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Design and Analysis of Thermo Electric Refrigerator Using Peltier Effect

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ABSTRACT

In the recent years, we have many problems such as energy crises and environment degradation due to the Increasing CO: emission and ozone layer depletion has become the primarily concern to both developed and developing countries. This paper does not need any kind of refrigerant and mechanical device like compressor, prime mover, etc for its operation. This paper presents the performance of refrigeration system by using Peltier module. Thermoelectric modules are the key elements in this refrigerator for providing the thermoelectric cooling. This projects system consists of Peltier module, heat sink, battery, Thermopolis box etc. Power consumption is one of the major issues now. But semiconductor is a great solution of this power consumption. Peltier module is one of the best solutions for this. In this project Peltier module is used where one side gets cooled and other side become hot and rejects heat to the environment with the help of fans for producing cooling effect, this means that cooling is done without use of greenhouse gaseous. Which would ultimately reduce the global warming which is usually caused by conventional refrigeration system? The supply used is de and system will be cooled up to 9°C and heat will be produced till 85°C. Due to the use of charge controller, system gets efficient output. Due to these advantages of our system over conventional system are beneficial. This system having no moving parts, due to which system became rugged and reliable, they can be extremely compact much more than compressor. It is portable and economical system. By using Peltier module in our daily life to save electricity or power consumption.

INTRODUCTION

In recent years, with the increasing awareness towards environmental degradation caused by CFCs and HCFCs from refrigerants in conventional refrigeration systems, it has become a subject of due concern. Besides, rural areas won't have to rely as much on power from the grid for their refrigeration and cooling needs, by using the battery to power the thermoelectric refrigeration system (TER). Also, in situations where efficiency is a less important issue than small size, low weight and high reliability, thermoelectric refrigeration systems would be the preferred choice. Researchers are continuously striving towards the development of eco-friendly refrigeration technologies like thermoelectric, adsorption, magnetic and thermo acoustic refrigeration.[1] Thermoelectric cooling uses the Peltier effect to create a heat flux between the junctions of two different types of materials. This effect is commonly used in camping and portable coolers and for cooling electronic components and small instruments. Applying a DC voltage difference across the thermoelectric module, an electric current will pass through the module and heat will be absorbed from one side and released at the opposite side. One module face, therefore, will be cooled while the opposite face simultaneously is heated. On the other hand, maintaining a temperature difference between the two junctions of the module, a voltage difference will be generated across the module and an electrical power is delivered. Thermoelectric phenomenon was discovered nearly two hundred years ago. Since last sixty years the practical applications from thermoelectric had been exploited.

The first breakthrough that would eventually be used to form the thermoelectric effect was discovered in 1820. Several other breakthroughs in the field were discovered over the next few decades but their relationship was not realized for a full 38 years. William Thomson in 2007 discovered that heat is absorbed or produced when current flows in material with a certain temperature gradient and that the heat is proportional to both the electric current and the temperature gradient.

Thermoelectric coolers which is also known as thermoelectric module or Peltier cooler is widely used in the market for several cooling applications.

They are able to cool or heat within the same module depending on the polarity of the applied DC power. Traditional refrigeration systems are almost impossible to manufacture without using chlorofluorocarbons or other chemicals that are harmful to the environment. TE devices do not use or generate gases of any kind.

LITERATURE REVIEW

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Koetsch and Madden (2009) examined on thermoelectric cooling versus conventional cooling in industrial enclosures. Conventional cooling systems such again conditioners and air to-water heat exchangers rely on chemical refrigerants or water to cool, or remove heat from, enclosures.

Thermoelectric property was also implemented in pick up refrigerated trucks. Studies based on thermoelectric cooling unit for thermostatic body on refrigerated trucks were conducted by Bulat and Nekhoroshev (2003). In this study a comparison between thermoelectric cooling units with vapour-compression installations was also made.

These are excellent examples of spot cooling property of a TE module. Once such prototype was made by Bartlett and Sukuse (2007) they built an air-conditioned cooling helmet which used a thermoelectric device. The product was designed to give comfort for the user. The idea of cooling helmets was also discussed by Buist and Streitwieser (1988).

The 12-volt personal cooling system worked well to cool the head of a race driver. The 225 grams helmet cooling system reduced 5-to-6-degree Cekius form ambient.

There are many TEC manufacturers in the market and to facilitate the search, a few of them provide downable software search facilities. One such piece of software is provided by Laird Technologies, which is an excellent tool for thermoelectric module simulation. It can be used for the analysis and selection of TECs or TEMS. Selection of a TEC from various manufactures can be tedious. Tan and Fok (2008) have conducted an analytical study on the method of selecting a TBC from different manufacturers before designing a cooling system. Their purpose of study was to assist the designers to help on developing an optimized thermoelectric cooling system design in minimum amount of time. The designers will benefit from this study to implement a cooling system with TEC.

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PROBLEM SPECIFICATION

Basic Theory of Peltier History

Early 19th century scientists, Thomas See beck and Jean Peltier, first discovered the phenomena that are the basis for found that if you placed a temperature gradient across the junctions of two Dissimilar conductors, electrical current would flow. Peltier, on the other hand, learned that passing current through two dissimilar electrical conductors, caused heat to be either emitted or absorbed at the junction of the materials. It was only after mid-20th Century advancements in semiconductor technology, however, that practical applications for thermoelectric devices became feasible. With modern techniques, we can now produce thermos electric efficient solid-state heat-pumping for both cooling and heating: many of these units can also be used to generate DC power at reduced efficiency. New and often elegant uses for thermo-electrics continue to be developed each day [2]

Figure: 1 Peltier Module

When DC voltage is applied to the module, the positive and negative charge carriers in the pellet array absorb heat energy from one substrate surface and release it to the substrate at the opposite side. The surface where heat energy is absorbed becomes cold; the opposite surface where heat energy is released becomes hot. Reversing the polarity will result in Reversed hot and cold sides.[2]

Peltier Structure

A typical thermoelectric module consists of an array of Bismuth Telluride semiconductor pellets that have been carrier-either positive or negative-carries the majority of current. The pairs of P/N pellets are configured so that they are connected electrically in series, but thermally in parallel. Metalized ceramic substrates provide the platform for the pellets and the small conductive tabs that connect them.

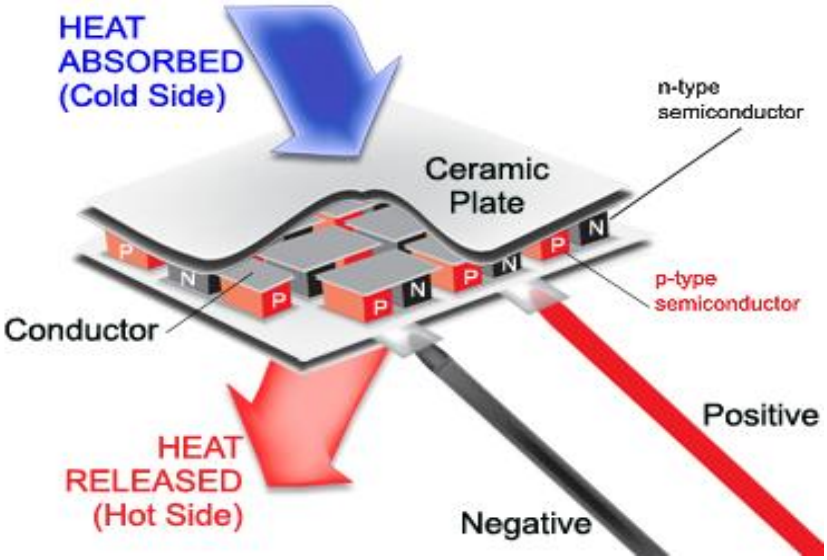

Figure: 2 Peltier Structures

Principal and Characteristics of Thermoelectric Refrigerator

Thermoelectric coolers operate by the Peltier effect. The device has two sides, and when a DC electric current flows through the device, it brings heat from one side to the other, so that one side gets cooler while the other gets hotter. The "hot" side is attached to a heat sink so that it remains at ambient temperature, while the cool side goes below room temperature. In some applications, multiple coolers can be cascaded together for lower temperature. Thermoelectric refrigeration work on the principle of seebeck effect in which the voltage is applied between two different combinations of metal and due to effect of seebeck the cooling and heating phenomena is happened which can be used accordingly for different purpose.[5]

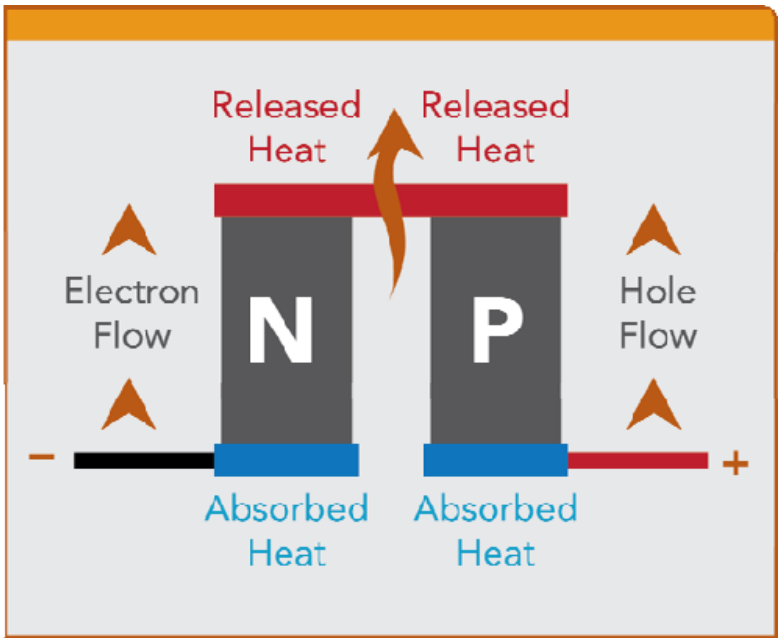

Figure: 3 Principle of Peltier Effect

Types of Peltier Modules:

All Peltier modules use the same principle and have similar design, obtaining the datasheet will let you know how to power them correctly.

There are basically 3 series:

- **TES1 series:** Micro Peltier modules that work with low voltages.
- **TEC1 series:** Standard Peltier modules from 10x10mm to 80x80mm.
- **TEC2 series:** Multi-stage Peltier modules, basically, is two or more Peltier making a pile or a Peltier sandwich.

Micro and Mini-Peltiermodules: TES1 series data sheet of TES1 micro and mini Peltier series.

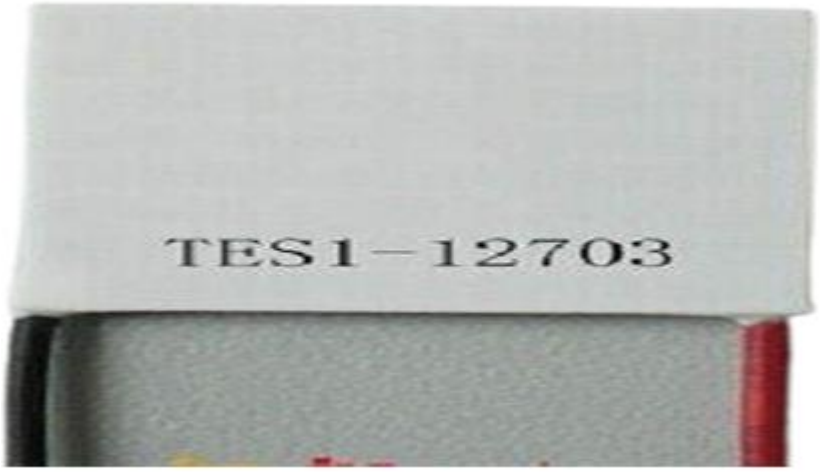

Fig: 4 TES1-12703 Series Module

Standard Peltier Modules: TEC1 series datasheet These are the standard size Peltier Thermoelectric modules, ranging from size of 10x10mm to 80x80mm,

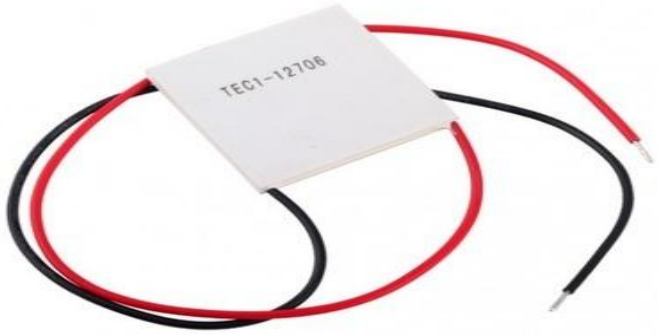

Fig: 5 Tec1-12706 Module Series

Multi-Stage Peltier Modules: TEC2 Series Datasheet: Multi-stage Peltier modules are designed to provide higher temperature differentials between the hot and cold side than with the standard single modules. The cold side is the little one, the hot side is the wider one. On this setup peltier modules are stacked in a way that the hot side of the last peltier module (the little one that produce the cold surface is kept very cold, so this little peltier will be able to produce a very low temperature, because its hot side is kept cold.

Fig : 6 Multi Stage Peltier Module

Specification of Peltier Module

Table 1.Specifications of Peltier Module

Model Number	TEC2 -19006
Voltage	12V
Dimensions	40MM x40MMx6MM
Type	COOLING CELLS
Usage	Refrigerator or warmer
Certification	RoHS

RESULTS AND DISCUSSION

Table 3 Shows That As Temperature Increases Time Decreases.

TEMPERATURE °C	TIME (Minutes)
34	0
30	2.4
26	3.9
22	5.1
18	6.8
14	9.2
10	12.1

Table 3.Temperature Vs Time

CONCLUSIONS

SincePeltiercoolingisnotefficientcomparativelyandduetoitssmallsizeapplications, it is not widely used. It found its application only in electronics cooling etc. But,we have seen that there is a huge scope of research in this field about thermoelectric materials,its fabrication, heat sink design etc. Researchers are working on reducing irreversibility in thesystems, because Peltier cooler has more potential which we can see from the vast difference between value of first law efficiency and second law efficiency.

When the required cooling capacity is high, the coefficient of performance of this refrigerator is significantly lower than that of a conventional compressor-type refrigerator, whereas the coefficient of performance of the conventional unit rapidly decreases as the cooling capacity increases and that of the thermo electric unit remains constant. So, when a high cooling capacity is needed, a conventional refrigerator is preferred, and when a low cooling capacity is required, a thermoelectric refrigerator should be selected. Refrigeration was accomplished using the thermoelectric module's cold side, and heat was removed from the hot side of the module using heat sinks and fans. Due to the cooling units' small size, quiet operation, lack of liquids or gases, lack of moving parts, and long lifespan. The rate of cooling can be easily adjusted by adjusting the current, and the system responds quickly to changes in supply. However, switching the current's direction turns a cooling system into a heater with a performance coefficient greater than unity, or a heat pump for an oven. This work involved the construction and testing of a portable cooling unit without a compressor.

Fig.1 Testing of Project

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