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THERMOELECTRIC REFRIGERATION USING PELTIER EFFECT

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ABSTRACT

In the field of military and medical science there are refrigerators used to cool samples or specimens for preservation. They include refrigeration units for storing blood plasma and other blood products, as well as vaccines and other medical or pharmaceutical supplies. They differ from standard refrigerators used in homes or restaurant because they need to be very hygienic and completely reliable. However, in case of transportation of component from one place to another place there is no refrigeration system. Due to such problem, portable refrigeration system is to be used. Thermoelectric refrigeration is new alternative because it can convert waste electricity into useful cooling, is expected to play an important role in meeting today fossil energy challenges. Therefore, thermoelectric refrigeration is greatly needed, particularly for developing countries where long life and low maintenance are needed. Thermoelectric devices are solid state devices. They are reliable energy converters and have no noise or vibration as there are no mechanical moving parts. They have small size and are light in weight. As refrigerators, they are friendly to the environment as CFC gas or any other refrigerant gas is not used. Due to these advantages, the thermoelectric devices have found a large range of applications. In this paper, basic knowledge of the thermoelectric devices and an overview of these applications are given.

KEYWORDS: Refrigeration, Thermo-electrical system, Peltier effect.

INTRODUCTION

Air-conditioner (AC) has become almost indispensable for every family, but the traditional air-conditioner has some disadvantages as following:

1) Traditional AC systems consume too much energy. To meet their demands, natural resources are burned to generate electricity, which causes greenhouse effect and to exacerbate a lot of pollution on the earth.
2) The refrigerant of traditional air conditioner, Freon, once leaked, will cause irreversible damage to the ozone sphere and make life suffer from ultraviolet radiation.

Hence buildings composited thermoelectric cooling and heating systems are proposed. 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. The Peltier effect was discovered in 1834 by a French watchmaker and part time physicist Jean Charles Athanase Peltier. Peltier found that the use of a current at an interface between two dissimilar materials results in the absorption of heat and release of heat at the subatomic level, this is a result of the different energy levels of materials, particularly n and p type materials. As electrons move from p type material to n type material, electrons jump to a higher energy state absorbing energy, in this case heat, from the surrounding area. The reverse is also true. As electrons move from n type material to p type material, electrons fall to a lower energy state releasing energy to the surrounding area. Objective of this project is to design thermoelectric Refrigerator Utilize Peltier effect to refrigerate and maintain a specified temperature, perform temperature control in the range 5 °C to 25 °C. Interior cooled volume of 5 Liter and Retention for next half hour.

MATERIAL REVIEW

Thermoelectric module is made of two different semiconducting materials, which generate thermoelectric cooling effect (Peltier effect) when a voltage of similar polarity & in appropriate direction applied through the connected junction. Two heat sinks & fans are attached to hot and cold sides of thermoelectric module in order to enhance heat transfer and system performance. There exists optimum current & optimum voltage for maximum coefficient of performance (COP) for a specific module and fixed hot/cold side temperatures

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THERMOELECTRIC COOLING

In Thermo-electrical refrigeration system, the Peltier effect is the phenomenon of to create a heat flux between the junctions of two different types of materials. A Peltier heater, cooler or thermoelectric heat pump is a solid-state active heat pump, which convert heat from one side of the device to the other, with consumption of electrical energy, depending on the direction of the current. Such an instrument is also called a Peltier device, Peltier heat pump, solid state refrigerator, or thermoelectric cooler (TEC).Thermoelectric cooling uses the Peltier effect to create a heat flux between the junctions of two different types of materials. They can be used either for heating or for cooling (refrigeration), although in practice the main application is cooling. It can also be used as a temperature controller that either heats or cools. This technology is far less commonly applied to refrigeration than vapor-compression refrigeration. The main advantages of a Peltier cooler are its lack of moving parts or circulating liquid, near-infinite life and potential to avoid leaks, and its small size and flexible shape. Its main disadvantage is high cost and poor power efficiency. Many researchers and companies are trying to develop Peltier coolers that are both cheap and efficient.

PELTIER EFFECT

A Peltier cooler can also be used as a thermoelectric generator. When operated as a cooler, a voltage is applied across the device, and as a result, a difference in temperature will build up between the two sides.

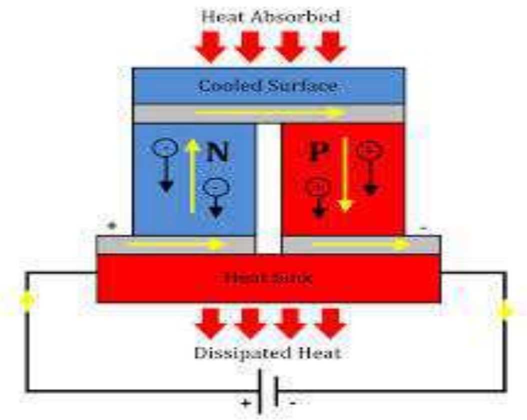

Fig. - Peltier effect

When operated as a generator, one side of the device is heated to a temperature greater than the other side, and as a result, a difference in voltage will build up between the two sides.

SEEBECK EFFECT

When the two junctions of a pair of dissimilar metals are maintained at different temperatures, there is the generation of emf (electromotive force).He conducted a series of tests by varying the temperatures of the junctions of various combinations of a set of materials. The emf output was found to be:

$$\Delta E \propto \Delta T \text{……………………………...(1)}$$

Where ΔE and ΔT the emf output and the temperature difference of the junctions. The phenomenon of generation of emf is called Seebeck effect the proportionality constant of Eq.1is denoted by

$$\alpha ab = \Delta E / \Delta T \text{……………………….(2)}$$

and is called Seebeck coefficient or the thermo electric power. It is to be noted that αab(αa- αb) is the coefficient for a pair of different metals (A and B or P and N or p and n).

WORKING PRINCIPLE

A typical thermoelectric module is composed of two ceramic substance that serve as a foundation and electrical insulation for P-type and N-type Bismuth Telluride dice that are connected electrically in series and thermally in parallel between the ceramics. The ceramics also serve as insulation between the modules internal electrical elements and a heat sink that must be in contact with the hot side as well as an object against the cold side surface. Electrically conductive materials, usually copper pads attached to the ceramics, maintain the electrical connections

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inside the module. Solder is most commonly used at the connection joints to enhance the electrical connections and hold the module together Couple is term used in most modules as even number of P-type and N-type dice and one of each sharing an electrical interconnection. While both P-type and N-type materials are alloys of Bismuth and Tellurium, both have different free electron densities at the same temperature. Deficiency of electrons is in P-type dice, while N-type has an excess of electrons. As current flows up and down through the module, it attempts to establish a new equilibrium within the materials. The current treats the P type material as a hot\ junction needing to be cooled and the N-type as a cold junction needing to be heated. Since the material is actually at the same temperature, the result is that the hot side becomes hotter while the cold side becomes colder. The direction of the current will determine if a particular die will cool down or heat up. In short reversing the polarity will switch the hot and cold sides.

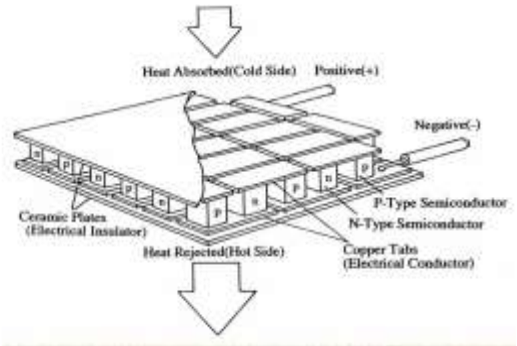

Fig.2 Peltier Module

Couple is term used in most modules as even number of P-type and N-type dice and one of each sharing an electrical interconnection. While both P-type and N-type materials are alloys of Bismuth and Tellurium, both have different free electron densities at the same temperature. Deficiency of electrons is in P-type dice, while N-type has an excess of electrons. As current flows up and down through the module, it attempts to establish a new equilibrium within the materials. The current treats the P type material as a hot\ junction needing to be cooled and the N-type as a cold junction needing to be heated. Since the material is actually at the same temperature, the result is that the hot side becomes hotter while the cold side becomes colder. The direction of the current will determine if a particular die will cool down or heat up. In short reversing the polarity will switch the hot and cold sides.

The TEM operating working principle is based on the Peltier effect. The Peltier effect is a temperature difference created by applying a voltage between two electrodes connected to a sample of semiconductor material. One of the TEM sides is cooling and the other side is heating. When a TE module is used, you must support heat rejection from its hot side. If the temperature on the hot side is like the ambient temperature, then we can get the temperature on the cold side that is lower. According to current value that is, leaking through a thermoelectric module the degree of the cooling is depended. Electrons act as the heat carrier in a thermo electric heat exchanger. The heat pumping action is actual function of the quantity of electrons crossing over the p-n junction.

Performance specification

Hot Side Temperature (°C)	25°C	50°C
Qmax (Watts)	50	57
Delta Tmax (°C)	66	75
Imax (Amps)	6.4	6.4
Vmax (Volts)	14.4	16.4
Module Resistance (Ohms)	1.98	2.30

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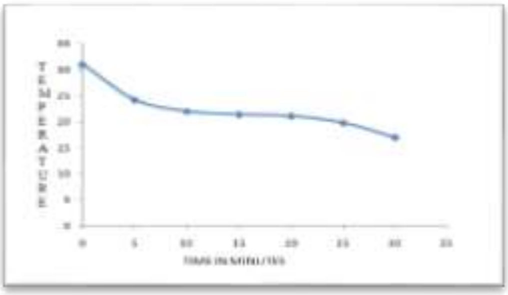
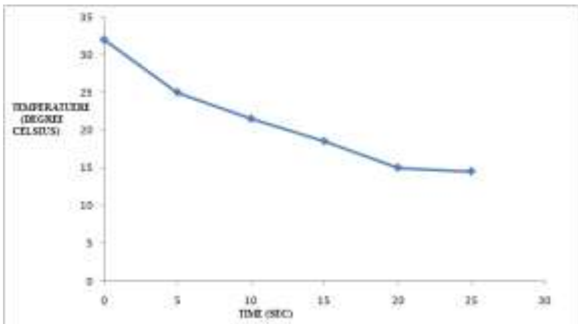
FEATURES OF PELTIER MODULE

1) Peltier module can convert thermal energy into electricity, or when electricity is provided to the peltier module then absorption of heat(cool side) on one side and rejection of heat(hot side) on other side.
2) Conventional systems can use or generate harmful gasses like Chloro Fluoro Carbons (CFCs) and Hydro Chlorofluorocarbons (HCFCs).The peltier module can't use or generate these harmful gasses.
3) Peltier module can operate on DC power source.
4) By using proper closed loop circuit, the peltier module can control precise temperature.

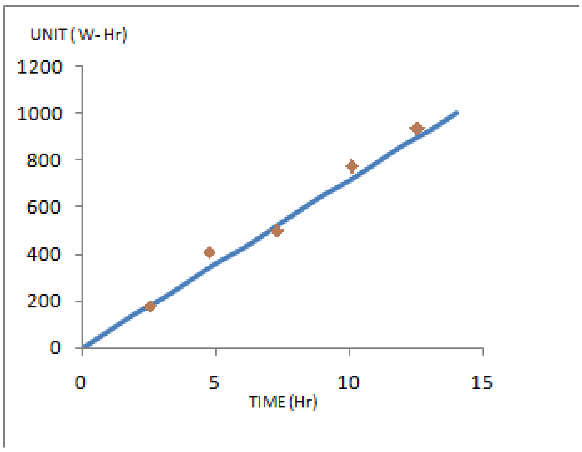
OBSERVATION



Graph 1-graph of time vs temperature when fan is on.



Graph 2 – graph of time vs temperature of peltier (When fan is off)



Graph 3- Unit consumption of thermo-electric refrigerator

CONCLUSION

This paper reviews the developments in TER system over the years. This study on the thermoelectric refrigeration emphasize that the TER system is a novel refrigeration system which will be a better alternative for conventional refrigeration system. The research and development work carried out by different researchers on TER system has been thoroughly reviewed in this paper. This paper also concludes that, to achieve better COP & temperature

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control we can combine TER with other refrigeration systems. For example combining VCR & TER systems reduces the energy consumption, gives high COP & good temperature control within the refrigerated area. Hence it is better to have such hybrid systems & devices to reduce total energy consumption.

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