

Fabrication of Thermo Electric Solar Fridge

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Abstract: Thermoelectric couples are solid-state devices capable of generating electrical power from a temperature gradient, known as the Seebeck effect, or converting electrical energy into a temperature gradient, known as the Peltier effect. A solar panel is charge by photo voltaic effect through sun light. A battery is connected to the solar panel which is charged through solar power the thermo electric module zip is connect to battery while current is passed through zip heat is produced on one side and cool is produced on another side of the zip. A typical thermoelectric module is composed of two ceramic substrates that serve as a housing and electrical insulation for P-type and N-type (typically Bismuth Telluride) elements between the substrates. Heat is absorbed at the cold junction by electrons as they pass from a low energy level in the p-type element, to a higher energy level in the n-type element. At the hot junction, energy is expelled to a thermal sink as electrons move from a high energy element to a lower energy element. A module contains several P-N couples that are connected electrically in series and thermally in parallel. The generated cool is to be utilized for refrigeration and heat is send to surrounding environment.

Key Words: Bismuth Telluride, Thermo couple, PELTIER EFFECT

I. Introduction

The first important discovery relating to thermo electricity occurred in 1823 when a German Scientist, Thomas Seebeck, found that an electric current would flow continuously in a closed circuit made up of two dissimilar metals provided that the junctions of the metals were maintained at two different temperatures. Some 12 years later French watchmaker, Jean Charles Athanase Peltier, 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.

“Faster, mightier & smaller” is still the keyword for every invention and development. In day-to-day world we concentrate on the compactness and efficiency of every product. Keeping this in our thought we have designed and fabricated an economical and reliable unit known as “Thermo electric air conditioner”.

“Human comfort is that condition of mind, which expresses itself with the thermal environment”. In our project two rival properties of cool water and cool air are obtained. This system can be used continuously.

II. Domain of the Project

Thermo Electric Module

The classic vacuum diode is on the top left. Used in vacuum tubes, television screens and numerous scientific instruments and tools, the vacuum diode is a highly mature technology. The Thermionic Converter is in the middle. Conceived at the beginning of the 20th century, the thermionic converter was proven to work in the 1950s, but largely abandoned by the early 1970s. The thermionic converter harnesses a thermal differential to create electrical output power. The Cool Chip is the Power Chip in reverse. Instead of creating power from a thermal difference, the Cool Chip creates a thermal difference (cooling) from electrical power.

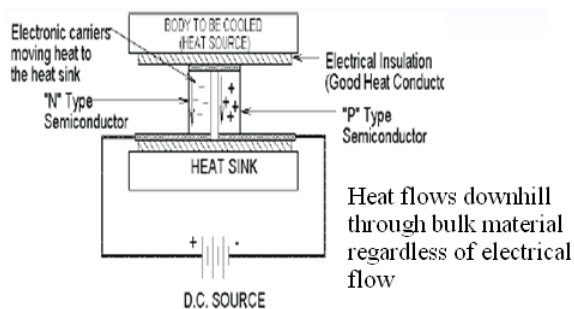


Fig.1(a): Thermo electric module circuit

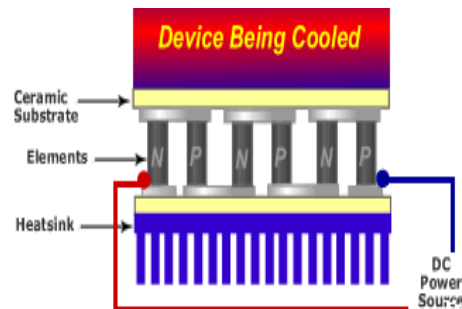


Fig. 1(b): Thermo electric system Layout

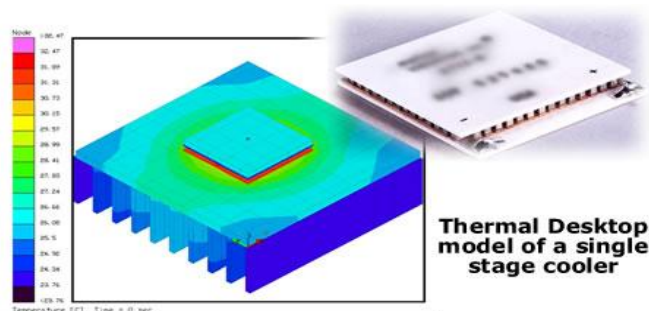


Fig. 2: Thermo electric module Zip

Thermoelectrics also has a long pedigree. Using a combination of the Seebeck, Thomson and Peltier effects, cooling occurs when electricity flows through materials and specific junctions. Classic thermoelectric work, but with very low efficiency. The reason is simple. Heat will flow through any material, and does not require electrons to do so. So as soon as one side becomes colder than the other, then natural conduction will seek to equilibrate the two sides. As a result, efficiencies, expressed as a percentage of the Carnot-defined maximum, do not exceed 5-8%. For decades, researchers have hunted for the ideal material which would make thermoelectric efficient.

That material would conduct electrons (and their energy) with ease, yet be a very good thermal insulator. The best bulk material found for thermoelectric was found in the 1950s: bismuth telluride. Since then, despite many hundreds of millions of research dollars spent, a better bulk solution has yet to be found. It has been suggested that the perfect material, one with both excellent electrical conductivity properties, and superb thermal insulation, might as well be dubbed “unobtainium”.

Thermoelectric coolers (TECs) employ the Peltier effect, acting as small, solid-state heat pumps. The TECs are ideally suited to a wide variety of applications where space limitations and reliability are paramount. The TECs operate on DC current and may be used for heating and cooling by simply reversing the direction of the DC current.

Thermoelectric coolers (TECs) are solid-state heat pumps that have no moving parts and do not require the use of harmful chemicals. The ability to use TECs to heat as well as cool benefits applications that require temperature stabilization of a device over a wide ambient temperature range, such as laser diode, portable temperature chambers, and airborne equipment. A bidirectional DC current is required for those applications requiring both heating and cooling. The TEC requires a smooth DC current for optimum operation. A ripple factor results in degradation in delta T. A number of methods can be used to regulate the magnitude and direction of the TEC current.

Liner regulation can be used but it is very inefficient and requires a bipolar power supply. The pulse width modulation (PWM) technique can be used to improve the efficiency and reduce overall system size, as long as its switching frequencies are above 5 kHz with suitable LC filters. To suppress temperature fluctuation because of ambient temperature variation and uncertainties of the load condition, the controller must be capable of either sourcing or removing heat to maintain control without temperature overshoot or undershoot. These requirements can be met by implementing closed-loop control for both heating and cooling.

Seebeck Effect: The thermocouple conductors are two dissimilar metals denoted as X and Y materials. With heat applied to the end B of the thermocouple and the end A is cooled, a voltage will appear across terminals T1 and T2. This voltage is known as the see beck effect.

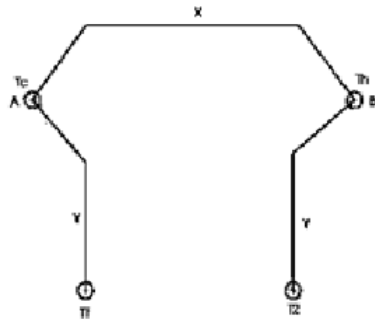


Fig. 3(a): Seebeck effect

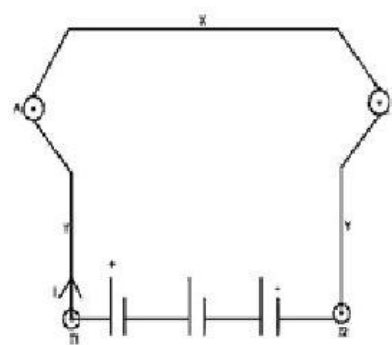


Fig. 3(b): Peltier effect

Peltier Effect: The Peltier effect bears the name of Jean-Charles Peltier, a French physicist who in 1834 discovered the calorific effect of an electrical current at the junction of two different metals. When a Current (I) is made to flow through the circuit, heat is evolved at the upper junction (T2) and absorbed at the lower junction (T1). The Peltier heat absorbed by the lower junction per unit time is equal to $(I) \pi AB$ Where πAB is the Peltier coefficient. Peltier heat is reversible, when the direction of current is reversed; the Peltier heat is the same, but in opposite direction. Peltier coefficient depends on the temperature and materials of a junction. Fig. 2 Illustrates the Peltier effect. If a voltage is applied to terminals T1 and T2, electric current (I) will flow in the circuit. As a result of the current flow, a slightly cooling effect will occur at thermocouple junction Note that this effect will be reversed whereby a change in the direction of electric current flow will reverse the direction of heat flow.

Heat Sink: The heat sink usually made of aluminum, is in contact with the hot side of a thermoelectric module. When the positive and negative module leads are connected to the respective positive and negative terminals of a Direct Current (D.C) power source, heat will be rejected by the module's hot side, the heat sink expedites the removal of heat. Heat sink typically is intermediates stages in the heat removal process whereby heat flows into a heat sink and then is transferred to an external medium. Common heat sinks include free convection, forced convection and fluid cooled.

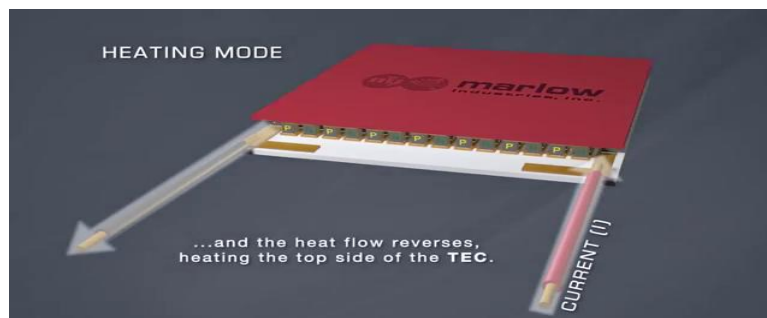


Fig. 4: Heating mode

Cold mode: The cold side also made of aluminum is in contact with the cold side of a thermoelectric module, when the positive and negative module leads are connected to the respective positive and negative terminals of a direct current (D.C) power source, heat will be absorbed by the module's cold side. The hot side of a thermoelectric module is normally placed in contact with the object being cold.

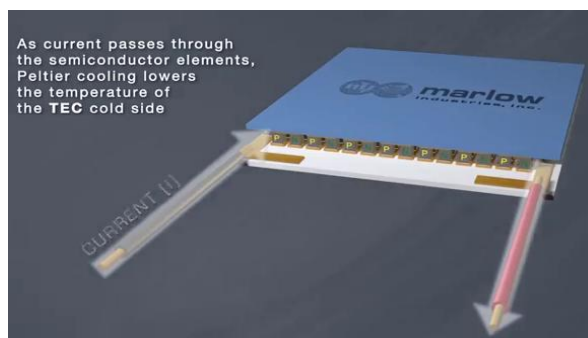


Fig. 5: Cooling Mode

D.C. Blower: The fan (impeller) rotates inside the shell. The shell is so designed that the air is rushed out force. The blower consists of two main parts. They are

- D.C motor
- Impeller Blades(Fan)

The D.C motor is directly coupled with Impeller blades. The water pump is used to circulate the water to the blower. The cool air is rushed out force. The battery is connected to the D.C motor, so that D.C motor runs directly.

D.C Motor Principle: The D.C motor is used to control the direction of hot air flow. In our project the hot air is distributed in all direction with the same rate by using D.C motor tilting mechanism.

Principle of Operation: The basic principle of motor action lies in a simple sketch. The working principle tells that, when a current carrying conductor is placed in a magnetic field, a force is produced to move the conductor away from the magnetic field

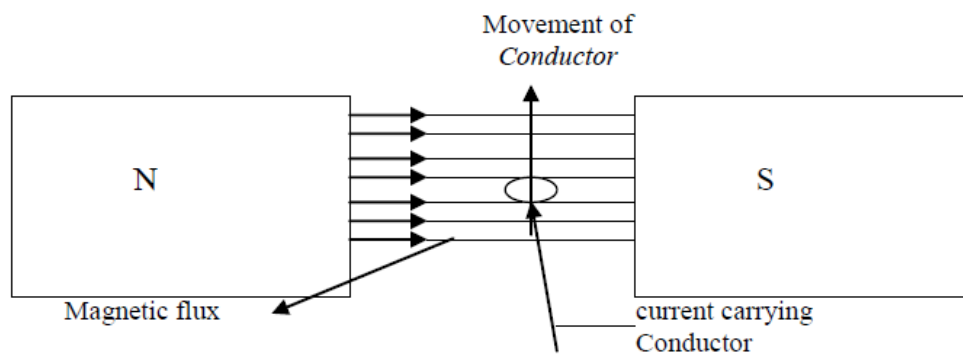


Fig. 6: Conductor

The force given by the equation,

$$F = B I L \text{ Newton's}$$

Where,

B = Flux density in WB/sq.m

I = Current through the conductor

L = Length of the conductor

Let us consider a single turn coil. The coil side A will be forced to move downward, where as the coil side “B” will be forced to move upward. Due to this movement now the coil is made to rotate. Since the coil is arranged into rotate. Since the coil is arranged in the armature when it rotates in emf is induced in the coil and that emf which is induced in the coil is in opposite to supply emf. Therefore we can call the emf induced as back emf (B-emf). Hence when motor runs normally the supply emf (V) is equal to B-emf.

$$\text{Therefore } V = V_b + V_a \text{ (or) } V = V_b + I_a R_a \text{ (Since } V = IR)$$

Multiplying both sides by I_a ,

Therefore $V I_a = V_b I_a + (I_a \times I_a) R_a$, Where $V I_a$ is the electrical equivalent of the mechanical power developed in the motor and $(I_a \times I_a) R_a$ is armature drop.

This process that motor converts electrical energy mechanical energy where $(I_a \times I_a) R_a$ is the copper loss which is to be neglected.

Now consider a single turn coil carrying a current as shown in the above figure 6. in view of the reasons given above, the coil side A will be forced to move downwards, whereas the coil side B will be forced to move upwards. The forces acting on the coil sides A and B will be of same magnitude. But their direction is opposite to one another. As the coil is wound on the armature core which is supported by the bearings, the armature will now rotate. The Commutator periodically reverses the direction of current flow through the armature. Therefore the armature will have a continuous rotation.

The conductors are wound over a soft iron core. DC supply is given to the field poles for producing flux. The conductors are connected to the DC supply through brushes.

Let's start by looking at the overall plan of a simple 2-pole DC electric motor. A simple motor has 6 parts, as shown in the diagram below.

- An armature or rotor
- A commutator

- Brushes
- An axle
- A field magnet
- A DC power supply of some sort

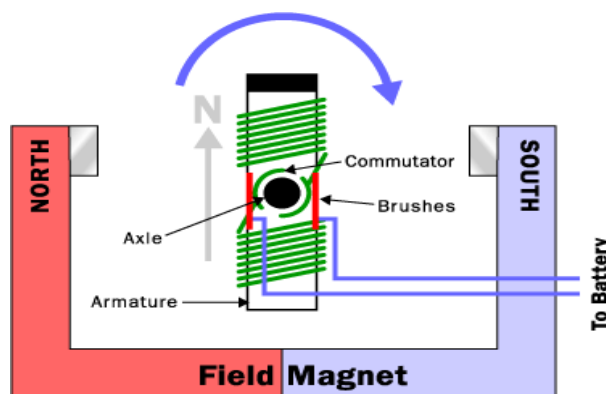


Fig. 7: Principle of DC motor

An electric motor is all about magnets and magnetism: a motor uses magnets to create motion. If you have ever played with magnets you know about the fundamental law of all magnets: Opposites attract and likes repel.

So if you have 2 bar magnets with their ends marked north and south, then the North end of one magnet will attract the South end of the other. On the other hand, the North end of one magnet will repel the North end of the other (and similarly south will repel south). Inside an electric motor these attracting and repelling forces create rotational motion.

In the diagram above and below you can see two magnets in the motor, the armature (or rotor) is an electromagnet, while the field magnet is a permanent magnet (the field magnet could be an electromagnet as well, but in most small motors it is not to save power).

Electromagnets and Motors: To understand how an electric motor works, the key is to understand how the electromagnet works. An electromagnet is the basis of an electric motor. You can understand how things work in the motor by imagining the following scenario. Say that you created a simple electromagnet by wrapping 100 loops of wire around a nail and connecting it to a battery. The nail would become a magnet and have a North and South pole while the battery is connected.

Now say that you take your nail electromagnet, run an axle through the middle of it, and you suspended it in the middle of a horseshoe magnet as shown in the figure below. If you were to attach a battery to the electromagnet so that the North end of the nail appeared as shown, the basic law of magnetism tells you what would happen: The North end of the electromagnet would be repelled from the north end of the horseshoe magnet and attracted to the south end of the horseshoe magnet.

The South end of the electromagnet would be repelled in a similar way. The nail would move about half a turn and then stop in the position shown.

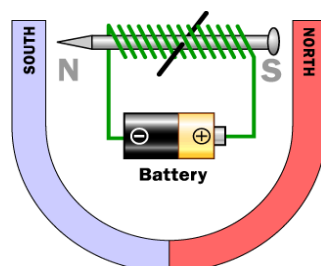


Fig. 8(a): Principle of rotation

You can see that this half-turn of motion is simple and obvious because of the way magnets naturally attract and repel one another. The key to an electric motor is to then go one step further so that, at the moment that this half-turn of motion completes, the field of the electromagnet flips. The flip causes the electromagnet to complete another half-turn of motion.

You flip the magnetic field simply by changing the direction of the electrons flowing in the wire (you do that by flipping the battery over). If the field of the electromagnet flipped at just the right moment at the end of each half-turn of motion, the electric motor would spin freely.

The Armature: The armature takes the place of the nail in an electric motor. The armature is an electromagnet made by coiling thin wire around two or more poles of a metal core. The armature has an axle, and the Commutator is attached to the axle. In the diagram above you can see three different views of the same armature: front, side and end-on. In the end-on view the winding is eliminated to make the Commutator more obvious. You can see that the Commutator is simply a pair of plates attached to the axle. These plates provide the two connections for the coil of the electromagnet.

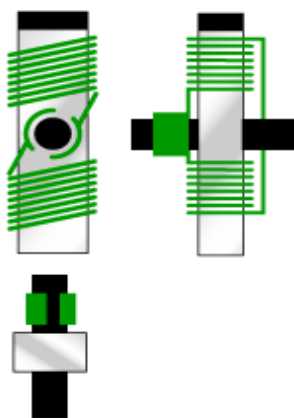


Fig. 8(b): Armature winding

The Commutator and brushes: The "flipping the electric field" part of an electric motor is accomplished by two parts: the **Commutator** and the **brushes**. The diagram at the right shows how the Commutator and brushes work together to let current flow to the electromagnet, and also to flip the direction that the electrons are flowing at just the right moment.

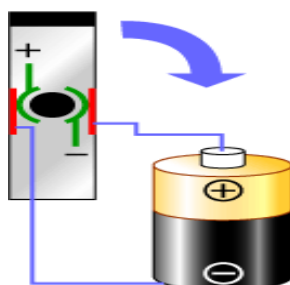


Fig.8(c) : Commutator and brushes

The contacts of the Commutator are attached to the axle of the electromagnet, so they spin with the magnet. The brushes are just two pieces of springy metal or carbon that make contact with the contacts of the Commutator.

Putting it all Together: When you put all of these parts together, what you have is a complete electric motor. In this figure, the armature winding has been left out so that it is easier to see the Commutator in action. The key thing to notice is that as the armature passes through the horizontal position, the poles of the electromagnet flip.

Because of the flip, the North Pole of the electromagnet is always above the axle so it can repel the field magnet's North Pole and attract the field magnet's South Pole. If you ever take apart an electric motor you will find that it contains the same pieces described above: two small permanent magnets, a Commutator, two brushes and an electromagnet made by winding wire around a piece of metal.

Almost always, however, the rotor will have three poles rather than the two poles as shown in this article. There are two good reasons for a motor to have three poles:

- It causes the motor to have better dynamics. In a two-pole motor, if the electromagnet is at the balance point, perfectly horizontal between the two poles of the field magnet when the motor starts; you can imagine the armature getting "stuck" there. That never happens in a three-pole motor.

- Each time the Commutator hits the point where it flips the field in a two-pole motor, the Commutator shorts out the battery (directly connects the positive and negative terminals) for a moment. This shorting wastes energy and drains the battery needlessly. A three-pole motor solves this problem as well.
- It is possible to have any number of poles, depending on the size of the motor and the specific application it is being used in.

Impeller: Impeller consists of more number of blades. The number of blade increases the cold air rushed out fiercely. The impeller blades are slightly bended, so that the cold air fiercely transmitted to the outside.

III. Working Principle

The solar fridge consists of a silicon cells solar panel which converts sun light I to electricity. The convert electricity is pass through the battery which makes to run thermo electric module consists of semiconductor. The semiconductor materials are N and P type, and are so named because either they have more electrons than necessary to complete a perfect molecular lattice structure (N-type) or not enough electrons to complete a lattice structure (P-type). The extra electrons in the N-type material and the holes left in the P-type material are called “carriers” and they are the agents that move the heat energy from the cold to the hot junction. Heat absorbed at the cold junction is pumped to the hot junction at a rate proportional to carrier current passing through the circuit and the number of couples. Good thermoelectric semiconductor materials such as bismuth telluride greatly impede conventional heat conduction from hot to cold areas, yet provide an easy flow for the carriers. In addition, these materials have carriers with a capacity for transferring more heat. Thermoelectric cooling couples are made from two elements of semiconductor, primarily Bismuth Telluride, heavily doped to create either an excess (n-type) or deficiency (p-type) of electrons. Heat absorbed at the cold junction is pumped to the hot junction at a rate proportional to current passing through the circuit and the number of couples.

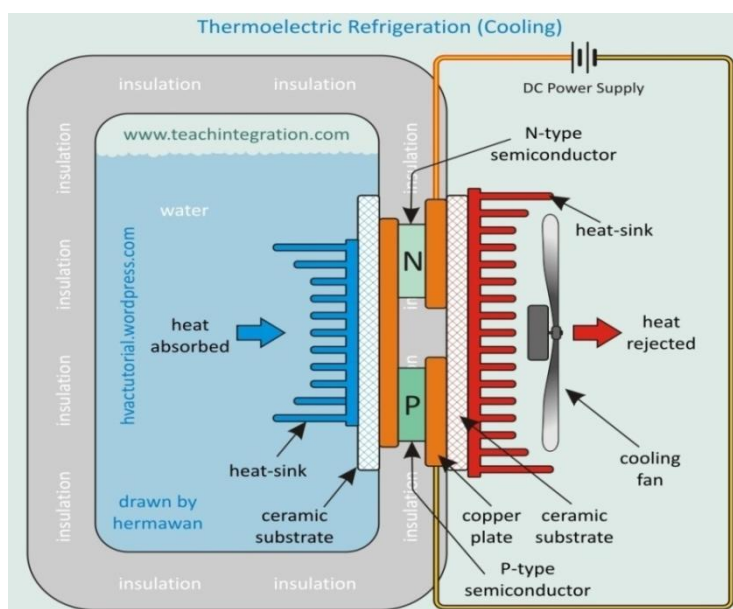


Fig.9: Thermoelectric Refrigeration (Cooling)

Thermoelectric module: In practical use, couples are combined in a module (Fig.) where they are connected electrically in series, and thermally in parallel. Normally a module is the smallest component commercially available. Modules are available in a great variety of sizes, shapes, operating currents, operating voltages and ranges of heat pumping capacity. The present trend, however, is toward a larger number of couples operating at lower currents. The user can select the quantity, size or capacity of the module to fit the exact requirement without paying for excess power.

In a typical domestic refrigerator, a cooling power of about 50 watt is needed. The thermo elements are connected by flat strips of a good electrical conductor, e.g. copper or aluminum, so as to form a rectangular array. If the spaces between the elements are large they should be filled with a good thermal insulator, but if they are small this is unnecessary. The faces of the metal connectors are ground flat and are pressed against the felt surfaces of two large metal slabs to which fins are attached. It is important that the slabs should be electrically insulated from the metal connecting strips but the thermal contact must be good. These metal slabs are drawn together by bolts arranged round their periphery.

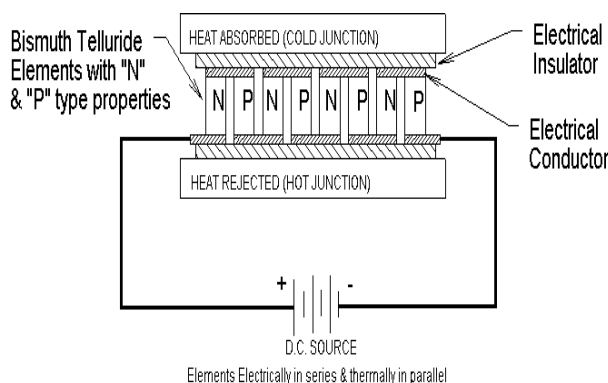


Fig.10: Thermoelectric module Assembly

The material used for the assembly components deserves careful thought. The heat sink and cold side mounting surface should be made out of materials that have a high thermal conductivity (i.e., copper or aluminum) to promote heat transfer. However, insulation and assembly hardware should be made of materials that have low thermal conductivity (i.e., polyurethane foam and stainless steel) to reduce heat loss.

The fins attached to the hot face of the cooling unit are larger than those entering the cooled chamber. This is because the latter fins merely have to abstract heat from the chamber whereas the former have to pass this heat, as well as that developed in the thermocouples, on to the surroundings. Ideally the fins should be of sufficient area for the temperature of their bases to be insignificantly different from their respective ambient temperatures. However such fin areas are generally so large as to be economically impracticable and a balance must be drawn between the reduction of the fin sizes and the lowering of the temperature differences between the metal slabs and their surroundings.

These temperature differences must be taken into account while calculating the coefficient of performance of the units. They must be added to the temperature difference between the cooled chamber and ambient air in order to obtain the difference of temperature between the thermocouples junctions. It is also necessary to add any temperature differences across the electrical insulation between the metal slabs and the connectors. Such differences could be avoided by attaching separate fins to each junction but this would result in a mechanically weak structure.

Table 1: List of Materials

| Sl.No. | Parts | Qty. | Material |
|--------|----------------------------|------|------------|
| 1. | Thermo Electric Zip cooler | 1 | Fiber |
| 2. | Solar panel | 1 | Aluminium |
| 3. | Air Conditioner Blower | 1 | |
| 4. | Battery | 1 | Lead acid |
| 5. | Frame | 1 | Mild steel |
| 6. | Wires | 6 | Copper |
| 7. | Switch | 1 | Stain less |

IV. Result Analysis

First The Experiments Were Conducted For Performance Rate After That Evaluation Of Above Specified Single Thermoelectric Cooling Module. The Performances (Cooling Down Rate And Temperature Stability) Of Tem Was Evaluated At Variable Input Electrical Current Conditions (0.25imaxi, 0.5imaxi & 0.75imaxi) And At Natural As Well As Forced Air Convection Condition For Heat Dissipation From Hot Side Of Tem. The Evaluated Input Electrical Current Condition And Heat Dissipation Condition For Optimum Performances Of Tem Was Used For Performance Evaluation Of First Prototype Of Developed Thermoelectric Refrigeration System.

The Test Results Showed For Input Electrical Current 0.5imaxi (I=2.0 Ampere &V= 5.5 Volt) And At Forced Air Convection Condition The Cooling Down Rate (Temperature Reduction At Cold Side Of Module With Respect To Ambient At 300c) Was Higher Than At Natural Air Convection. Also The Temperature Stability (Duration Of Reduced Temperature Difference) Was Longer For Forced Air Convection At Input Electrical Current 0.5imaxi. The First Developed Prototype Of Ter Was Tested For Performance Evaluation With These Optimized Conditions. The Temperature Of Refrigeration Space Of Ter System Was Reduced From 29.10c To 17.60c In First 70 Minutes With Respect To 30c Ambient Temperature And After That This Temperature Difference Was Stable Because No Further Heat Is Dissipating From Hot Side Of Tem For Given Operating Condition. The Temperature Of Inside Wall Of Refrigeration Enclosure Was Reduced Rapidly From

19.20c To 40c In First 6 Minutes Due To High Thermal Conductivity Of Copper Sheet And Higher Heat Transfer Temperature Reduced Gradually

Scope: The units of energy production can be developed in the various regions by using thermoelectric modules. In these days the society face the energy crisis but also the harmful effects of pollution. The thermoelectricity is a “Green Technology” to generate electricity without any harmful effect. The educational institutions, furnace regions, metro cities, industrial areas, universities and other locations can be selected for the establishment of such energy centers where the waste heat can be easily available and can be recycled after conversion to the same system.

Thermoelectric devices achieved an importance in recent years as viable solutions for applications such as spot cooling of electronic components, remote power generation in space stations and satellites etc. These solid state thermoelectric devices are free from moving parts, having good reliability however their efficiency depends on the selection of materials. Such devices with higher efficiency can be implemented for refrigeration also. Actually the combination of Seebeck Effect and Peltier Effect is the absolute advent for such refrigeration. If heat from solar energy is provide as the input to this implementation the cooling will be the output. Surely this research work will be an idea for better refrigeration and becomes an effort to overcome the energy crisis by the means of refrigeration from waste heat. In the instruments like the low grade waste heat can be utilized for cooling and can also be recycled to improve their performances. However, they require some modifications related to their size and the selection of materials but their cheapness, eco friendly nature, no cause to global warming are enough inputs to motivate the engineers for their implementations in almost all the suitable applications of daily life in near future.

V. Conclusion

In this changing modern world every day there is a new discovery in all fields of science and technology, benefiting the mankind. In this work the design of thermo electric air conditioner is slightly modified with an addition air cooler. If one utilizes energy which goes as waste even more useful things can be made. Thermo electric and thermoelectric cooling are being studied exhaustively for the past several years and various conclusions have been conceived regarding the efficient functioning of thermoelectric refrigerators.

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 TE 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

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