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Solar Based Thermoelectric Refrigerator Using Peltier Module

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Abstract: ***Refrigerators being used nowadays, utilize a compressor and coolant as a working fluid for the transmission of the heat. Thermal energy is absorbed and released as the coolant used goes through expansion and compression and its state changes from liquid to vapor and vice-versa. The solar-based thermoelectric refrigerator also known as the Peltier refrigerator offers several advantages over conventional systems. It consists of solid-state devices, with no mobile parts, which makes the system dependable, and less noisy. There is no use of ozone-depleting chlorofluorocarbons, which have an inadequate effect on the environment. They occupy a very small room for operating, much less than the conventional systems. Temperature is controlled (< ± 7 °C) with the help of Peltier coolers. The efficiency of these coolers is less as compared to compressor-based refrigerators. Thus, they are used in specific applications where their unique advantages. However, some large-scale applications have been considered Peltier coolers are generally used in applications where small size is needed and the cooling requirement is low, for instance, cooling electronic components. The main motto of this project is to design a prototype of a thermoelectric Refrigerator using the Peltier effect to maintain a specified temperature, perform temperature control in the range of 5 °C to 25 °C, and provide refrigeration in the remote areas where the power supply is not possible.***

Keywords: solar refrigerator, Peltier module, thermoelectric, Peltier effect, refrigeration

I. INTRODUCTION

Among all the sources of renewable energy Solar energy has the greatest potential, even if a small amount of solar energy could be used, it will be one of the most important supplies of energy. Solar energy maintains the temperature of the world above than in colder space, a current is caused in the atmosphere and seas, is responsible for the water cycle, and also helps in the photosynthesis process in plants. The worldwide demand for power for all needs of the civilization is 10 Watts. Hence the sun provides us a thousand times more power than we require. If we utilize 5% of this energy, it will be fifty times what the whole globe will require. Electricity can be generated from solar energy with photovoltaic solar cells, which convert the solar energy to electricity. The significant applications of a photovoltaic cell in Asia are the energization of pump sets for farming irrigation, drinking water, rural electrification, covering the street lights, community TV sets. Refrigeration is the most common way of keeping a thing below room temperature by keeping a substance intended to cool or freeze. Refrigeration has numerous applications such as household fridges, modern coolers, cryogenics, and hotness siphons. The absence of heat is cold, consequently, to lower the temperature, one must eliminate heat, rather than add coldness. To fulfill the second law of thermodynamics, work must be performed. Thermoelectric Cooling/ Refrigeration uses the Peltier effect to generate a heat flux between the junction of two different types of semiconductor materials. Peltier Plate transfers heat from one side to the other, with consumption of electrical energy, which depends on the current's direction. Such an instrument is also called a Peltier device, Peltier module, and thermoelectric cooler (TEC). It will be used for cooling moreover as for the heating purpose, though practically the most aim is cooling. It can even be used as a temperature controller. The benefits of a Peltier cooler as compared to a vapor-compression fridge are the area unit, its non-movable components or current fluid, long life, protection to the leaks, compact size, and its versatile form. The disadvantages are a unit its means too high-priced and poor output rate. A lot of researchers and companies are trying to develop Peltier coolers that are price-effective and contain additional power. Peltier's plate once operated for cooling purpose, across the device a voltage is applied, consequently, a distinction in temperature are aroused between the 2 sides. Once operated as an electrical generator, one facet of the device has a temperature greater than the opposite facet, and hence, a voltage distinction is raised between the 2 sides of the plate (known because of the Seebeck effect). Thermoelectric cooler (TEC) is cooler and heater both. This is possible because of the combination of 2 different materials to own hot and cold junctions at its ends. This impact is achieved by the action of electrical voltage or potential. TEC works on the Peltier impact principle within which the electrical voltage applied turns into the thermal gradient. Electricity impact is visible once electrical phenomenon is applied across the semiconductor materials P and N kind. The direction of the present flow is to blame for the heating and cooling impact, the energy is carried by lepton from cold to a hot junction. Though having too several benefits' TEC cooler have a low constant of performance because the heat absorption at the cold junction is incredibly less than energy equipped.

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II. OBJECTIVE

A. The objective of the project is to develop a thermoelectric cooling system by using solar energy.
B. To study the different thermoelectric materials that are essential to enhance the thermoelectric cooler coefficient of performance.
C. To use the solar-based refrigerator as an alternative to using the compressor.
D. To achieve a higher coefficient of performance.

III. METHODOLOGY

Thermoelectric refrigerators operate using the Peltier effect (thermoelectric effect). Peltier effect in short is a generation of heat from electrical energy. Peltier plate (TEC) is made up of two unique semiconductors, one is n-type and one is p-type. They are used because they have different electron densities. The alternating p & n-type semiconductors are placed thermally in parallel to each other and electrically in series and then joined with a thermally conducting plate on each side and sand witched between two ceramic insulators.

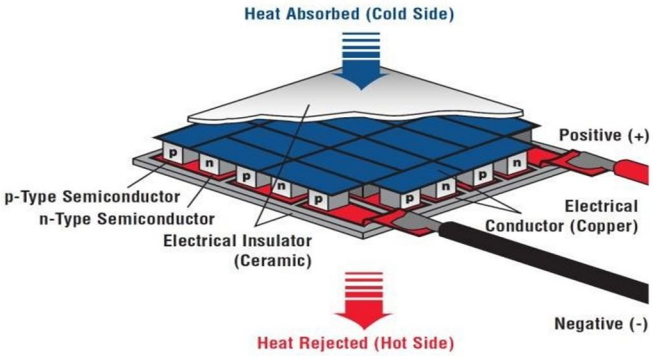


Fig.1 Structure of Peltier module

When a voltage is applied to the free ends of the two semiconductors using copper rods there is a generation of junctions at two semiconductors. The flow of DC across the junction of the semiconductors builds a temperature difference. The device has two sides, and when a current flows through the device, it produces heat from one side to the other, so that one side gets cooler while the other gets hotter. The side with the low temperature i.e. cool side absorbs heat which is then transported by the semiconductor to the other side of the device, so another side becomes hot. The hot side is attached to a heat sink so that it remains at normal temperature while the other side goes below ambient temperature. In some applications, multiple Peltier modules (TEC) can be packed together for obtaining the desired temperature.

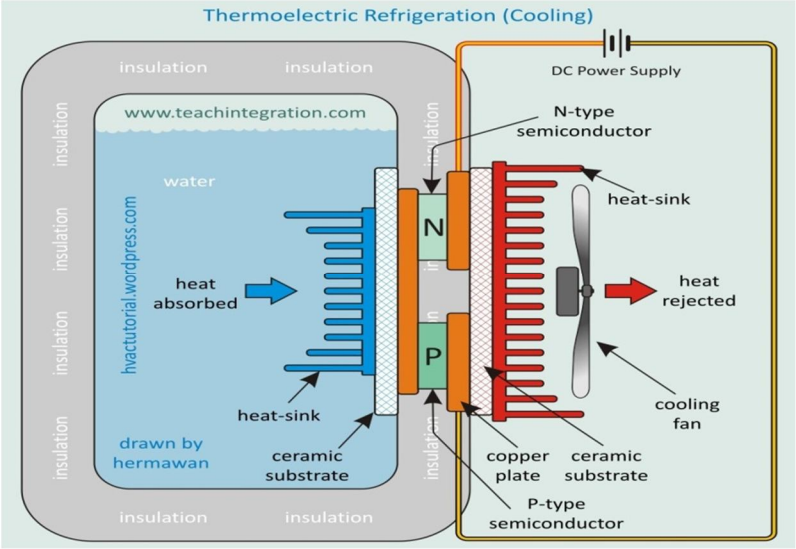


Fig.2 Schematic representation.

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The solar panel converts light energy into electrical energy. Two types of solar panels can be used Monocrystalline and polycrystalline solar panels. According to project specifications we use monocrystalline type due to its high efficiency so, these panels produce DC. The battery is used for the storage of electricity coming from solar panels, sometimes batteries built with inverters are used for the conversion of DC to AC. This current is passed to copper rods then it goes to n & p semiconductors through it. Formation of junctions takes place due to passing a current through semiconductors, heat is produced and one side becomes cool by absorbing heat & other become hot. The heat sink is attached to the hot side for the release of heat in the atmosphere.

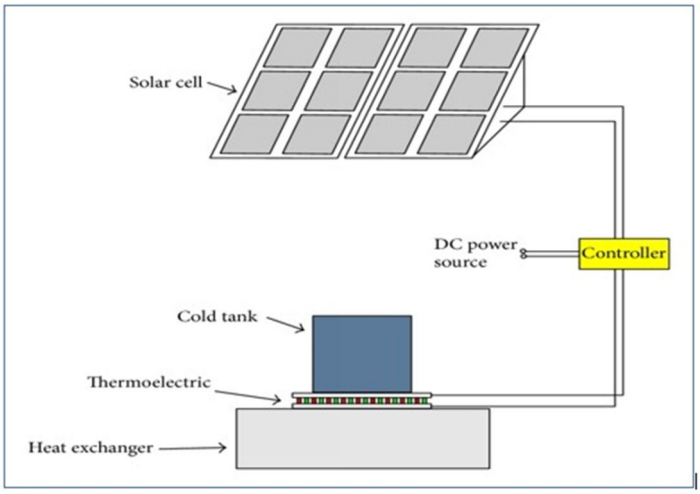


Fig.3 Assembly of System

IV. CALCULATIONS

For the results of our project, after assembling all the parts, we had taken trials for No-load (Air Cooling), medium load (normal water), and cold water. The readings were noted and then 3 plots of time versus temperature drop, time versus heat rejected, and time versus COP were plotted for each case. The results obtained are given below.

A. Trial on Cold Water

Time Vs Temperature drop:

In this trial, it was concluded that as time commences, the temperature drops decrease up to a certain limit and thereafter it increases.

For Normal Water the Theoretical and Actual COP Calculations are as follows:

m = mass of water

Cp =specific heat

ΔT = temperature difference.

t = time

$$Q_{(rej)} = \frac{m * Cp * \Delta T}{t}$$

V. MATERIALS

1) Inner Steel Casing
2) Outer Plastic Casing
3) Inner Plastic Insulation with Thermal Grease
4) Ampere regulator/ Battery / SMPS
5) TEC1-12706 – 1 in Numbers
6) Heat Sink (Rectangular) – 8 in numbers
7) Blower – 1 in numbers

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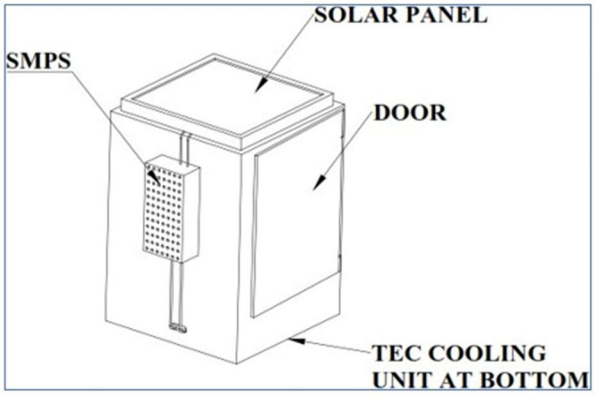


Fig 4. Design of solar refrigerator

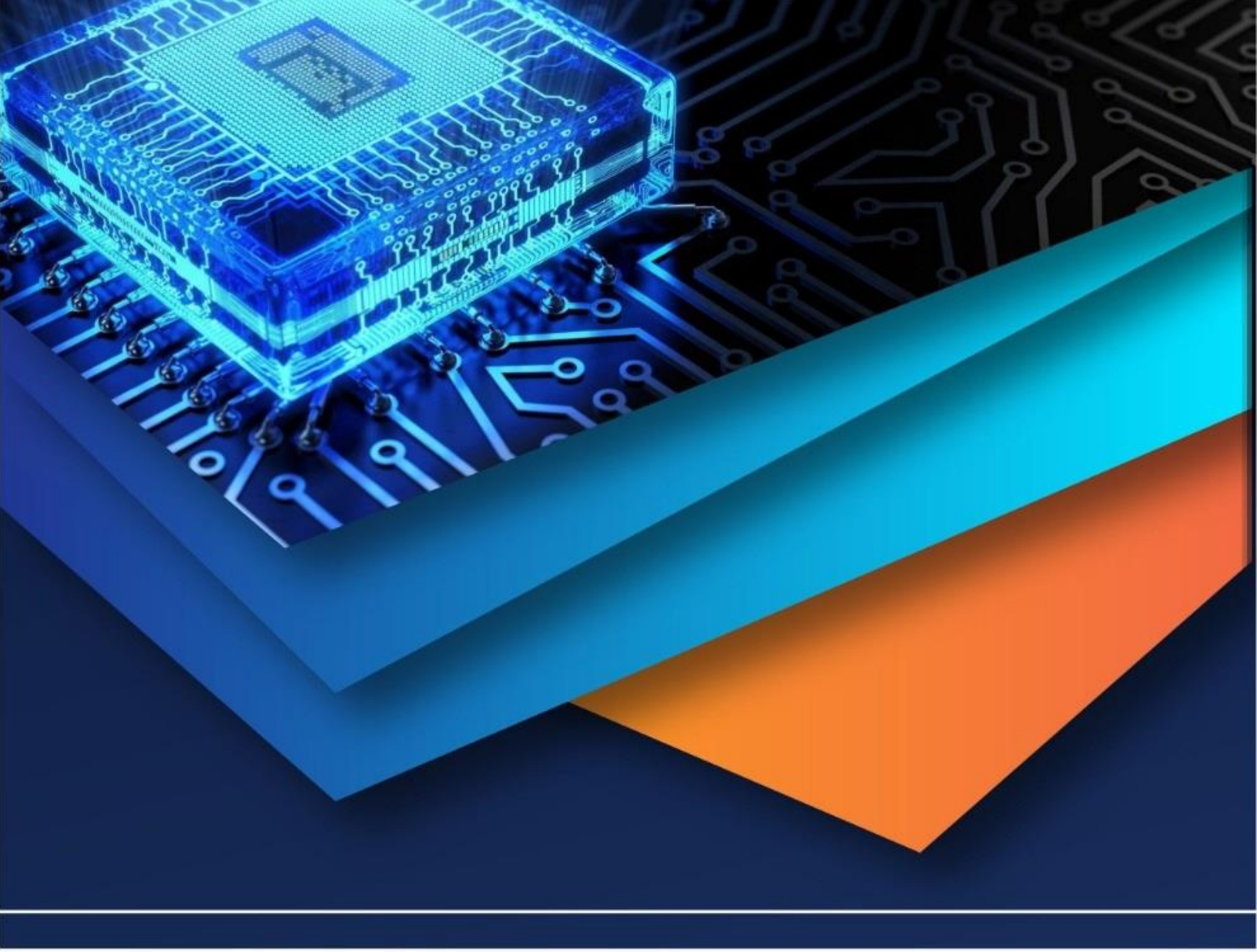
VI. CONCLUSION

TEC is a versatile component that is very compact in size as compared to a compressor-based system that works on the Peltier principle. The performance of TEC depends on the Peltier cooler coefficient, the electric current, also Seeback coefficient, and the difference of temperature between the two junctions. Optimization of the Conventional pyramid-styled and cuboid-styled multi-stage cooler deals with determining the optimum ratio of the number of Thermoelectric modules and optimum ratio of electric current between stages respectively.

Also, we can conclude that the reliability of the Peltier module available in India is less with an unsatisfactory level of cooling. Thus more research is required in the cooling module design with high-quality Peltier modules to be made available from research-based countries like the U.S or Europe.

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