Design & Construction of an Air Cooler Using Peltier Module

A Thesis
By

Md.Ruhul Amin Sharder	ID:ME2101023202
Md.Mamun	ID:ME2102024598
Indrojit Paul	ID:ME2102024503
Avijit Paul	ID:ME2102024500
Shafikul Islam	ID:ME2102024205

Submitted to the

DEPARTMENT OF MECHANICAL ENGNEERING (ME)
SONARGAON UNIVERSITY (SU)

In fulfillment of the requirement for the award of the
degree of the Bachelor of Science in Mechanical Engineering

JANUARY 2025

Letter of Transmittal

To

The supervisor

Toriqul Islam

Lecturer,

Department of Mechanical Sonargaon University

Sonargaon University of Bangladesh

Subject: Submission of Project report.

Dear Sir,

We are pleased to submit the project report on “Peltier Module Air Cooler”. It was a great pleasure to work on such an important topic. This project has been done as per instruction of your supervision and according to the requirements of the Sonargaon University.

We expect that the project will be accepted by the concerned authority we will remain happy to further explanation that you may feel necessary in this regard.

Sincerely yours,

Md. Ruhul Amin Sharder	ID: ME2101023202
Indrojit Paul	ID: ME2102024503
MD. Mamun	ID: ME2102024598
Shafikul Islam	ID: ME2102024205
Avijit Paul	ID: ME2102024500

DECLARATION

We do hereby solemnly declare that, the work presented here in this project report has been carried out by us and has not been previously submitted to any University /Organization for award of any degree or certificate We hereby ensure that the works that has been prevented here does not breach any existing copyright. We further undertake to indemnify the university against any loss or damage arising from breach of the foregoing obligation.

Signature

1.Md. Mamun
ID: ME2102024598 ----------

2.Md. Ruhul Amin Sharder
ID: ME2101023202 ----------

3.Indrojit Paul
ID: ME2102024503 ----------

4.Avijit Paul
ID :ME2102024500 ----------

5.Shafikul Islam
ID: ME2102024205 ----------

Approval Sheet

This thesis titled “Design & Construction of an Air Cooler Using Peltier Module” submitted by this group of students of Mechanical Engineering Department of Sonargaon University has been examined, accepted & approved.

Approved By:

Mr. Toriqul Islam
Lecturer
Department of Mechanical Engineering
Sonargaon University Bangladesh.

Acknowledgement

We would like to express our greatest gratitude to the people who helped and supported us throughout this work. First and foremost, we would like to thank our honorable supervisor, Md. Tariqul Islam Lecturer, Department of ME, for giving us enormous support, advices and valued guidance concerning this thesis.

We are grateful to Professor Md. Mustofa Hossain, honorable acting Chairman, Department of ME, Faculty of Engineering, Sonargaon University for his comments, encouragement and support.

Next, we would like to thank our family and friends for their valuable support to complete this thesis.

Finally, we would like to express our heartiest gratefulness to Almighty Allah for His heavenly blessings. Without his blessings it would not possible to complete our work successfully.

Thank you

All Authors

Abstract

This project focuses on the design and construction of an air cooler using a Peltier module, a thermoelectric device that utilizes the Peltier effect to transfer heat and create a cooling effect. The objective is to develop a compact, energy-efficient, and environmentally friendly cooling solution suitable for small spaces or electronics. The system works by using a Peltier module to absorb heat from the cold side and expel it from the hot side, with the help of heat sinks and fans for optimal heat dissipation. The cooler can be used for personal comfort or electronic cooling, offering an alternative to traditional refrigerant-based cooling systems. The project explores the practical applications of Peltier modules, including their potential for enhancing thermal management in electronic devices and small-room cooling. Key design considerations include efficient heat management, proper insulation, and airflow optimization. The result is a functional prototype that demonstrates the feasibility of using thermoelectric cooling for small-scale cooling applications.

Table of Contents

Acknowledgement…….....…….……5

Abstract …….....…….……6

Table of Contents…….…….....……7

List of Tables …….…….…….....8

List of Figures...…….....……9

Chapter 01: Introduction

1.1 Objective …….....……10

1.2 Background …….....……11

1.3 Scope of the project …….....……12

1.4 Advantages…….....……...12

1.5 Importance …….....……13

Chapter 02: Literature Review …….….....….14-15

Chapter 03: Design& Construction…….….....…….…...16-17

Chapter 04: Experimental Element…….....…….……18-22

Chapter 05: Methodology…….....…… 23-24

Chapter 06: Result …….….....…….24-29

6.1 COP Calculation …….....…….……...25

6.2 Experimental Graph ……..…….....…..……..27-29

Chapter 07: Cost Analysis …….…….....……..30

Chapter08: Conclusion…….…….....….31

Chapter 09: Reference …….….....……32-33

List of Tables

Table 1.1 Experiment data of Hot side..... 26
Table 1.2 Experiment data of Cold side..... 26

List of Figures

Fig 3.1 Project Model..... 15
Fig 3.2 Project View..... 16
Fig 4.1 Peltier Module.....17
Fig 4.2 Water Block.....17
Fig 4.3 Heat Sink.....18
Fig 4.4 Temperature Controller.....18
Fig 4.5 Thermocouple.....19
Fig 4.6 Relay.....19
Fig 4.7 Water pump.....20
Fig 4.8 Cooling Fan.....20
Fig 4.9 Power Supply.....21
Fig 4.10 Copper Tube……...21
Fig 5.1 Project Diagram.....22
Fig 6.1 Hot side power for different water inlet temperature.....26
Fig 6.2 Cold side power for different water inlet temperature.....26
Fig 6.3 Experimental Result.....27

Chapter 1

Introduction

1.1 Objective

I. To design & construct an air cooler using Peltier modules.

II. To design & construct an air cooler for sophisticated application.

III. To design & construct an environment friendly air cooler.

IV. To design & construct air cooler without using CFC gas.

V. To design & construct cost effective air cooler without using CFC gas.

1.2 Background

The need for efficient and environmentally friendly cooling solutions has become increasingly important in various industries, from personal cooling devices to thermal management in electronics. Traditional refrigeration systems, which rely on compressors and refrigerants, are energy-intensive, bulky, and have significant environmental impacts due to the use of harmful gases. As a result, there has been growing interest in alternative, more sustainable cooling technologies. One such technology is thermoelectric cooling, which leverages the Peltier effect to transfer heat. The Peltier effect occurs when an electrical current passes through two different conductors or semiconductors, causing one side to absorb heat and the other to release heat. This solid-state cooling method is environmentally friendly, as it doesn't require refrigerants or moving parts, making it quieter and more compact than traditional air conditioning systems. Peltier modules, also known as thermoelectric coolers (TECs), are widely used in various applications, including cooling small electronic devices, portable refrigerators, and cooling systems for scientific instruments. However, despite their advantages, Peltier modules typically offer limited cooling capacity and efficiency compared to traditional cooling technologies. The challenge, therefore, lies in maximizing their effectiveness by improving heat dissipation, optimizing thermal management, and enhancing system design. The concept of using a Peltier module for an air cooler aims to explore the practical application of thermoelectric cooling for personal or small-scale use. This project investigates how to design an efficient, cost-effective, and environmentally friendly air-cooling system using a Peltier module. By integrating fans, heat sinks, and insulation, the goal is to improve the overall performance of the system and demonstrate the potential for thermoelectric coolers in everyday applications. This approach offers a new direction in cooling technology, addressing the need for smaller more sustainable alternatives to traditional refrigeration systems. As energy efficiency and environmental concerns continue to drive innovation, the use of Peltier-based coolers could, become an essential part of future cooling solutions.

1.3 Scope of the Project

The scope of the Peltier-based air cooler project spans a variety of practical applications. It includes personal cooling solutions such as portable coolers or wearable devices, electronics cooling for components like CPUs and small appliances, and eco-friendly and energy- efficient systems that operate without refrigerants. The technology is also applicable in medical and pharmaceutical fields for temperature-sensitive storage, as well as remote refrigeration in off-grid locations. Additionally, it offers opportunities in consumer products, educational projects, and research applications for temperature control and thermoelectric studies. While currently ideal for small-scale applications, the technology can be scaled for larger needs and integrated with renewable energy solutions. Overall, the Peltier cooler holds significant potential for various industries looking for sustainable and efficient cooling solutions.

1.4 Advantages

Peltier-based air coolers offer several key advantages, making them a promising alternative to traditional cooling systems. They are environmentally friendly, as they do not rely on harmful refrigerants and use solid-state thermoelectric technology. These coolers have no moving parts, resulting in quieter operation and reduced maintenance needs. Their compact size and lightweight nature make them ideal for portable applications, such as personal coolers or electronics cooling. Additionally, they can be energy-efficient for small-scale cooling tasks and provide customizable solutions by using multiple modules. Peltier coolers are also versatile, with applications ranging from personal comfort to electronic temperature management, all while being eco-conscious and cost-effective.

1.5 Importance

The Peltier-based air cooler is important because it offers an eco-friendly, energy-efficient, and cost-effective solution for cooling. It eliminates the need for harmful refrigerants, reducing environmental impact, and can be powered by renewable energy. This technology is versatile, with applications in personal cooling, electronics, medical devices, and off-grid refrigeration. It also offers scalability, making it suitable for both small and large-scale cooling needs. Additionally, the project advances thermoelectric technology and provides educational value by promoting hands-on learning in STEM fields. Overall, it provides a sustainable and innovative approach to cooling, with numerous practical applications**.**

Chapter 2

Literature Review

Matthieu Cosnier et al1 presented an experimental and numerical study of a thermoelectric air-cooling and air-heating system. They have reached a cooling power of 50W per module, with a COP between 1.5 and 2, by supplying an electrical intensity of 4A and maintaining the 5°C temperature difference between the hot and cold sides.

Suwit Jugsujinda et al2 conducted a study on analyzing thermoelectric refrigerator performance. The refrigeration system of thermoelectric refrigerator (TER; 25 × 25 × 35 cm3) was fabricated by using a thermoelectric cooler (TEC; 4 × 4 cm2) and applied electrical power of 40 W. The TER was decreased from 30 ºC to 20 ºC for 1 hr and slowly decreasing temperature for 24 hrs. The maximum COP of TEC and TER were 3.0 and 0.65. Wei He et al3 Conducted did Numerical study of Theoretical and experimental investigation of a thermoelectric cooling and heating system driven by solar. In summer, the thermoelectric device works as a Peltier cooler when electrical power supplied by PV/T modules is applied on it. The minimum temperature 17 degree C is achieved, with COP of the thermoelectric device higher than 0.45. Then comparing simulation result and experimental data.

Riff and Guoquan 4Conducted an experimental study of comparative investigation of thermoelectric air conditioners versus vapour compression and absorption air conditioners. Three types of domestic air conditioners are compared and compact air conditioner was fabricated.

Riffat and Qiu5 compared performances of thermoelectric and conventional vapor compression air-conditioners. Results show that the actual COPs of vapor compression and thermoelectric air-conditioners are in the range of 2.6-3.0 and 0.38-0.45, respectively. However, thermoelectric air conditioners have several advantageous features compared to their vapor-compression counterparts.

Astrain, Vian & Domınguez6 conducted an experimental investigation of the COP in the thermoelectric refrigeration by the optimization of heat dissipation. In thermoelectric refrigeration based on the principle of a thermosyphon with phase change is presented. In the experimental optimization phase, a prototype of thermo syphon with a thermal resistance of 0.110 K/W has been developed, dissipating the heat of a Peltier pellet with the size of 40*40*3.9 cm, experimentally proved that the use of thermo syphon with phase change increases the coefficient of performance up to32%. Shen, Xiao et al7 investigated a novel thermoelectric radiant air-conditioning system (TE-RAC). The system overcome these demerits by replacing the existing HVAC system with newly emerging thermoelectric couple or cooler which works on Peltier and see beck effect. Yadav and Mehta11 presented combined experimental and theoretical study of thermoelectric materials and application. The present study develops an optimization design method for thermoelectric refrigerator. This device is fabricated by combining the standard n- and p-channel solid-state thermoelectric cooler with a two-element device inserted into each of the two channels to eliminate the solid-state thermal conductivity Manoj Kumar et al 12 presented an experimental study of novel potential green refrigeration and air-conditioning technology. They are analyzing the cause and effect of an existing air-condition system. Thermoelectric cooling provides a promising alternative R&AC technology due to their distinct advantages. The available literature shows that thermoelectric cooling systems are generally only around 5–15% as efficient compared to 40–60% achieved by the conventional compression cooling system. Huang. B et al13 conducted an experimental study of design method of thermoelectric cooler. They are fabricated the thermoelectric cooler and analyses various considerations. The system simulation shows that there exists a cheapest heat sink for the design of a thermoelectric cooler. It is also shown that the system simulation coincides with experimental data of a thermoelectric cooler.

Chapter 3

Design & Constriction

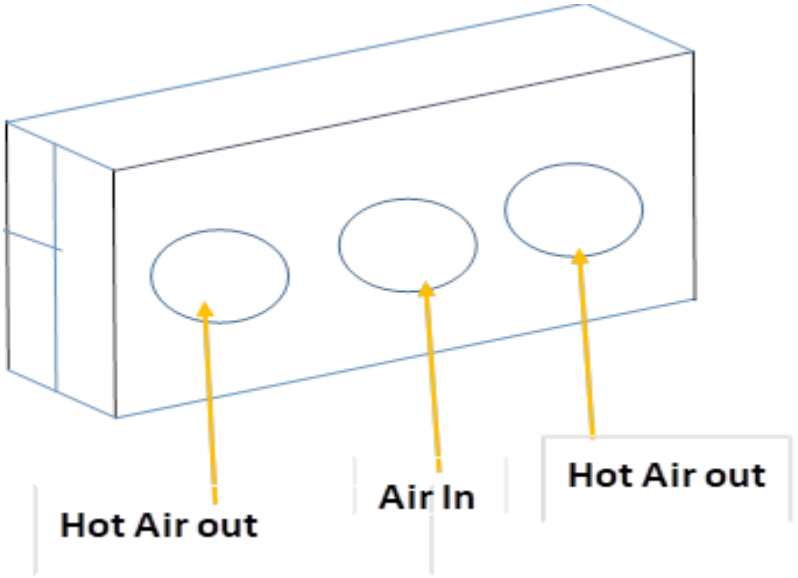


Figure 3.1: Project Model (hot side)

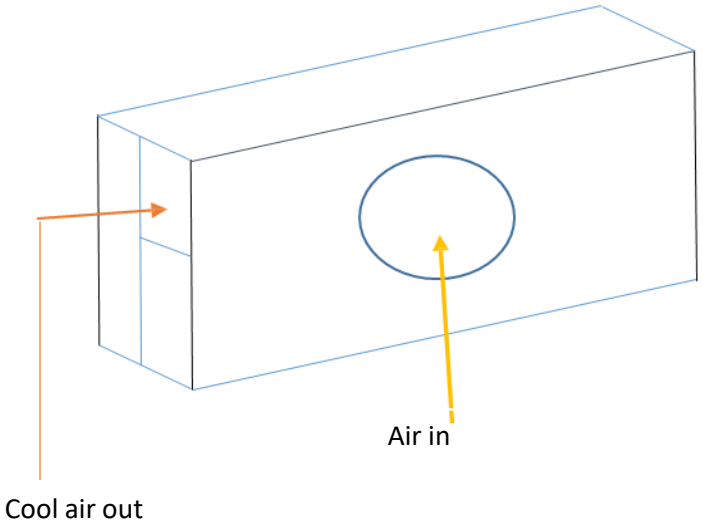


Figure 3.2: Project Model (cool side)



Figure 3.3 Top View



Figure 3.4 Back Side view

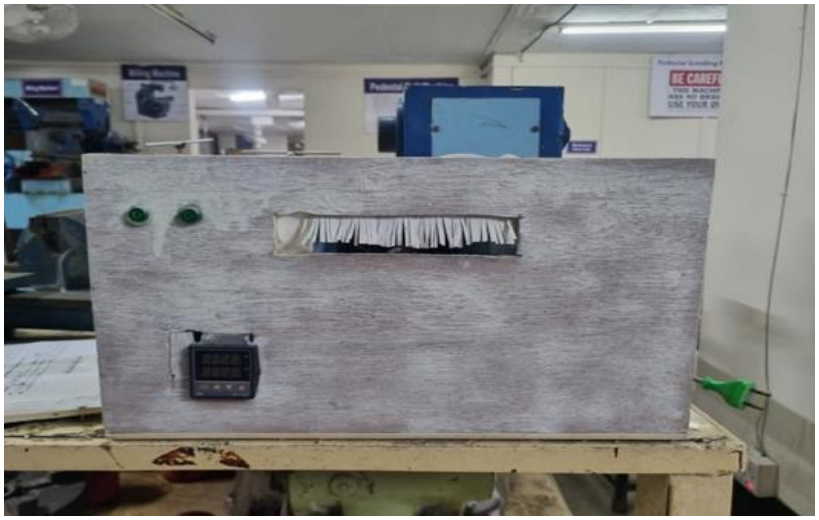


Figure 3.5 Front View

Chapter 4

Experimental Element

Peltier Module:

Peltier module (thermoelectric module) is a thermal control module that has both "warming" and "cooling" effects. By passing an electric current through the module, it is possible to change the surface temperature and keep it at the target temperature.

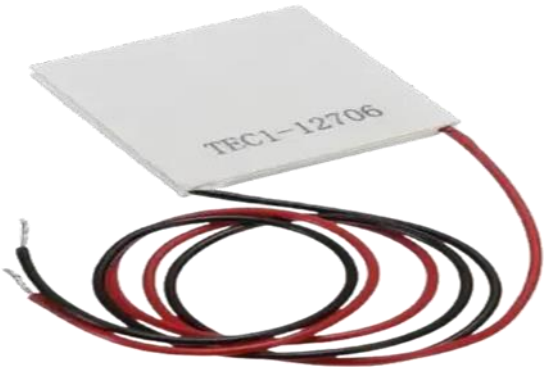


Figure 4.1: Peltier Module

Water Block:

A water block is a component in a liquid cooling system that removes heat from one parts and transfers it to the cooling fluid.



Figure 4.2: Water Block

Heat Sink:

A heat sink is a component that absorbs and disperses heat generated by electronic components to prevent overheating. Heat sinks are typically made of thermally conductive materials like aluminum or copper.



Figure 4.3: Heat Sink

Temperature controller:

Temperature controller is measurement devices used for temperature control. Dividing into thermocouple-type and resistor-type, the electronic temperature controllers obtain the temperature change from the sensor and send the measured data to the electronic process



Figure 4.4: Temperature controller

Thermocouple:

Thermocouple is a sensor that measures temperature. It consists of two different types of metals, joined together at one end. When the junction of the two metals is heated or cooled, a voltage is created that can be correlated back to the temperature.



Figure 4.5: Thermocouple

Relay:

Relay is an electrically operated switch that uses electrical signals to open and close circuits. It's used to control higher power signals with lower power inputs. Relays are commonly used in industrial automation systems, automotive electronics, home appliances, and HVAC systems.



Figure 4.6: Relay

Water Pump:

A water pump is used to transport water from one location to another. To suck water in so that it can be expelled, a pump must be able to rapidly alter pressure within a system. How a water pump achieves this pressure change is what allows certain pumps to be more beneficial to certain applications than others.



Figure 4.7: Water Pump

Cooling Fan:

This is used to maintain a healthy operating temperature of the cooling water. They provide sufficient air flow in the radiator.



Figure 4.8: Cooling Fan

Power Supply:

It provides the essential power for the system. This unit contains a multi taped transformer and rectifier circuit. By Changing the terminals, we can control the voltage and thereby the current through the Peltier module.



Figure 4.9: Power Supply

Copper Tube:

The coil of **copper tubing**, typically used in applications such as plumbing, refrigeration, air conditioning, or heat exchangers. Its high thermal conductivity makes it ideal for efficient heat transfer in cooling systems or for transporting liquids or gases.



Figure 4.10: Copper Tube

Chapter 5

Methodology

The blower forces air sucked from space to be cooled in the compartment Which gets cooled after flowing over fins (forced circulation for higher heat transfer rate). Cooled air comes out from grids attached on face of casing in the room to be cooled. Grids are made manually adjustable to control the direction of flow of air.

In our system, there are two circuits in two different insulated chambers, one circuit cools water directly through contact with Peltier Plate and Second Circuit cools air to be circulated to be conditioned.

The Peltier plates attached on water cooling block where one face absorbs the heat from water with consumption of electricity. This heat transfer is enhanced by the use of a fin. Also, the cold side of Peltier plate does not contact directly water. Cold side is in contact with thin highly conductive fins. On hot side of Peltier plate heat is rejected outside of the space to be cooled and again heat flow rate is enhanced by use of a fan (Induced circulation) and highly conductive finned plate. Water after losing heat is sucked by pump. It forces water to move inside the cooling block. To avoid heat gain during this journey piping and pump is kept thermally insulated.

Water becomes comparatively hot at outlet and goes again in to container for cooling completing the water circuit. The piping communicating outlet of cooling coil and inlet of container is again insulated to stop heat absorption from surrounding. This is done because the water after coming out of cooling coil may still be colder than surroundings and the unwanted increased load on Peltier modules can be avoided.

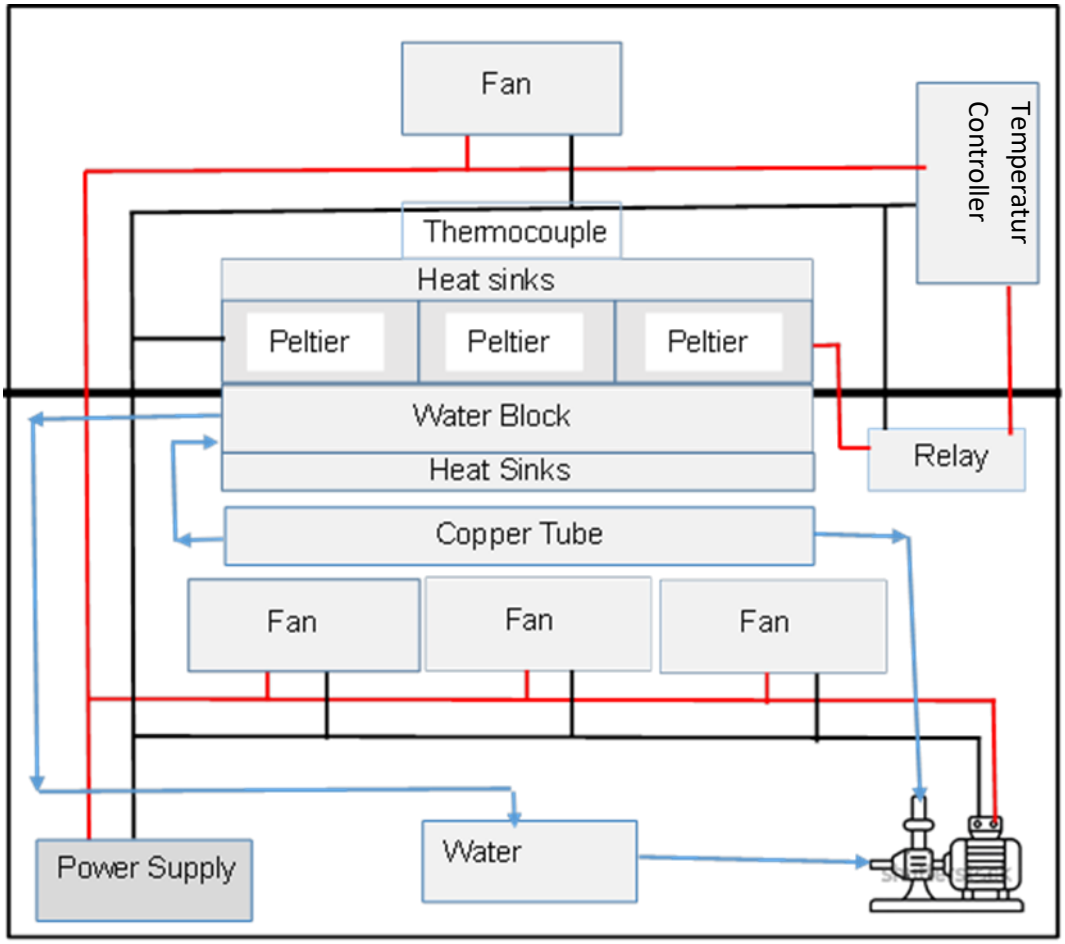


Figure 5.1: Project Diagram

Chapter 6

Result

6.1. COP Calculation

To calculate the coefficient of performance of two parallel Peltier modules, the following procedure is adopted. Some known amount of water is poured inside a beaker. Its initial temperature is measured. Then the beaker is kept on hot side of Peltier plates. Now the plate and fan are supplied safe amount of electricity using the power supply unit and its wattage is measured. Certain power is set and accordingly the final temperature is measured with the amount of time taken and the recorded data is substituted in following equations.

The current Peltier module has following observed data.

Initial Temperature = 33℃ Final Temperature = 10℃

Temperature Difference (dt) = 23℃ Volume of water (m) = 900 ml = 0.9 liters Time (t) = 15 minutes = 900 seconds

All modules were connected in parallel connection.

Power Utilized by Heat Sink Fan = 4 x 0.3 A x 12 V = 14.4W Power utilized by Peltier Module = 3 x 2 A x 12 V = 72W

Power Utilized = Power utilized by heat sink fan + Power utilized by Peltier Module = 14.4 + 72

= 86.4 watts = 86.4 x 10-3 kw

Heat absorbed (Q) = m Cpdt = 0.9 x 4.18 x 23 =86.53 kJ

Work consumed (W) = Power Utilized x Time Duration = 86.4 x 10-3 x 900 = 77.6 kJ
COP = Heat absorbed / Work consumed = Q / W = 86.53 / 77.6 = 1.11

Average cooling effect = Q/t =86.4/900 =0.096kW= 96W

Accordingly, number of modules required for the required refrigeration effect can be calculated considering some losses due to resistance of conduction (finned wall), resistance of convection from wall to water, water to cooling block and cooling block to air. The number of modules determines the container wall and the casing dimensions by knowing the module geometry and spacing between the modules.

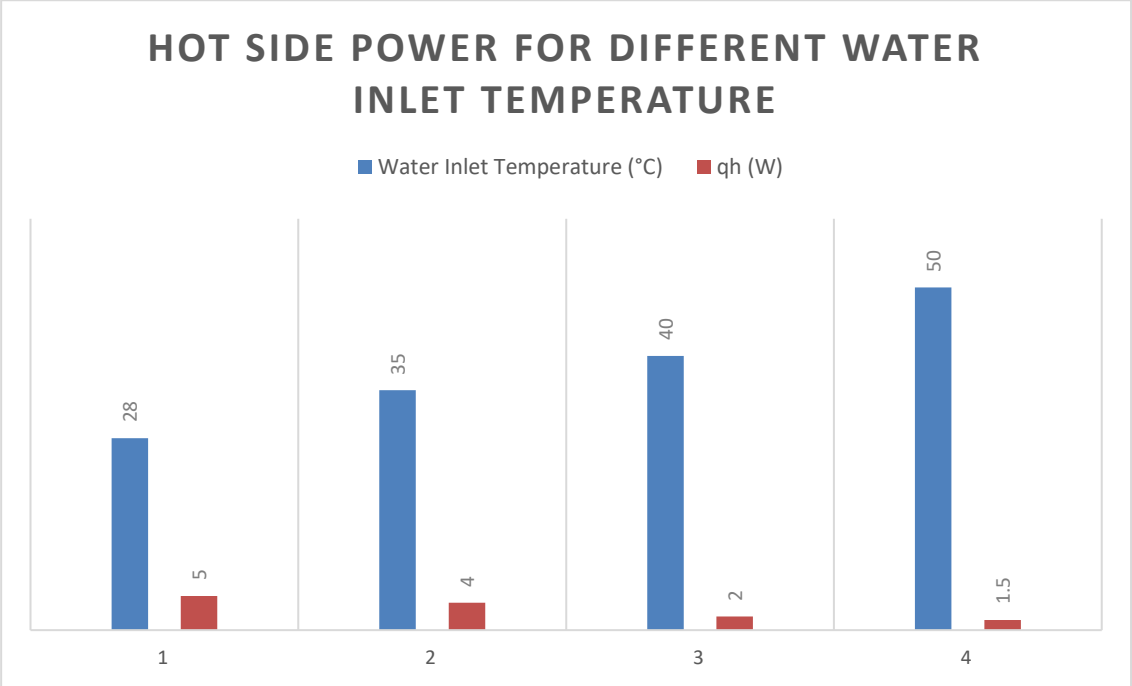
According to flow rate of air desired and refrigeration effect needed, one can find the required flow rate of water. From this, blower and circulating pump could be selected. However, pressure drop considerations will also be important for selection of these two. Mass of water desired will also decide size of container. Blower area for desired air flow rate will also determine size of casing and grid sizing.

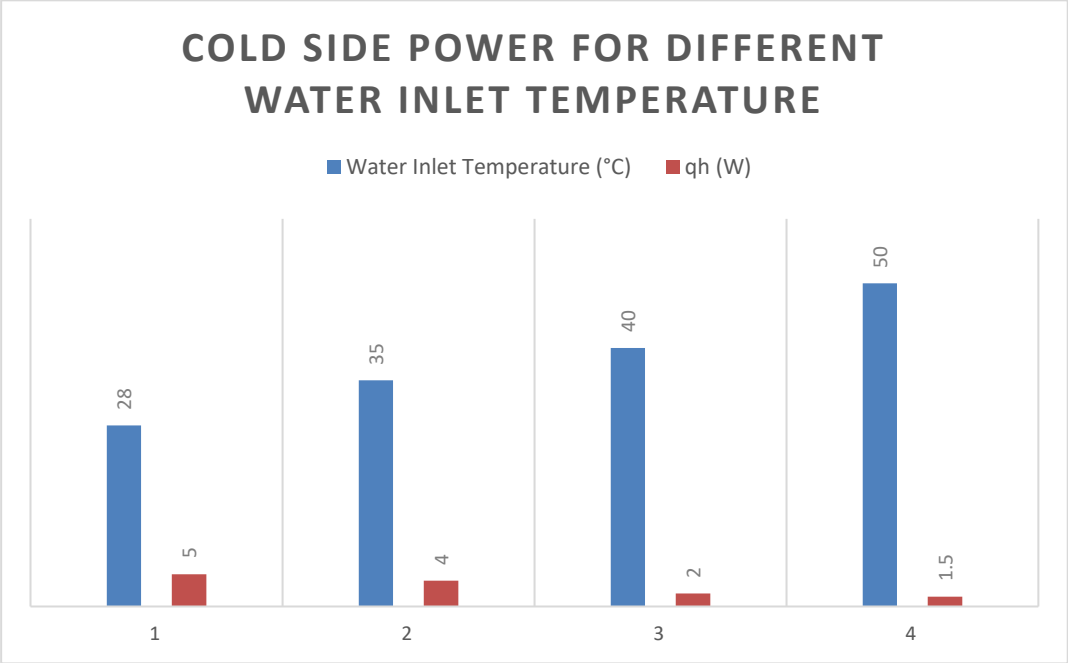
SL	Water Inlet Temperature (°C)	qh (W)
1	28	8
2	35	6
3	40	3
4	50	2.5

Table 1.1: Experimental data of hot side power for water inlet temperature

SL	Water Inlet Temperature (°C)	qc(W)
1	28	5
2	35	4
3	40	2
4	50	1.5

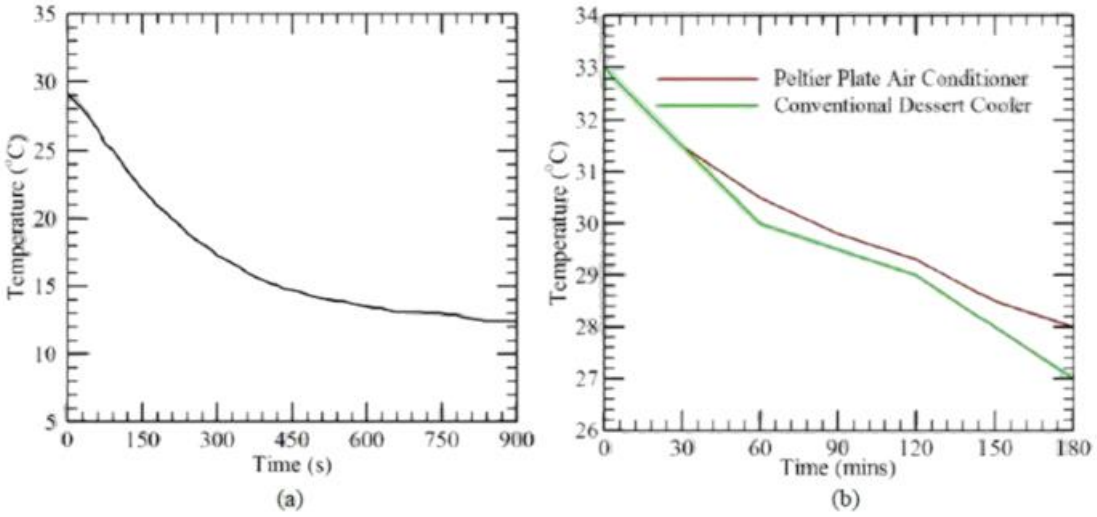
Table 1.2: Experimental data of cold side power for water inlet temperature


HOT SIDE POWER FOR DIFFERENT WATER INLET TEMPERATURE
Water Inlet Temperature (°C)
qh (W)
28
5
35
4
40
2
50
1.5
1
2
3
4


COLD SIDE POWER FOR DIFFERENT WATER INLET TEMPERATURE
Water Inlet Temperature (°C)
qh (W)
28
5
35
4
40
2
50
1.5
1
2
3
4

6.2 Experimental Results

From the project setup, we generate different graphs associated with the project and compare them with the rated graphs for proper validation of the project.



a. Change in temperature with respect to time for three Peltier using water cooling in cold side.
b. Room temperature variation between our project vs conventional dessert cooler.

Figure 6.3(a)

Figure 6.3(a) shows the change in cold side temperature with time. It shows that with time, the rate of temperature change slows down. Initially, a sharp decrease takes place in the curve up to around 7 minutes. Afterwards, the slope of the curve decreases and the variation tends to slow down. The cold side tends to settle in a steady temperature around 14℃. It occurs because the temperature difference between the hot and cold side reached a stable value due to the increase of the water temperature of the reservoir. Therefore, the cooling in the hot side becomes inefficient and the cold side temperature cannot be reduced less than 14℃.

Figure 6.3(b) shows the comparison between room temperatures for a conventional dessert cooler and our current project. It shows that initially they both perform similarly. However, after some time, the cooling effect of the Peltier air conditioner seems to decrease and the conventional one shows better performance. After a certain time, when the room temperature goes down to around 28℃, the Peltier air conditioner seems to reach its maximum performance. However, the conventional dessert cooler keeps reducing the room temperature down to around 25℃ due to continuous use of evaporative pad and water distributor with reservoir.

Chapter 7

Cost Analysis

In our economic consideration, we are showing the total cost of our project which is cheaper than any conventional air cooler. But if we want to increase the efficiency, we need to use more efficient thermos-electric module and sensors which will cost more.

Component	Cost per unit (BDT)	No. of units	Price (BDT)
Peltier Module	200	3	600
Power Supply Unit	800	1	800
Water Block	300	1	300
Water Pump	200	1	200
Water Tube	300	1	300
Fin	50	6	300
Thermal Paste	120	1	120
12V DC Fan	300	5	1500
Temperature Controller	600	1	600
Thermocouple	120	1	120
Relay	200	1	200
Electric Wire	100	1	100
Water tank	170	1	170
Transportation	470	1	470
Total			6780

Chapter 8

Conclusion

Peltier module has been used and experimentally verify the temperature performance according to the time when we supply 12V DC. The entire performance graph can be analyzed. The cooling and heating from Peltier module are totally depend upon the stress and contacting terminal of the Ceramic plate which is acting like two electrodes. Power supply is one of the important factors in case of heating. Without controlled power supply and switching, its performance will be down and device will stop working. This Peltier module is very important electronics component for better power saving. This has very low power and high output. So, in general life we can use this device. We success to achieve a temperature reduction of 5℃ of room temperature from this Peltier module. Peltier module is very inefficient and for better performance more efficient Peltier module need to be used. There is a lot of scope for improvement in each component for better performance in thermoelectric Peltier module and it can be a successful replacement of conventional air conditioner which also will reduce the harmful effect of greenhouse gas effect.

Chapter 9

References

1.Cosnier M, Fraisse G, Luo L. An experimental and numerical study of a thermoelectric air- cooling and air-heating system. International journal of refrigeration. 2008 Sep 1;31(6):1051-62.

2.Jugsujinda S, Vora-ud A, Seetawan T. Analyzing of thermoelectric refrigerator performance. Procedia Engineering. 2011 Jan 1;8:154-9.

3.He W, Zhou J, Hou J, Chen C, Ji J. Theoretical and experimental investigation on a thermoelectric cooling and heating system driven by solar. Applied energy. 2013 Jul 1;107:89- 97.

4.Riffat SB, Qiu G. Comparative investigation of thermoelectric air-conditioners versus vapor compression and absorption air-conditioners. Applied Thermal Engineering. 2004 Oct 1;24(14- 15):1979-93.

5.Riffat SB, Qiu GQ. Design and characterization of a cylindrical, water-cooled heat sink for thermoelectric air-conditioners. International journal of energy research. 2006 Feb;30(2):67-80.

6.Maneewan S, Tipsaenprom W, Lertsatitthanakorn C. Thermal comfort study of a compact thermoelectric air conditioner. Journal of electronic materials. 2010 Sep;39:1659-64.

7.Raut MS, Walke PV. Thermoelectric air cooling for cars. International Journal of Engineering Science and Technology (IJEST). 2012 May;4(5):2381-94.

8.Yadav and Nirves. Review on “Thermoelectric materials and applications”,. International Journal for Scientific Research & Development, 1,413-417,2013.

9.Manoj Kumar., Chattopadhyay and Neogi., A review on developments of thermoelectric refrigeration and air conditioning systems: a novel potential green refrigeration and air conditioning technology. International Journal of Emerging Technology and Advanced Engineering, 38,362-367, (2013).

Huang B., Chin C.J., and Duang C.L., A design method of thermoelectric cooler. International Journal of Refrigeration, 23,208-218,(1999)