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# Devolopment of Portable Solar Thermoelectric Refrigerator

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**Abstract**— The main objective of this project is to design and develop a solar thermoelectric refrigerator inorder to produce a small amount of refrigeration effect by using solar energy.The design of refrigerator is based on the principle of peltier effect.The thermoelectric couples are solid state devices capable of producing a temperature gradient from electrical energy.The experiment results indicates the temperature reduction of 15$^{0}$c with 500ml water kept inside refrigeration space in 50 minutes with respect to 27$^{0}$c ambient temperature.The coefficient of performance of refrigerator was calculated and found to be about 0.17.

**Index Terms**—Peltier effect,Thermoelectric module,coefficient of performance,solar cell

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## INTRODUCTION

Solar thermoelectric refrigerator is type of refrigerator which utilizes solar energy instead of conventional electrical energyto power the thermoelectric module that has been used to cool the refrigeration space.Thermoelectric (TE) modules are solid-state refrigerators that utilize the Peltier effect between the junctions of two semiconductors. Thermoelectric cooling works on the principle of Peltier effect, when a direct current is passed between two electrically dissimilar materials heat is absorbed or liberated at the junction.

In this study, it used 6 nos. of thermoelectric module in design of refrigerator. The experimental results indicated that the temperature of the refrigeration was reduced from 27oC to 10oC in approximately 50 min. The coefficient of performance of the refrigerator was calculated and found to be about 0.17.

The main objective of the refrigerator service is to be suitablefor use by the people who live in the remote areas of different countries where electricity is not available.

## LITERATURE REVIEW

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. For example, 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. Bansal and Martin also reported that as the TE technology has advanced, the reliability and cost of TE cooling systems have changed favorably and at present TE systems are available for the domestic market at comparable prices. Min and Rowe investigated a number of prototype TE-coolers and evaluated their performances in terms of the cop.

## CONSTRUCTION

Here this system cool the product using thermo-electricmodule.the construction set up for this system require following parts ,

1. Solar panel, 2. Insulated Box
3. Charge controller, 4. Battery
5. Fins 6.Exaust fan
7. Thermoelectric module, 8.Metal box

### A.Solarpanel

The direct conversion of solar energy is carried out into electrical energy by means of the Photovoltaic effect i.e. the conversion of light or Other electro magnetic radiation intoelectricity. Heat can be converted directly into electrical energy by solar cell,more generally a photovoltaic cell.

### B. Charge Controller

The charge controller is a simple, efficient and precise controller designed to operate with the charge source such as solar panels and windgenerator to prevent overcharge. Output drives current-1.0 Amps.

### C. Battery

The battery is an electrochemical device for converting chemical energy into electrical energy. The main purpose of the battery is to provide a supply of current for operating the cranking motor and other electrical units. Capcity of battery-12v.

### D.Thermoelectric module

A typical thermoelectric module is composed of two ceramic substrates that serve as a foundation and electrical insulation for P-type and N-type Bismuth Telluride dice that are connected electrically in series and thermally in parallel between

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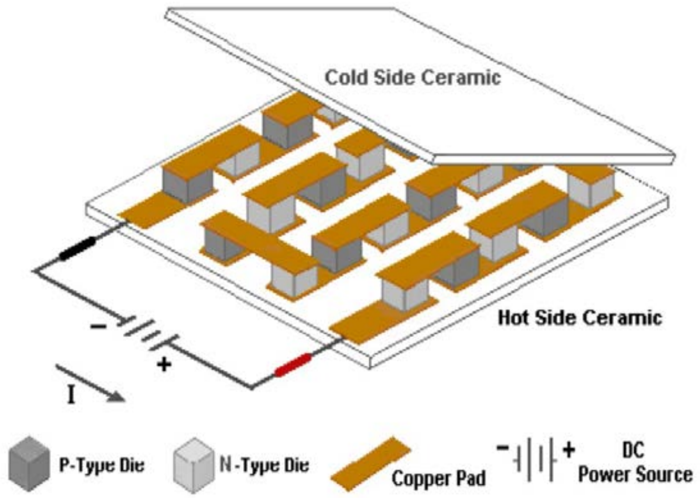
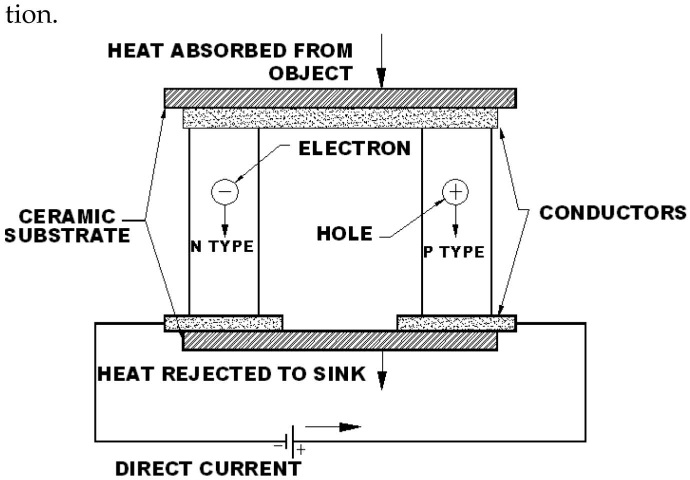
the ceramics.The P-type and N-type materials are alloys of Bismuth and Tellurium, both have different free electron densities at the same temperature.




**WORKING PRINCIPLE OF THERMOELECTRIC 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. One of the TEM sides is cooling and the other side is heating. When a TE module is used, you must support heat rejection from its hot side. If the temperature on thehot side is like the ambient temperature, then we can get the temperature on the cold side that is lower. The degree of the cooling is depended from the current value that isleaking through a thermoelectric module. 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.




Calculation of the power consumed by the 10 modules used in the prototype

Each module takes a maximum of 2.5 A and 3.8 V.

The power needed to give maximum cooling efficiency

2.5 × 3.8 =9.5W.

The total power consumed by the 10 module units¼

6×9.5 =57W.

Calculation of the power consumed by the fans

Each fan consumed 4W.

Three fans consumed 12W.

Total power needed from solar cells

Total power =power consumed by the modules+power Consumed by fans = 57+12 =69W.

When the designed solar thermoelectric refrigerator was tested, it was found that the inner temperature of the refrigeration area was reduced from 27℃ to 12℃ in approximately 50min, a difference of 15℃. Below is an example, which shows how the coefficient of performance of the refrigerator (COPR) was calculated. It was assumed that the refrigerator used to cool a 0.5 L canned drink from 27 ℃ to 12 ℃ in 50 min. In these calculations, it was assumed that the properties of canned drinks are the same as those of water.

(Density = 1 kg/L and C =4.18 kJ/kg).

V=0.5 L canned drink.

Cools from 27 ℃ to12℃ in 50 min.

Calculate COPR:

COPR =Qcooling/Win

m = 0. 5 kg

Qcooling = mC$\Delta$T =0:5 ×4180×(27-12)=31350 J

Qcooling =

Qcooling/$\Delta$t =

31350/60 × 50 =10.45W

Win = 61J

COPR =10.45/61

=0.1713

## .EXPERIMENTAL SECTION

A thermoelectric refrigeration cabinet has been developed with outer casing of GI sheet and for thermal insulation a thermocol has been provided inside the box to prevent reversal of heat flow.Six numbers of thermoelectric module(TEC1-12706_TC/WG+) have been used to reduce inside temperature of refrigeration space. Cold side of TEM mounted on GI sheet and hot side of modules were fixed with heat sink fan assembly.

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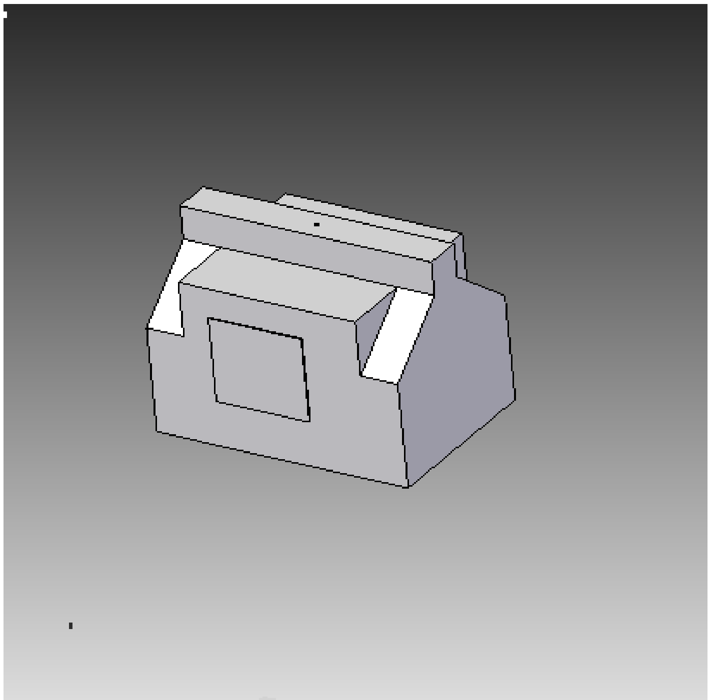

## CONCLUSION

The experimental results of developed prototype of TER system shows that the performances were optimum for a given operating conditions.An 15$_{o}$C temperature reduction at 500 ml water inside refrigeration space of developed TER has been experimentally found with respect to 27$_{o}$C ambient temperature in 50 minutes. Also the calculated COP of thermoelectric refrigeration cabinet was 0.17. Also it has been experimentally found that the developed thermoelectric refrigeration system can continuously work for 15 hours when battery is fully charged with solar panel. The performance of TER system can be improved further with use of increased figure of merit Peltier modules and efficient heat exchange technology.



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