THERMOELECTRIC REFRIGERATION

A project report submitted in partial fulfillments of the requirement for the award of the Degree of

BACHELOR OF TECHNOLOGY

in

MECHANICAL ENGINEERING

Submitted by :-

SUBRAT MALLIK	:1901206253
RAKESH KUMAR SAHOO	:1901206241
BISHAL MALLICK	:1901206219
OM PRAKASH MOHANTY	:1901206234

Under the guidance of

PROF.PABAK MOHAPATRA

DEPARTMENT OF MECHANICAL ENGINEERING

AJAY BINAY INSTITUTE OF TECHNOLOGY, CUTTACK

BATCH (2019 – 2023)

DEPARTMENT OF MECHANICAL ENGINEERING

AJAY BINAY INSTITUTE OF TECHNOLOGY, CUTTACK

DECLARATION

I do hereby declare that the project entitled, "**THERMOELECTRIC REFRIGERATION**" submitted in the Department of Mechanical engineering , Ajay Binay Institute of Technology, Cuttack of Biju Patnaik University of Technology, Odisha in partial fulfillments of requirement for the award of 7th semester B.Tech Degree in Mechanical Engineering is an authentic work carried out by us during 2022-2023 under the supervision of **Prof. Pabak Mohapatra.** The matter presented in this report has not been submitted in any other University/Institute for the award of B.Tech Degree.

Submitted by :-

SUBRAT MALLIK :1901206253

RAKESH KUMAR SAHOO :1901206241

BISHAL MALLICK :1901206219

OM PRAKASH MOHANTY :1901206234

DEPARTMENT OF MECHANICAL ENGINEERING

AJAY BINAY INSTITUTE OF TECHNOLOGY, CUTTACK

CERTIFICATE

The foregoing project named "**THERMOELECRTIC REFRIGERATION**" is a bonafide work carried out by :-

SUBRAT MALLIK	**:1901206253**
RAKESH KUMAR SAHOO	**:1901206241**
BISHAL MALLICK	**:1901206219**
OM PRAKASH MOHANTY	**:1901206234**

The partial fulfillment for the award of the degree of Bachelor of Technology in Mechanical Engineering, Ajay Binay Institute of Technology, Cuttack of Biju Patnaik University of Technology, Odisha in the year 2022-2023is an authentic work carried out under my guidance and supervision.

The matter embodied in this project has not been submitted to any other university/institute for the award of any degree to the best of our knowledge.

DEPARTMENT OF MECHANICAL ENGINEERING

AJAY BINAY INSTITUTE OF TECHNOLOGY, CUTTACK

CERTIFICATE OF APPROVAL

This is to certify that the project report entitled "**THERMOELECTRIC REFRIGERATION**" is the work done by:

SUBRAT MALLIK	**:1901206253**
RAKESH KUMAR SAHOO	**:1901206241**
BISHAL MALLICK	**:1901206219**
OM PRAKASH MOHANTY	**:1901206234**

Of B.Tech (Mechanical Engineering) of ABIT, Cuttack under BPUT,Odisha submitted in partial fulfillment for the award of degree. I am satisfied that they have worked sincerely and with proper care.

Signature of Project Guide **Signature of External Examiner** **Signature of H.O.D**

DEPARTMENT OF MECHANICAL ENGINEERING

AJAY BINAY INSTITUTE OF TECHNOLOGY, CUTTACK

ACKNOWLEDGEMENT

The satisfaction and euphoria that accompany the successful completion of any task would be incomplete without the mentioning of the people whose constant guidance and encouragement made it possible. We take pleasure in presenting before you, our project, which is result of studied blend of both research and knowledge. We express our earnest gratitude to **Prof. Pabak Mohapatra**, Department of MECH, our project guide, for his constant support, encouragement and guidance. We are grateful for his cooperation and valuable suggestions. We feel to avail ourselves of this opportunity to express our deep sense of gratitude to **Prof. Chinmay Das**, HOD, Dept. of Mechanical Engineering, for the facilities made available and instructions given to us in accomplishing this project successfully. Finally,we express our gratitude to all other members who are involved either directlyor indirectly for the completion of this project.

Submitted By:-

SUBRAT MALLIK	:1901206253
RAKESH KUMAR SAHOO	:1901206241
BISHAL MALLICK	:1901206219
OM PRAKASH MOHANTY	:1901206234

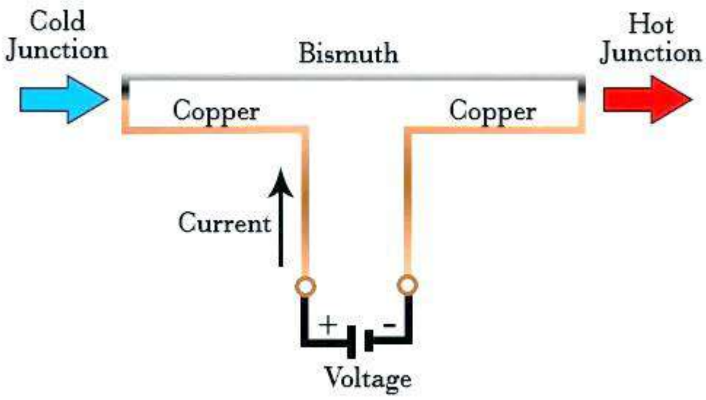
ABSTRACT

Conventional refrigeration systems have been majorly exploited since the 20th century. This has eventually caused major problems in the use and disposal of chlorofluorocarbons (CFCs) and hydro-chlorofluorocarbons (HCFCs); ozone layer depletion being the worst-case scenario. However, efforts have been directed towards the development of non-conventional types of refrigeration technology such as thermoelectric refrigeration, magnetic refrigeration and thermoacoustic refrigeration which has proved to be eco-friendly, cost-effective and efficient in operation. The present work showcases the performance parameters of thermoelectric refrigerators in two different cases. As a result, there will be less power consumption and totally eco-friendly refrigeration compared to conventional refrigeration with the same refrigerating effect. Thermoelectric couples are solid-state devices capable of generating electrical power from a temperature gradient, known as the ***Seebeck effect***, or converting electrical energy into a temperature gradient, known as the ***Peltier effect.*** A typical thermoelectric module is composed of two ceramic substrates that serve as a housing and electrical insulation for P-type and N-type (typically Bismuth Telluride) elements between the substrates. Heat is absorbed at the cold junction by electrons as they pass from a low energy level in the P-type element, to a higher energy level in the n-type element. At the hot junction, energy is expelled to a thermal sink as electrons move from a high energy element to a lower energy element. A module contains several P-N couples that are connected electrically in series and thermally in parallel.

TABLE OF CONTENT

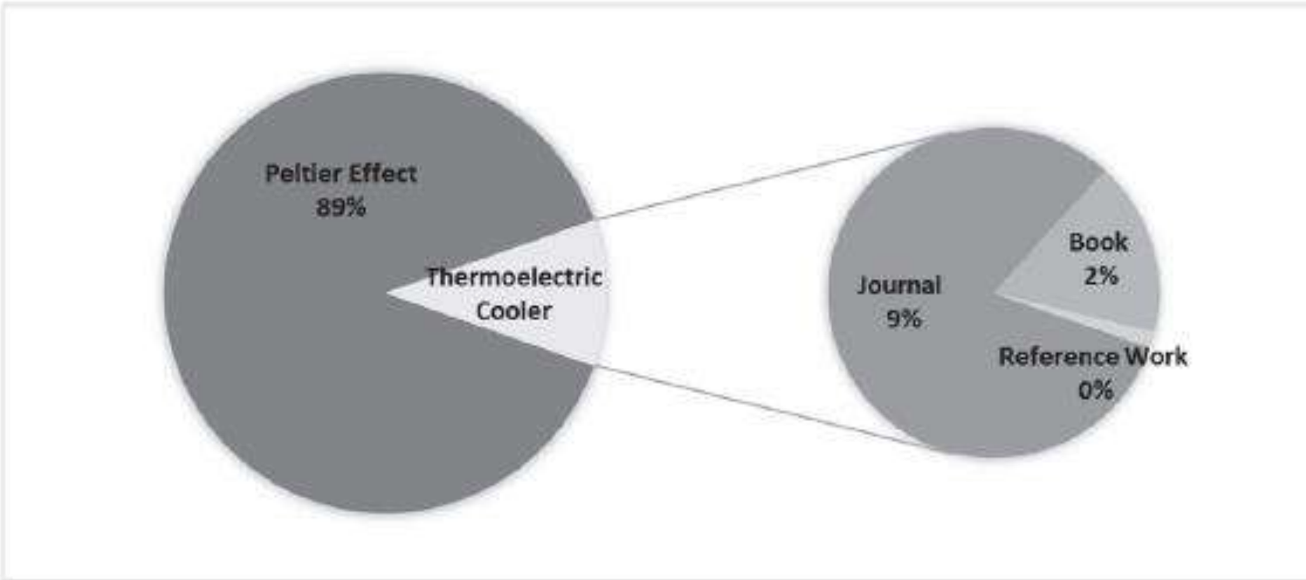
INTRODUCTION

Conventional refrigerators consist of bulky moving parts like compressor, pump and condenser which consume a lot of energy. The invention and use of non-conventional alternatives has been effective to a great extent due to the numerous researches employed towards the design and development of green energy sources. Thermoelectric refrigeration has been through a topic of research interest for more than a decade now. Recent advancements in the field include improvement of thermoelectric materials, peltier unit powered by solar energy source, studies on performance characteristics of single stage and multi stage thermoelectric modules, analysis of temperature distribution along the width of peltier unit. Detailed literature survey follows. The thermoelectric effect is the direct conversion of temperature differences to electric voltage and vice versa. A thermoelectric device creates voltage when there is a different temperature on each side. Conversely, when a voltage is applied to it, it creates a temperature difference. At the atomic scale, an applied temperature gradient causes charge carriers in the material to diffuse from the hot side to the cold side. Thermoelectric cooling uses the Peltier effect to create a heat flux between the junctions of two different types of materials. The device has two sides, and when DC current flows through the device, it brings heat from one side to the other, so that one side gets cooler while the other gets hotter. In 1821, J. T. Seebeck (1770-1831) discovered that dissimilar metals that are connected at two different locations (junctions) will develop a micro-voltage if the two junctions are held at different temperatures. This effect is known as the "Seebeck effect"; it is the basis for thermocouple thermometers. Fig.1, in 1834, a scientist called Peltier discovered the inverse of the Seebeck effect, now known as the "Peltier effect": He found that if a thermocouple is taken and voltage applied, this caused a temperature difference between the junctions. This resulted in a small heat pump, later referred to as also known as a thermo-electric cooler (TEC). Practical TECs use several thermocouples in series, which allows a substantial amount of heat transfer. A combination of the semiconductors Bismuth and Telluride is most commonly used for the thermocouples; the semiconductors are heavily doped, which means that additional impurities are added to either create an excess (N-type semiconductor), or a lack (P-type semiconductor) of free electrons. The thermocouples in TECs are made of N-type and P-type semiconductor pieces bonded together. Since Peltier elements are active heat pumps, they can be used to cool components below ambient temperature - which is not possible using conventional cooling, or even heat pipes. The theoretic background behind the theory and the basic thermoelectric principals and how they can be applied to energy conversion devices. It will also cover recent developments in the field of thermoelectrics



LITERATURE REVIEW

Albeit the systematic revision techniques of literature- RSl come from the health performed researches [12-14]. There is a growing trend in the implementation of these techniques in the different ambits of knowledge, like engineering [15]. This study has taken [16] as a reference, where there is a RSL methodology, implemented from the correlation of two ambits (health and engineering). Three phases were proposed in this study: 1) definition of search parameters, 2) Information identification and filtering starting from the specialized data sources, and 3) results submission and analysis. In [16] the data submission was set in two categories (scientometric and technical). However, this proposal focused solely in the analysis of variables from the scientometric approach. For the phase of search parameters definition, the following hypothesis was proposed: "Peltier effect is a research field that is moving forward more and more, because its implementation in refrigeration systems with thermoelectric energy generates low CO2 emissions, producing a positive environmental incidence." Key words were identified from this hypothesis. For the identification and filtering phase, a search string was set starting from the key words ("thermoelectric energy" and "Peltier effect" and not "Seebeck effect" and not "Joule effect"), said string was used in the specialized database Science Direct, and articles, proceedings, and books were downloaded that fit the search criteria. With the collected information from the different sources, a data acquisition matrix was made, that documented different scientometric variables (year of publication, journal, document typology, quartile of the journal, country of publication of the journal, among others). Finally, the results were submitted in a consolidated manner, with graphics, and its analysis contributed to the proposal of results. The measurement of the degree of scientific development lies in the quality and quantity of publications made on the subject in question, by making a scientific analysis in one of the most recognized databases worldwide as it is Science Direct [17], we can find the results shown in Fig. 1.



Jincan Chena et al.,[1]:- According to non-equilibrium thermodynamics ,cycle models of single-stage and two-stage semiconductor thermoelectric refrigeration were experimentally investigated. By using the three important parameters which governs performance of thermoelectric refrigerator i.e. coefficient of performance (COP), the rate of refrigeration, and the power input, development of general expressions performances of the two-stage thermoelectric refrigeration system took placed. It was concluded that performance of thermoelectric refrigerator depends on temperature ratio of heat sink to cooled space. When this ratio is small, the maximum value of COP of a two-stage thermoelectric refrigeration system is larger than COP of a single-stage thermoelectric refrigeration system; however maximum rate of refrigeration is smaller than that of a single- stage thermoelectric refrigeration system. Hence it is convenient to use single stage thermoelectric refrigerator when ratio is small. When temperature ratio is large two stage thermoelectric refrigerator is observed to be superior than single stage by both parameters i.e. maximum value of COP and maximum rate of refrigeration

X.C. Xuan et al., [2]:- In this paper Two stage thermoelectric refrigerator was investigated with two design configurations. Two configurations were pyramid style and cuboid style as shown in respective figures. In pyramid style configuration top side is being coldest as current is unidirectional. In cuboid style configuration current can be alternated causing top and bottom side to be switched between heating and cooling mode. To obtain optimization methods other multi stage designs can be used. The point of maximum cooling capacity and maximum COP both were taken into consideration while investigation for optimization for the two-stage TE coolers. It was concluded that value lies between 2.5-3 for both parameters that is optimum limit of ratio of number of thermo electric modules of two stages in pyramid style TE cooler and optimum limit of ratio of electric current between stages of cuboid style TE cooler. Maximum temperature difference of pyramid-style cooler is greater than single stage cooler.

Jun Luo et al., [3]:- Using finite time Thermodynamics theory performance of a thermoelectric refrigeration system, with multielements was analysed. To improve and maximise the cooling load and coefficient of performance (COP) optimisation of the ratio of the heat transfer surface area of the high temperature side to the total heat transfer surface area of the heat exchangers was done. The analysis of number of parameters which affects optimum performance of Thermoelectric system was done , parameters were number of thermoelectric refrigerating elements, the Seeback coefficients, internal heat conductance, the heat source temperature and internal electrical resistance. As
well as the analysis of other parameters like influences of total heat transfer surface area and working electrical current on the optimum performance was done. They concluded that the cooling load and coefficient of performance (COP) of TE system is greatly influenced by total heat transfer surface area and working electrical current. These results can be used for designing and manufacturing of practical Thermoelectric refrigerators.

D. Astrain et al.,[4]:- In this paper a device using phase change material based on Thermosyphon principle was developed. This device was used and tested as a heat dissipater for hot side of TE cooler. Performance of TE cooler with this device was compared with TE cooler with conventional heat dissipater made up of fins. It was concluded that with the help of developed phase changing device it is possible to reduce thermal resistance between hot side of TE cooler and atmosphere up to 23.8% at 293 K ambient temperature and 51.4% at 308 K ambient temperature, compared to commercial finned heat sink . Decrease in thermal resistance ultimately causes heat to dissipate more effectively from heat sink of TE cooler, therefore improving the COP of TE cooler. At the same values of temperatures it was observed that COP increases by 26% and 35% respectively.

Yuzhuo Pan, et al, [5]:- Author of this paper designed and analyzed an Irreversible multi-couple thermoelectric refrigerator, which operates between two reservoirs maintained at constant temperature. Effect of other factors like external and internal irreversibility of thermoelectric refrigerator on performance was also studied. They have specified many important parameters which affects coefficient of performance (COP) of system. Results of obtained from experiments leads to knowledge of information about performance characteristics of real multi- couple thermoelectric refrigerator. This information may be used to manufacture and design thermoelectric refrigerator which will perform at its optimum level.

Hongxia Xi.et al, [6]:- In this paper Author done survey on solar based driven Thermo electric technology. A brief history of development of solar based driven Thermo electric technology was presented. It's today's status and drawbacks present in current Technologies were reviewed. Applications, future scope, advantages over conventional technology where also discussed. In this paper they have discussed about two main modes, that are solar based thermoelectric power generation and refrigeration. Current status of both Technologies was described. Problems related to this technology and there possible solutions were presented. Ultimately these Technologies with some more development may lead to solve demand of Environment protection and energy conservation

Suwit Jugsujinda et al, [7]:- In this paper they have fabricated thermoelectric refrigerator using thermoelectric cooler. Thermoelectric refrigerator (25 × 25 × 35 cm3) and thermoelectric cooler (4 × 4 cm2). This system was applied to 40 W electric power without any cooling fan as heat dissipater at heat sink. They have measured temperature of this system at ten different points. It was concluded that

these experiments results into temperature of cold side of thermoelectric cooler to be decreased from 30°C to -4.2°C for 1 hour and decreased to -7.4°C for 24 hours with heat plate temperature being 50 °C. Temperature of cold side of thermoelectric refrigerator decreased from 30°C to 20°C for 1 hour and decreased further in 24 hours. 3 and 2.5 are the maximum value of coefficient of performance (COP) of thermoelectric cooler and thermoelectric refrigerator respectively

S.A.Omer et al, [8]:- This paper presents some results of thermoelectric refrigeration system using phase change materials (PCM) integrated with thermosyphones. They investigated two models of thermoelectric refrigeration system, one with conventional finned devices as heat dissipater and other with phase change material (PCM) as heat dissipater. After results they have concluded that coefficient of performance (COP) and effectiveness of thermoelectric refrigeration system with Phase Change Material (PCM) is higher than conventional one. They have also compared thermoelectric refrigeration system of two kinds, one is using phase change materials (PCM) without thermal diode and other integrated with thermal diode (Thermosyphones). Results shows that thermosyphones used prevent leakage of heat during power off. Overall they have concluded system can be work with the help of renewable energies like solar energy producing electricity. It is suited for medicine and food storage.

PROBLEM STATEMENT

Chip cooling is one of the bottlenecks in high density electronics. An enormous amount of heat flux is generated by the modern processor chip. Nowadays many complicated designs of air cooled heat sinks are used, but off late the heat fluxes have attained such a level that to handle them very large volume flow rate of air is required. So due to space constraint, in order to achieve large flow rates, air should be blown at very high velocities which in turn result in increased levels of noise. Another major disadvantage of air cooling is that we can't go below ambient temperature and as a consequence, tendency of chip failure in the computers working in ambient condition of about 35°C – 45°C increases a lot.

For all these reasons it has become apparent that the heat fluxes have reached such a level that air cooling can't handle them efficiently. Thus the present scenario necessitates the use of active cooling devices. Thermoelectric coolers having the ability to cool below ambient and having advantage of being compact, light weight, free of moving parts and precise temperature control have high potentials for chip cooling.

It is known that the temperature of the thermoelectric module is the main criterion for its reliability and performance. The temperature rise of the hot side above ambient is dependent on the thermal resistance of the path that the heat sink. Reducing the thermal resistance of the heat sink contributes to the reduction of the thermal resistance of the path and hence an increase in the performance. So a liquid heat exchanger with spiral flow passage having dimples is used. Dimples result in effective heat transfer by creating turbulence and thus enhancing the performance of the system.

OBJECTIVE

The objectives of this study is design and develop a working thermoelectric refrigerator interior cooling volume of 5L that utilizes the Peltier effect to refrigerate and maintain a selected temperature from 5 °C to 25 °C. The design requirements are to cool this volume to temperature within a time period of 6 hrs. and provide retention of at least next half an hour. The design requirement, options available and the final design of thermoelectric refrigerator for application are presented

METHODOLOGY

SL No.	Name Of Component	Price
1	Peltier Module 1 & 2	400
2	Big Heatsink	600
	Small Heatsink	400
3	Big Cooling Fan	600
	Small Cooling Fan	400
4	Thermal Paste	50
5	Wire & Connectors	100
6	Plastic aluminum composite plate	460
7	SMPS Power Supply	600
8	Digital Thermometer	200
9	Thermocol	60
10	Screw & Joint	200
11	Araldite Glue	130
Total		4200

Components and specification

1. Peltier

Specification

- **Model TEC1-12706**
- **Couples. 127**
- **Umax (V). 15.2**
- **Imax (A). 6**
- **ATmax (C). 67**
- **Qmax (W). 61.0 w 91.2w**
- **Dimensions. 40 x 40 x 3.9**
- **Resistance(Ω) 1.90~2.20**
- **Weight. 25 gms**

2.Heatsink

Specification

Big Heatsink Size: 2.71" x2.71" x 1.41" /69 mm x 69mmx 36mm (L*W*H)

Small Heatsink size Aluminium Heat Sink for Chips and Boards 35x25x15mm

- 3 Cooling Fan

Specification

Big cooling fan 12v 1.2Amp
Small cooling fan 12v 1.2 Amp

4.Thermal Paste

- **Specification**
  10g Thermal Paste Heat Sink Compound/Grease for CPU Fan, White Carbon Based Thermal Paste and thermal conductivity 1.93 W/mK

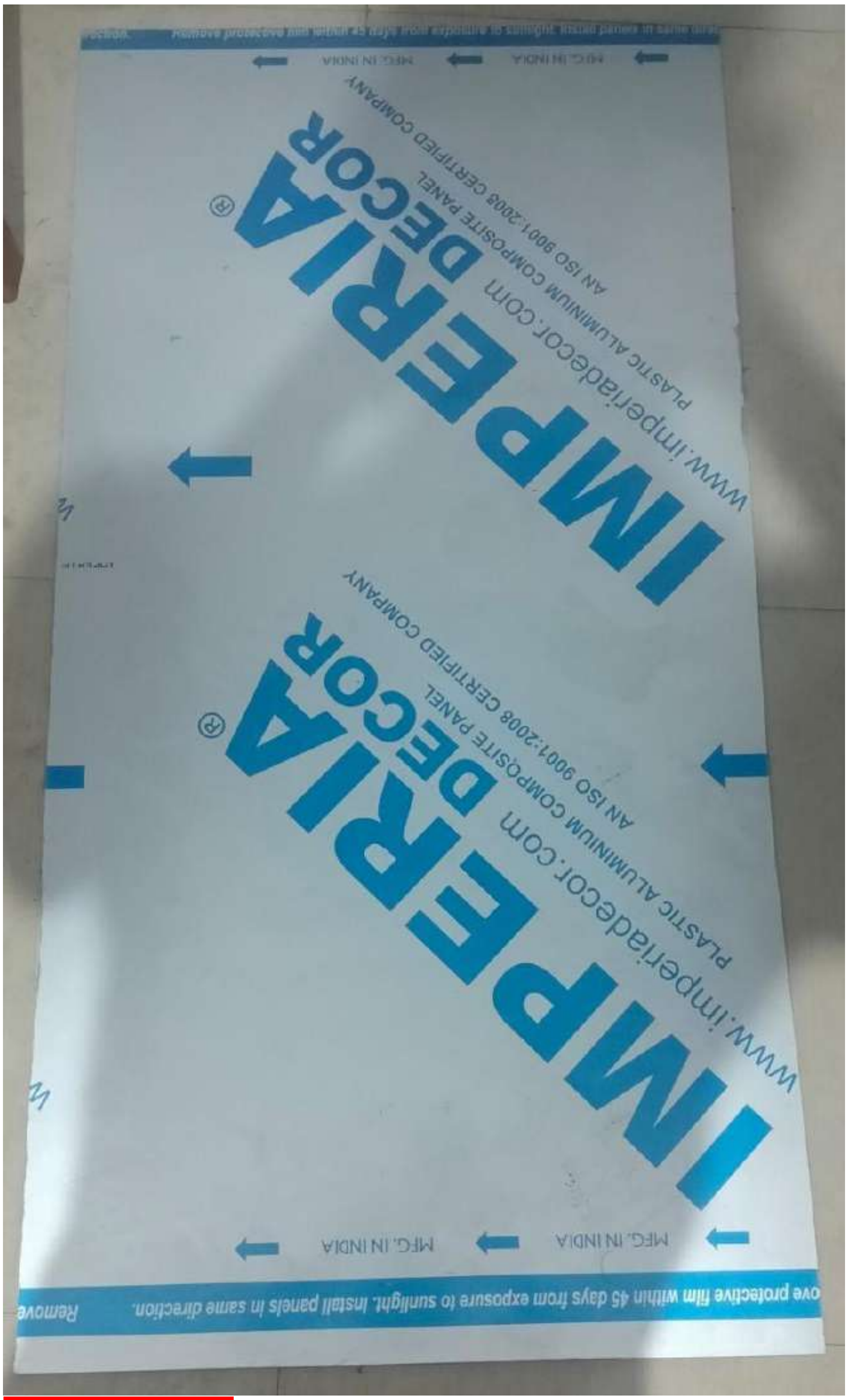
Composition - Silicone fluid with 20% metal oxide

- **5 Wires and Connectors**

Specification

(8 Meters) 14/36 Multi Colour Wire {3 Mtr Each Red, Green, Blue, Yellow, Black}

6.Plastic aluminium composite plate



Specification

3m*1m*0.4mm(L*W*T)

7.Power Supply

Specification

Input Voltage: AC 90 - 264V 50 / 60Hz
Output Voltage: 12V DC, 5A, and 60Watt
Output Voltage: Adjustment Eange: ±20%
Output Voltage Type - DC Current
Shell Material: Metal Case / Aluminum Base
Color: Sliver
Weight: 380g Approx
Dimension: 158 x 98 x 42 mm Approx

8 .Digital Thermometer

Specification

Mini LCD thermometer · Type: Digital · Applications: Aquarium, Fridge, Outdoor, etc. · Sensor cable length: 1 meter · Batteries: LR44 coin cell (Easily available) (2 x Batteries are included in this product) · Feature: · A-Set probe to display the temperature at the location of the probe. · Can be used in brew fridge fish tank keg incubator and beer tap. · Product Attributes: Color: White Black · Quantity: 1 Pcs · Probe cable length: 100cm/39.37inch · Temperature Range: 50â"ƒ ~ +70â"ƒ · Power source: 2 x LR44 button cell (included)

9. Thermocol

Specification

EPE Foam 15mm sheet, Black and White colour. 12 Inches Length & 12 Inches Width. Available In Set of 5, 10, 15 pieces.

10.Screws & Joints

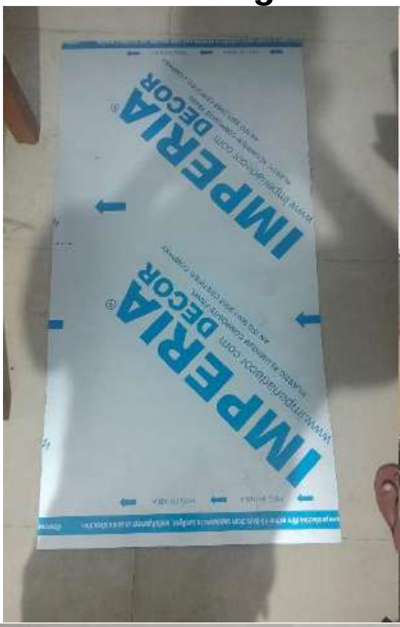
    

Specification

Above all material are used in fabrication on frame of refrigerator

FABRICATION

1.sheet marking & cutting



We cut (1×1) foot 2 and (1.5×1) foot 4 sheet for Frame making . We use PVC cutter for cutting

2.Fileing

Fileing all side of sheet by file for better finishing

3.Drilling & Cutting



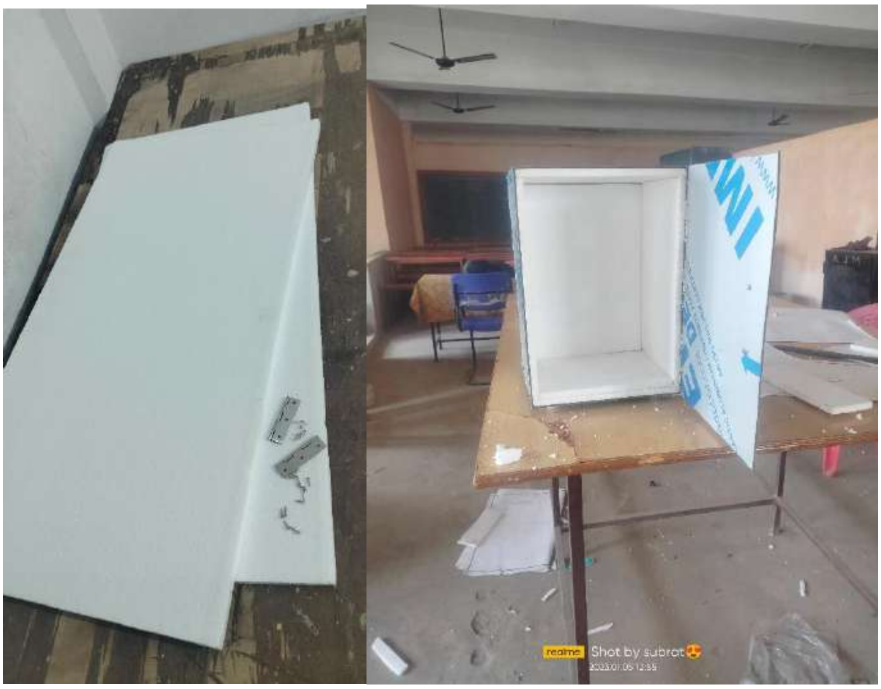
- We Make different types of hole for corner joint by drilling machine

Joint corner by nut and bolt and cut additional part of bolt by sander machine

4.Frame making

By v shape corner joint. Nut and bolt .washer . Door handle and door connector door locker and Leg we successfully make frame of refrigerator

5.Install thermocoal



- We install thermocoal inside the refrigerator for keep the temperature

6.install cooling component






- Install cooling component backside of the refrigerator and install a digital thermometer front of the refrigerator

Make separate space for better cooling inside the refrigerator. Upper space are use in instant cooling and lower space are use in store water bottle or food.

7.Connection & power supply

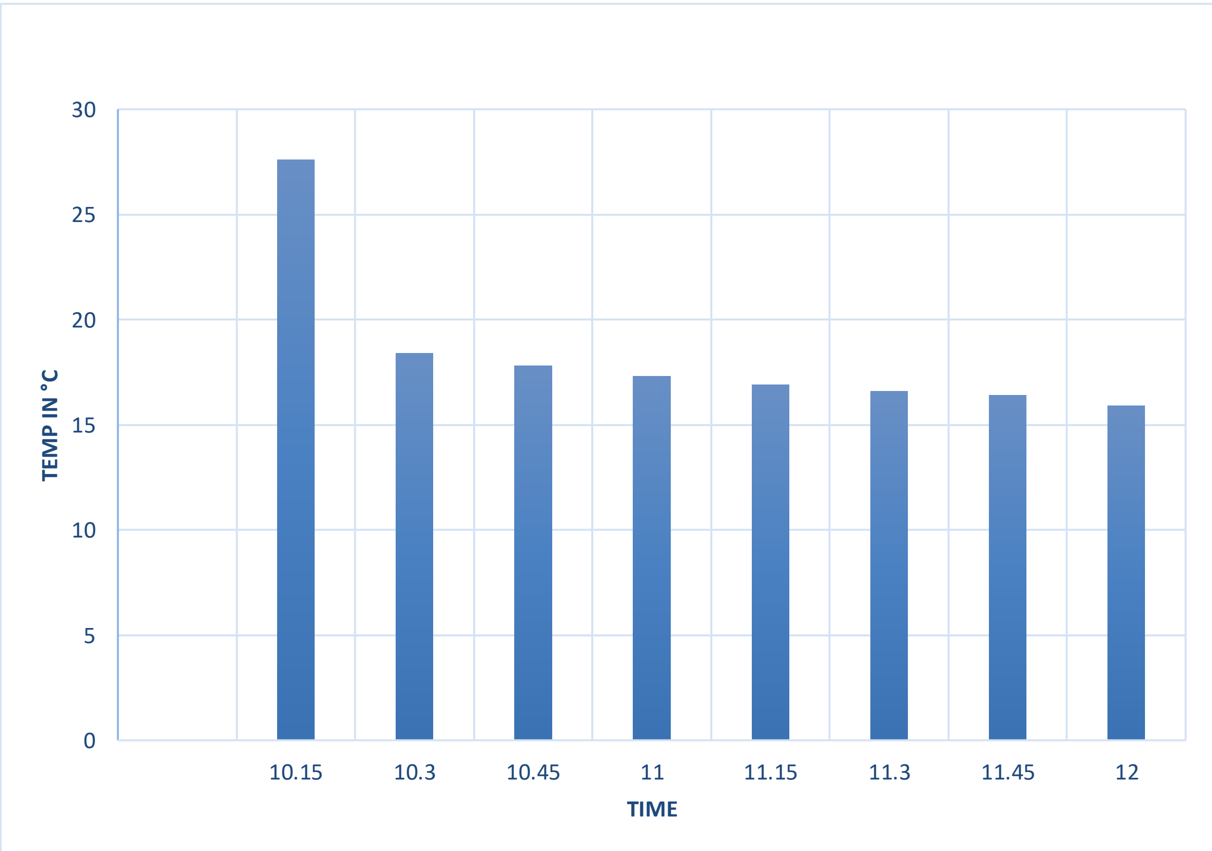

We install a SMPS power supply and connect all wire safely

RESULT ANALYSIS

The thermoelectric cooling was used electric power of 12V 6AMP. The TER without cooling fan for the coldness circulates in a refrigerator. The relationship of temperature and time were measured for finding temperature increases rate, difference temperature and calculation of TER. It results show that, the temperature inside refrigerator was decreased with increasing time. The inside temperature of TER was decreased rate of 1.1 °C/15min in the time interval 0–45 minutes, the minimum temperature was 14 °C, about 0.6

Time	10.15	10.30	10.45	11.00	11.15	11.30	11.45	12.00
Temp in °C	27.6	18.4	17.8	17.3	16.9	16.6	16.4	15.9

for 2 hour.



CONCLUSION

After the study of thermoelectric refrigeration system, we could demonstrate the cooling ability of the Peltier module and its use as an alternative to refrigerant based cooling systems. The study concludes that there are a no. of places where TEC can play a more promising role than the conventional ACs with the added advantage of not using the refrigerants and hence protecting the ozone layer. With its reliable cooling and precise temperature control, this solidstate cooling technology can replace conventional cooling in a multitude of applications. Also with the advancements in material technology, there shall be a drastic rise in the cooling performance. This project was just an effort to demonstrate the need and means of replacing the conventional systems due to their adverse environmental effects and to highlight the future scope of the Thermoelectric Cooling Devices.

FUTURE SCOPE

Peltier module based refrigerator has a clearer approach of working so it can work as a good alternative to conventional refrigeration. It can be integrated with solar cells thus can help in switching to renewable source of energy. It will be a much cheaper source of refrigeration. It can be very helpful in rural and remote areas where electricity supply is not reliable. It can be used in military and mobile ambulances to preserve medicines.

REFERENCE

[1] Jincan Chen, Yinghui Zhou, Hongjie Wang, Jin T. Wang: " Comparison of the optimal performance of single- and two-stage thermoelectric refrigeration systems" Applied Energy 73 (2002) 285–298.

[2] X.C. Xuan,K.C.Ng,C.Yap,H.T.Chua: "Optimization of two-stage thermoelectric coolers with two design configurations" Energy Conversion and Management 43 (2002) 2041–2052.

[3] Jun Luo,Lingen Chen,Fengrui Sun,Chih Wu: "Optimum allocation of heat transfer surface area for cooling load and COP optimization of a thermoelectric refrigerator" Energy Conversion and Management 44 (2003) 3197–3206.

[4] D.Astrain,J.G.Vian,M.Domınguez: "Increase of COP in the thermoelectric refrigeration by the optimization of heat dissipation" Applied Thermal Engineering 23 (2003) 2183–2200.

[5] Yuzhuo Pan, Bihong Lin, Jincan Chen,: "Performance analysis and parametric optimal design of an irreversible multi-couple thermoelectric refrigerator under various operating conditions" Applied Energy 84 (2007) 882–892.

[6] Hongxia Xi, Lingai Luo, Gilles Fraisse: "Development and applications of solar-based thermoelectric technologies" Renewable and Sustainable Energy Reviews 11 (2007) 923–936.

[7] Suwit Jugsujinda, Athorn Vora-ud, Tosawat Seetawan: "Analysing of Thermoelectric Refrigerator Performance" Procedia Engineering 8 (2011) 154–159.

[8] S.A.Omar,S.B.Raffit,Xiaoli Ma: "experimental investigation of thermoelectric refrigeration system employing a phase change material integrated with thermal diode (thermosyphons)"Applied thermal Engineering 21(2001)1265-1271.