JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

SOLAR POWERED VACCINE REFRIGERATOR

[1]Anushree N S, [2]Kaushik Srinivas, [3]Ramya K G, [4]Varshini Nataraj, [5]Ashwini A

[1]Final year student, [2]Final year student, [3]Final year student, [4]Final year student, [5]Assistant Professor
[1,2,3,4,5] Department of EEE,
[1,2,3,4,5] BNM Institute of Technology, Bangalore, India

Abstract: Demand for preservation is increasing day by day for applications like food storage, vaccine storage. This calls for design of devices with new technologies which are cost effective and portable. Heating or cooling applications can be achieved using Peltier. A Peltier cooler is a solid-state active heat pump that transfers heat from one side of the device to the other. Peltier's which are cheap and efficient are being developed by many researchers. This paper deals with the design of a solar-powered vaccine storage refrigerator. As we have seen during the pandemic, vaccine storage has been very challenging, therefore we need efficient vaccine storage systems. Frequent power outages which depend on grid-powered cooling are not practical for vaccine storage. The continuity of the vaccine cold chain is a serious challenge especially in remote areas. Although there have been alternatives, they are plagued by problems with gas supply interruptions, poor temperature control and low efficiency. Therefore, there is a need for solar refrigerator systems, and refrigeration is achieved by the Peltier module.

***Index Terms* – Peltier, Vaccine storage**

I. INTRODUCTION

The demand for cooling is increasing in the fields of refrigeration, food preservation, storages, medical services especially in vaccine storage, and cooling of electronic devices has led to production of more electricity. This has led to increased levels of CO_2 all over the world which contributes to global warming . With the increase in awareness about environmental degradation, thermoelectric cooling has emerged as a very suitable alternative. This is because of the conversion of waste electricity into useful cooling. It is friendly to the environment and uses electrons than refrigerants as a heat carrier. Here we are designing a solar-powered vaccine refrigerator based on the thermoelectric effect. Photovoltaic energy is the best alternative source using solar irradiation. Due to the reduction of the manufacturing price of PV panels, we can consider a photovoltaic vaccine refrigerator as a very interesting option. A conceptual study of a refrigerator intended for vaccine storage that operates with a Peltier module is done here. The electrification of the vaccine refrigerator is achieved by a photovoltaic system which is consists of a PV device connected to the power electronic converter. The proposed system of the vaccine refrigerator is consisting of: -PV panel, DC-DC buck & boost converter with MPPT control, Battery, and vaccines refrigerator.

II. BLOCK DIAGRAM

The block diagram of the Solar Vaccine Refrigerator using the Peltier Module is shown in fig.1. The solar panels absorb solar energy, which is converted into electrical energy. A diode or MPPT controller can be used to regulate the voltage according to the battery ratings. The Peltier module is placed such that the cooling side faces the aluminum container inwards and the heating side faces outwards. The aluminum container is chosen here as it is cost-efficient, retains cooling and is noncorrosive. The top lead cover is to retain the cooling developed inside the container. The exhaust fan assembly is to remove the heat generated inside. The exhaust fan assembly receives power from the power supply. The aluminium container is enclosed by plastic enclose to provide insulation.

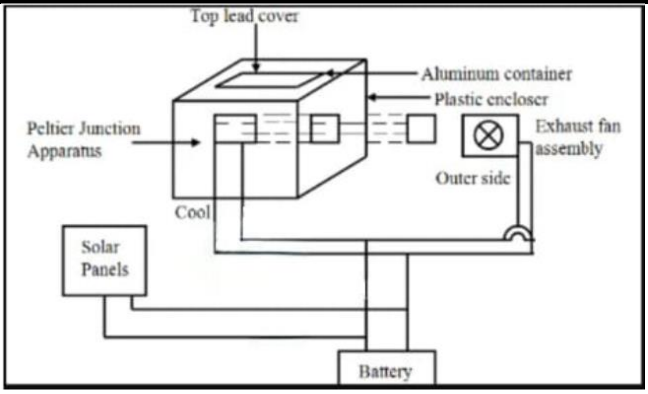


Fig.1 Block Diagram of the Solar Vaccine Refrigerator

III. PELTIER SYSTEM

A Peltier cooler can also be utilized as a thermo-electric generator. To operate it as a cooler, a voltage is applied across the device, due to this a temperature difference will be built up between the two sides. When it is operated as a generator, one side of the device is heated to a temperature greater than the other side, because of this a difference in voltage will build up between the two sides. Here our main application of Peltier module is for cooling purpose.

Fig 2 shows a Peltier Module & fig 3 shows Peltier with heat sink. The basic building block of a thermoelectric / Peltier module is a semiconductor couple and it comprises of one p-type and one n-type semiconductor block connected by a metallic strip. This metal strip serves as a junction between the two semiconductors. The ceramic substrate holds the complete structure together mechanically. It is also used to shield the individual elements electrically from each other. A Peltier module is created by assembling many couples electrically in series, thermally in parallel and is placed between substrates that are generally ceramic. The cooling capacity is directly proportional to number of couples in the module.

The internal structure of the Peltier element comprises semiconductor material. N-type and P-type Bismuth Telluride thermoelectric materials are used in a thermoelectric cooler. The extra electrons in the N material and the holes in the P material are the carriers which carry heat energy through the thermoelectric material. When the current flows through the junctions of the conductors, heat is removed at one junction and cooling occurs. The heat sink absorbs the heat load at the hot side of the Peltier and dissipates it to the surrounding air.

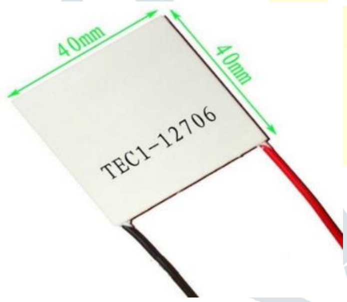


Fig 2: Peltier Module 12V, 6A

Fig 3: Peltier Module with heat Sink

IV. DESIGN

4.1 Components

The various components required to design the solar powered vaccine refrigerator includes Peltier module, fan, heat sink, digital thermostat, temperature sensor, solar panel, battery and solar charge controller. The components and their ratings are listed in the Table. 1.

Table. 1 Components and ratings

Components	Ratings
Peltier Module	12V, 6A-TE12706
Fan & heat sink	12V, 6A
Digital Thermostat	12V
Temp Sensor	-50 to 110 Degree Celsius
Solar Panel	150-200W
Battery	200-250W,12V,6A
Solar Charge Controller	12V

4.2 Design Parameter of the Components

The main components used in the prototype are shown in the fig 4 and 5. A Peltier module with heat sink and fans on both heating and cooling side is used. A digital thermometer is used to measure the temperature inside the box. SMPS supply is used to power the entire module. All the components are assembled together to give the required cooling.

Two Peltier of 6A and 12V is used as 65W power is required. Solar panels of 100W, Solar charge controller and lead acid battery of 12V ratings are used. The refrigerator can be powered using Solar panels, SMPS (Switched Mode Power Supply) and Battery. The battery takes about 4hrs to get charged and discharge time is 2hrs.

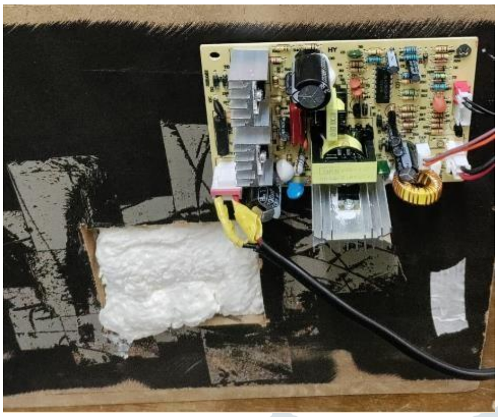


Fig.4 SMPS supply

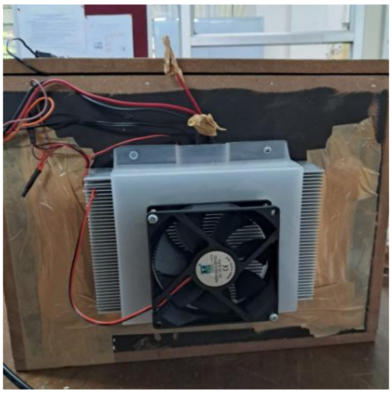
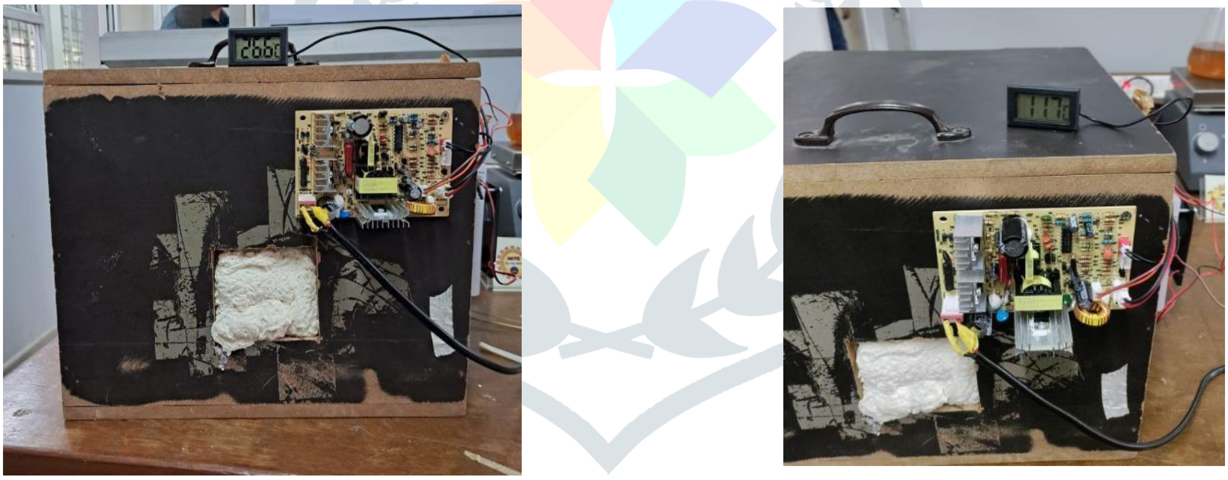


Fig.5 Box with Peltier and heat sink fixed

IV. HARDWARE IMPLEMENTATION

5.1 Working

The wooden box (1ft×1ft×1ft) is taken with an aluminum container (10inch×10inch×10inch) inside. Aluminium is chosen as it is a good thermal conductor and non-corrosive in nature. The insulation foam is used to insulate the gap between the aluminum container and the wooden box. The Peltier modules with heat sink are fitted on all four sides of the box according to polarity such that the heating side faces outwards, and the cooling side faces inwards. The heat from the Peltier module is taken out using the fan assembly. Effective cooling is achieved within the container.



Before After

Fig 6: Temperatures before and after cooling

5.2 Observation

The temperature drop observed as time passed was recorded and is presented in Table. 2. As we can see from the table that a drop of about 15 degrees centigrade was obtained after 70 mins. A graph is plotted for the readings in table 2. The temperature is taken on y-axis and time is taken on the x axis. We can see that the drop is more initially and it almost reaches a constant value towards the end. Fig 7 shows the plot of temperature v/s time. The results shown were obtained when either of the power supplies was used. After reaching the required temperature if the power supply is removed then it takes about 1hr for the temperature of the refrigerator to come back to room temperature.

Table. 2 Temperature drop with time taken

Sl.No	Time elapsed(min)	Temperature(°C)	Temperature drop (°C)
1	0	26.8	0
2	4	25.4	1.4
3	10	23.6	3.2
4	15	21.0	5.8
5	25	18.0	8.8
6	32	15.5	11.3
7	47	13.8	13
8	53	12.2	14.6
9	59	11.7	15.1
10	70	11.2	15.6

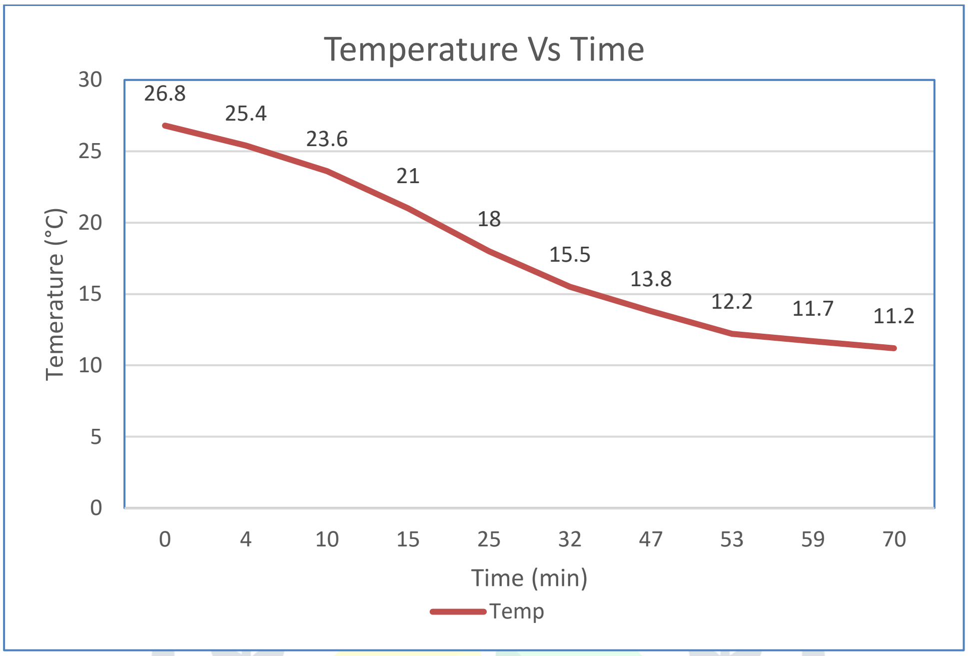


Fig 7: Graph plotted for temperature v/s time

VI. RESULTS AND CONCLUSION

Vaccine storage requires very efficient cooling. We have tried to achieve this cooling using Peltier module and powered it using solar power, making it cost effective as well as environment friendly. This work portrays a study and a realization of a new prototype of photovoltaic refrigerators which largely respects our environment.

We have designed a photoelectric refrigerator which has successfully achieved a 15-degree centigrade drop from the room temperature (from 26.6 to 11.7 degree centigrade), making it almost equal to the temperature required to store vaccines.

This refrigerator can be powered using solar panels, battery and SMPS. Alternate power supplies have been provided so that it can work efficiently by using any of the power supplies. The battery that we have used takes about 2hrs to discharge. In situations where SMPS is not able to power the refrigerator then the battery can power the refrigerator. The battery is charged by solar panel or SMPS.

6.1 Future Scope

- The insulation can be improved so that the cooling achieved can be retained for longer durations.
- Peltier modules and heat sink with further efficiency can be used so that cooling can be achieved in shorter duration. Solar panels of higher ratings can be used for the same.
- The project can be automated using IoT technologies.

VII. ACKNOWLEDGMENT

Our sincere acknowledgement to the New Gen Innovation and Entrepreneurship Development Centre. Our most sincere acknowledgement to the Management of B.N.M Institute of Technology. We would like to thank our guide Smt. Ashwini A, Dept.of EEE, BNMIT for the constant guidance, support and suggestions throughout the project.

VIII. REFERENCES

[1] Farzad AFSHAR, "A review study on Peltier cooling devices; application and performance", December 18-20, 2020 published in Research Gate.

[2] Uttam Kumar Chaudhary, "Solar Refrigeration using Peltier Module by International Journal of Engineering and Techniques", Volume 4 Issue 2, Mar-Apr 2018.

[3] Abhishek Sharma, Alka Bani Agrawal, “Thermoelectric Based Solar Powered Refrigeration System”, published in International Journal on Emerging Technologies, 02nd August 2019.

[4] Sunil Kumar Mahapatro, “Maximum Power Point Tracking (MPPT) Of Solar Cell Using Buck-Boost Converter”, Vol. 2 Issue 5, May – 2018 published in International Journal of Engineering Research & Technology (IJERT)

[5] Chetan Singh Solanki, Solar Photovoltaics: Fundamentals, Technologies and Applications, PHI Learning Pvt Ltd. 2011.

[6] Min, G., Rowe, D. M. (2016). “Experimental evaluation of prototype thermoelectric domestic-refrigerators”. Applied Energy, 83(2), 133-152