DESIGN & FABRICATION OF SOLAR POWERED THERMOELECTRIC REFRIGERATION SYSTEM

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Abstract -
In this new year, energy urgency and climate debasement as a result of CO2 emanation and consumption of ozone layer has turned into fundamentally bigger problems to both industrially developed and developed countries. In solar operated thermoelectric refrigeration system, we can use Peltier modules which does not require refrigerants or other components like evaporators, compressors, condensers etc. Solar energy is used for this project. Solar energy-based system using Peltier modules will be eco-friendly, economical, and climate amicable framework. Cooling effect must be feasible in framework that is possible because of Peltier modules. This system is specifically used where there is scarcity of electricity in developing countries. The targets of this review is to foster a functioning thermoelectric fridge that utilizes Peltier effect to chill and keep the temperature between 15 ^{0}C to 30 ^{0}C. The main function of this project is to cool the liquid to the desired temperature inside the cooling chamber and maintain that temperature upto 30 minutes.

***Keywords:* Heat Sink, Thermoelectric Generator, Refrigeration Unit, solar energy, temperature etc.**

1. Introduction

From recent century upto now refrigeration has been one of the essential elements of everyday life. The recent inclination of principal world is to view at sustainable power assets as the wellspring of energy. Because of the evergreen population in the world, we need refrigeration for people's luxury and for the contamination of different products. So here we are using solar energy which is available in abundance in nature [1].

Refrigeration is the process of transferring heat from a lower temperature body and moving it to a higher temperature body. Crafted by heat move is customarily determined by means of mechanical energy, yet can likewise is drive by heat, attraction, power, laser. Refrigeration system has numerous packages, inclusive of, yet no longer restrained to: own family fridges, contemporary coolers, cryogenics, and cooling. Heat siphons might utilize the hotness result of the refrigeration cycle, and furthermore might be intended to be reversible, however are generally like cooling units [2].

In most the nations, urban areas are intensely reliant upon refrigeration in grocery stores, to acquire their nourishment for day by day utilization. The expansion in food sources has prompted a bigger centralization of horticultural deals coming from a more modest level of existing branches. Cultivates today have a lot bigger result for each individual in contrast with the last part of the 1800th century, That has brought about latest version of food sources accessible for whole population, which to a great extent affects the nourishment of society. The fundamental thought is the execution of solar controlled system from either DC current source or solar power (when required) with a battery source [3].

2. Basic Principle of Project

A thermoelectric module in this way uses a series of fixed intersections in which the current is applied and because of that one intersection becomes cold and the other becomes hotter. As we know that thermoelectric system is a type of refrigeration system, that gives the benefit of being silent and it doesn't use any refrigerant. As there is no moving parts with the exception of certain fans, uses no refrigerant, and doesn't need any component that are required in conventional refrigeration system. So this thermoelectric refrigeration system is eco-friendly, cheaper than conventional system. As it is light in weight and small in size so it can be in various purposes.

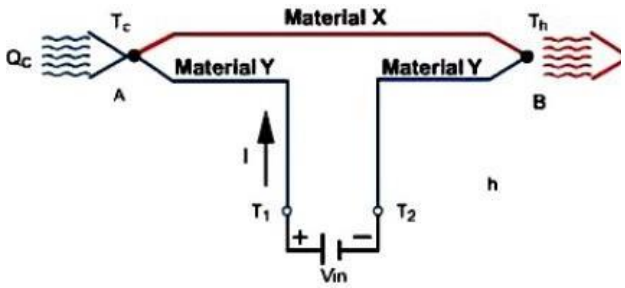


Fig.1. Peltier effect

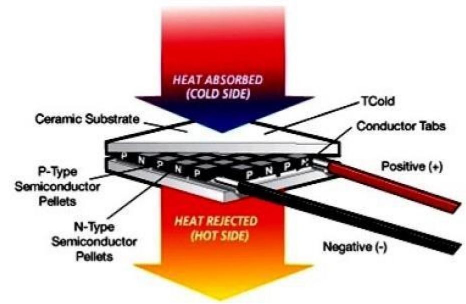


Fig..2. Thermoelectric module assembly

In 1821 a scientist named Thomas Seebeck found that whenever two dissimilar metals are connected together and the one side is cool and the other is hot then there is a generation of current. This phenomenon which we have discussed above is Seebeck Effect. In 1834, Jean Charles Athanase Peltier discovered that when there is supply of electric currentin two dissimilar metals which are connected together then one surface will be hot and the the other will be cold and this is Peltier effect and is displayed in the above diagram.1. Lenz a scientist in 1838 discovered that relying upon the bearing of flow stream in the framework, hotness can be eliminated from an intersection to change over liquid into solid, or switching course of ebb and flow, hotness is producedto dissolve ice. The quantity of thermal energy ingested or dismissed over the intersection is corresponding to the current power. steady of proportionality is known as the Peltier coefficient.

3. Thermoelectric peltier modules

Despite the fact that Peltier impact was found over 150 years ago, thermoelectric concept have just been applied economically from many years. Recently, a sensational expansion in the use of Thermoelectric arrangements in electronic gadgets have been noticed, like Diode lasers, photograph finders, strong State siphoned lazers, charge coupled gadgets (CCD) and there are others also. Thermoelectric modules comprises of thermocouples shaped with sets of P types and N types semi- conductor thermoelectric components which are associated in series and current is applied and heat is transferred. Because of their strong state development the modules are viewed as profoundly dependable. In most of the application they would give big, inconvenient assistance. For cooling purpose, an current supply is applied to peltier modules, thermal energy is moved from one part to the another, and the result is that the modules are going to get cooler at one part and sizzling on another side.

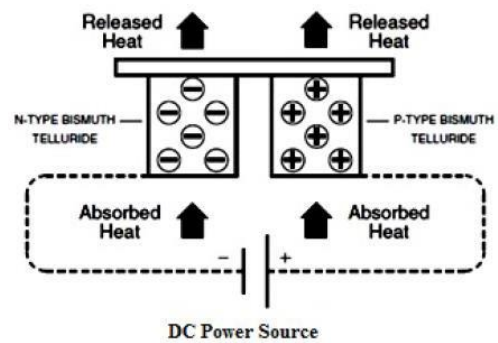


Fig.3. Modules working

This 2nd figure shows a specific peltierthermoelectric modules get together. The fundamental benefits of using thermoelectric modules in cooling refrigeration are, they are cheaper, don't have moving parts and are tiny in size, its unwavering quality and flexibility in plan to satisfy specific necessities.

This 3rd figure describes the working principle of peltier thermoelectric modules. At the point when a DC current is supplied to the Thermoelectric module, the negative and positive charge transporters over pellet gathering assimilate thermal energy from one surface and is rejected to the another on the contrary side. surface from where thermal energy is extracted becomes cool ; the contrary the other surface where thermal energy is transferred, it becomes heat sink where all heat is absorbed. Turning around the extremity will bring about switched hot and cold sides.

4. Specification of TEC

Table.1. specifications of TEC

Product	TEC-12706
Operational voltage	12V DC
Current max	6 Amp
Voltage max	15.4 V
Power max	92.4
Power nominal	60
Couples	127
Dimensions	40 x 40 x 3.5 mm

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 06 Issue: 04 | April - 2022 Impact Factor: 7.185 ISSN: 2582-3930

5. Literature Review

Audit of various protected thermoelectric cooler plans, a photovoltaic direct/roundabout Thermoelectric refrigeration system, And exploration details from the writing is depicted in these accompanying segment.

- a basic plan was prepared by Beitner in 1978 comnsisting of peltier modules straightforwardly are regulated by outside Direct Current supply and there is one outer heat sink to dissipate hotness to surrounding by using convention convection cooling process.
- In 1982, hatcher and reed created a powerful manner to produce the hotness disseminating ability at the hot surface of peltier thermoelectric modules by using the cooling fan.
- In 1996, Park et al. proposed an alternative plan of thermoelectric fridge because it gives advantages of peltier materials which are cheaper and ecofrioendly with thermoelectric refrigeration system and this refrigeration system can keep the temperature cool inside the cooling chamber without using various components that are required in conventional systems and thisthermoelectric concept is ecofriendly and harmless.
- In 1999,Gillery and Tex prepared the concept of manufacturing a thermoelectric cooler with the help of consolidating thermal exchangers to so that heat is transferred from one side to another that can be called as heat sink of the refrigerator.

6. Concept

Similarly cooling is the method of achieving and maintaining the temperature at the bottom of the earth, which chills an object or place to the ideal temperature. The seebeck coefficient is the difference between the electric fields and the voltage or slope and temperature difference between the closure of the sample. The Celtier coefficient of intersection is the property of the force acting on two substances and the ratio of potential moving from it at intersection. Thomson's Coefficient is the amount Of advanced current per unit of volume in proportion to the provided current and slope.

7. Experimental Setup

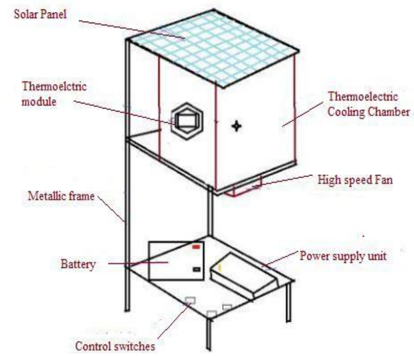


Fig.4. Experimental setup of Project

8. Working flow diagram

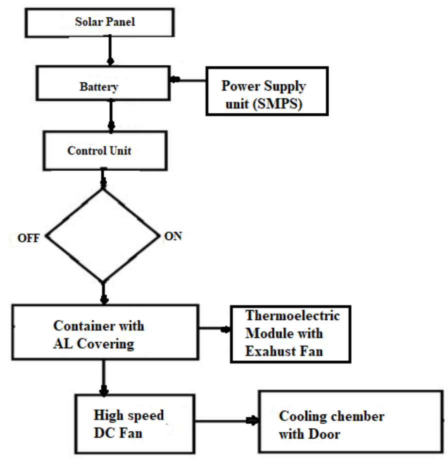


Fig. 5. Working flow diagram

9. Components and Its Specification

Table 2. Components and Specification of system

Sr. No.	Components	Ratings	Specification
	Thermoelectric Module		Provide cooling Effect
2	Battery	12v, 14 ah	Provide Power
			Executed waste heat
4	SMPS	12V, 10ah	External power source
5	Solar Panel	12v. 30w	Internal power source
6	Temperature sensor	5v	Measure Temperature
7	Aluminum sheet	-	For spreading cooling effect

10. Experimental working

• Project Renewable energy sources, for example, sun oriented energy will be utilized in this undertaking. A sunlight powered charger of 12v 30w is utilized to extricate sun oriented energy and convert it into electrical energy.

• Electrical This electrical power is put away in a 12v, 14 Amp battery. The entire framework works from this stockpiling energy.

• Power An outer power hotspot for crises when very little power is free Minimum battery is an additional advantage.

• Unit Control unit likewise gives to fill every role. At the point when an item is filled a refrigeration chamber unit. Attempt to close the frontentryway of the lodge. To keep up with and diffuse the cooling temperature inside the lodge/chamber, the whole lodge is protected with aluminum sheet.

• The Specify the temperature inside the holder. Thermoelectric units (with aluminum block, aluminum sink and exhaust fan) are covered on the two sides of the holder. Furthermore attempt to cool the inside temperature. Rapid fans are likewise addedto the inside unit of the compartment for more prominent proficiency in cooling.

• An aggregate of 4 thermoelectric frameworks are utilized to cover the 4 aprox. 2 liter limit of room. The fast fan with LED lights inside this room gives the right cooler feel. A temperature sensor is set external the room, which estimates the drop-down temperature of the cooling room.

• Sun oriented this kind of sunlight based fueled compact fridge will carry more advantages to the destitute individuals of India.

11. CAD Design Modeling

x 0.065m

0.14 x 0.093 m

calculation

Fig. 6. Design of project

12. Actual Model

Fig. 7. Project Image

13. Experimental Investigation

An analysis is done both experimentally and also their performance is checked on fabricated thermo electric refrigerator. There are two sides one is cool side which can be called as cooling chamber and other hot sink of the thermoelectric module was utilized in refrigerator to produce the cooling effect in the refrigerator chamber and a thermo meter is utilized to take the reading of the temperature and measure it properly. The heat sink is where the heat is dissipated from cooler side . In order to evaluate the performance

,whether working is proper or not and cooling requirement is fulfilled by the system, this experiment was done over the refrigerator.

Geometry With the constraints imposed by the objectives a triple walled rectangular box with an insulation sandwiched between the walls is selected and having the following dimensions

Top and bottom panel dimensions =0.14m x 0.065m

Vertical side panel dimension = 0.093

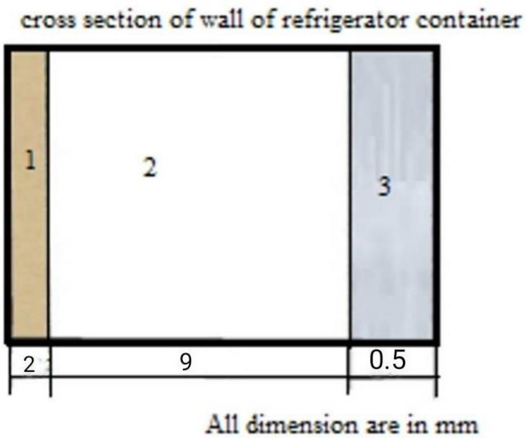
Front and back panel dimensions =

Heat load

Passive heat load

Temperature to be maintained inside the cabin = 18 C Outside temperature or ambient temperature = 32C Temperature difference between the cabin walls = 32 – 10 = 20

13.1. Thermal Resistance of Refrigerator Container



(1) Plastic Thickness $t_1 = 2$ mm, Thermal conductivity $k_{plastic} = 0.33^{W}/mk$
(2) Thermocol of Thickness t_2=9mm, Thermal conductivity k_{th} =0.033$^{W}/mk$
(3) Aluminium of Thickness t_3 = 0.5mm Thermal conductivity =205$^{W}/mk$
(4) Air of Heat transfer coefficient h_{air}=15 $w/m2k$

Q1 = 0.1767W
Q2 = 0.2660 W
Q3 = 0.0548 W
Passive load through the wallsQP = (Q1+ Q 2 + Q3) x 2 =0.995 ≈ 1 W
Infiltration air load due to opening and closing, Q C ≈ 10 W
Q TP = Q P + Q C = 1+ 10 = 11 W
For safety, Q TP ≈ 25 W
R H T = (TH - TA) / (V x I +Q) R H T = (45 - 30)/ (12 x 5 + 20) = 0.176 0 C/W Our proposed system using a TEC1-12706 module and a thermosiphon water cooling system meets the criteria for this application. Heat load required to be dissipated from hot side: The Peltier module is running at 12V and 5 amps of current at nominal operation Q H = PTEC + Q T = 6 x V x I + Q T = 6 x 12 x 5 + 25 = 385 W So Aluminium tank of Thermosiphon system must carry the sufficientamount of water to carry away the heat.

- The volume of water needed to dissipate the heat can be found by the equation, Q = m Cp Δ T Where Q is the amount of heat to be dissipated, m is the mass of water, Cp is the specific heat capacity of water and Δ T is the temperature difference. Volume of water = 6.03 x 10-6 m3 i.e.
- , 6.03 x 10-6 m3 of water is needed to remove 385W of heat.
- it was found that the inner temperature of the refrigeration area was reduced from 29.8 ˚C to 27.08 ˚C in approximately 70min. Coefficient of performance of the refrigerator (COPR) was calculated. Water is used in place of vaccine for taking measurements and calculation. In these calculations, the properties of water are (density = 1 kg/L and CP = 4187 J/kg).V = 1 L.
- Coefficient of performance of the refrigerator (COPR) was
- calculated, COP = Q colling/W
- Q = m CPΔ T Mass of water, m = density x volume = 1 kg Total heat removed from the water = 11424 J
- QColling = Q/ ΔT
- *= 11424/70*60 = 2.72 W*
- Power given to the system for working, W IN = V x I + fan input = 12 x 4 + 2 = 50 W
- Coefficient of performance of this refrigeration system is
- given by COP = Qcolling/Win = 2.72/50 =0.0544

Mass of air inside Volume of air V = L*B*T = 0.14*0.065*0.093
V=0.0008463m^3
Densityofairρ=1.225kg/m^3 Massofair(m_{air})=V*ρ=0.001036kg
$mair$ =1.036x 10−3kg Heat removing capacity of Peltier module Specifications of Tec1-12706 peltier moduleImax=6A
Vmax=15.4V Qcmax=53.3WΔTmax=70℃ R=1.98Ω
Th=27℃Tc =15℃

- *Heat rejection capacity of peltier module*

$$Q_c = (\propto_m * T_c * I) - (\frac{1}{2} * I^2 * R_m) - (K_m * (T_h - T_c))$$

- *Where,*

$$\propto_m = \frac{V_{max}}{I_{max}} = \frac{15.4}{300}$$

- *∝m = 0.05133 V/K*

$$R_m = \frac{T_h - \Delta T_{max}}{T_h} * \frac{V_{max}}{I_{max}}$$

- *Rm = 0.367Ω*

$$K_m = \frac{T_h - \Delta T_{max}}{2\Delta T_{max}} * \frac{V_{max} * I_{max}}{T_h}$$

- *Km = 0.0193 W/K*

$$Q_c = (\propto_m * T_c * I) - (\frac{1}{2} * I^2 * R_m) - (K_m * (T_h - T_c))$$

- *Qc = 94.25J*
- *Length l = 0.02m, Face width b = 0.05m, Thickness t=0.002m, Base temperature T0=80℃, Surrounding temperature Ta=30℃, Heat transfer coefficient h =50^w /m^{2}k, Thermal conductivity kAl =205^w/mk.*

- *Amount of heat transferred through the fin :*

$$Q_{fin} = \sqrt{PhkA_{fin}}(T_0 - T_a)\tanh(ml)$$

Where Afin =b x y
Afin =0.0001m^2
P =2(b+y) P =0.104m

$$M = \sqrt{\frac{hp}{kA_{fin}}} = \sqrt{\frac{5.2}{0.0205}}$$

= 15.92/meter tanh(ml) =0.30805
Qfin =√0.1066∗50∗0.3080
Qfin =5.028 watt Number of fins = 4

Heat transfer For Number of Fins :
Qtotal =

$$n\,[kA_{cs}m\,(T_0 - T_a)\tanh(ml)]$$

Qtotal = 20.107 wattEfficiency of Fin ηfin=

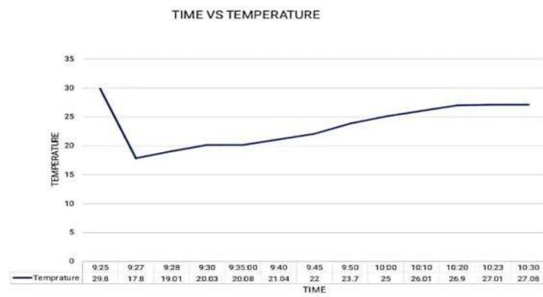
$$= \frac{\tanh(ml)}{ml} = \frac{0.2923}{0.3184}$$

ηfin = 96.75% Effectiveness of FinEfin=

$$= \sqrt{\frac{Pk}{hA_c}}$$

Efin =5.036

Graph for time vs temperature:



A versatile thermoelectric refrigeration framework was created and tried for the cooling reason. The cooler was planned dependent on the standard of a thermoelectric module to make a hot side and cold side. The virus side of the thermoelectric module was used for refrigeration purposes though the hotness from the hot side of the module was killed utilizing heat sinks to ingest the hotness and fans to dismiss it. To use environmentally friendly power, sun based energy was incorporated to control the thermoelectric module to drive the cooler.

Moreover, the sun powered thermoelectric cooler stays away from any superfluous electrical risks and gives a harmless to the ecosystem item. In such manner, the sun based thermoelectric cooler doesn't deliver CFCs and HCFCs which is accepted to cause consumption of the climatic ozone layer. Moreover, there will be no vibration or commotion due to the distinction in the mechanics of the framework. Likewise the dismissed hotness from the sunlight based thermoelectric cooler is immaterial when contrasted with the dismissed hotness from customary fridges. Thus, the sunlight based thermoelectric cooler would be less hurtful to the climate. The test consequences of created model of TER framework shows a 10 0C temperature decrease at 250ml water inside refrigeration space of created TER has been tentatively found concerning 31 0C surrounding temperature shortly.

The refrigeration bureau itself has been tentatively displayed to have a 160C decrease in temperature concerning 31 0C surrounding temperature shortly. Additionally it has been tentatively found that the created TER framework can consistently labor for 3 hours when the battery is completely energized with sun powered charger. The energy productivity of sun based thermoelectric fridges, in view of at present accessible materials and innovation, was still lower than its blower partners. By the by, an attractive sunlight based thermoelectric fridge would be made with a satisfactory exhibition through certain enhancements. For instance, further improvement of COP can be accomplished with utilization of expanded figure in merit peltier modules. The productivity of the framework may likewise be additionally improved by through further developing module contact obstruction, warm interfaces and hotness sinks. This can be accomplished by introducing more modules to cover a more noteworthy surface space of the framework.

14. Advantages

- It saves electrical power supply.
- It is the convenient framework.
- Energy proficient framework.
- Eco-accommodating framework.
- It has given a choice to the utilization of refrigerant by the TEC module.
- Eventually it diminishes the unsafe impacts which are happened by the refrigerant.
- It is the spotless wellspring of energy.
- Abundance power delivered by the fridge can be utilized for the other homegrown reason.
- Sun oriented cooler can be extremely valuable in distant remote spots where there is no persistent stock of power.

15. Applications

- Outside cooling, conveying the compact fridge along for food safeguarding, drinks protection, meds and so on
- Cooling in vehicles
- Cooling of electronic hardware
- Cooling of a test set-up, in a lab
- In provincial India, in summers when there is no power, sun based controlled thermoelectric cooler comes as a consolation
- Can be conveyed along when voyaging outside.

16. Limitations

- Refrigeration rate is very lethargic.
- Tedious framework.
- Exorbitant framework.

17. Conclusion

Solar powered portable thermoelectric refrigeration structure was collected that uses thermoelectric modules and electric control units and is utilized for the cooling . The fridge is sun based controlled and can be utilized in rustic parts where there is shortage of power and a remote part of the country. The main thing that ought to be noted : it is sun oriented fueled and it there is no need of refrigerants and is efficient. We have effectively planned a refrigeration framework that satisfies our goal. Yet there are sure limitations like it tends to be just be used for keeping a specific temperature. The heap changes are not taken care of in well way. Different modifications ought to be made over this idea before it is incorporated for efficient ordinaryutilization in day today life.

18. Future scopes

This model can be utilized as a climate control system just as warmer all the while, as it comprises two surfaces one sweltering and one virus. As it is sunbased controlled, it very well may be great option in contrast to nonrenewable wellsprings of energy.

Acknowledgement

The work has been performed in Institutional project.

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