APROJECT REPORT

ON

"SOLAR OPERATING HEATING AND COOLING SYSTEM"

Submitted by

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In partial fulfillment for the award of the Degree

Of

BACHELOR OF ENGINEERING

IN

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UNDER THE GUIDANCE

Of

Prof. ASIF GANDHI

DEPARTMENT OF MECHANICAL ENGINEERING

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CERTIFICATE

This is to certify that the project entitled

"SOLAR OPERATING HEATING AND COOLING SYSTEM"

Submitted by

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To the Kalsekar Technical Campus, New Panvelis a record of bonafide work carried out by him under our supervision and guidance, for partial fulfillment of the requirements for the award of the Degree of Bachelor of Engineering in Mechanical Engineering as prescribed by **University Of Mumbai**, is approved.

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Headof Department Principal

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APPROVAL OF DISSERTATION

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(Internal Examiner) **(External Examiner)**

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Date: ___________

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ABSTRACT

The purpose of this project is been to investigate the possibility of heating and cooling air by connecting Peltier Elements to a PV panel. The idea was initiated by Energiteknik i Teckomatorp AB, a company that provides heat pumps and coolers to small scale businesses and private customers. In the recent years, we all are facing electricity crisis. It's time to harness the renewable energy resources of the nature. Our project utilizes the solar energy to run a heating and cooling system. In this project we have fabricated a thermoelectric system using solar energy. It is an eco-friendly project, made by using thermoelectric module. The project supports both heating and cooling. The project has various applications like, military or aerospace, medical and pharmaceutical equipment etc. Thus it proves to be very helpful.This will be a suitable & affordable system for the people living in remote part of India where load-shading is a major problem. The major difference between the existing system & our system is that, our project works without use of mechanical device & without refrigerant too.

As the module is compact in size one can design (i.e. shape, capacity) the system according to his requirement. In this paper an attempt has been made to conduct an experimental study on small scale solar operated thermoelectric Heating & Cooling system.

INDEX

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 Basic Information:-

From the ancient age man always prefers to have cold water for drinking purpose. Also in India, our country the weather is too hot. Particularly in summer season, the normal water temperature in open space is 35 to38^0 C. The water is not suitable for drinking purpose. The required temperature is at the most 25^0 C. Hence lowering down of the temperature is an essential task

In old age there was ample space available to keep the earthen container also the houses were sheltered by the trees and bushes which were enough to lower down the water container temperature. Because in most of the situations the temperature was depending on the temperature of the flowing air.

Sweden is a country with cold climate and a great need for heating. 38% of the total end use is consumed by the building sector and 60% of the energy is used for heating and hot water production. In recent years there has been a trend of switching to more efficient systems, such as heat pumps and bio fuel boilers. It is also becoming more common with small scale energy production using renewable resources. Installing solar panels for electricity or hot water production is becoming more economically viable as the costs are cut, and there is a lot of research on how to better implement such systems.

1.2 Other Water Cooling Processes:-

The different water cooling processes incorporated are since old age isas follows:-

Earthen pots, Using ice and Using vapor compression refrigeration cycles. Cooling of water in earthen pot is one of the earliest methods employed by men for cooling the water in their houses. Only in recent years, it has been put on sound footing thermodynamically. It is a process of adiabatic saturation of air when cooling of surface water on container is made to evaporate to cool t with transfer of heat from water to the surroundings. The initial investment cost of such a system is low & the operation is simple & cheap. Simple evaporative cooling is achieved by direct contact of water particles & a moving air stream. The water may be sufficiently cooled by evaporative process to results a considerable degree of drinking comfort in climates of high dry-bulb temperatures associated with low relative humidity. The minimum outdoor temperature required for successful evaporative cooling is above 35^0 c & another requirement is a relatively low. Wet bulb temperature. The cooling effect given by the evaporative cooling always depends upon the outdoor temperature although the evaporative cooling does not perform all the function of true water-conditioning but it provides coolness by filtering heat & circulating the cooled air.

1.3 Limitation Of Simple Evaporative Cooling System:-

Its capacity is limited by WBT of the ambient air. Maximum cooling achieved is the wet bulb temperature. It is not useful for high D.B.T. & high summer weather conditions. However, even with all this limitations, there are many regions in India as the part of Rajasthan; part of Bihar Vidharbha in Maharashtra & some hot spot in North where evaporative cooling will produce a condition well within the summer comfort zone. There is increasing demand of evaporative earthen pot coolers in these regions, as they are quite inexpensive compared with refrigerated water-cooling system. Hence quick operating and reliable Vapour compression system, which is having the massive capacity of cooling, is used.

Generally refrigeration is defined as any process of heat removal. More Specially, refrigeration is defined as the branch of science that deals with process of reducing and maintaining the temperature of a space or material bellow the temperature of the surroundings. Since ancient times, human being searched for warmth in cold weather and cooling in hot weather. The ordinary people used lakes and rivers to get relief from hot weather. Others brought the lake water to houses and circulated it inside the house in the form of channels or fountains. But in modern time this search led to refrigeration systems. The system maintained at the lower temperature than surrounding atmosphere temperature is known as refrigeration system while the equipment used to maintain this lower temperature is known as refrigerating machines.

CHAPTER 2

PROBLEM DEFINATION

Nowadays many complicated designs of air cooled heat sinks are used, but off late the heat fluxes have attained such a level that to handle them very large volume flow rate of air is required. So due to space constraint, in order to achieve large flow rates, air should be blown at very high velocities which in turn result in increased levels of noise. Another major disadvantage of air cooling is that we can't go below ambient temperature for example:-chip failure in the computers working in ambient condition of about 35°C - 45°C increases a lot.

For all these reasons it has become apparent that the heat fluxes have reached such a level that air cooling can't handle them efficiently. Thus the present scenario necessitates the use of active cooling devices. Thermoelectric coolers having the ability to cool below ambient and having advantage of being compact, light weight, free of moving parts and precise temperature control have high potentials for chip cooling.

The temperature rise of the hot side above ambient is dependent on the thermal resistance of the path that the heat sink. Reducing the thermal resistance of the heat sink contributes to the reduction of the thermal resistance of the path and hence an increase in the performance.

And also we all know that Refrigeration or Cooling is the process of removing heat. This process may be accomplished by using one of the refrigeration systems; vapor compression, absorption or thermoelectric refrigeration systems. The first two systems need high and low pressure sides of a working fluid to complete the refrigeration cycle. The thermoelectric refrigeration system, however, uses electrons rather than refrigerant as a heat carrier.

Thermoelectric coolers are greatly needed, particularly for the developing countries situation where long life and low maintenance are needed. Thermoelectric cooler has been widely used in military, aerospace, instrument, and industrial or commercial products, as a cooling device for specific purposes. This technology has existed for about 40 years. Many researchers are concerned about the physical properties of the thermoelectric material and the manufacturing technique of thermoelectric modules. In addition to the improvement of the thermoelectric material and module, the system analysis of a thermoelectric refrigerator is equally important in designing a high-performance thermoelectric refrigerator.

CHAPTER 3

LITERATURE SURVEY

The first important discovery relating to thermoelectricity occurred in 1823 when a German scientist, Thomas Seebeck, s. Some 12 years later French watchmaker, Jean Charles AthanasePeltier, discovered thermoelectric cooling effect, also known as Peltier cooling effect, Peltier discovered that the passage of a current through a junction formed by two dissimilar conductors caused a temperature change. The true nature of Peltier effect was made clear by Emil Lenz in 1838, Lenz demonstrated that water could be frozen when placed on a bismuth-antimony junction by passage of an electric current through the junction.

Rowe [1]. Shortly after the development of practical semiconductors in 1950's, Bismuth Telluride began to be the primary material used in the thermoelectric cooling. 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. The direction of the heat flow depends on the direction of applied electric current and the relative Seebeck coefficient of the two materials.

Xi et al. [2] presented in their study that thermoelectric refrigeration emerges as alternative green refrigeration technology due to their distinct advantages as noiseless and wearless due to no moving parts, reliable, portable and compatible with Solar PV cell generated DC power, making them complete environment friendly

Dai et al. [3] have designed and developed a thermoelectric refrigeration system powered by solar cells generated DC voltage and carried out experimental investigation and analysis. They developed a prototype which consists of a thermoelectric module, array of solar cell, controller, storage battery and rectifier. The system with solar cells and thermoelectric refrigerator is used for outside purpose in daytime and system with storage battery, AC rectifier and TER is used in night time when AC power is available. Experimental analysis on the unit was conducted mainly under sunshine conditions. The studied refrigerator can maintain the temperature in refrigerated space at 5–10oC, and has a COP about 0.3 under given conditions.

Min et al. [4] developed a number of prototype thermoelectric domestic-refrigerators with different heat exchanger combination and evaluated their cooling performances in terms of the COP, heat pumping capacity, cooling down rate and temperature stability. The COP of a thermoelectric refrigerator is found to be 0.3-0.5 for a typical operating temperature of 5oC with ambient at 25oC. The potential improvement in the cooling performance of a thermoelectric refrigerator is also investigated employing a realistic model, with experimental data obtained from this work. The results show that an increase in its COP is possible through improvements in module contact resistances, thermal interfaces and the effectiveness of heat exchangers.

Wahab et al. [5] designed and developed an affordable thermoelectric refrigerator powered by solar cells generated DC voltage for the desert people living in Oman where electricity is not available. In this study the researchers used 10 nos. of thermoelectric module in design of refrigerator**.** The finned surface (heat sink) was used to enhance and increase the rate of heat transfer from the hot surface of thermoelectric module. Cooling fan was used to reject the heat from the hot side of module to ambient surroundings. The experimental data collected from running one thermoelectric module indicate that it is possible to achieve temperature difference upto 26.6oC at current 2.5 A and voltage 3.7 V. The coefficient of performance of the refrigerator was calculated and found to be about 0.16.

An experimental study on cooling performance of a developed combined Solar Thermoelectric- Adsorption cooling system has been carried out by ***Abdullah et al. [6]***. They developed a novel solar thermoelectric-adsorption cooling system and tested at eight different days. Cooling is produced via the Peltier effect during the day, by means of thermoelectric elements, and through adsorption process at night. They evaluate the coefficient of performance values by using derived equations, the average COP values of the overall system were found ~ 0.131 (adsorption) and ~ 0.152 (thermoelectric), respectively.

Putra [7] designed, manufactured and tested a portable vaccine carrier box employing thermoelectric module and heat pipe. The position of heat pipe as a heat sink on the hot side of the TEM enhanced the cooling performance. The minimum temperature in the vaccine carrier cabin reached -10oC, which shows that vaccine carrier can store the vaccine at desired temperature.

Adeyanju et al. [8] carried out a theoretical and experimental analysis of a thermoelectric beverage chiller. Comparison were also made between the thermoelectric beverage chiller’s cooling time with cooling times obtained from the freezer space and cold space of a household refrigerator. The result shows that for the refrigerator freezer space, the temperature of the water decreased linearly with increasing time and for thermoelectric beverage chiller the temperature of the water decreased exponentially with increasing time.

Lertsatitthanakorn et al. [9] evaluated the cooling performance and thermal comfort of a thermoelectric ceiling cooling panel (TE-CCP) system composed of 36 TEM. The cold side of the TEM was fixed to an aluminum ceiling panel to cool a test chamber of 4.5 m3 volume, while a copper heat exchanger with circulating cooling water at the hot side of the TE modules was used for heat release. Thermal acceptability assessment was performed to find out whether the indoor environment met the ASHRAE Standard-55's 80% acceptability criteria. The standard was met with the TE-CCP system operating at 1 A of current flow with a corresponding cooling capacity of 201.6 W, which gives the COP of 0.82 with an average indoor temperature of 27oC and 0.8 m/s indoor air velocity.

Gillott et al. [12] conducted an experimental investigation of thermoelectric cooling devices for small-scale space conditioning applications in buildings. They performed a theoretical study to find the optimum operating conditions, which were then applied in the laboratory testing work. A TEC unit was assembled and tested under laboratory conditions. Eight pieces of Ultra TEC were shown to generate up to 220W of cooling effect with a COP of 0.46 under the input current of 4.8A for each module.

Bansal et al. [13] conducted a detail study on energy efficiency and cost-effectiveness for vapour compression, thermoelectric and absorption refrigeration of similar capacity (about 50 liter). The investigated result show that vapour compression refrigerator was the most energy efficient (with a COP of 2.59) followed by thermoelectric (COP of 0.69) and absorption refrigerator (COP of 0.47). The Cost analysis results show that the total purchasing and operating costs over the life of the systems was the lowest for the vapour-compression unit at NZ$506, followed by the thermoelectric ($1381.2) and the absorption refrigerator ($1387.4). The researchers finally concluded that the VC refrigerator was the most energy efficient and cheaper unit followed by the thermoelectric and the absorption refrigeration.

CHAPTER 4

OBJECTIVES OF PROJECT

The overall short term aim was to develop a small, inexpensive and compact 12VDC cooler box using a TEC heat exchanger.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 system could be utilized during the day, achieving very high overall efficiency for the PV system.

The main aim of this dissertation is thus:-

- Understanding the basics of Thermoelectric coolers, working of Thermoelectric Cooling Systems and parameters that governs the performance of such systems.
- To research and understand the Peltier effect.
- To look at commercially available 12VDC cooler boxes.
- To construct a simulator and test the behavior and specifications of a TEC heat exchanger operating in a cooler box environment.
- To compare the results with manufacturers results.
- To compare results with theoretical results and to design and build an inexpensive cooler box ~at is compatible with a 12V RAPS system.

CHAPTER 5

METHODOLOGY ADOPTED

These are some of the important tasks that would be performed during this research:-

- Understanding the basic concepts of thermoelectric cooling.
- Literature review regarding the topic and study about the various equipments to be required.
- Market survey for all the required equipments.
- Procurement of the equipments.
- Design and fabrication of the equipments.
- Preparation of the experimental set up.
- Carrying out experiments and obtaining the results.
- Discussions and conclusion.

5.1 Market survey and cost analysis:-

Market survey was the primary stage to get the material which are required to make the system at lowest possible cost. Firstly price quotation of the each material is obtained from local shops. Then to get heavy discount on material to be purchased wholesaler and distributor were approached.

The materials which were used for making system other were surveyed for their optimum cost are as follows:

The materials which were used for making system other were surveyed for their optimum cost are as follows:

Sr.No	Name Of Component	Quantity	Cost (Rs)
1	SOLAR PANEL	2	2800
2	DC-DC CONVERTER	1	700
3	PELTIER PLATE	2	510
4	BATTERY	3	2500
5	DC FANS	2	300
6	TEMP.INDICATOR	1	180
7	COOLING &HEATING BOX	1	450
8	WIRES,SREW NUT	5	100
9	FRAME	1	600
	TOTAL	18	8140

CHAPTER 6

COMPONENTS

After the study of basic concept and research the components used for“SOLAR OPERATINGHEATING AND COOLING SYSTEM” are:-

- 1.Solar panel
- 2.Charge controller
- 3.Battery
- 4.Fins,thermister
- 5.Exaust fan,circuit kit
- 6.Thermoelectric module.
- 7.Metal (aluminium box,sheets)

6.1 Basic Principle:-

A semiconductor is used because they can be optimized for pumping heat and because the type of charge carriers within them can be chosen. The semiconductor in this examples N type (doped with electrons) therefore, the electrons move towards the positive end of the battery. The semiconductor is soldered to two conductive materials, like copper. When the voltage is applied heat is transported in the direction of current flow.

When a p type semiconductor (doped with holes) is used instead, the holes move in a direction opposite the current flow. The heat is also transported in a direction opposite the current flow and in the direction of the holes. Essentially, the charge carriers dictate the direction of heat flow.

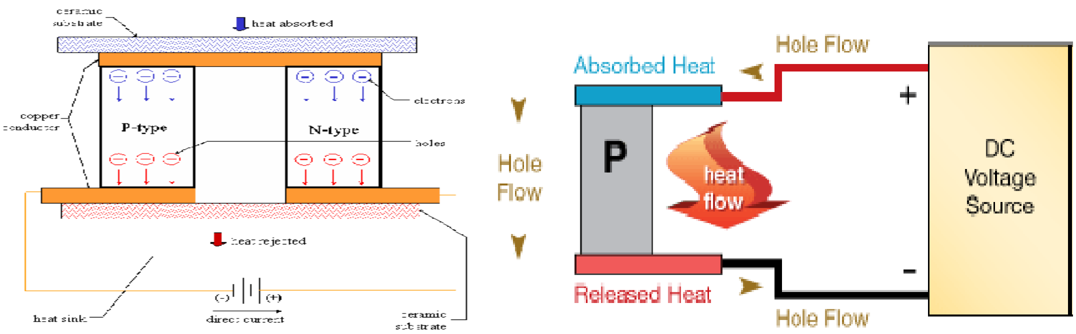


Figure No. 1

6.1.1 Seebeck voltage:-

In 1821 Seebeck detected that a needle of a magnet placed close to dissimilar metals connected electrically in series and thermally in parallel is deflected and exposed to a thermal gradient (Bell Lon E. ,2008). This discovery is the basis for thermoelectric power generation. If different temperatures are applied to a semi-conductive pair an electrical current will be produced. The voltage potential created by the temperature difference drives the flow of electrons. This is called the Seebeck voltage. Good electrical conductors are needed in order to make the process effective. The thermal conductivity however needs to be poor, or the there will be a backflow of heat which reduces the temperature difference between the junctions. As the moving electrons produce heat (Joule heating) and increased electrical current will reduce the Seebeck effect The best performance is found to be achieved by using heavily doped semi-conductors such as Bismuth-Telluride or Silicon-Germanium.

6.1.2 Thermoelectric devices:-

A Peltier element is a thermoelectric cooler, or TEC, which is simply a small heat pump. In 1821 J.T Seebeck discovered that two dissimilar metals connected at two different junctions create a micro voltage between them if held at two different temperatures. If two wires are connected, for example iron and copper, and the other ends applied to the terminals of a galvanometer a voltage can be recorded if the junction between the wires is heated. The wires are called a thermocouple. J. Peltierrealised, in 1834, that the inverse effect is possible as well. If a voltage is applied to a thermocouple a temperature difference will be initiated between the junctions. This is known as the Peltier effect. A heating or cooling effect of the junction is created depending on the direction of the current. In 1855 the dependency between the temperature change and the current application was proven by W. Thomson (or Lord Kelvin) who, by applying thermodynamics, established the relationship between the coefficients that described the Peltier and Seebeck effects, which is now known as the Thomson effect. This effect described reversible heating or cooling when there is a temperature gradient along with an electric current. What happens is the electrons carrying out the current possess different energy depending on the material. When the current reaches the junction it is transferred from one material to another and the energy is altered, causing the junction to heat up or cool down. Likewise, if the junction is heated the electrons can pass from the material with lower energy to that with higher, giving rise to an electromagnetic force.

6.2 Solar Panel:-

Figure No. 2

6.2.1 The basics of solar power:-

Using solar power to produce electricity is not the same as using solar to produce heat. Solar *thermal* principles are applied to produce hot fluids or air. *Photovoltaic* principles are used to produce electricity. A solar panel (PV panel) is made of thenatural element, silicon, which becomes charged electrically when subjected to sunlight.Solar panels are directed at solar south in the northern hemisphere and solar northin the southern hemisphere (these are slightly different than magnetic compassnorth-south directions) at an angle dictated by the geographic location and latitudeof where they are to be installed. Typically, the angle of the solar array is set withina range of between site-latitude-plus 15 degrees and site-latitude-minus 15 degrees,depending on whether a slight winter or summer bias is desirable in the system.Many solar arrays are placed at an angle equal to the site latitude with no bias forseasonal periods.This electrical charge is consolidated in the PV panel and directed to the outputterminals to produce low voltage (Direct Current) - usually 6 to 24 volts. The mostcommon output is intended for nominal 12 volts, with an effective output usually upto 17 volts. A 12 volt nominal output is the reference voltage, but the operatingvoltage can be

17 volts or higher much like your car alternator charges your 12 voltbattery at well over 12 volts. So there's a difference between the reference voltageand the actual operating voltage.The intensity of the Sun's radiation changes with the hour of the day, time of theyear and weather conditions. To be able to make calculations in planning a system,the total amount of solar radiation energy is expressed in hours of full sunlight perm², or Peak Sun Hours. This term, Peak Sun Hours, represents the average amountof sun available per day throughout the year.

It is presumed that at "peak sun", **1000 W/m²** of power reaches the surface of theearth. One hour of full sun provides **1000 Wh per m² = 1 kWh/m²** - representingthe solar energy received in one hour on a cloudless summer day on a one-squaremeter surface directed towards the sun. To put this in some other perspective, theUnited States Department of Energy indicates the amount of solar energy that hitsthe surface of the earth every +/- hour is greater than the total amount of energythat the entire human population requires in a year. Another perspective is thatroughly 100 square miles of solar panels placed in the southwestern U.S. couldpower the country.

6.2.2 Solar Panels:-

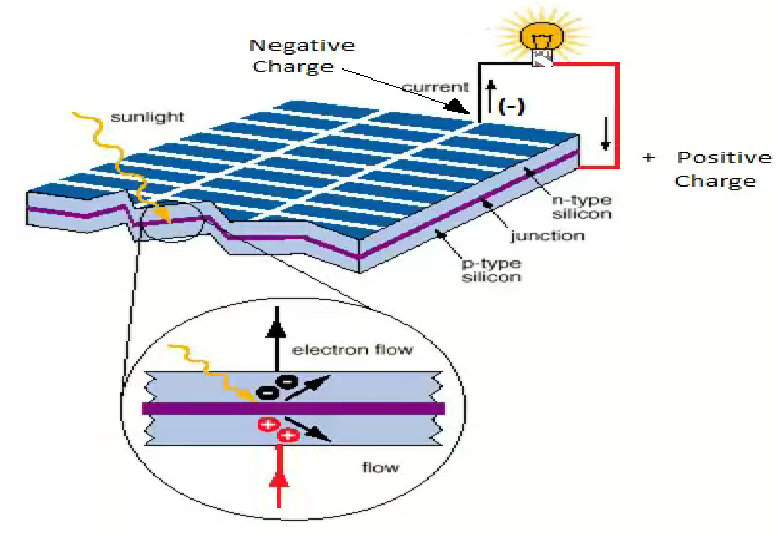


Figure No.3

In space, the most powerful source of energy is the sun. When in day, the sun provides of energy to the satellite [SMAD]. The trick, of course, is to harness this energy in a usable way. For about 60 years, humans have used solar cells (or photovoltaics) in order to convert this wealth of energy in the sun’s rays (photons) into usable energy in the form of current (electrons). This process uses semiconductors which when excited by the photons, release a free electron that is then lose to flow as current. The principles of this conversion are not as important to understand as the fact that with all forms of energy conversion, this process has efficiency. Manufacturing processes and material choices have improved over the years so that high grade cheaper terrestrial solar cells made from silicon can reach efficiencies of around 18% and more expensive space grade solar cells made from triple junction gallium arsenide can reach about 32% efficiency in production models [SMAD]. Some cells still in the R&D phases have been known to go up to 40% efficiency. The terrestrial models are cheaper and have less efficiency because they do not need to be as space efficient as space cells where the projects usually have extreme surface area requirements. Solar cells can be manufactured in all shapes and sizes depending on the manufacturer and the production material. Solar cells are electrically connected and mounted together to form solar arrays, also known as solar panels.

In order to obtain energy from other sources, those supplies must be carried up with the satellite on launch which is both inefficient in terms of space and costly so those options such as batteries or nuclear reactors will not be discussed here.

The intensity of the sun is the solar constant. The factor to account for free rotation and the degradation of cells per year were both found in SMAD. They take into account the random rotation of the satellite and the per year degradation of GaAs solar cells. The surface area is chosen by the size constraint of the cube satellite requirement. The solar cell efficiency is the efficiency of the purchased solar cells. The following equation is then used to calculate the power produced by the satellite while in the sun at the beginning of life.

6.2.3 Solar cells working and operation:-

Solar cells collect light from the sun and turn it into electricity. They do this in the following way.

- Energy from the sun falls on a thin slice of a silicon based material
- This causes the silicon material to have more energy, the electrons in the material move around faster
- Moving electrons create electricity
- The heat energy makes the electric current flow from the silicon material

- The greater the intensity of the sunlight the greater the amount of electricity produced
- The output from a solar cell is at its greatest when the light hits the cell at right angles.
- The amount of electrical power generated is affected by the temperature around the solar cell

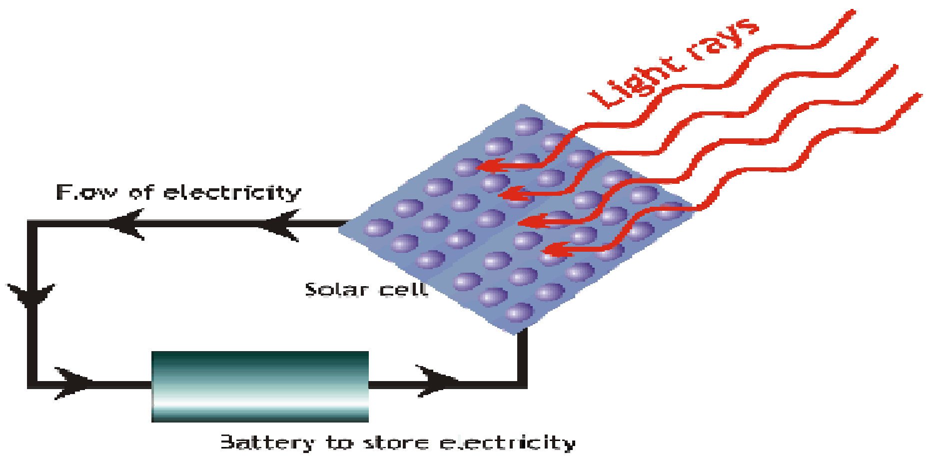


Figure No.4

Solar energy being used to generate electricity which is then stored.

Solar cells convert light energy into electrical energy either indirectly by first converting it into heat, or through a direct process known as the **photovoltaic effect**. The most common types of solar cells are based on the photovoltaic effect, which occurs when light falling on a two-layer semiconductor material produces a potential difference, or voltage, between the two layers. The voltage produced in the cell is capable of driving a current through an external electrical circuit that can be utilized to power electrical devices. This tutorial explores the basic concepts behind solar cell operation.

The tutorial initializes at an arbitrarily set "medium" photon intensity level, with photons randomly impacting the surface of the solar cell to generate free electrons. The released electrons complete a simple circuit containing two light bulbs that become illuminated when current flows through. In order to increase or decrease the photon flux, use the **Photon Intensity** slider to adjust the number of photons incident on the surface.

Today, the most common photovoltaic cells employ several layers of doped silicon, the same semiconductor material used to make computer chips. Their function depends upon the movement of charge-carrying entities between successive silicon layers. In pure silicon, when sufficient energy is added (for example, by heating), some electrons in the silicon atoms can break free from their bonds in the crystal, leaving behind a **hole** in an atom's electronic structure. These freed electrons move about randomly through the solid material searching for another hole with which to combine and release their excess energy. Functioning as free carriers, the electrons are capable of producing an electrical current, although in pure silicon there are so few of them that current levels would be insignificant. However, silicon can be modified by adding specific impurities that will either increase the number of free electrons (**n**-silicon), or the number of holes (missing electrons; also referred to as **p**-silicon). Because both holes and electrons are mobile within the fixed silicon crystalline lattice, they can combine to neutralize each other under the influence of an electrical potential. Silicon that has been doped in this manner has sufficient photosensitivity to be useful in photovoltaic applications.

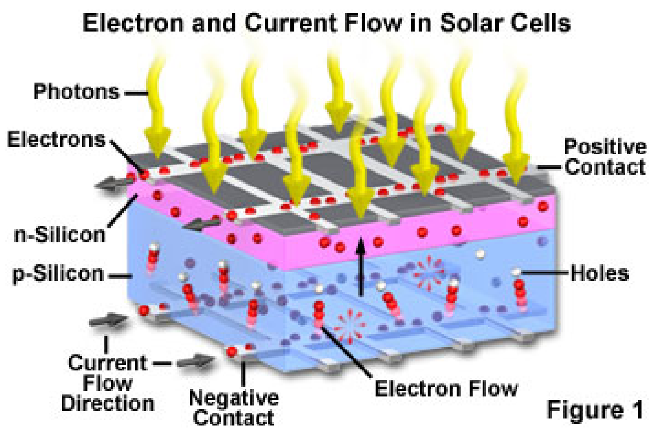


Figure No. 5

In a typical photovoltaic cell, two layers of doped silicon semiconductor are tightly bonded together (illustrated in Figure 1). One layer is modified to have excess free electrons (termed an **n-layer**), while the other layer is treated to have an excess of electron holes or vacancies (a **p-layer**). When the two dissimilar semiconductor layers are joined at a common boundary, the free electrons in the n-layer cross into the p-layer in an attempt to fill the electron holes. The combining of electrons and holes at the p-n junction creates a barrier that makes it increasingly difficult for additional electrons to cross. As the electrical imbalance reaches an equilibrium condition, a fixed electric field results across the boundary separating the two sides.

When light of an appropriate wavelength (and energy) strikes the layered cell and is absorbed, electrons are freed to travel randomly. Electrons close to the boundary (the p-n junction) can be swept across the junction by the fixed field. Because the electrons can easily cross the boundary, but cannot return in the other direction (against the field gradient), a charge imbalance results between the two semiconductor regions. Electrons being swept into the n-layer by the localized effects of the fixed field have a natural tendency to leave the layer in order to correct the charge imbalance. Towards this end, the electrons will follow another path if one is available. By providing an external circuit by which the electrons can return to the other layer, a current flow is produced that will continue as long as light strikes the solar cell. In the construction of a photovoltaic cell, metal contact layers are applied to the outer faces of the two semiconductor layers, and provide a path to the external circuit that connects the two layers. The final result is production of electrical power derived directly from the energy of light.

The voltage produced by solar cells varies with the wavelength of incident light, but typical cells are designed to use the broad spectrum of daylight provided by the sun. The amount of energy produced by the cell is wavelength-dependent with longer wavelengths generating less electricity than shorter wavelengths. Because commonly available cells produce only about as much voltage as a flashlight battery, hundreds or even thousands must be coupled together in order to produce enough electricity for demanding applications. A number of solar-powered automobiles have been built and successfully operated at highway speeds through the use of a large number of solar cells. In 1981, an aircraft known as the ***Solar Challenger***, which was covered with 16,000 solar cells producing over 3,000 watts of power, was flown across the English Channel powered solely by sunlight. Feats such as these inspire interest in expanding the uses of solar power. However, the use of solar cells is still in its infancy, and these energy sources are still largely restricted to powering low demand devices.

Current photovoltaic cells employing the latest advances in doped silicon semiconductors convert an average of 18 percent (reaching a maximum of about 25 percent) of the incident light energy into electricity, compared to about 6 percent for cells produced in the 1950s. In addition to improvements in efficiency, new methods are also being devised to produce cells that are less expensive than those made from single crystal silicon. Such improvements include silicon films that are grown on much less expensive polycrystalline silicon wafers. Amorphous silicon has also been tried with some success, as has the evaporation of thin silicon films onto glass substrates. Materials other than silicon, such as gallium arsenide, cadmium telluride, and copper indium dieseline, are being investigated for their potential benefits in solar cell applications. Recently, titanium dioxide thin films have been developed for potential photovoltaic cell construction. These transparent films are particularly interesting because they can also serve double duty as windows.

6.3 PELTIERPLATE

Figure No. 6

6.3.1 Introduction:-

Improvements in manufacturing methods, driven by the electronics industry, have made TE devices effective in numerous applications. Their compact size and light weight make TE modules especially well-suited for portable and dimensionally constrained applications. Although commercial TEC modules only date from 1960s, thermoelectricity studies started in 1821 when T.J. Seebeck discovered that a compass needle deflected, when placed in the vicinity of a closed loop formed from two dissimilar metal conductors, if the junctions were maintained at different temperatures, and that the deflection was proportional to the temperature difference, settings the origin of thermocouple thermometry.

When Jean Charles AthanasePeltier (1785 – 1845) was studying the Seeback effect in 1834, he realized the heating and cooling effects at the junctions. The basic concept behind thermoelectric (TE) technology is the Peltier effect and refers to the reversible heating or cooling .The Peltier effect occurs whenever electrical current flows through two dissimilar conductors. Depending on the direction of current flow, the junction of the two conductors will either absorb or release heat.

In the world of thermoelectric technology, semiconductors (usually Bismuth Telluride) are the material of choice for producing the Peltier effect—in part because they can be more easily optimized for pumping heat, but also because designers can control the type of charge carrier employed within the conductor (the importance of this will be explained later). Using this type of material, a Peltier device (i.e., thermoelectric module) can be constructed—in its simplest form—around a single semiconductor 'pellet' which is soldered to electrically-conductive material on each end (usually plated copper). In this 'stripped-down' configuration, the second dissimilar material required for the Peltier effect, is actually the copper connection paths to the power supply.

6.3.2 Basic Principle:-

Thermo electrics are based on peltier effect which states that when a dc current is applied across two dissimilar metals it causes a temperature differential resulting in development of hot and cold sides. If you put a drop of water in the hollow on the joint of 2 semiconductors Sb and Bi, and switch on the current, the drop would freeze (with the reverse direction of the current the drop would melt). This is how Peltier effect works. The typical thermoelectric module is manufactured using two thin ceramic wafers with a series of p & n doped bismuth –telluride semiconductor sandwiched between them. One p type and one n type make a couple. The thermoelectric couples are thermally in parallel and electrically in series. A thermoelectric module has one to several numbers of couples.

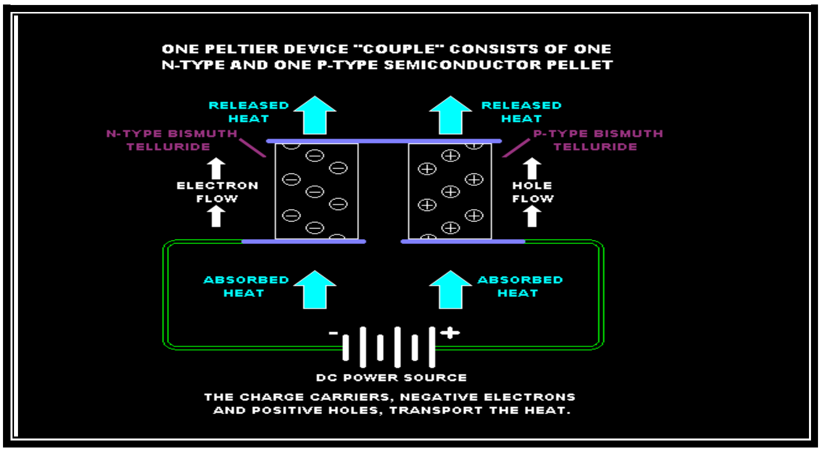


Figure No. 7

The n type material has excess of electrons while p type material has a deficit of electrons. As electrons move from p type to n type through an electrical connector, the electrons jump from higher energy state absorbing thermal energy (cold side). Continuing through the lattice material, the electrons move from n type to p type dropping to lower energy state and releasing energy as heat to the heat sink. The transfer of heat is caused by the change in electron energy levels when electrons access the conduction band as defined by quantum physics. Thermo electrics can be used to heat and cool depending upon the direction of current.

6.3.3 Thermoelectric module:-

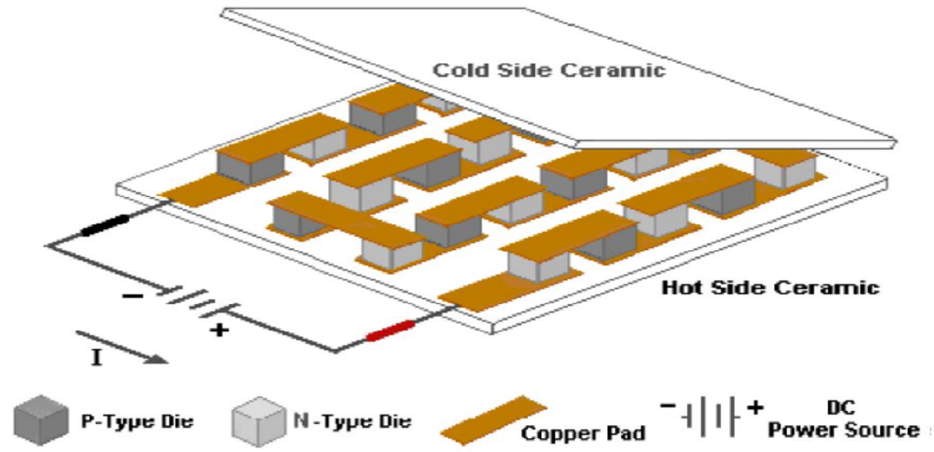
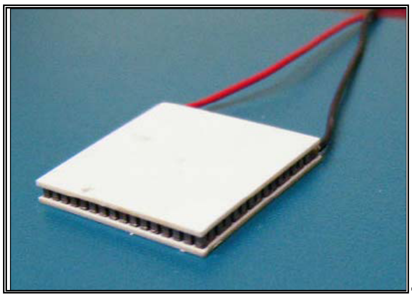
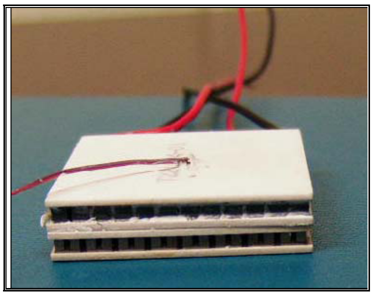


Figure No. 8

A typical thermoelectric module is composed oftwo ceramic substrates that serve as a foundationand electrical insulation for P-type and N-typeBismuth Telluride dice that are connectedelectrically in series and thermally in parallelbetween the ceramics. The ceramics also serve asinsulation between the modules internal electricalelements and a heat sink that must be in contactwith the hot side as well as an object against thecold side surface. Electrically conductive materials,usually copper pads attached to the ceramics, maintain the electrical connections inside themodule. Solder is most commonly used at theconnection joints to enhance the electricalconnections and hold the module together [6]. Mostmodules have and even number of P-type and Ntypedice and one of each sharing an electricalinterconnection is known as, "a couple." [6].While both P-type and N-type materials arealloys of Bismuth and Tellurium, both havedifferent free electron densities at the sametemperature. P-type dice are composed of materialhaving a deficiency of electrons while N-type hasan excess of electrons. As current (Amperage)flows up and down through the module it attemptsto establish a new equilibrium within the materials.The current treats the P-type material as a hotjunction needing to be cooled and the N-type as acold junction needing to be heated. Since thematerial is actually at the same temperature, theresult is that the hot side becomes hotter while thecold side becomes colder. The direction of thecurrent will determine if a particular die will cooldown or heat up. In short, reversing the polaritywill switch the hot and cold sides





Single stage module**Figure No. 9**Cascaded module

- TEC can achieve temperature differences up to 70°C, or can transfer heat at a rate of 125 W. To achieve greater temperature differences (up to 131°C), select a multistage (cascaded) modules. The use of thermoelectric modules often provides solutions, and in some cases the ONLY solution, to many difficult thermal management problems where a low to moderate amount of heat must be handled.

6.3.4 What are Peltier elements made of:-

Peltier thermo-elements are mainly made of semiconductive material. This means that they have P-N contacts within. Actually, they have a lot of P-N contacts connected in series. They are also heavily doped, meaning that they have special additives that will increase the excess or lack of electrons. The following drawing shows how the P-N contacts are connected internally within a PeltierTEC: Now, imagine tens or hundreds of that P-N material between two plates. The following drawing shows how many P-N contacts can exist in a rectangular area like a Peltier TEC. You can see how the P and N material are connected in series together to implement a long strip of P-N junctions. The top plate is the hot plate and the bottom is the cold plate. When power is applied to the two wires, the heat will be transferred from the cold plate to the hot plate and thus the cold plate shall cold.

6.3.5 Construction And Working:-

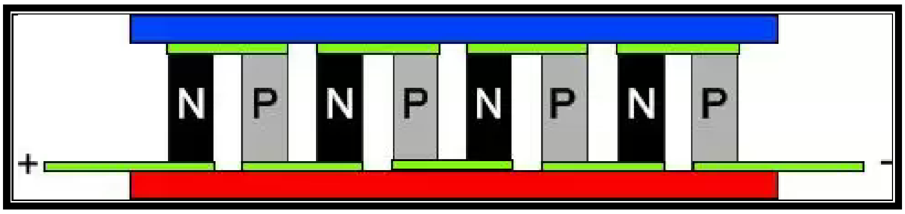


Figure No.10

Thermoelectric modules are solid-state heat pumps that operate on the Peltier effect (see definitions). A thermoelectric module consists of an array of pand n-type semiconductor elements that are heavily doped with electrical carriers. The elements are arranged into array that is electrically connected in series but thermally connected in parallel. This array is then affixed to two ceramic substrates, one on each side of the elements (see figure below). Let's examine how the heat transfer occurs as electrons flow through one pair of p- and n-type elements (often referred to as a "couple") within the thermoelectric module:

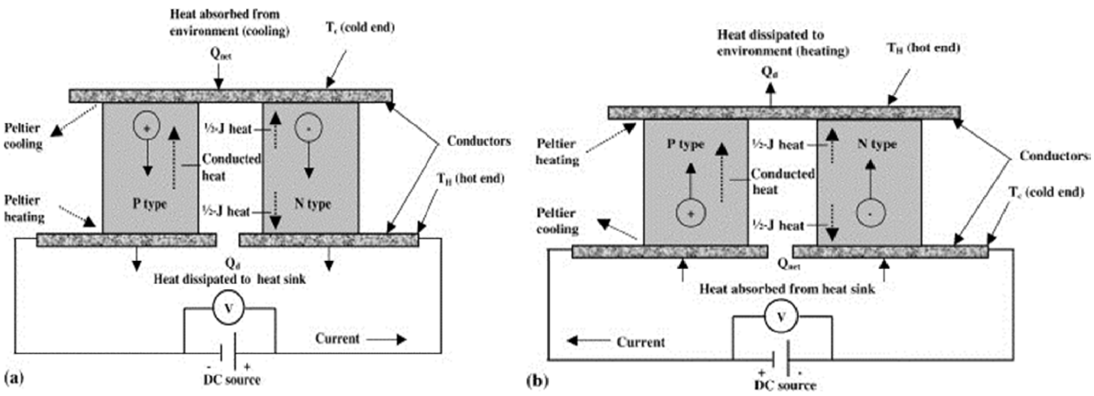


Figure No.11

The p-type semiconductor is doped with certain atoms that have fewer electrons than necessary to complete the atomic bonds within the crystal lattice. When a voltage is applied, there is a tendency for conduction electrons to complete the atomic bonds. When conduction electrons do this, they leave “holes” which essentially are atoms within the crystal lattice that now have local positive charges. Electrons are then continually dropping in and being bumped out of the holes and moving on to the next available hole [8]. In effect, it is the holes that are acting as the electrical carriers.

Now, electrons move much more easily in the copper conductors but not so easily in the semiconductors. When electrons leave the p-type and enter into the copper on the cold-side, holes are created in the p-type as the electrons jump out to a higher energy level to match the energy level of the electrons already moving in the copper. The extra energy to create these holes comes by absorbing heat. Meanwhile, the newly created holes travel downwards to the copper on the hot side. Electrons from the hot-side copper move into the p-type and drop into the holes, releasing the excess energy in the form of heat.

The n-type semiconductor is doped with atoms that provide more electrons than necessary to complete the atomic bonds within the crystal lattice. When a voltage is applied, these extra electrons are easil moved into the conduction band. However, additional energy is required to get the n-type electrons to match the energy level of the incoming electrons from the cold-side copper. The extra energy comes by absorbing heat. Finally, when the electrons leave the hot-side of the n-type, they once again can move freely in the copper. They drop down to a lower energy level, and release heat in the process.

6.3.6 Peltier characteristic curves:-

Peltier elements can give more than to 80°C temperature difference between their plates. But this is not a standard value. Actually, this would only be achieved in ideal conditions. The actual temperature difference (ΔT) is usually smaller. The specifications of a TEC usually show the achieved temperature difference in conjunction to the power transferred in watts. The diagram should look like the following:

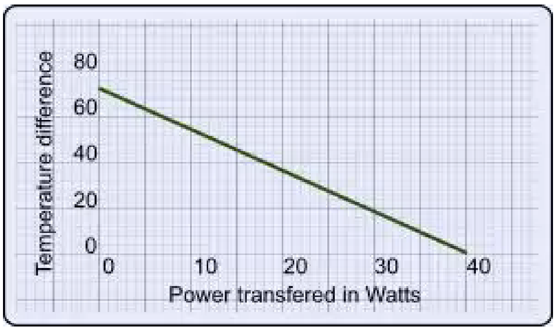


Figure No. 12

Looking the above diagram, we can calculate the temperature difference that will be achieved according to the power that the TEC will have to move across the plates. The power is measured in watts, but we actually talk about the thermal power. You can use our temperature unit converter to convert watts to your desired units. You should not confuse the power of Peltier operation with the power that it transfers. It is most common that TECs are sold with the electric power indicated. A 125 Watt peltier may NOT be able to transfer 125 Watts of thermal power across the plates. Instead, it is most possible that it will draw 125 Watts electric power at max conditions. Peltiers comes usually with the datasheet that indicates the performance curves of the device. Those curves are essential if you want to make your theoretical calculations for the optimal device operation. The first characteristic curve for a peltier is the Temperature difference vs Heat pump capacity. This curve indicates the temperature difference to be achieved in order to pump specific power of heat. It may be one or more curves for different current loads. An example of such a curve is shown in the following diagram:

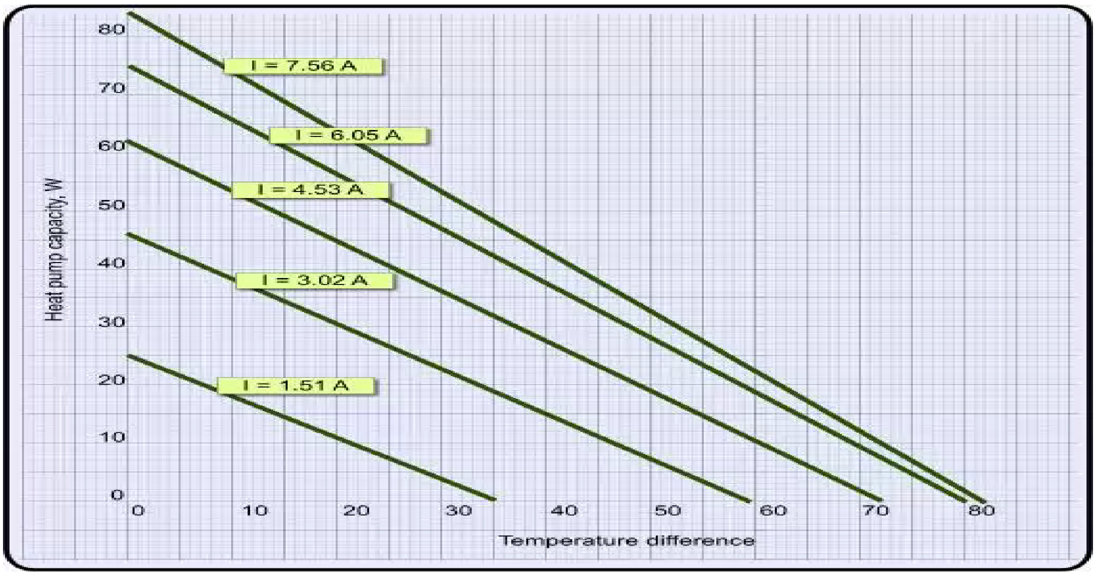


Figure No. 13

The above curves comes from a real Peltier and are not imaginary. What we could conclude from the above is that if we need for example to transfer 30 Watts of heat, then - with appropriate voltage as we will see right next - there would be created a temperature difference of 20 degrees and the TEC would draw as much as 3.02 Amperes. The next characteristic curve is the Temperature difference VS voltage. With this curve, we can calculate the voltage needed to be applied on the TEC in order to achieve the appropriate temperature difference. Here is one -also real- characteristic curve:

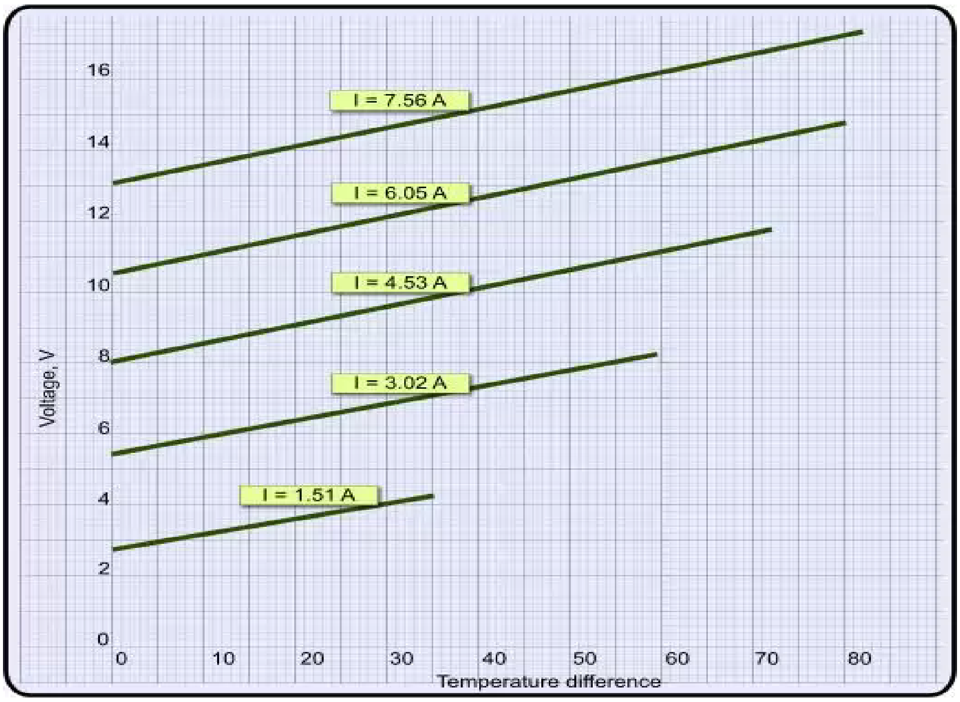


Figure No. 14

Let's continue the example we started before. We calculated that we need 20 degrees temperature difference and 3.02 amperes to achieve the 30 Watts power transfer. How much voltage must we apply to the Peltier to achieve this? From the above diagram, it's easy to find that we need about 6.5 Volts.

6.4 TEMPERATURE INDICATOR:-

Temperature indicator is used to measure the temperature inside the coolingchamber or heating chamber .many different types of temperature indicators are available in market .digital ,analog etcDigital are costly but easy to read. Errorless, analogindicator is difficult to read and erroroccurs due to surrounding effect or manufacturing defect. A temperature sensor is a device, typically, a thermocouple or RTD that provides for temperature measurement through an electrical signal. A thermocouple (T/C) is made from two dissimilar metals that generate electrical voltage in direct proportion to changes in temperature. An RTD (Resistance Temperature Detector) is a variable resistor that will change its electrical resistance in direct proportion to changes in temperature in a precise, repeatable and nearly linear manner.

Figure No. 15

6.5 BATTERY:-

Figure No. 16

Batteries play a vital role in solar photovoltaic cooling and heating systems. Despite breakthroughs in operational characteristics of various components of such systems, lead acid batteries continue to be the only viable electrical energy storage devices as of date. The purpose of this paper is to report the results of characterization of a lead acid battery system as a component of a small capacity uninterrupted cooling and heating system. The charging characteristics on solar energy, mains and a generator set powered by an internal combustion engine are presented.

Figure No.17

The following attributes would support the eventual substitution of Li batteries for lead acid batteries in solar vaccine cooling and heating. These attributes are broadly described as:

1.) ***Reliability and Safety*****:** Li batteries will need to exhibit reliability and safety equal to lead acid batteries;

2.) ***Longer Service Life***: Li batteries will need to demonstrate the extent to which Li battery service life exceeds that of lead acid batteries and provide increased warranty;

3.) ***Technical Support***: Improved technical support must be provided by both battery makers and solar industry specifically for standalone solar power recharging applications; and

4.) ***Cost****:* Although a 20 year Li battery has a life cycle cost advantage the initial cost of Li batteries likely will need to decline to establish market penetration

6.5.1Background:-

Solar vaccine refrigerators are most often used in remote health posts and clinics lacking reliable electricity. Current practice is to permanently install a solar photovoltaic (PV) power array to recharge a lead acid battery to power the refrigerator. Lead acid batteries have a service life of three to five years with rare reports of life of ten years. Lead acid battery life is significantly less than the 20+ year service life of solar PV modules and refrigerators with service life of 10 to 20 years This is because replacing lead acid batteries is expensive, requires a trained technician, will have complicated logistics and high quality batteries may not be readily available in country. Battery replacement must be planned at the onset of a solar vaccine cooling and heating projects and funds must be available prior to the need for battery replacement.

6.6 D.C. FAN:-

Figure No.18

6.6.1 Introduction:-

Cooling fans and blowers provide cooling solutions to your system thermal problems. The need for forced-air cooling by using an AC or DC axial fan or blower should be determined at an early stage in the system design. It is important that the design plans for good airflow to heat-generating components and allows adequate space and power for the cooling fan or blower.While electronic cooling fans are necessary for a variety of electronic machinery, one of the most common uses of cooling fans is to draw heat away from cooling and heating systems.

There are cooling and heating system cooling fans built in to all cooling and heating systems that are sold commercially, but sometimes these cooling fans aren't enough to do the job. The issue is with your CABIN. As you just learned, the CABIN, or Central Processing Unit, generates a great deal of heat and is highly temperature sensitive. If your CABIN should overheat, your system will crash. In a new cooling and heating system that performs only basic computing duties, the cooling fan that comes built into your cooling and heating system can keep the CABIN cool and keep your systems functioning. If the cooling and heating system has been through some wear, or is trying to keep up with constant, complex operations, the amount of heat generated may be too much for the system to dissipate internally with its own cooling fan, which is when quality, powerful CABIN cooling fansbecome critical. If your cooling and heating system is suddenly shutting down without warning, there's a good chance that overheating is the issue.

Check your cooling and heating system vent. Is there a tremendous amount of hot air coming out? This may mean your system is overworked. The right cooling fan can make all the difference in restoring your cooling and heating system to full operating capacity. In addition, the sooner you replace your cooling fans, the better. Although your system is designed to shut down as soon as it begins to overheat, repeated overheating can do permanent damage to your cooling and heating system's internal components. Finding the right cooling fan for your system and installing it as soon as possible is the key to long cooling and heating system life.

6.6.2 What are cooling fan ?

Cooling fans and blowers are essential to systems that produce a significant amount of heat like TE DEVICEs and other electronic components. Different systems are engineered to work with specific types of fans. Cooling fans come in all shapes and sizes as well as voltage, airflow, and case size. Some are even weather resistant and can stand up against the elements. It's important to know the specific type of fan your CABIN / electronic component requires as fans and blowers are not universal. Be sure to reference the fan part number before you buy a replacement. Installing the wrong fan type can cause more harm to your TE DEVICE/system.

6.6.3 Why Cooling Fans and Blowers are Necessary?

The TE device system generates the most heat in your typical system. It's also the most temperature-sensitive. That's why fans are necessary to aid in cooling the system. Without them, the TE device system would overheat and cease functioning. But the TE device system isn't the only heat-generating component in a system. The power supply also increases the temperature of a system. So although the TE DEVICE SYSTEM generates the most heat, the power supply also makes it necessary to have a cooling system in place to keep temperatures low and keep it from overheating. Without a way to maintain its temperature, a system won't last.

6.7Electric Wires:-

To enable wires to be easily and safely identified, all common wiring safety codes mandate a color scheme for the insulation on power conductors. In a typical electrical code, some color-coding is mandatory, while some may be optional. Many local rules and exceptions exist. Older installations vary in color codes, and colors may shift with insulation exposure to heat, light, and aging.

Many electrical codes now recognize (or even require) the use of wire covered with green insulation, additionally marked with a prominent yellow stripe, for safety earthing (grounding) connections. This growing international standard was adopted for its distinctive appearance, to reduce the likelihood of dangerous confusion of safety earthing (grounding) wires with other electrical functions, especially by persons affected by red-green colour blindness.

Figure No.19

6.8Nitrile rubber:-

Nitrile rubber insulation is a very versatile and flexible insulation. It is widely used the Industrial insulation, air-conditioning, plumbing and Hvac industries. It is a closed cell elastomeric insulation and is resistant to water vapour, oil and most acids. Because of its flexibility it is ideal for insulating vessels, curved or irregular shapes. It is used in the automotive and aeronautical industry to make fuel and oil handling hoses, seals, grommets, andself-sealing fuel tanks, since ordinary rubbers cannot be used.[1] It is used in the nuclear industry to make protective gloves. NBR's ability to withstand a range of temperatures from −40 to 108 °C (−40 to 226 °F) makes it an ideal material for aeronautical applications. Nitrile butadiene is also used to create moulded goods, footwear, adhesives, sealants, sponges, expanded foams, and floor mats.

6.8.1 Composition and Characteristics:-

Nitrile rubber (Armaflex) is a versatile and flexible closed cell elastomeric insulation suitable for applications up to an approximate maximum continuous operating temperature of 105ºC. Nitrile rubber materials. Elastomeric products are commonly based on a blend of poly vinyl chloride (pvc) and nitrile butadiene rubber (nbr) using a chemical blowing agent.

Figure No.20

The basic processing steps in manufacturing the product are mixing, extrusion, or shaping or heating. During the heating step, the elastomeric portion is crosslinked, or vulcanized, and the chemical blowing agent decomposes to produce primarily nitrogen gas.

6.8.2 Properties and application:-

- Elastomeric products offer excellent flexibility.
- Resistant to water vapour.
- Resistant to thermal transmittance properties.
- Oil and acid resistant (refer to manufacturer’s data sheets before installation).
- Excellent adhesive and coating receptiveness.
- Good cutting characteristics and easy to fabricate.Proper installation is critical to the insulation system’s performance.
- Refrigeration pipe work, heating and ventilation pipe work, airconditioning pipe work.
- Heating and ventilation ductwork systems.
- Vessels and curved or irregular surfaces.

CHAPTER 7

CALCULATION

7.1 COP Of The Heating System

1. ATMOSPHERIC TEMPERATURE:- 35^0C
2. TEMPERATURE INSIDE THE SYSTEM :-34^0C

➢ FORMULA:-

C.O.P= $\frac{T2}{T2-T1}$

T_{1}= LOW TEMPERATURE

T_{2}=HIGH TEMPERATURE

Table No. 2

Time (Min)	System Temperture Inlet In ^{0}c (T2)	Exhaust Temperture Outlet In ^{0}c (T1)	C.O.P
5	39.3	36.7	15.11538462
10	50.1	35.2	3.362416107
15	53.9	34.4	2.764102564
20	55.4	34.5	2.650717703
25	57.1	34.8	2.560538117
30	58.6	34.6	2.441666667
35	59.9	34.8	2.386454183
40	61.9	34.9	2.292592593
45	63.2	35.2	2.257142857
50	65.1	35.1	2.17
55	67.3	35.2	2.096573209
60	69.1	35.4	2.050445104
		TOTAL C.O.P	**42.14803372**

AVG C.O.P=(TOTAL C.O.P/13)	3.512336143

7.2 COP Of The Cooling System

3. ATMOSPHERIC TEMPERATURE:- 35^0C

4. TEMPERATURE INSIDE THE SYSTEM :-34^0C

- FORMULA:-

C.O.P=$\frac{T1}{T2-T1}$ T_1= LOW TEMPERATURE

T_2=HIGH TEMPERATURE

Table No. 3

Time (Min)	System Temperture Inlet In ^{0}c (T_1)	Exhaust Temperture Outlet In ^{0}c (T_2)	C.O.P
5	29.7	39.9	2.911764706
10	29.5	41.5	2.458333333
15	29.3	41.2	2.462184874
20	29	41.1	2.396694215
25	28.8	40.9	2.380165289
30	28.6	40.8	2.344262295
35	28.5	40.3	2.415254237
40	28.4	40.8	2.290322581
45	28.3	40.2	2.378151261
50	28.2	40.5	2.292682927
55	28.1	40.2	2.32231405
60	28	40.1	2.314049587
65	27.9	40.2	2.268292683
		TOTAL C.O.P	**31.23447204**

AVG C.O.P=(TOTAL C.O.P/13)	2.402651695

CHAPTER 8

APPLICATION & ADVANTAGES

8.1 Application:-

TE technology can be used for electricity generation as well as cooling. This flexibility results in a huge variety of possible applications. TE devices have many possible applications beyond cooling CABIN chips. Among These applications are portable coolers, environmental control for optoelectronic equipment, and power generation in remote environments. Some consumer applications include a TE powered watch, a TE temperature controlled vest, a Cannon digital camera], and a portable cooler.

Electronics — miniature cooling units for incoming stages of highly sensitive receivers and amplifiers; coolers for high power generators, laser emitters and systems, CCD cameras, parameticamplfiers, vacuum and solid-state photo detectors and CPU coolers

Medicine — mobile cooling containers for storage and transportation of tissue, blood, liquids, etc; opthamalogical devices for crystallic lens transplantation; micropincers; cooling blankets and sheets; dermatology treatment devices;anaesthesiologic equipment, cosmetic and pharmaceutical items; scalp coolers to minimise hair loss during chemotherapy

Scientific and Laboratory Equipment — cooling chambers; freezers; cooling incubators; temperature stabilized chambers; cold laboratory plates and tables; thermocalibrators; stage coolers; thermostats; coolers and temperature stabilisers for multipurpose sensors

Consumer Goods — portable picnic boxes; drinking water and beverage coolers; cooling boxes and cabinets for stores and cafes; massage equipment

Climate Devices — multipurpose thermoelectric conditioners; airflow cooling fans; room air conditioner-humidifiers for electronics racks, cabinets, libraries (including video libraries); temperature stabilisers for aquariums and terrariums

Automotive — seat cooling and heating for climatic seats; driver in-cab face and drink cooling for buses, tractors, mechanical diggers, trucks; coolers for motorcycle helmets.

8.2 Advantages:-

Simple technology without moving parts enables a reliable system. Technology mainly used for very small surfaces, but also for small transportable fridges.TE coolers will often provide substantial advantages over alternative technologies.

Some of the more significant features of thermoelectric modules include:

a) No Moving Parts: A TE module works electrically without any moving parts so they are virtually maintenance free.

b) Small Size and Weight: The overall thermoelectric cooling system is much smaller and lighter than a comparable mechanical system. In addition, a variety of standard and special sizes and configurations are available to meet strict application requirements.

c) Ability to Cool below Ambient: Unlike a conventional heat sink whose temperature necessarily must rise above ambient, a TE cooler attached to that same heat sink has the ability to reduce the temperature below the ambient value.

d) Ability to Heat and Cool with the same module: Thermoelectric coolers will either heat or cool depending upon the polarity of the applied DC power.

e) Precise Temperature Control: With an appropriate closed-loop temperature control circuit, TE coolers can control temperatures to better than +/- 0.1°C.

f)High Reliability: Thermoelectric modules exhibit very high reliability due to their solid state construction. Although reliability is somewhat application dependent, the life of typical TE coolers is greater than 200,000 hours.

g) Electrically "Quiet" Operation: Unlike a mechanical cooling and heating system, TE modules generate virtually no electrical noise and can be used in conjunction with sensitive electronic sensors. They are also acoustically silent.

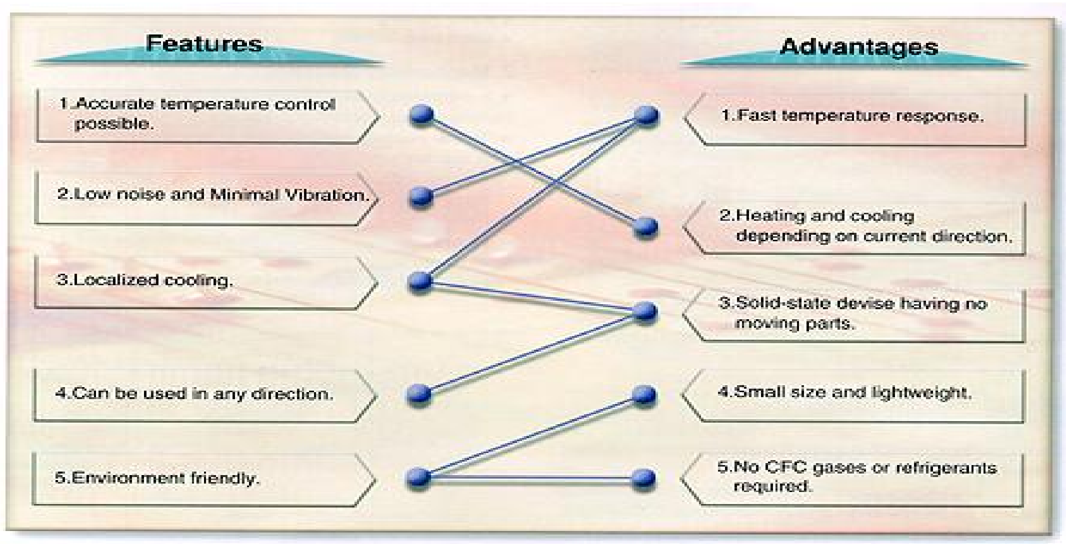
h) Operation in any Orientation: TEs can be used in any orientation and in zero gravity environments. Thus they are popular in many aerospace applications.

I)Convenient Power Supply: TE modules operate directly from a DC power source.

j) Spot Cooling: With a TE cooler it is possible to cool one specific component or area only, thereby often making it unnecessary to cool an entire package or enclosure.

k) Ability to GenerateElectrical Power: When used "in reverse" by applying a temperature differential across the faces of a TE cooler, it is possible to generate a small amount of DC power.

l) Environmentally Friendly: Conventional cooling and heating systems cannot be fabricated without using chlorofluorocarbons or other chemicals that may be harmful to the environment. Thermoelectric devices do not use or generate gases of any kind.



CHAPTER 9

FUTURE SCOPE

The objective project is to achieve the long term cooling in case of power failure for refrigerator. A TER Cooling system is has been designed and developed to provide active cooling with help of single stage 12 V TE module is used to provide adequate cooling.

To build a real time model replacing both air conditioner & room heater in one system i.e. thermoelectric hot & cold room conditioner.

CHAPTER 10

REFRENCES

10.1 JOURNALS:-

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