iJRASET
International Journal For Research in
Applied Science and Engineering Technology

# INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

**Volume:** 10 **Issue:** IV **Month of publication:** April 2022

**DOI:** https://doi.org/10.22214/ijraset.2022.41380

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
*ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538*
*Volume 10 Issue IV Apr 2022- Available at www.ijraset.com*

# Design and Fabrication of Solar Powered Portable Medical Refrigerator for Remote and Rural areas based on Peltier Effect

Gautam A. Dubey[1], Vinay R. Chaurasia[2], Amit Kumar S. Chaurasiya[3], Vidyesh T. Churi[4], M. A. Gulbarga[5]
*[1, 2, 3, 4] Student, [5]Head of Department, Department of Mechanical Engineering, Theem College of Engineering, Boisar 401501*

***Abstract: The medicine and vaccine require to store in the refrigerator the continuous provision of electrical energy is required so that their efficacy is not affected. This represents an important problem for rural areas where there is no continuous electrical energy. In this work, we design a solar energy system for refrigeration of cold storage medicines to be used in rural towns without giving continuous electrical. The system uses a thermoelectric refrigerator based on the Peltier effect, which produces a temperature difference when electrical power is provided to it. It will be shown that for a typical application for vaccine refrigeration, the required solar panel is about 100W peak connected to batteries with a storage capacity of 20Ah. The designed refrigeration system has a 14-liter volume capacity of vaccines at temperatures in the range of 14° to 15°C using a Peltier cell (TEC) that consumes 28 W at 12V.***
***Keywords: Refrigeration, Thermoelectric, Solar energy, Peltier.***

## I. INTRODUCTION

There are several types of Refrigeration on the market that are designed to produce cooling. Thermoelectric is one of them. It is also known as Peltier Effect The main objective of our project is to produce a cooling effect by using the Peltier Module. By using the vapor compression refrigeration system we neglect the harmful refrigerant and usage of greenhouse gases and CFCs. For protecting our environment thermoelectric refrigeration is used. The Peltier effect is the reverse phenomenon of the Feedback effect. The Peltier effect is created a temperature difference by transferring heat between two electrical junctions when a circuit of two dissimilar metals and two junctions is formed a current will flow between the junction or the circuit this phenomenon is known as the Feedback effect. The Peltier effect is discovered by French physicist Jean-Charles-Athanase -Peltier.

Increasing refrigeration in various fields led to the production of more electricity and henceforth more release of harmful gas like $CO_2$ all over the world which is contributing factor to global warming climate change. Thermoelectric refrigeration is a new method the thermoelectric modules are made of many P-type and N-type semiconductor couples which are electrically connected series configurations thermally in parallel to create a cold and hot surface. Many researchers reported that the Peltier thermoelectric refrigeration system has a small size, less weight, no refrigerant, and no moving part such as a compressor and it can be operated using a DC power supply the TEC is used in consumer products, Industrial, Science and imaging, military, aerospace thermoelectric can be used to heat and cool, depending on the direction of current In an application requiring both heating and cooling mode

Throughout the world, refrigeration is a critical means for storing medicine and essential item that require low temperature in Rural areas. Because of expensive and require high watt power electricity so rural areas people face problem with storing medicine and vaccine and after the covid-19 every person must get vaccine and medicine on proper time our objective is to bring the refrigeration to rural areas for people at low cost, solar-powered and portable to use everywhere so people are not deprived for essential medicine.

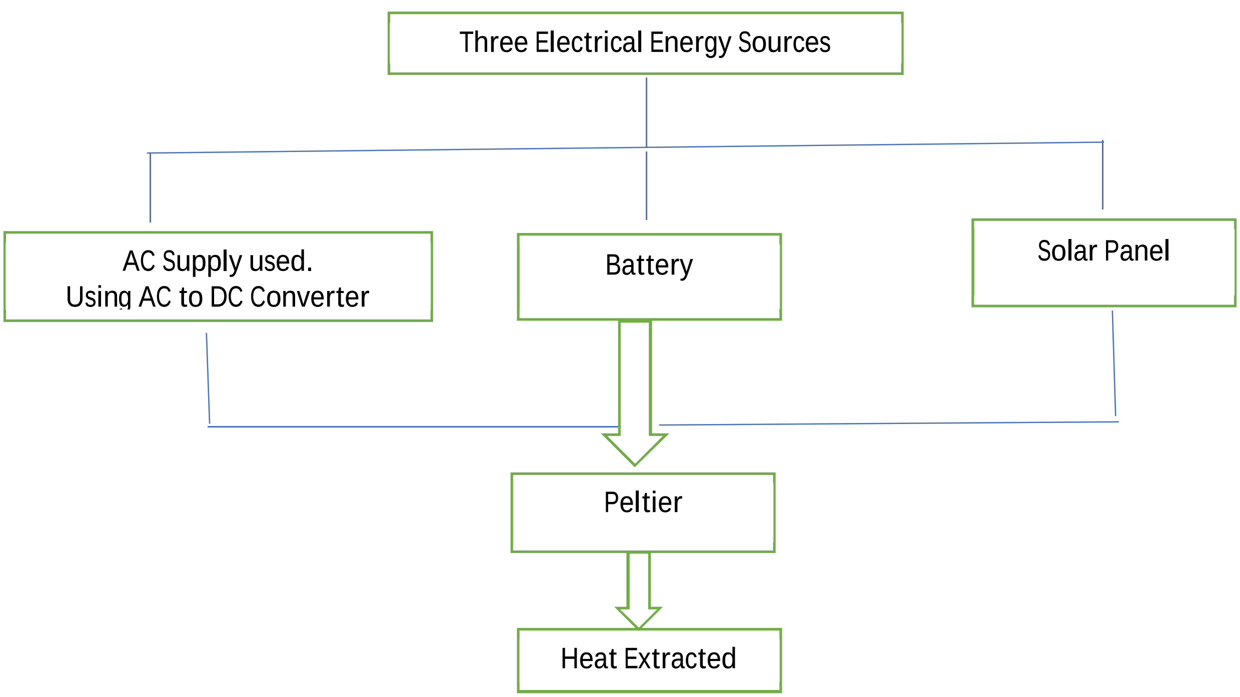
## II. LITERATURE REVIEW

1) *Awasti, M., & Mali, K. (2012). Design and Development of Thermoelectric Refrigerator. International Journal of Mechanical Engineering and Robotics Research(Volume No. 3).* The retention time achieved was 52 min with the designed module in this project. To achieve a higher retention time, another alternative was incorporated. This consists of the additional heater on a heat sink.
2) *Chetan Jangonda, K. P. (2016). Review of various Applications of Thermoelectric Module.* Thermoelectric cooling added a new dimension to cooling. It has a major impact on a conventional cooling system. It is compact in size, no frictional elements are present, no coolant is required and the weight of the system is low.

3) *D. SUMAN, P. H. (2020). DESIGN AND FABRICATION OF THERMOELECTRIC REFRIGERATOR USING PELTIER MODULE.* The efficiency and life of the Peltier refrigerator are maximized by using these water pockets and the temperature was controllable by changing the input voltage and current so we can maintain the things at the required temperature. Finally, it has been recorded the minimum temperature i.e., 2°c
4) *Jatin Patel, M. P. (2016). Improvement in the COP of Thermoelectric Cooler.* This study experimentally investigates the performance of the single-stage and multistage TEC air-cooling module. It is quite easy to achieve a significant temperature difference in the single-stage TE module, but, the COP of the single-stage module is very less for domestic use. In the multistage TE module, It is possible to get the required COP as well as better thermal performance
5) *Kshitij Rokde.Mitali Patle, T. k. (2017). Peltier Based Eco-Friendly Smart Refrigerator for Rural Areas.* The efficiency of the refrigerator can be increased by increasing the number of Peltier plate modules which will eventually help in decreasing the temperature in less time. The number of Peltier plate modules used can be calculated using the heat transfer formula.
6) *V.Rajangam, M. (2015). DESIGN AND CFD ANALYSIS OF THERMOELECTRIC COOLING SYSTEM.* The design parameters involved a thermoelectric cooling system. Experimental work is carried out to obtain a temperature up to 5 degrees Celsius. An attempt was made in validating the experimental work with the CFD analysis by giving sufficient boundary conditions. Further, this work could be enhanced with different thermoelectric materials to attain high performance.

## III. RESEARCH METHODOLOGY

The proposed refrigeration has three sources of Electrical energy if we have electricity of 240 v Ac Supply then we directly connect to refrigeration by using SMPS (switch mode power supply) to convert 240v to 12v and if we do not have electricity we can use battery give power to Peltier module or we also use the solar panel to charge the battery and Peltier module is a device that after giving current in two-terminal one side it gave hot temperature and another side cold temperature we require cold side temperature to keep for cooling in cabin box we used aluminum cabin box. and for hot side, temperature Heat Extracted by heat sink fan. we use Armaflex for insulation to decrease the transfer of heat from the ambient to the cabin box. and to watch the temperature we can use the temperature controller which can also control the temperature, and power will cut off after reaching the required temperature.
The below diagram Shows the Process of Energy supply



International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue IV Apr 2022- Available at www.ijraset.com

## IV. CALCULATION AND MATERIAL SELECTION

With the above constraint imposed by the objective, we selected a rectangular wooden box with insulation sandwiched between the aluminum wall and its dimension of box length*breadth*height = 35*20*20 cm Volume of the box is 14 cubic meters. In this we calculate two types of load Heat absorbing load in the cabin and Heat rejection load through the outside Heat sink fan.

First, we have to calculate how much amount of power is required to absorb the heat of a 14 cubic meter size of volume box at 35°c outside Temperature. So there is a heat-absorbing load formula Q = m*Cp*(Th- Tc). so we have to calculate Mass.

Mass = Density * volume = 1000*0.014 = 14 kg

Q = m*Cp*(Tamb -Tc) = 14*4.187*(35 -15) = 1172.36 KJ = 326 watt-h or 163 watt in 2 hr

So we required a total 163-watt heat-absorbing load in a 14 cubic meter volume box to reach 15°c In 163 watts we select 6 Peltier each Peltier would take 28 watts of load to cool up to 15°c

## V. SELECTION OF MATERIAL

### *A. Peltier*

Above calculation of cabin load for per Peltier, we required 28 watts and 12v dc supply 2.3 amperes current for this amount of power we select TEC1-12706 Module Peltier that characteristic is

| | | |
|---|---|---|
| Hot Side Temperature (°c) | 25 | 50 |
| Qmax (watts) | 50 | 57 |
| Delta Tmax (°c) | 66 | 75 |
| Imax (Amps) | 6.4 | 6.4 |
| Vmax (Volts) | 14.4 | 16.4 |
| Module Resistance (Ohms) | 1.98 | 2.30 |


### *B. Heat Sink Fan*

Heat rejection Load = Q = h*A (Th-Tc)

= 15 * 5.1*(50-35) = 0.31 = 0.31 watt-h per Heat sink Fan

Total we require  watt-h for Heat rejection Load

We select 0.6 ampere 12v heat sink fan

The total Max power taken to reject  heat is 7.2 watts per Peltier Total of 6 Peltier max power to reject heat is 43.2 = 44watt

Total watt required = heat absorb load + heat reject load = 163+44 = 207 watt-h

207-watt Total power required to remove the heat in 14 cubic meter volume box heat till 15°c

### *C. Selection of Battery*

For 207 watt amount of load we required a battery to run this load hence we calculate capacity of battery :

Power calculation = Voltage Load * Current Load = 12*3 (∴ 3 = 2.33+0.6)

= 36 watt

Battery capacity = total load / battery voltage = 207/12 = 17.25 Ah

We select 20 Ah battery  to run this refrigerator

To charge the battery we select Flate Plate solar panel We need a Charge the battery in 4hr

20Ah/4H = 5A

5A*12V = 60watt

100-watt Solar Panel Require Charge Battery in require time

The output power of solar panel = 60W

Total power generated by solar panel = 100W

Total time required to charge the battery = Watt-hour of Battery / output power of solar panel

= 240/60  = 4hr

Aluminum: Aluminium material is used inside cabin boxes and its thermal conductivity is 239 (w m-1 k-1) it is corrosion resistant and aluminum is a superb heat sink as compared to other materials that heat can be drained away rapidly that why used in many applications.

Insulation: we used 10mm Armaflex to resist heat from outside temperature to inside temperature and Armaflex is the best material because its service temperature is -50 to +80° thermal conductivity is 0.003 (w/m.k) controls condensation reduced energy loss and protects against frost on the aluminum wall, lightweight and flexible it is closed cell structure it means no additional vapor barrier is required

We want to calculate how much thickness insulation we required :

$$X = k\{[(t_h-t_a)/q_{max}]-(1/f)\} = 0.035*\{[42-35)/249]-(1/5.7)\}$$

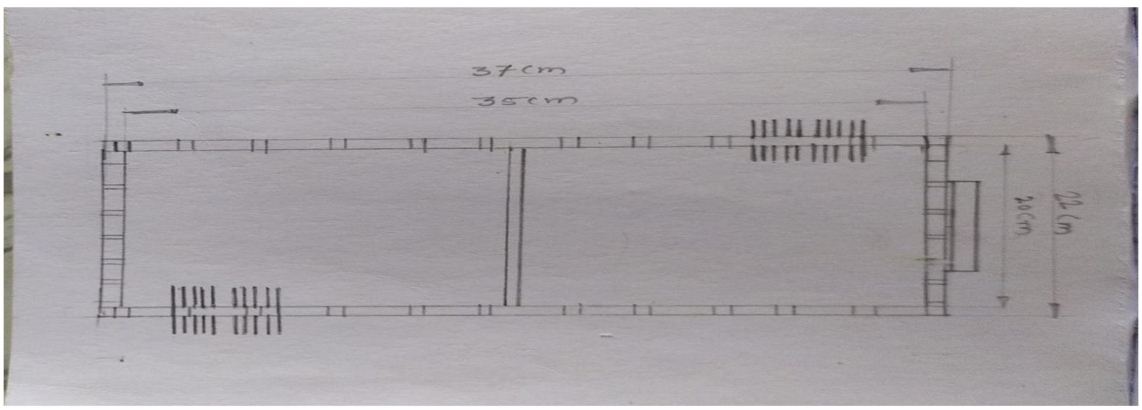
$$= 0.008m = 8mm = 10mm(\text{approx.}) \text{ insulation thickness}$$

Wooden box: wood is a low thermal conductivity material compared to other materials and is best sustainable for portable

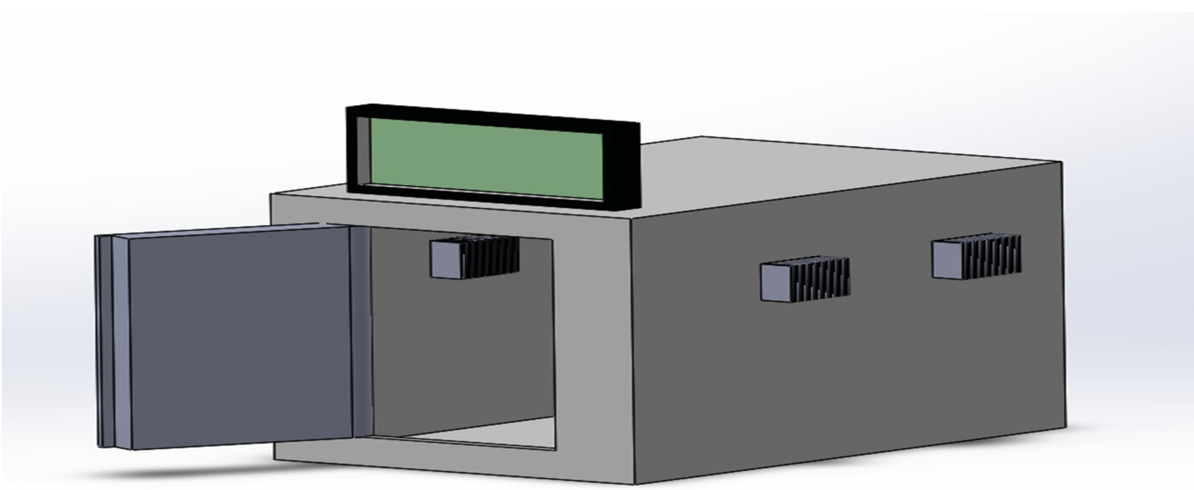
Temperature controller: we used W1209 is an incredibly low-cost yet highly functional thermostat controller. With this module, you can intelligently control power to most types of electrical devices based on the temperature sensed by the included high accuracy NTC temperature sensor.

## VI. DESIGN

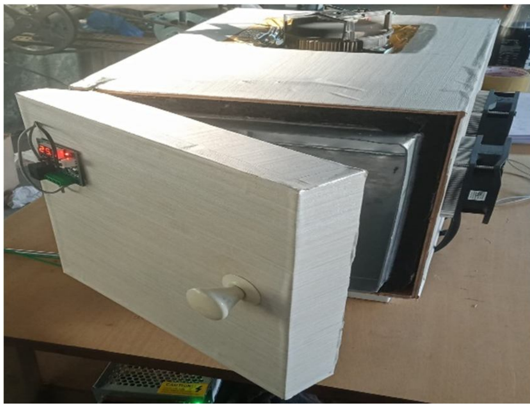
Firstly we design a 2D view of the refrigeration system




Cad model view

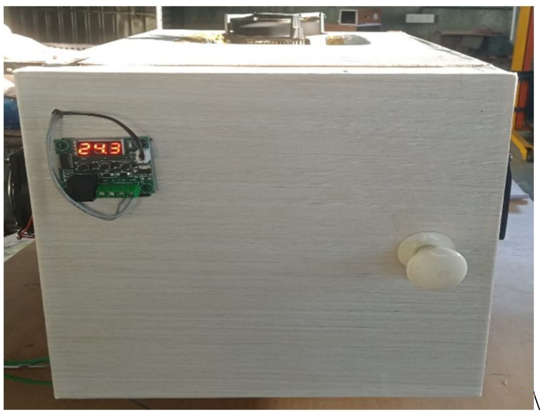


Actual Design Model



Top View

Back View



Front View

Side View

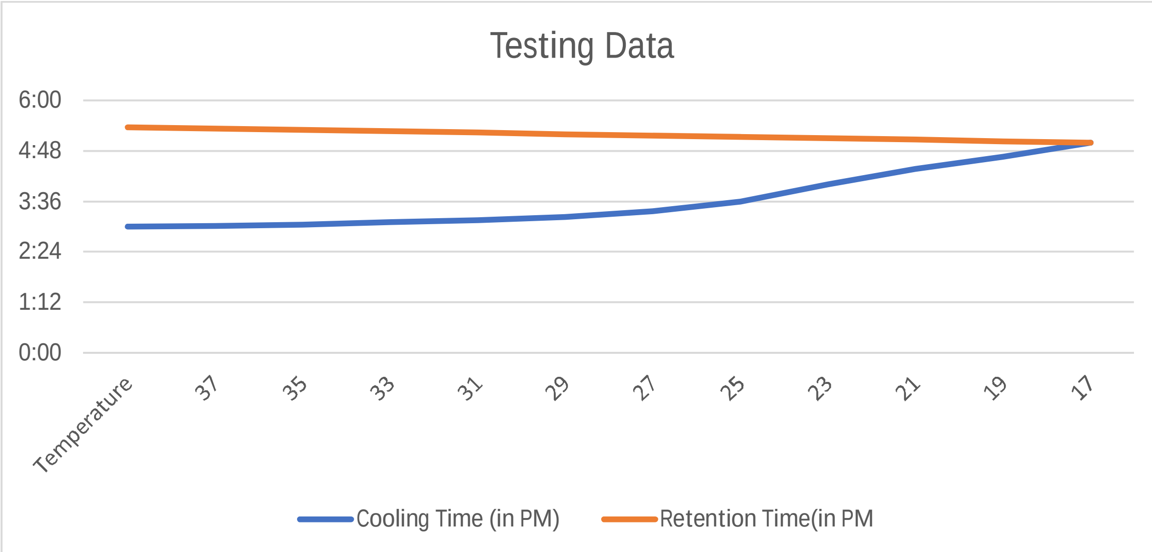
## VII. RESULTS AND DISCUSSION

To verify the above system design analysis, we designed and built a prototype thermoelectric refrigerator and perform an experiment.

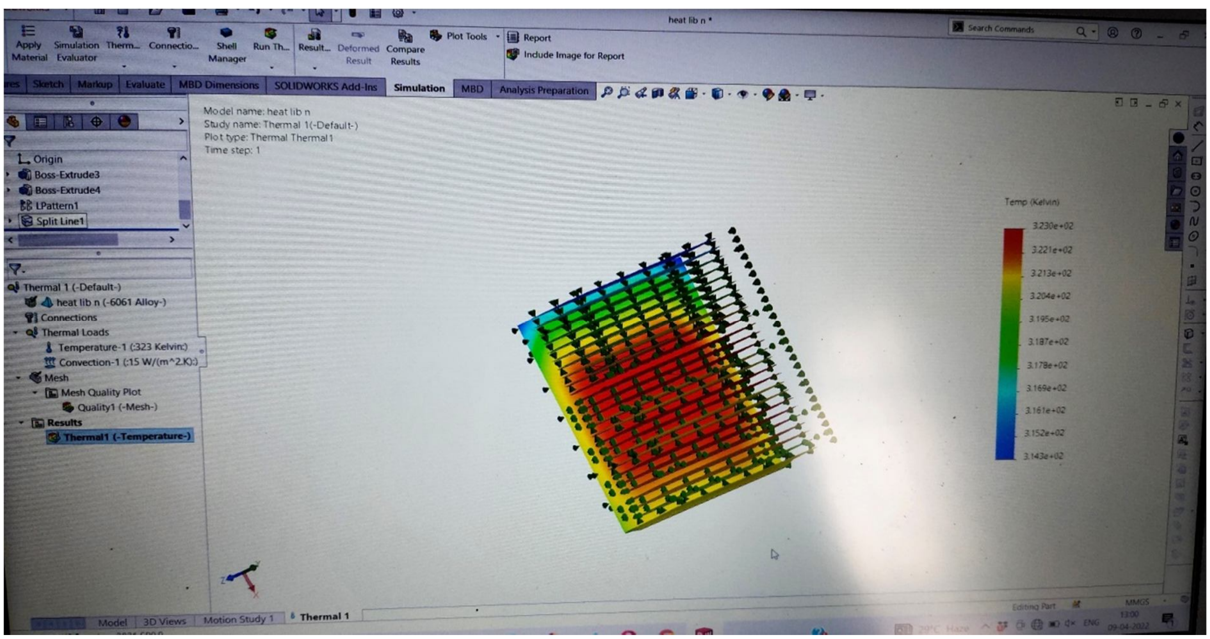
For the above calculation, we got theoretical data on how much current is required to run this system. For finding practical data test was conducted at an ambient temperature of 37°c. In 2 hr we get 15°c we have done this test in the empty box. so In the empty box total 156 watt-h load we required Per heat sink fan we get a total of 28 watt-h. Per Peltier, we require 21.3 watt-h and 1.8-ampere current. In theoretical data, we calculate in full volume capacity load.

| Temperature | Cooling Time (in PM) | Retention Time(in PM |
|---|---|---|
| 37 | 03:00 | 05:22 |
| 35 | 03:01 | 05:20 |
| 33 | 03:03 | 05:18 |
| 31 | 03:06 | 05:16 |
| 29 | 03:09 | 05:14 |
| 27 | 03:14 | 05:12 |
| 25 | 03:22 | 05:10 |
| 23 | 03:36 | 05:08 |
| 21 | 04:00 | 05:06 |
| 19 | 04:22 | 05:04 |
| 17 | 04:40 | 05:02 |
| 15 | 05:00 | 05:00 |

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
*ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538*
*Volume 10 Issue IV Apr 2022- Available at www.ijraset.com*




We simulate the heat rejection convection coefficient to calculate heat rejection load In the simulation we find out we require 15 w/m$^2$.k to reject hat till ambient temperature.



The above figure shows that hot side of Peltier there is a 50°c temperature. Cooled the Peltier with a heat sink fan at 35°c we require a 15 w/m2.k heat transfer coefficient.

## VIII. CONCLUSION

The objective project is to achieve long-term cooling in case of power failure for the refrigerator. A Peltier Cooling system has been designed and developed to help active cooling of single-stage 12 V and 3A TEC modules is used to provide adequate cooling. First, the cooling load calculations for this TER compartment considered under study were presented. Simulation tests have validated the theoretical design parameters and established the feasibility of providing cooling with a single-stage thermoelectric cooler tested in the environmental chamber. The total power required to run TEC Refrigerator in the empty box is 156 watt-h. The retention time achieved was 22 min with the designed module in this project. To achieve a higher retention time and more cooling temperature another alternative was incorporated. This consists of the additional Peltier and Heat sink fan.

## IX. FUTURE SCOPE

We have to work on little further in Peltier Module Which can reduce the temperature difference from the hot side to cold, On the hot side we must have to reduce temperature to ambient or below ambient, it will increase efficiency and temperature will cool down in cold side in very less time. To increase the retention time first reduced cooling loss using the best insulation and needs to be explored with quick switching mechanism from thermoelectric cell off state of heater to on state, so that temperature drop in the thermoelectric cell can be reduced. These System are pollution free, silent and compact and also requires less maintenance, so innovation should be done to improve performance.

## REFERENCES

[1] Angamuthu. K, A. D. (2020). Design and Manufacturing of Thermoelectric Mini Portable Refrigerator using Autodesk Fusion 360 with Additive Manufacturing. *IJRTE*, 7.
[2] Awasti, M., & Mali, K. (2012). Design and Development of Thermoelectric Refrigerator. *International Journal of Mechanical Engineering and Robotics Research*(Volume No. 3), 11.
[3] Chetan Jangonda, K. P. (2016). Review of various Applications of Thermoelectric Module. *IJIRSET*, 8.
[4] D. SUMAN, P. H. (2020). DESIGN AND FABRICATION OF THERMOELECTRIC REFRIGERATOR USING PELTIER MODULE. *JETIR, 7*(3), 5.
[5] Elavarasan E, S. S. (2018). Design and Fabrication of Mini Refrigerator with Thermoelectric Cooling. *IJERT*, 4.
[6] Gagan Bansal, Y. j. (2021). Solar Based polio-drop box system with Peltier effect technology: A review. *ELsevier*, 6.
[7] Jatin Patel, M. P. (2016). Improvement in the COP of Thermoelectric Cooler. *IJSTR*, 4.
[8] José Armando Gastelo-Roque, A. M.-A. (2017). Design of a photovoltaic system using thermoelectric Peltier Cooling for Vaccine Refrigeration. *IEEE*, 4.
[9] Kshitij Rokde.Mitali Patle, T. k. (2017). Peltier Based Eco-Friendly Smart Refrigerator for Rural Areas. *IJARCSSE*, 4.
[10] Pawan Attavane, A. G. (2017). Solar Powered Portable Food warmer and cooler based on Peltier Effect. *IEEE*, 4.
[11] Rohit Sharma, V. K. (2009). Peltier Effect Based Solar Powered Air Conditioning System. *IEEE*, 5.
[12] Sabah A. Abdul-Wahab a, *. A. (2007). Design and experimental investigation of the portable solar thermoelectric refrigerator. *ELSEVIER*, 5.
[13] V.Rajangam, M. (2015). DESIGN AND CFD ANALYSIS OF THERMOELECTRIC COOLING SYSTEM. *ICRAMET*, 5.