechanical engineering where problems such as heat transfer between the module and cheap manufacture of modules are of concern. For refrigeration, unlike airconditioning,the power consumption is relatively small, typically 50 Watts which means that the number of modules and their cost is also small. This means that the main issue for refrigeration is heat transfer between the module and its external environment. The level of interest in these engineering problems is intensifying as the efforts of physicists and materials scientists produce thermoelectric materials with usefully high levels of performance.

There has been steady progress in raising the performance of the materials and construction of thermoelectric modules since the first application of bismuth telluride in the 1950's. A purified form of bismuth telluride now enables the manufacture of thermoelectric modules with a Coefficient of Performance approximately equal to unity for temperature differences of 29 degrees Kelvin. The standard test temperature difference for a refrigerator cabinet is 29 degrees Kelvin where the cabinet interior is set at 3 degrees Celsius and the exterior at 32 degrees Celsius. The thermoelectric module would operate at a higher temperature difference than this because of conduction and convection losses in the thermoelectric refrigerating system. A high efficiency of the Peltier module is obtained when these secondary temperature losses are reduced to very small values compared to the temperature difference across the Peltier module.

Enhancement of the heat transfer between the hot and cold faces of a Peltier module and the working fluid is still however a major topic of research since the relative power consumption of a Peltier when used in a refrigeration system remains high. The key factor to improve energy efficiency is efficient heat transfer. A major problem is the small size of the Peltier modules compared to their heat output which means that a generous heat transfer coefficient is needed to prevent a large temperature difference between the module and the working fluid. It is fortunate that water is an effective heat transfer since the choice of fluids is greatly limited by considerations of nontoxicity and non-corrosiveness for a domestic refrigerator. The sensitivity of Peltier module efficiency to temperature difference between hot and cold face means that even a saving of 1 degree in temperature losses can generate a significant increase in the overall Coefficient of Performance. A fundamental problem is that the same pumps and fans which generate vigorous convective heat transfer and thereby raise the coefficient of performance of the Peltier module, also consume power to lower the overall system efficiency. The efficiency of the pumps and manifolds should be as high as possible with a balanced distribution of electrical power to the various subsystems within the refrigerator.

REFERENCE

1. Jonathan Michael Schoenfeld, Master of Science,2008 “Computational Model for Refrigerators Based on Peltier Effect Application”, Applied Thermal Engineering, Vol. 25, No. 13, pp. 3149-3162.

2. Bass et al. (2004), “Multi-layer quantum well (MLQW) thermo electrics in a cooling application” International journal of research in aeronautical and mechanical engineering ISSN (online): 2321-3051

3. Chain and Chen Vol. 120 (2011) “Performance Prediction and Irreversibility Analysis of a Thermoelectric Refrigerator with Finned Heat Exchanger” Wuhan 430033, P.R. China, ACTA PHYSICA POLONICA No.03

4. Riff at and Qiu (2005) “Air conditioning systems with an air and water cooled heat sink” International Journal of Emerging Technology and Advanced Engineering Volume 3, Special Issue 3: ICERTSD 2013, Feb 2013, ISSN 2250-245

5. Zhang H Y (2010), “A General Approach in Evaluating and Optimizing Thermoelectric Coolers”, Int. Journal of Refrigeration, Vol. 33, No. 10, pp. 1187-1196.

6. Gaurav Maradwar, ” Fabrication And Analysis Of Problems In Thermoelectric Refrigerator” International Journal Of Core Engineering & Management(IJCEM) Volume 1, Issue 2, May 2014, ISSN:2348 9510

7. Onoroh Francis, Chukuneke Jeremiah Lekwuwa, “Performance Evaluation of a Thermoelectric Refrigerator” International Journal of Engineering and Innovative Technology (IJEIT) Volume 2, Issue 7, January 2013, ISSN: 2277-3754

8. By C.P.Arora,” Refrigeration & Air Conditioning” 2nd Edition, TMH Publication, ISBN 0-07-463010-5

9. http://www.ijmerr.com/currentissue.php397.

10. http://www.wikipedia.org.

11. http://www.electronicsforyou.com.