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Full Length Article

Design of Mini Cooler by Using Peltier Module

Manikandan.S[1], Arunkumar . K[2], Bharani . K[3], Meganathan . M[4]

[1]*Assistant professor, Department of Mechanical Engineering Erode Sengunthar Engineering College ,Thudupathi ,Erode*

[2,3,4.]*Students, Department of Mechanical Engineering Erode Sengunthar Engineering College ,Thudupathi ,Erode*

***Corresponding Author**
Arun17sky@gmail.com
(K.Arunkumar)
Tel.: +91 9790248928

ABSTRACT: Portable cooling is something we all have wanted for a long time. Coolers are usually very large heavy equipments and require AC power supply to work. Here we demonstrate a mini cooler using peltier based cooling. The mini cooler uses peltier along with heat sink, mini fan, thermal isolation covering switch based arrangement to achieve maximum cooling. Our system allows for portable cooling using a small device. We fabricate device by using the peltier in a particular arrangement with heat sink coupled with thermal isolation in order to achieve the maximum cooling in uch a small setup. Thus we successfully develop a mini peltier bassed cooler.

Keywords: Peltier, Heat sink, Mini fan, Thermal isolation covering

1 Introduction

Refrigeration is the process of heat-removal from a space in order to bring it to a lower temperature than surrounding temperature. "Peltier cooling module" which works on thermoelectric refrigeration, aims to provide cooling by using thermoelectric effects rather than the more prevalent conventional methods like 'Vapour compression cycle' or the 'Vapour absorption cycle'.

There are three types of thermoelectric effect: the Seebeck effect, the Peltier effect, the Thomson effect. From these three effects, Peltier cooler works on the Peltier effect; which states that when voltage is applied across two junctions of dissimilar electrical conductors, heat is absorbed from one junction and heat is rejected at another junction.

Peltier coolers are basically used as a cooling element in laser diodes, CCD cameras , blood analyzers, portable picnic coolers laser diodes, microprocessors, blood analyzers and portable picnic coolers.

2. Experimental Setup

As we have seen in previous section, for producing thermoelectric effect couples of P and N type semiconductors are connected in series by metal plates. By doing this it absorbs the heat from one side and releases the heat to another side.

So, when solid state P-N materials are connected electrically in series and thermally in parallel it makes one thermoelectric

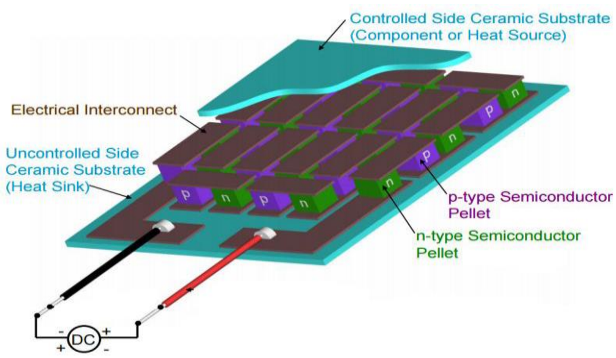
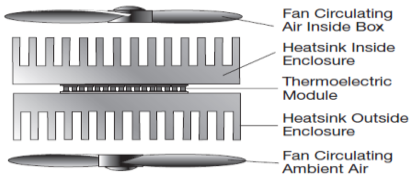


Fig.1.1Fabrication of Peltier Module

A typical TEC module comprises of two highly thermally conductive substrates (A12O3, AlN, BeO) that



serve as Hot/Cold plates. An array of p-type and n-type semiconductor (Bi2Te3, Sb2Te3, Bi2Se3, PbTe, Si-Ge) pellets are connected electrically in series sandwiched between the substrates. The device is normally attached to the cold side of the TEC module, and a heat sink which is required for enhanced heat dissipation is attached to the hot side. Solder is normally used to connect the TEC elements onto the conducting pads of the substrates. The construction of a single stage thermoelectric module. Considering a typical thermoelectric system designed to cool air in an enclosure (e.g., picnic box, equipment enclosure, etc.) this is probably the most common type of TE application. Here the challenge is to gather heat from the inside of the box, pump it to a heat exchanger on the outside of the box, and release the collected heat into the ambient air. Usually, this is done by employing two heat sink/fan combinations in conjunction with one or more Peltier devices. One of the heat sinks is used on the inside of the enclosure; cooled to a temperature below that of the air in the box, the sink picks up heat as the air circulates between the fins. In the simplest case, the Peltier device is mounted between this cold side sink and a hot side sink. As direct current passes through the thermoelectric device, it actively pumps heat from the cold side sink to the one on the hot side. The fan on the hot side then circulates ambient air between the sink's fins to absorb some of the collected heat. Note that the heat dissipated on the hot side not only includes what is pumped from the box, but also the heat produced within the Peltier device itself.

Fig.1.2 Configuration of air-to-air thermoelectric cooler

Let's look at this in terms of real numbers. Imagine that we have to pump 25 watts from a box to bring its temperature to 3^{o}C from 20^{o}C (ambient). To accomplish this, we might well have to take the temperature of the cold side sink down to 0°C. Using a Peltier device which draws 4.1 amps at 10.4 V, the hot side of the system will have to dissipate the 25 watts from the thermal load plus the 42.6 watts it takes to power the TE module (for a total of 67.6 watts). Employing a hot side sink and fan with an effective thermal resistance of 0.148 C°/W. The temperature of the hot side sink will rise approximately 10°C above ambient.

Heat sink

Performance of thermoelectric cooler can be improved by working on thermal side. By properly designing the heat sink on hot side and cold side can improve this system. To obtain the best performance, a Peltier cooler must be designed with heat sink thermal resistance as small as possible. The conventional heat sink unit utilized at the TEC hot side is composed of fins and a fan. The fins are employed to increase heat transfer area. The fan conducts heat transfer through convection. The conventional heat sink can only be employed in situations where space is not restricted. Various researchers are working on designing proper heat sinks that can be applied to TEC, which includes

1. Phase change materials

2. Thermo-syphonic heat exchanger

3. Micro-channels

3. Working Process

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 because they can be more easily optimized for pumping heat. 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 configuration, the second dissimilar material required for the Peltier effect, is actually the copper connection paths to the power supply.

It is important to note that the heat will be moved in the direction of charge carrier movement throughout the circuit (actually, it is the charge carriers that transfer the heat)

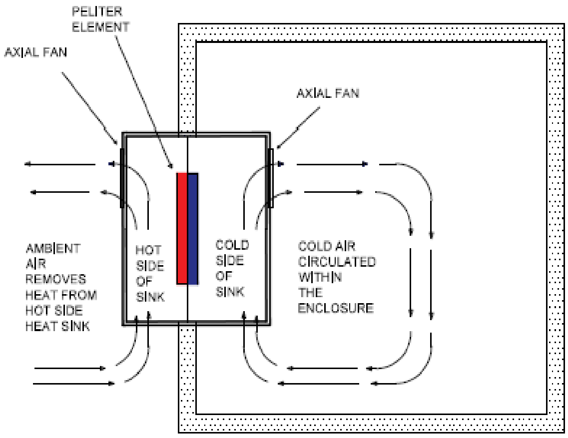


Fig.1.3 Peltier Setup

4. Conclusion

Since Peltier cooling is not efficient comparatively and due to its small size applications, 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. Researcher are working on reducing irreversibility's in the systems, because Peltier cooler has more potential which we can see from the vast difference between value of first law efficiency and second law efficiency.

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