Abstract—In the recent years, electricity crisis is main problem for us. It’s time to use the renewable sources of the nature. Our project uses the solar energy to run a heating and cooling system. In this project we have fabricated a thermoelectric system using solar energy. It is eco-friendly project. It is made by using thermoelectric module. The project supports both heating and cooling. The purpose of this project has been to investigate the possibility of heating and cooling air by connecting Peltier Elements to a PV panel. Design and developmental methodology of thermoelectric refrigeration has been explained in detail also the theoretical physical characteristics of thermoelectric cooling module used in this research work have been investigated. We designed and developed an experimental prototype of thermoelectric refrigeration system working on solar photo voltaic cells generated DC voltage. The project has various applications like, military or aerospace, medical equipment etc. Thus it proves to be very helpful.

Keywords—Thermo-Electric module, Peltier circuit, Solar Panel

I. INTRODUCTION

A. Overview

Currently, even in 21st century there are many places in India where there is no less electricity available therefore storage and refrigeration of food stuff is a big issue in rural areas. Solar is freely available in plenty. This system should prove to be 100% eco-friendly and cheapest refrigeration system for such people. As our project run on solar system, people can take benefits of cooling and heating effect from this system.

B. Objective

The main objective of our project is to charge 12 volts DC battery with the help of solar panel and then the power of battery is used for cooling and heating goods placed in insulated chamber with the help of thermoelectric circuit (peltier circuit). We use peltier circuit as a thermoelectric circuit. A peltier element provides a cold or warm surface depending on the polarity of the electric power. This enables a system with rechargeable batteries as the only energy source.

C. Applications

Main advantages of our project are that use simple technology without moving parts enables system. Technology mainly used for very small surface, but also for small transportable fridge. Our project imposes several applications like electronic, medicine, scientific and laboratory equipment, consumer goods, climate devices and automotive system.

II. LITERATURE REVIEW

The principle on which modern thermoelectric module are based actually date back to early 1800’s. the commercial thermoelectric module are available from 1960. The first important discovery related to thermoelectricity occurs in 1821 when on German scientist Thomas seeback; found that electric current passed from continuously in closed circuit made up of two dissimilar metal provided that the junction of the metals were maintained at two different temperature seeback did not actually comprehend scientific basic for this discovery.

In 1834, a French watchmaker and part time physiist, Jeon Peltier, while investigating seeback effect found that there is a opposite phenomenon, where by thermal energy could be absorbed at one dissimilar metal junction and discharge at the other junction when an electric current flowed within the closed circuit and it is tie fundamental principle behind a thermoelectric system. The material used in the thermoelectric module in early 1950’s is metal. Metals are good due to the high thermal conductivity. Since 1950’s with the discovery of semiconductors are used in the thermoelectric module. Semiconductors are good electric conductor but having low thermal conductivity, this provide much improved cop % compare to metal. Type of metal composition used is alloy of element Bi, cd, se, zn. This standard metals used in the manufacturing of thermoelectric module.

This was because material with high temperature conduction co-efficient is used because of temperature conduction between the hot side and cold side of T.E heat exchanger. Since discovery of semiconductors, the co-efficient of performance of TEC was drastically improved. Since materials could be used with low temperature conduction co-efficient but by doping it. The Semiconductor could be made to conduct exerting electrical conductor properties found in metal.

There are number of experiment and studies that characterised the performance of the thermoelectric module for example LUO, performed experiment and verify that thermoelectric system is more efficient than electric system is more efficient than electric heating device its coefficient reaches more than 1.6 with suitable operating condition. Riffat and Qiu, compared performance of thermoelectric air conditioner with two other type of domestic air conditioner.
Bansal and Martin investigate and compared the performance characteristic of their domestic refrigeration namely the vapour compression the thermoelectric and the absorption refrigeration based on actual experimental data. Bansal and Martin also reported that thermoelectric cooling system are advance reliable and cost of thermoelectric cooling have change favour and at resent thermoelectric system available for the domestic market at comparable price.

Min and Roue, investigate a number of prototype thermoelectric cooler and evaluate their performance in terms of cop. Dai, conducted experiment on portable thermoelectric refrigeration for small scale remote application or in area where electric supply is available their result can show that the unit maintain the inside temperature at 5-10 c and have cop of approximate 0.3.

III. CONSTRUCTION

Here this system heat or cool the product using thermo-electric module. the construction set up for this system require following parts

A. Solar panel,
B. Insulated Box
C. Charge controller,
D. Battery
E. Exhaust fan
F. Thermoelectric module.

<table>
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<th>TABLE I BILL OF MATERIAL</th>
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<tr>
<td>Part name</td>
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<tr>
<td>1. solar panel</td>
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<td>2. insulated box</td>
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<td>3. charge controller</td>
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<td>4. battery</td>
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<td>5. thermister</td>
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<td>6. exhaust fan</td>
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<tr>
<td>7. thermoelectric module</td>
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<td>8. metal (sheets)</td>
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A. Solar Panel

Solar panels mainly consist of P.V cells. P.V cells are known as photovoltaic cells. Photovoltaic cell is manufactured from semiconductor like silicon base.

When this material is exposed to light its produces an electric current. P.V cells can be made from crystalline silicon (polycrystalline silicon). Which thickness of about 100-300 um thick there are also polycrystalline thin film cell with thickness of 1-10 um. That layer merged on each other to form cells. That sets of cells place on a board or metallic plate to form solar panel.

B. Insulation Box

Insulation box that term define as providing insulation from temperature difference to place inside temperature constant or at required temperature. The insulation box contain both cooling and Heating container which is equally dividing in to two section The total insulation box is dividing into three sections first top section is for heating purpose and another one is for cooling. The bottom part of the insulation box is utilized as a storage space for the thermo electrical circuit and cooling fans.

C. Charge Controller

Charge controller consist of the electronics circuit which is having different diodes and resisters that act for the controlling purpose of variation in current and another phenomenon are given below:

a. Charge controller takes current from P.V panels.
b. Solar battery charging controller regulates the voltage outputs from the solar panels and preventing from being overcharging.
c. It also blocking reverses current.
d. It can disconnect the lower voltage supply.
e. It gives overload protection.

D. Battery

When for the solar battery is constructed it will work with nearly any 12 V battery technologies it will usually operated best with lead acid battery. Its consist of combination of lead plates and electrolyte to convert electrical energy into potential chemical energy and vice versa Lead acid battery is an electrical storage device that use as a chemical reaction to store and relies energy.

The basic construction of lead acid battery is given below:

a. A resilient plastic container,
b. Positive and negative internal plates made of lead,
c. Plate separates made of porous synthetic material,
d. Electrolyte –A diluted solution of sulphuric acid and water (battery acid),
e. Battery terminals.

E. Exhaust Fan

Exhaust fan remove heat from heat sink plate. Fans can be used for the thermal management of the compartment using thermal inertia. Exhaust fan can be controlled by transforming circuit. For the transforming circuit electricity is also provided from battery.
F. Thermoelectrical module

Thermoelectrical circuit consist of the P and N type semiconductors pairs (refers to as a couple) Thermoelectrical circuit used a phenomenon of thermoelectrical refrigeration with the rte of reverse heat absorption. When current passes through the junction of the two different types of conductors it result in temperature change on both side of a module. After that one side become hot and another side become cold.

Solar cells are made by bonding together p-type and n-type semiconductors. The negatively charged electrons move to the n-type semiconductor while the positively charged holes move to the p-type semiconductor. They collect at both electrodes to form a potential. When the two electrodes are connected by a wire, a current flows and the electric power thus generated can be transferred to an outside application.

That produce electricity is supply to the charging controller. A charge controller is an essential part of nearly all power systems that charge batteries, whether the power source is PV. Its purpose is to keep your batteries properly fed and safe for the long term. The basic functions of a controller are quite simple. Charge controllers block reverse current and prevent battery overcharge. Some controllers also prevent battery over discharge, protect from electrical overload, and/or display battery status and the flow of power. That controlling voltage is send to the battery for storing purpose battery store that electric current in the form of chemical as we know battery storing by electric energy that will converted in to the chemical energy. That storing electric energy will distributed through transformer to thermoelectric circuit and another for Fan.

When two terminals of battery are connected to the Thermoelectric circuit the circuit come is picture to perform their main and important operation of producing the cooling and heating effect. In a thermo-electric heat exchanger the electrons acts as the heat carrier. The heat pumping action is therefore a function of the quantity of electrons crossing over the p-n junction. Since the amount of current in a conductor represents the quantity of electrons flowing in a conductor, it can therefore be said that the cooling effect in a thermo-electric heat pump is directly proportional to the current flowing through the device. The TEC consists of a p-n material junction. The operation can also be explained using the p-n junction theory used in diodes - the most simple semiconductor device. If a LED (light emitting diode) is analysed, it can be seen that the light that is produced by LED, follows the same principle as thermoelectric cooling. In p-material, the charge carriers are holes and in n-material the charge carriers are electrons.

The free electrons in then material move in the conduction band, and movement will only take place under the influence of an applied voltage. This is known as electron motion. The hole transfer in p-material is a process in which energy levels in the valence band are not occupied by an electron. Holes, as with electrons, move in the valence band, but in the opposite direction. In any p-n junction where a voltage is applied, the holes and the electrons continually recombine (when current flows from the n-material to the p-material).
In the case of the LED, electron flow is from the p-material to the n-material. The electrons move from the conduction energy level (n-material) to the valence band (p-material).

The change in energy level from a higher energy level to a lower energy level causes the electron to give off energy and this energy is given off in the form of visible light the same principle can be applied to thermo-electric cooling. As the electron moves from the higher energy state in the n-material to a lower energy state in the p-material energy is released (heating effect). If the electron moves from the p-material to then material, energy is absorbed because the electron moves from a lower energy level to a higher energy level, needing additional energy to cross the junction, which in the case of thermo-electric cooling, is obtained in the form of heat a Thermo-electric cooler can be constructed by connecting many p-n junctions in series.

Consider a p-n-p junction in a thermo-electric cooler; when the electron moves across the p-n junction, heat is absorbed due to the change from a lower energy level to a higher energy level, causing a cooling effect As the electron moves across the n-p junction, the electron moves from a higher energy level to a lower energy level, causing the electron to give off energy, causing a heating effect A heat pump is then formed, pumping heat (energy) from the cold side to the hot side. If the current is reversed, the cold side will change into the hot side and the heat will be pumped into the opposite direction.

V. DESIGN

A. Design of Thermo-electric Module

\[ Q_{\text{max}} = 100 \text{ W} \]
\[ V_{\text{max}} = 12 \text{ V dc} \]
\[ I_{\text{max}} = 1.4 \text{ A} \]
\[ T_{\text{hot}} = 46 \text{ c} \]
\[ T_{\text{cold}} = 20 \text{ c} \]
\[ T_{\text{diff}} = 46-20 = 26 \text{ c} \]

Types of heat load:
- Active Load
- Radiation
- Convection
- Conduction

\[ Q_{\text{active}} = V^2/R \]

Where,
\[ Q_{\text{active}} = \text{Active heat load} \]
\[ V = \text{voltage applied to device being cooled (V)} \]
\[ R = \text{device resistance (Q)} \]
\[ I = \text{current through the device (A)} \]

\[ V = 1 \times R \]
\[ 12 = 1.4 \times R \]

\[ R = 12/1.4 = 8.57\Omega \]
\[ Q_{\text{active}} = V^2/R = 12^2/8.57 = 16.80 \text{ W} \]
\[ Q_{\text{active}} = 16.80 \text{ W} \]

Radiation
\[ Q_{\text{radiation}} = F \cdot e \cdot s \cdot A \cdot (T^4_{\text{hot}} - T^4_{\text{cold}}) \]

Where
\[ Q_{\text{radiation}} = \text{radiation heat load (W)} \]
\[ F = \text{shape factor (a worst case factor of 1 can be used)} \]
\[ e = \text{emissivity (worst case value of 1 can be used)} \]
\[ s = \text{Stefan-Boltzman constant (5.667} \times 10^{-8} \text{W/m}^2\text{K}^4) \]
\[ A = \text{area of cooled surface (m}^2\text{)} \]
\[ T_{\text{A}} = \text{ambient temperature (K)} = 273 + 30 = 303 \text{ C} \]
\[ T_{\text{C}} = \text{TEe cold side ceramic temperature (Kelvin)} = 273 + 20 = 293 \text{ C} \]
\[ Q_{\text{radiation}} = F \cdot e \cdot s \cdot A \cdot (T^4_{\text{hot}} - T^4_{\text{cold}}) \]
\[ Q_{\text{radiation}} = 1 \times 1 \times 5.667 \times 10^{-8} \times 1.6 \times 10^{-3} \times (303^4 - 293^4) = 0.0967W \]
\[ Q_{\text{radiation}} = 0.0967W \]

Convection
\[ Q_{\text{convection}} = h \cdot A \cdot (T_{\text{air}} - T_{\text{C}}) \]

Where
\[ Q_{\text{convection}} = \text{convective heat load} \]
\[ h = \text{convective heat transfer co-efficient} (21.7 \text{ watt/m}^2 \text{ for air at 101.3kPa)} \]
\[ A = \text{exposed surface area (m}^2\text{)} \]
\[ T_{\text{A}} = \text{temperature of surrounding air} = 273 + 30 = 303 \text{ C} \]
\[ T_{\text{C}} = \text{temperature of cold surface} = 273 + 20 = 293 \text{ C} \]
\[ Q_{\text{convection}} = h \cdot A \cdot (T_{\text{air}} - T_{\text{C}}) \]
\[ Q_{\text{convection}} = 21.7 \times 1.6 \times 10^{-3} \times (303-293) = 0.347 \text{ W} \]
\[ Q_{\text{convection}} = 0.347 \text{ W} \]

Conduction
\[ Q_{\text{conduction}} = k \cdot A \cdot \Delta T/L \]

Where
\[ Q_{\text{conduction}} = \text{conductive Heat load (W)} \]
\[ k = \text{thermal conductivity of the material} = 0.86W/m\text{C} \]
\[ A = \text{cross-sectional area of the material (m}^2\text{)} = 1.6 \times 10^{-3} \text{ m}^2 \]
\[ L = \text{length of the heat path (m)} = 0.004 \text{ m} \]
\[ \Delta T = \text{temperature difference across heat path (hot side - cold side)} = 46 - 20 = 26^\circ \text{C} \]
\[ Q_{\text{conduction}} = 0.86 \times 1.6 \times 10^{-3} \times 26/0.0045 = 0.0045 \text{ W} \]
\[ Q_{\text{conduction}} = 8 \text{ W} \]

Total heat load on peltier plate
\[ Q_{\text{total}} = Q_{\text{active}} + Q_{\text{radiation}} + Q_{\text{convection}} + Q_{\text{conduction}} \]
\[ Q_{\text{total}} = 16.80 + 0.0967 + 0.347 + 8 = 25.24 \text{ W} \]
B. Insulation Box Design

For insulation purpose require low thermal conductivity material.
We take ceramic porcelain (k = 1.1 w/m.k)

\[ Q = \frac{(kA\Delta t)}{dx} \]

Heat lost in cooling = \[1.1\times0.2\times0.1\times(30-20)/0.1\] = 2.2 W

Heat lost in heating = \[1.1\times0.2\times0.1\times(46-30)/0.1\] = 3.62 W

C. Total Heat Supplied Calculations

Total heat supplied required (cooling) = total heat load + heat loss during cooling

= 25.24 + 2.2
= 27.44 W

Total heat supplied required (heating) = total heat load + heat loss during heating

= 25.24 + 3.52
= 28.76 W

By calculations, thermoelectric module of 33W selected.

VI. 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 32°C to 15.5°C in 35 minutes.

GRAPH 2-HEATING (WITHOUT LOAD)

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

VII. CONCLUSION

Thermoelectric refrigerators are greatly needed, particularly for developing countries, where long life, low maintenance and clean environment are needed. In this aspect thermoelectric cannot be challenged in spite of the fact that it has some disadvantages like low coefficient of performance and high cost. These contentious issues are the frontal factors hampering the large scale commercialization of thermoelectric cooling devices. The solution to above problems can only be resolved with the development of new techniques. There is a lot of scope for developing materials specifically suited for Thermoelectric cooling purpose and these can greatly improve the C.O.P. of these devices. Development of new methods to improve efficiency catering to changes in the basic design of the thermoelectric set up like better heat transfer, miniaturization etc. can give very effective enhancement in the overall performance of thermoelectric refrigerators. Finally, there is a general need for more studies that combine several techniques, exploiting the best of each and using these practically.

Thermoelectric module for producing effective heating and cooling placed inside an aluminium cabinet. By using a temperature sensor inside the cabinet surface, we get the corresponding temperature values for each instant which are displayed in an LCD (Liquid crystal display).
The graph between temperature produced inside the cabinet against corresponding time interval are also presented and results are in line with the predictions. The advantages of the thermoelectric heater cum refrigeration system in comparison with the existing heater and refrigeration system are elaborated. The physical dimensions and specifications of the thermoelectric module are presented. It is observed that the life span of thermo electric heater cum refrigeration system is more than twice the life span of existing conventional refrigeration or heater system. The principle of solar panel along with its specifications and dimensions are displayed. As the future relies heavily on Non conventional energy resources, the solar powered thermoelectric heater cum refrigeration system will definitely be a large aspect in terms of energy saving capacity and the fact that the system is eco-friendly. The important aspect to be noted is that it is a one time investment and is maintenance free.

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