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SOLAR POWERED COLD STORAGE USING PELTIER

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Abstract: In this paper the creation of cold storage systems powered by solar energy using peltier module is developed. This project involves an advancement in cold storage technology that combines flexibility and portability with solar energy's efficiency. The need for cold storage solution is growing. In the contemporary world particularly in rural areas and off-grid locations. The solar powered cold storage system might have a significant in an area including agriculture, medications in health centers, emergency supplies etc. Solar powered cold storage system using peltier provides a number of benefits over traditional refrigeration systems due to its light weight, environmental friendliness, silent operation etc.

Index Terms – Refrigeration, Peltier module, Water block

I. INTRODUCTION

Solar powered cold storage system using peltier technology leverage solar energy to generate electricity, which powers peltier modules for cooling. This system provides off-grid cooling solutions for preserving perishables goods such as food and medicine in areas with limited access to electricity. They offer sustainable and friendly to the environment alternatives to conventional refrigeration methods, contributing to energy efficiency and reducing reliance on fossil fuels. In this project we use peltier modules, also known as thermoelectric coolers, which are solid-state devices that utilize the Peltier effect to create the difference in temperature between the two sides of the module when an electric current passes through it. One side of the module becomes hot while the other side becomes cold, allowing for heat transfer without the need for refrigerants or moving parts. These modules are frequently utilized in portable refrigeration, temperature regulation in electrical gadgets, an small-scale cooling applications. In solar-powered cold storage systems, Peltier modules play a crucial part in providing the necessary cooling without relying on traditional compressor-based refrigeration systems.

Traditional cold storage methods can rely on expensive, environmentally risky diesel generators or grid electricity. They generally only work in fixed places, which limits the utility in remote or dynamic environments. The cold storage using peltier method is noiseless, eco-friendly, compressor less, no emit of freons, compact, less expensive. The demand for cold storage facilities in India is being increasing day by day due to the growth of food processing industry and the need to reduce post-harvest losses that helps to extent their shelf life and maintain their quality. 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

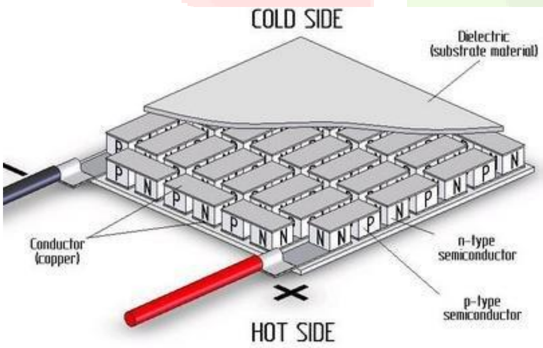
II. Literature survey

2.1 Y. Xu et al. focused their research on the experimental investigation of solar photovoltaic operated ice storage air conditioning system. They have tested two operational models by experiments. The findings of their investigation showed that it is feasible to use ice thermal storage instead of battery bank to store solar energy in the field of distributed photovoltaic refrigeration. The significant findings that were made from the experiments were that the battery bank could be completely replaced by ice in energy storage process of ice thermal air conditioning driven by distributed photovoltaic energy system in sunny day. The average efficiencies at that time were 5.62 times of the average efficiencies under working mode1.

C. Gabriele et al. investigated the viability of Cold Thermal Energy Storage (CTES) in hot climates with year-round cooling seasons for building demand management applications. They created a fresh metric called Savings per energy unit to evaluate CTES's efficacy. For their case study, they used an existing building in Singapore. In order to take advantage of the chance to increase overall efficiency and distribute the difference between peak and off-peak energy tariffs, the CTES was coupled to the current cooling system. Various methods have payback times ranging from 8.9 years at lowest to 16 years at maximum.

III. Methodology

In this solar powered cold storage system we use peltier modules, also known as thermoelectric coolers, are solid-state devices that utilize the practicality of Cold Thermal Energy Storage (CTES) for building demand management applications in hot regions with continuous cooling seasons.,the module when an electric current passes through it. One side of the module becomes hot while the other side becomes cold, allowing for heat transfer without the need for refrigerants or moving parts. These modules are frequently utilized in portable refrigeration, temperature regulation in electronic devices, and small-scale cooling applications. In solar-powered cold storage systems, Peltier modules electronic 6 devices, and small-scale cooling applications. In solar-powered cold storage systems, Peltier modules play a key role in providing the necessary cooling without relying on traditional compressor-based refrigeration systems. The Peltier module is structurally composed of positive and negative doped pellets of semiconductor material placed between two electrically insulated but thermally 8 conductive ceramic plates.. When electricity is passed through the module, electrons move in one element and positive holes move in the other element, this is called the "Peltier effect." This allows one side of a substrate to absorb heat and the other to emit heat, 3 causing the hot and cold sides to alternate according on the direction of flow.



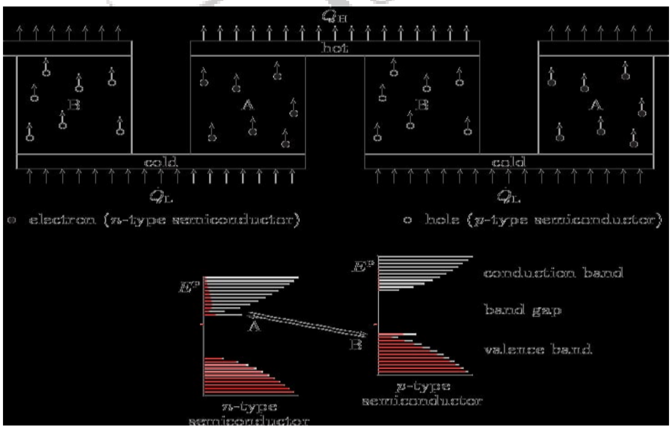


Fig a. Structure of peltier module TEC1-12706 **Fig b. Peltier module for thermoelectric cooling**

3.1 The equation for peltier effect is,

$$\mathbf{q = I} \ldots (1)$$

$$\mathbf{q = \pi ab * I} \ldots (2)$$

Where,

q= Peltier heating and cooling rate.

πab= Peltier coefficient.

I = current in the peltier module.

3.2 The Peltier Module has two features:

1. It can transform thermal energy into electricity, or when it receives power.

2. Hazardous gases such as hydro chlorofluorocarbons (HCFCs) and chloro fluorocarbons (CFCs) can be produced or used by conventional systems. These dangerous gases cannot be produced or used by the peltier module.

3. During operation, the traditional refrigeration system may produce some noise. No noise can be produced by peltier module while it is operating.

4. A DC power supply can be used to power a Peltier module.

5. The Peltier module can precisely adjust temperature by utilizing an appropriate closed loop circuit.

In this method of refrigeration system a heat sink is necessary to remove the heat generated from the peltier module's heated side hence water blocks are employed for removing the heat generated from the peltier, rather than water block we can use fans for cooling, but efficiency of cooling through fans is less than the water blocks. The viper motor is employed for pumping the motor through water blocks. A water block is better at dissipating heat than an air-cooled heatsink due to waters higher specific heat capacity and thermal conductivity.

Water block

3.3 Block diagram:

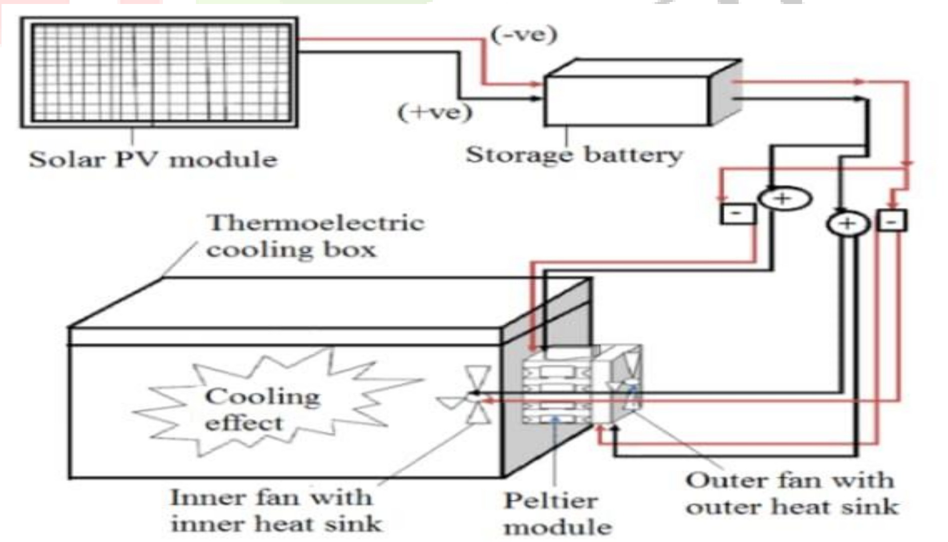


Fig c. Block diagram of Solar powered cold storage using peltier module

A electric current generated from the solar photovoltaic module is sent to the Peltier modules, the electric current is converted to the temperature different of a designated material. The designated material is composed of P-type and N-type semiconductor connected in series electrically and parallel in thermal. The DC power is connected to the system heat is transferred from one side to another resulting a disparity in temperature of both sides of Peltier element. By applying thermoelectric principle, a proper cold storage system is developed. In the inner part of cold storage, cold junction of a peltier element is attached while hot junction faces the environment temperature. For a proper removal of heat from hot junction water blocks are used as heat sink, for the movement of water a motor is employed for the pumping of water. The cooling chamber is cooled.

3.4 Components used:

3.4.1 Solar panel: A Solar photovoltaic module was a package interconnected assembly of PV cells known as Solar cells. An installation of PV modules is known as Solar Panel. A Poly crystalline solar panel is utilized because it can produce more energy in less space which consists of pure silicon with different silicon fragments. A poly crystalline or a multi crystalline solar photo voltaic module consist of several crystals of silicon in a single PV cell. When the photons from the sunlight fall on the PN junction between N-type and P-type, it imparts energy to the electrons so that they can flow electric current.

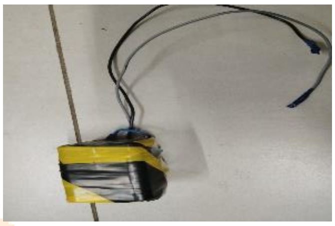


Fig d. solar panel

Specifications: 12 V, 5 watt
Temperature co-efficient is -0.3%/c to -1%/c
Current at max power is 2A

3.4.2 Battery: For a constant refrigeration, batteries are used in cold storage system as a backup power. Lithium-ion battery is used for backup power supplies and for continuous power supply. It provides reliable starting power and delivers a strong and consistence electric current to run the peltier module.

Li-ion 12V, (2500mAh) cells are used, 9 batteries are connected series which produces approximately 1500 watts, 19Ah of power for the efficient power supply for the peltier module.

Li-ion the energy density of batteries is high, when it comes to energy density, lithium-ion batteries are top performers. It has long lifespan and good temperature tolerant. It has low self-discharge.

Fig e. Li-ion battery

3.4.3 Peltier module: The Peltier module is structurally composed of positive and negative doped pellets sandwiched between two electrically isolated yet thermally conducting layers of semiconductor material ceramic plates. When electricity is passed through the module, electrons move in one element and positive holes move in the other element, this is called the "Peltier effect." This allows one side of a substrate to absorb heat and the other to radiate heat, so the hot and cold sides to be switched depending on the current direction.

In this project , we are using Peltier module TEC1-12706

Operating voltage: 12v
Maximum current: Imax(A) is 6A
Maximum output power: 55 W
Dimensions: 40*40*3.6mm

Advantages: Vibration free, noise free, no moving parts, compact.

Fig f. Peltier module

3.4.4 Water block: Liquid coolers excel at delivering cooling to concentrated heat sources such as peltier elements and for delivering cooled fluid where the cooling assembly itself cannot be located. The basic operation is fluid flows in one tube, it is cooled and then it flows out the other tube. An external pump is required, a typically small DC magnetic-drive pumps are used to minimise the amount of pump power(heat) that is imparted to the fluid.

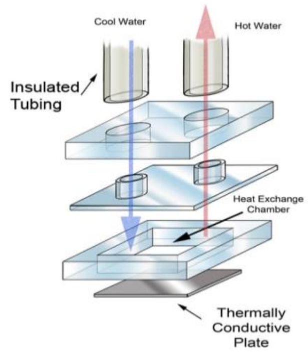


Fig g.Water block (12V DC) Fig h. Inner view of water block

3.4.5 **Motor:** To remove the hot temperature, form the hot side of the peltier module the water is pumped through the water block. To pump the water the viper motor is used. It is a 12V dc motor.

Fig i, Viper motor (12V DC)

3.4.6 Thermometer: It is used to measure the temperature of the cold storage chamber. A digital thermometer is used for accurate measurement of temperature.

Fig j, Digital thermometer

3.4.7 Cooling chamber: The chamber that generate a cool and humid environment to protect the perishables i.e. fruits, vegetables, medicines etc. wood is used for insulation for this project as it is small scale presentation.

Fig k, Cooling chamber

4. Working of Solar powered cold storage system using peltier module:

The Peltier module used in the experimentation is TEC1-12706, which is operated by a 12 V power supply. The water to be cooled down is kept in a small water tank that is mounted on the cold side of the Peltier module, and the water flowing via a water block dissipates the heat produced on the hot side of the Peltier module. The water block is attached by thermal paste on the hot side of the module. A 12 V water pump was placed inside a tub full of water to ensure the flow of water through a pipe. Water flows through pipes and passes through water blocks attached to remove the heat. A thermo-electric module (TEM) is a solid-state current device when power is applied heat will move from the cold side to the hot side, acting as a heat exchanger. Combination of many pairs of p and n-semiconductors allows creating cooling units - Peltier modules of relatively high power. A Peltier module consists of semiconductors mounted successively, which form p-n-p and n-p-n junctions. When switching on the current of the definite polarity, there forms a temperature difference between the radiators one of them warms up and works as a heat sink, and the other work as a refrigerator.

5. CONCLUSION

The cold storage using Peltier functions best when the photovoltaic (PV) module and the battery are put together as the source of energy continuously. Peltier devices are solid-state components with no moving parts, resulting in greater reliability and durability compared to mechanical refrigeration systems. This inherent robustness translates to reduced maintenance needs and extended operational lifespans, enhancing the overall cost-effectiveness of solar cold storage solutions. We can achieve the cooling up to 1-2 degree Celsius using this Peltier modules. If the power supply is continuous, we can even get the temperature in minus degree Celsius.

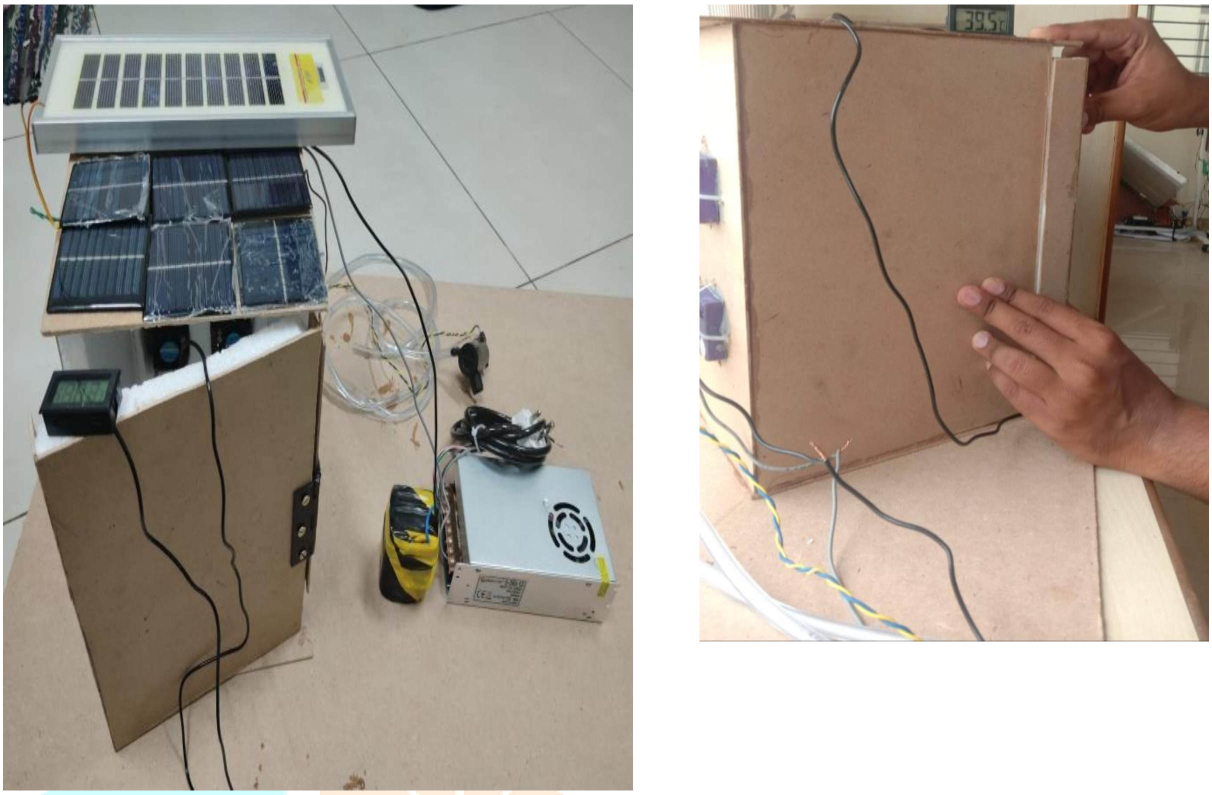


Fig.L Final view of solar powered cold storage system using peltier

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