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Solar Refrigerator and Oven Using Thermoelectric Module

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ABSTRACT : In the recent year, we have many problems such as electrical energy and environmental degradation, due to the increasing co_2 emission and ozone depletion has become primarily concerned to both developed and developing countries. Our project utilizes the solar energy for its operation. Solar refrigeration/heating using the thermoelectric module (Peltier device) is going to be one of the most cost effective, clean and environment friendly project. This project does not need any kind of refrigerant, microwave cavity and mechanical devices like compressor, condenser, etc. for its operation .The main purpose of this project is to provide refrigeration/heating effect to the village area where power is not possible. Now refrigeration/heating has been one of the most important factors of our daily life. The current tendency of the world is to look at renewable energy resources as a source of energy. This is done for the following two reasons. Firstly, the lower quality of life due to air pollution and secondly due to pressure of the increasing world population puts on our natural energy resources. In this project, we are using peltier effect for refrigeration/heating effect. This effect was discovered by Jean Charles AthanasePeltier in 1840. Solar panel is use for converting solar energy to electrical energy. Battery isused for stored energy. This energy is given to peltier device which is used for refrigeration/heating.

Keywords – Seebeck effect, Refrigeration, Peltier effect, Thermo-electric module, Solar energy.

I. INTRODUCTION:

From last century till now refrigeration and oven has been one of the most important factors of our daily life. The current tendency of the world is to look renewable energy resources as source of energy. This is done for following two reason; firstly, the lower quality of the life due to air pollution; secondly, due to the pressure of the ever increasing world population puts on our natural energy resources. From this two facts comes the realization that the natural energy resources available will not last indefinitely.

The basic idea is implementation of photovoltaic driven refrigerating system powered from direct current source or solar panel (when needed) with a battery bank. In 1821, the first important discovery relating to thermoelectricity occurred by German scientist Thomas Seebeck who found that an electric current would flow continuous in a closed circuit made up of to dissimilar metals, provided that the junction of the metal where maintained at two different temperature. Without actually comprehending the scientific basis for the discovery, Seebeck, falsely assumed that flowin heat produced the same effect as flowing electric current. Later, in 1834 while investigating the Seebeck Effect, a French watchmaker and part-time physicist, Jean Peltier found that the there was an opposite phenomenon where by thermal energy could be absorbed at one dissimilar metal junction and discharge at the other junction when an electric current flows within the closed circuit. Afterwards, William Thomson describes relation between Seebeck and Peltier effect without any practical application. After studying some of the earlier thermoelectric work, Russian scientist in1930, inspired the development of practical thermoelectric module based modern semiconductor technology by replacing dissimilar metals with doped semiconductor material used in early experiment.

The Seebeck, Peltier and Thomson effects together with several other phenomena form the basis of functional thermoelectric modules. Thermoelectric refrigeration aims at providing cooling and heating effect using thermoelectric effect rather than the more prevalent conventional methods like those using the ‘vapour compression cycle’ or the ‘gas compression cycle’.

Objectives:-overall short term aim was to develop a small, inexpensive and compact cooler box using a TEC heat Exchanger. As has already The been

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explained in section above an important design parameter should be the ability to Function under variable input power conditions. By using a cooler box, all the power provided by the PV systemCould be utilized during the day, achieving very high overall efficiency for the PV system.

1. To make use of environmentally friendly refrigeration system.
2. To investigate the cost and effectiveness of the design or TE module.
3. To identify the improvements on the experiment.
4. To study the results coming out from this project.
5. To compare results with theoretical result.
6. To look at commercially available 12VDC cooler boxes.
7. To construct a test on the behaviour and specifications of a TEC heat exchanger operating in a cooler box.

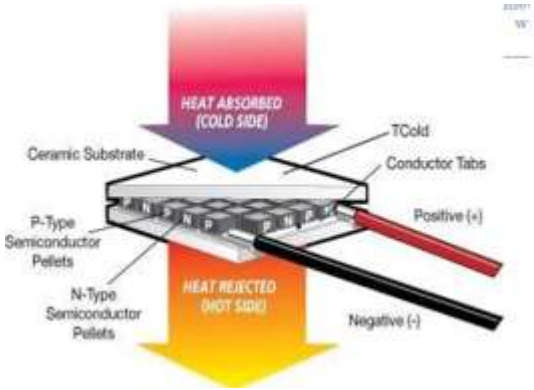
Principle of Working of Thermoelectric Refrigerator:- The solar plate absorbs solar energy and which passes this energy to energy convertor. This convertor converts solar energy into electrical energy and this energy is stored in battery. Battery isconnected to bridge rectifier to protect the circuit when a battery is connected in reversed. It is connected to 2 way switch which is connected to Peltier device and exhaust fan. When a current passes thro ugh a Peltier device, the Peltier effect is formed. Due to this Peltier effect one side of the Peltier device will get cooled and other side get heated. The heat sink is used to prevent thermal run away. Exhaust fan is used to dissipate the heat from heat sink to surrounding. 2 way switches is used to change the junction effect (hot to cold or cold to hot).

Figure 1.Peltier device

Thermoelectric cooling uses the peltier effect to create a heat flux between the junctions of two different types of materials. A peltier, heater or thermoelectric heat pump is a solid state active heat pump which transfer heat from one side of the device to other, with consumption of electric energy depending on the direction of current. Such an instrument is also called a peltier device, A peltier heat pump, solid state refrigerator or thermoelectric cooler (TEC). It can be used either for heating or cooling, although in practice the main application is cooling. It can also be used as temperature controller that either heats or cool.

Construction:- It consists of the one thermoelectric module which is connected to 12V 1.0amp battery which get charged by solar panels. This thermoelectric module is placed in the one insulation box and Heat sink is used to transfer the heat generated by the device on the back side of box and also fan is used to transfer heat from heat sink to surrounding and which is driven by motor also. **List of parts**

1. Thermoelectric module
2. Thermal casing
3. Heat sink and Fan
4. Battery
5. Solar cell
6. Frame



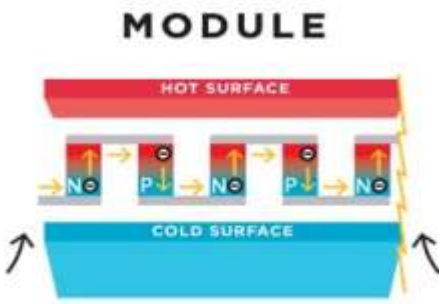


Figure 2. Construction of Peltier device **Figure 3**. Working of Peltier device

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Efficiency

COP = Q/P

Where, Q = Refrigeration effect. P = Power required.

Q = (m*Cp*ΔT)/(t * 60)

P = Power for TEC + Power for fan

Where, T = Tinitial – Tfinal m = Mass of water

Cp = Specific heat capacity of water

Results

ForCooling

Table 1.Result for Cooling

Reading No.	Time Required (min)	Obtain temperature (^{o}c)
1	0	33.38
2	12	31.3
3	24	27.1
4	36	23.7
5	48	21.4
6	60	18.2
7	70	17.6

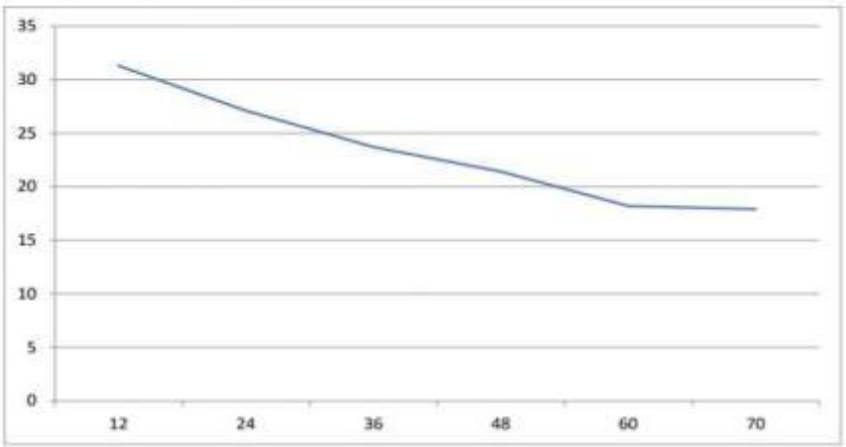

Figure 4.Graph for Cooling Result

COP FOR COOLING –

COP = Q/P

= Refrigerating effect / Power required

T1= 34 ^{O}C = 307 ^{O}K T2 = 18 ^{O}C = 291 ^{O}K

Q = m*Cp*(T1 - T2) / (t*60) = 1*4.186*(307 - 291) / (60*60) Q = 0.0186 KJ/S

P = Power required to Peltier device + Power required to fan

= 12V* 1amp + 12V *0.17amp

= 12w + 2.02w = 14.02 w = 0.014 kw

COP = Q/P = 0.0186 / 0.014

COP = 1.32

For Heating

Table 2. Result for Heating

Reading No.	Time Required (min)	Obtain temperature (^{o}c)
1	0	33.38
2	12	37.5
3	24	40.8
4	36	44.6

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5	48	48.2
6	60	52.4
7	70	53.1

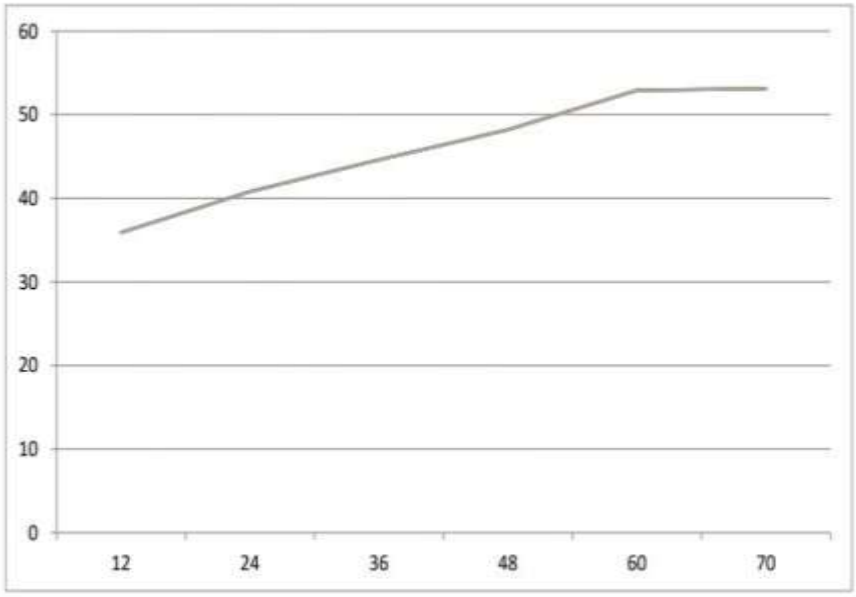

Figure 5. Graph for heating Result

COP FOR HEATING -

COP = Q/P

= Refrigerating effect / Power required

T1= 53 ^{O}C = 326^{O} K T2 = 34 ^{O}C = 307 ^{O}K

Q = m*Cp*(T1 - T2) / (t*60) = 1*4.186*(326 - 307) / (60*60)

Q = 0.022 KJ/S

P = Power required to Peltierdevice + Power required to fan

= 12V* 1amp + 12V *0.17amp

= 12w + 2.02w = 14.02 w = 0.014 kw

COP = Q/P = 0.022 / 0.014

COP = 1.58

II. CONCLUSION

The TE devices can act as coolers, heat pumps, power generators, or thermal energysensors and are used in almost all the fields such as military, aerospace, instrument,biology, medicine, industrial or commercial products. The major challenge faced in TE cooling is lower COP especially in large capacitysystems. However, as the energy costs are elevating and environmental regulations regarding the manufacture and release of CFCs have become more firm with time. TE chilling of beverage can be done at the farm level to inhibit any enzymatic or microbial change in quality of the beverage.Research in `the field of thermoelectricity and experimentation with different materials is required to improve the COP of the TE cooler.

In the coming years thermoelectricity has a lot of potential to create energy saving and effective solutions for the industry and commercially as well. The minimum temperature achieved was found to be 18◦c for cooling and the maximum temperature was 53◦c for heating in this experiment.

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