"Solar Power Based Thermo-Electric Portable Refrigeration cum Oven System"

[1]Mohnish Fulzele,[2]Tushar Prajapati,[3]Dharti Tagde,[4]Shubham Ingle,[5]Ghanshyam Malaiya, [6]Prof. Priyanka Gaurkhede.

[1,2,3,4,5]Student of Suryodaya College of Engineering and Technology, Nagpur.

[6]Prof.,Department of Electrical Engineering, Suryodaya College of Engineering and Technology, Nagpur.

Abstract

Thermoelectric Cooling (TEC) solar refrigerator runs on energy provided by sun, which includes photovoltaic or solar thermal energy. The Thermoelectric module refrigerator work on the principle of Peltier effect. Recently, the application of TEC modules in an industry is dramatically increased. They have been adopting the solar refrigeration, widely recognized as alternative to the conventional vapour compression system for their merits of energy saving and being eco-friendly.

The paper presents a design of TEC solar refrigeration using thermoelectric cooling and heating. The aim of this paper is to establish an alternative eco-friendly refrigeration cycle for producing a temperature usually encountered in a conventional refrigerator. By designing and manufacturing such type of refrigerator adds new dimension to the world of refrigeration. The proposed solar refrigeration system using TEC module is a feasible alternative for local refrigeration system. Briefly, the paper presents an economical and feasible model of solar refrigeration system.

Key Words: **Thermo-Electric Module, Peltier Effect, Solar Energy ,Refrigeration, Oven system.**

1.1 Introduction

Thermoelectric heating (or cooling) technology has received renewed interest recently due to its distinct features compared to conventional technologies, such as vapour-compression and electric heating (or cooling) systems. Thermoelectric (TE) modules are solid-state heat pumps (or refrigerators in case of cooling) that utilize the Peltier effect between the junctions of two semiconductors. The TE modules require a DC power supply so that the current flows through the TE module

in order to cause heat to be transferred from one side of the TE module to other, thus creating a hot and cold side . Heat sinks are used with high-power semiconductor devices such as power transistors and optoelectronics such as lasers and light emitting diodes (LEDs), where the heat dissipation ability of the basic device is insufficient to moderate its temperature. cabinet may be crate by Plastic is a material consisting of any of a wide range of synthetic or semi-synthetic organics that are malleable and can be moulded into solid objects of diverse shapes. Plastics are typically organic polymers of high molecular mass, but they often contain other substances. They are usually synthetic, most commonly derived from petrochemicals, but many are partially natural. Plasticity is the general property of all materials that are able to irreversibly deform without breaking, but this occurs to such a degree with this class of mouldable polymers that their name is an emphasis on this ability.

The main objective of the heating & cooling system service is to be suitable for use by the people who live in the remote areas of country where load-shading is a major problem. The system can also be used for remote parts of the world or outer conditions where electric power supply is not readily available.

1.2 Methodology

As we know that, the physical principles upon which modern thermoelectric coolers are based actually date back to the early 1800's, although commercial thermoelectric (TE) modules were not available until almost 1960. The first important discovery relating to thermoelectricity occurred in 1821 when a German scientist, Thomas Seebeck, 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. In 1834, a French watchmaker and part time physicist, Jean Peltier, while investigating the "Seebeck Effect," discovered the “Peltier Effect” and it is the fundamental principal behind a thermo-electric system.

There are a number of experimental and numerical studies that characterized the performance of TE heating and cooling systems. Luo, et al. performed experiments and verified that a TEHP system is more efficient than an electrical heating device, for its heating coefficient reached more than 1.6 with suitable operating conditions.

Riffat and Qiu compared the performance of the thermoelectric air-conditioner with two other types of domestic air-conditioners, namely the vapour compression air-conditioner and the absorption air-conditioner.

\Dai et al. conducted an experimental investigation on a portable solar-TE refrigerator for small-scale remote applications or in areas where electric supply is unavailable. Their results showedthat the unit can maintain the inside temperature at 5–10oC, and have a COP of approximately 0.3

1.3 Block Diagram

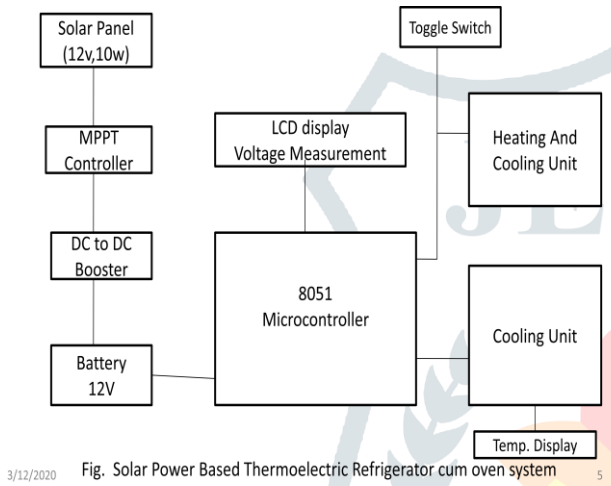


Fig 1.3.1. Solar Power Based Thermo-Electric Portable Refrigeration cum Oven System

Working

A thermoelectric device will create a voltage when there is temperature difference on each side of the device. On the other hand when a voltage is applied to it, a temperature difference is created. The temperature difference is also known as Peltier effect. Thus TEC operates by the Peltier effect, which stimulates a difference in temperature when an electric current flows through a junction of two dissimilar materials. A good thermoelectric cooling design is achieved using a TEC, which is solid state electrically driven heat exchanger. This depends on the polarity of the applied voltage. When TEC is used for cooling, it absorbs heat from the surface to be cooled and transfers the energy by conduction to the finned or liquid heat exchanger, which ultimately dissipates the waste heat to the surrounding ambient air by means of convection.

Here we are using Micro controller (AT89S52) allows dynamic and faster control. Liquid crystal display (LCD) makes the system user-friendly.

In this project we are using solar panels for charging a Lead Acid Battery (12V, 1.2 Amp hrs), a pelteir thermoelectric device when connected to battery generates cool effect and hot effects depending on the mode required by the user. Since we are using this for fridge we need only cool mode. A peltier thermoelectric device is connected to the battery to generate cooling effect.We need to display the voltage for that we are using ADC0808 which is given to the controller. For this ADC we are giving a clock pulses through 555 timer to perform its operation.

This project uses regulated 5V; 500mA power supply. A 7805 three terminal voltage regulator is used for voltage regulation. Bridge type full wave rectifier is used to rectify the ac out put of secondary of 230/12V step down transformer.

1.4 Operating Principle Of The Thermo-Electric Module

The TEM operating principle is based on the Peltier effect. The Peltier effect is a temperature difference created by applying a voltage between two electrodes connected to a sample of semiconductor material to create a hot side and a cold side. The cold side of the thermoelectric module is utilized for refrigeration purposes; provide cooling to the refrigerator space. On the other hand, the heat from the hot side is utilized for heating purpose.

In a thermo-electric heat exchanger the electrons acts as the heat carrier. The heat pumping action is therefore function of the quantity of electrons crossing over the p-n junction.

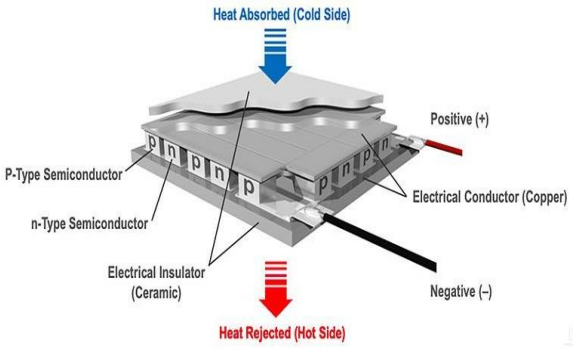


Figure 1.4.1 : Operating principle of thermo-electric module (adapted from scientific and production firm module -ISO 9001)

1.5 Advantages

In this project thermoelectric cooling offers a number of advantages over traditional refrigeration methods, as:

1. System have no moving parts,
2. No Freon's or other liquid or gaseous refrigerants required,
3. Precise temperature control,
4. High reliability & durability - We guarantee 5 years hours of no failures,
5. Compact size and light weighted,
6. Noiseless operation,
7. Relatively low cost and high effectiveness,
8. Easy for maintenance,
9. Eco-friendly.

1.6 Disadvantages

1. C.O.P. is less as compared to conventional refrigeration system.
2. Suitable only for low cooling capacity.

1.7 Limitation

In rainy season it cannot be possible to charge battery due to irregular atmospheric condition as our project is totally based on solar energy. This is the limitation of our project, but this problem can be solved by giving direct electric supply.

1.8 Scope

1. In these days the society face the energy crisis but also the harmful effects of pollution. The thermoelectricity is a "Green Technology" to generate electricity without any harmful effect.

2. The educational institutions, furnace regions, metro cities, industrial areas, universities and other locations can be selected for the establishment of such energy centres where the waste heat can be easily available and can be recycled after conversion to the same system.

3. This system would be used for air ventilation in car.

4. This system is boost for government policies like solar cities and solar cities as well.

1.9 Applications

1. Can be uses for remote place where electric supply is not available,

2. Medical and pharmaceutical equipment,

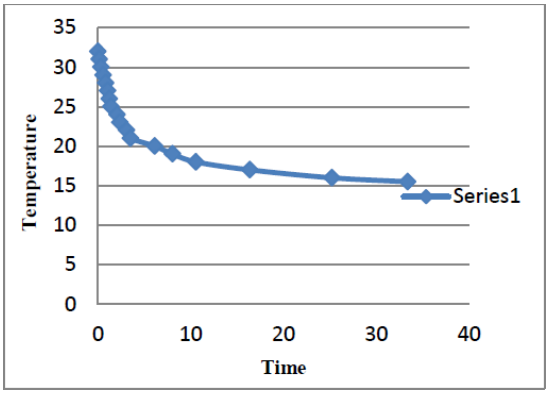
3. Military applications,

4.Laboratory, scientific instruments, computers and video cameras.

5. In restaurants /hotels.

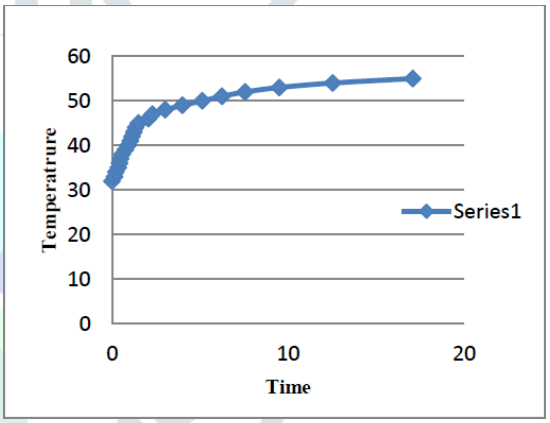
1.10 RESULTS AND DISCUSSIONS

We have done experimentation on project without load. Cooling and heating by using peltier circuit is done. Temperature change with respect to time is measured,



GRAPH 1-COOLING (WITHOUT LOAD)

Cooling by thermo-electric device reduces temperature 32oC to 15.5oC in 35 minutes.



GRAPH 2-HEATING (WITHOUT LOAD)

Heating by thermo-electric device increases temperature 32oC to 60oC in 20 minutes.

1.11 Conclusion

A portable Heating & Cooling system was fabricated using thermoelectric module & electric control unit & tested for the cooling and heating purpose. The system is self powers

& can be used in isolated & a remote part of the country where load-shading is a major problem. The important aspect to be noted is that it is a onetime investment & is free from maintenance.

The heating & cooling rates for different modes of heat transfer (conduction & convection) for water; fruit (orange) & metal (Al) are analyzed. Analysis of various materials such as metal, fruit and water is plotted on graph as time on X-axis and temperature on Y-axis. The analysis of various materials indicates that

a. Cooling rate for conduction of water is higher compared with convection of water.

b. The heating rate of water is higher than cooling rate.

Further improvement in the efficiency of the system may be possible through improving module contact-resistance & thermal interfaces. This could be achieved by installing more modules in order to cover a greater surface area of the system.

1.12 Acknowledgement

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