International Journal of Advanced Technology in Engineering and Science
Vol. No. 09, Issue No. 12, December 2021
www.ijates.com
ijates
ISSN 2348 - 7550

An Empirical study and analysis of Water Cooling System Using Peltier Module

Syed Areeb Hasan

Department of Mechanical Engineering,Zakir Hussain College of Engg & Tech,
AMU, Aligarh, India.

ABSTRACT

With climate change being a reality and temperatures soaring up, water at low temperature is a necessity everywhere. Since the means of cooling the water is not readily available to all sections of the society, an alternate method to do so is the need of the hour. A cooling system based on Peltier Effect uses very less power and is portable. It uses a very thin thermoelectric module through which the required heat transfer can be achieved. Low temperatures are a necessity everywhere around the world, in one respect or the other. Its usage varies from the storage of medicines to daily life matters such as drinking water. As technology has evolved, the ways of producing these low temperatures has changed too. From the harvesting of snow and ice to the air-conditioners and heat exchangers, we have indeed come a long way. However, every system has its own problems and ill effects attached to it. Thermoelectric cooling is a novel method that can be used to get the desired results with less harms. In this paper we will study and analysis the watercooling system Using Peltier Module.

Keywords: Low Temperature, Heat Transfer, Thermodynamics, Alternate Cooling System, Peltier Effect, Thermoelectric Module. Peltier Module, Peltier Cooling, Peltier Heating, Water System

I. INTRODUCTION

The Peltier Module effects explain that a thermal gradient exists at the junction of two dissimilar Conductors. When an electric current is flowing through the junction of these conductors. Cooling is produced at one Junction of two dissimilar conductors and Heat is produced at the other Junction. This generated heat is called Peltier Heat.

First studies regarding thermoelectric cooling dates back to 1823 when it was found that an electric current would flow continuously in a circuit made up of two dissimilar metals if the junctions of these metals were maintained at two different temperatures. A German scientist, Thomas Seebeck, was the man behind this observation. Based on this concept, Jean Peltier discovered the reverse of this effect where a temperature difference would be produced if a constant current were passed through a similar circuit. It is on the principle of this discovery that the thermoelectric cooling works. Courtesy of further developments in the field by Emil Lenz and Altenkirch, it was known that this effect even has the potential to freeze water and that the thermoelectric materials need to have certain properties such as high Seebeck coefficient, high electrical conductivity, low thermal conductivity, etc. Moreover, the direction of the heat flow depends on the direction of applied electric current and the relative Seebeck coefficient of the two materials. Based on this, a Peltier module or thermoelectric module was designed that is a solid-state active heat pump which consist a number of p- and n- type semiconductor couples connected electrically in series and thermally in parallel are sandwiched between two thermally conductive and electrically insulated substrate.

The Peltier heat absorbed at the cold end and rejected at the hot end are given by:

Heat absorbed or generated is directly proportional to current.

$Q \propto i$

$Q = \Pi i$

$Q = (\Pi c + \Pi h)$

Where,

Q = Total heat at the junction of Conductors
Πc = Peltier coefficient of cooling end
Πh = Peltier coefficient of heating end
I = Current flow through the conductor

The Application of the Peltier effect (Peltier Module) creates a Temperature Difference on each side. Therefore, they can be used to either warm something or cool something down, depending on which side you use. In our Experiment, we are using Peltier module TEC1 12715. [Peltier heating or cooling are the work of build-in contact electric and valence forces on moving charges and the generation (or Recombination) in space charge region. this device that works on this is sometimes called a thermoelectric module. The problem that occurs in this module is the temperature difference. The. Junction temperature is slightly different from layer temperature. We cannot evaluate the exact temperature of the layer. It depends upon the ΔT.

$$\Delta T = T1 - T2$$

Where T1 is the temperature of one side and T2 is the temperature of another side][1]. In our experiment, the Heat Sink is connected to the hot side end of the Peltier Module. The major problem of the pettier module when we give the power supply more than mentioned voltage then the Peltier module will heat up and be damaged. And the other problem of the Peltier Module is the [minimal temperature which is possible to reach the cooled junction (junction with the temperature Tc) of a thermoelectric module (TEM), Fig1. Schematically TEM consists of a “p” semiconductor branch with a positive See beck coefficient “α” and an “n” semiconductor brunch with a negative α. These two branches are joined by a metal interconnect, Fig 1. In the presence of DC electric current created by an external battery the junction between n and p branches is cooled due to the Peltier effect]. Lowering the body’s temperature when someone touched the cold side of the Peltier Module[2].

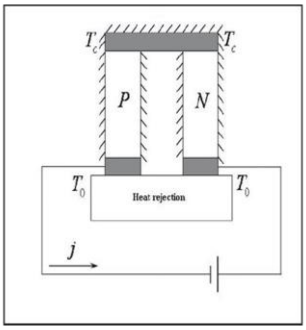


Fig 1. Diagram of Thermoelectric Module

Significance of Peltier module that it can be used either for heating or cooling. The main application of the Peltier module is cooling. It can be used as a temperature controller and TEC systems have no moving parts that are why reduced instances of failure due to fatigue and

Fracture from mechanical vibrations and increase in lifespan of Peltier Module and it also reduces the maintenance cost. If we used semiconductors in a good manner then we can reduce power consumption. The primary advantage of the Peltier module as compared to others is small in size, invulnerability to leaks and flexible shape.

Another significance of TEC is that it does not use any refrigerants during operation and doesn't contribute significantly to ozone depletion. It also has less impact on the environment as compared to many refrigerants such as Chlorofluorocarbons (CFCs).

But TEC has notable disadvantages as compared to efficiency. It has limited energy as compared to a conventional vapour compression system. Another issue with performance is size. Being small in size the hot end side and the cold side will be very near to each other it making it easier for the heat to go back to the cool side. And it's harder to insulate the hot and cool sides from each other.

Now, how can the low temperature that is produced on one side of the module be trapped to make use of it? Will the temperature from the hot side of the module not affect the cooling phenomenon? In what capacity should the modules be used for optimum results? How is thermoelectric cooling more advantageous than the conventional systems?

II. PELTIER COOLING

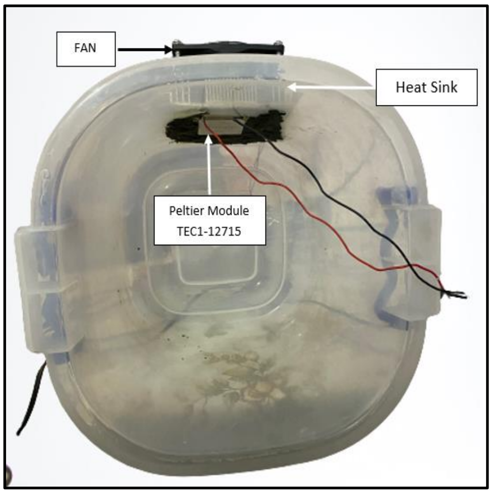


Fig 2. Top View of Water Cooling System

The attached figure 2 shows the cooling system designed with the Peltier module. In this system, we have used different components. As we discussed above the difference between cold junction and hot junction is always the same. But, sometimes it doesn't follow ideality. To control this problem. We alter this system which is shown in the figure.

The hot side of the Peltier module is attached to the heat sink which is made up of Aluminum which has fins on lower sides. It has the ability to withdraw or extract heat from the system. Heat sink compounds are also used to fill that gap between the heat sink and Peltier Module for efficient transfer of heat from the heat-generating component to the heat dissipating device. After that the heat sink is connected with Fan, It forced air across the heat sink, which allows more unheated air to move across the heat sink surface, thus increasing the total thermal gradient across the heat sink system and allowing more heat to exit the overall system.

In our experimental setup, below shown in the figure 3 the plastic bucket (System) is filled with water and the cooling side of the Peltier module is attached inside the system to decrease the temperature of the water. This filled water loses its temperature due to the Peltier module cold junction. Due to the sufficient amount of cooled water it creates a cool environment inside the system, Peltier module consumes less amount of power. It is about 70 to 80 W. In these days of power consumption if an element cooled our household equipment with low power then it will be very beneficial for us.

Fig 3. Side View of Water Cooling System

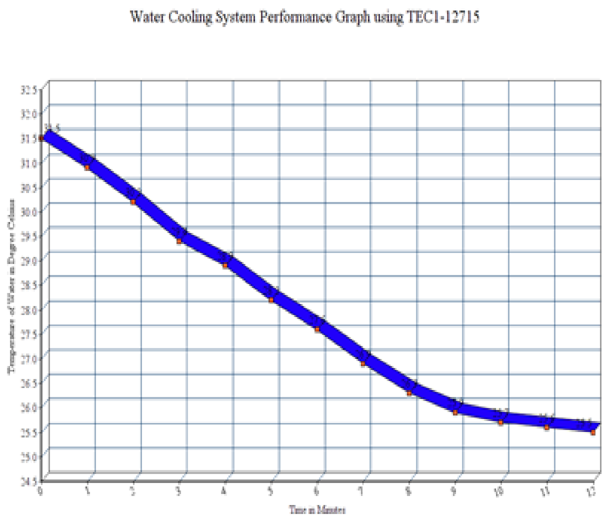
III. EXPERIMENT RESULT

Our Experiment is performed on Peltier Module
TEC1-12715. The Specification Peltier Module Mention in Table I.

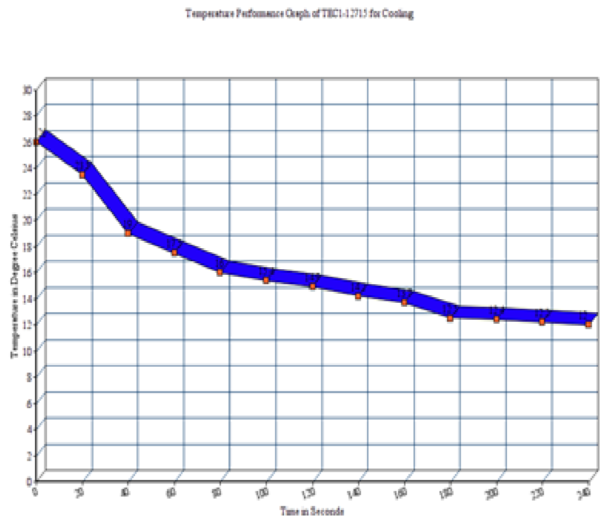
Name of Peltier Module	Dimension of Peltier Module (L*W*H)	Input Voltage (V)	Input Load (W)	Max Cooling Power (W)	Max Heating Power (W)
TEC1-12715	40×40 ×3.6	12V, 2A	60W	12°	82°

Table 1. Peltier Module Specification

Refer to Figure 2, Peltier Module is attached with the system (Plastic Bucket) filled with 4 litres of water. After that, we gave a constant supply of 12V and 2A in Peltier Module and the temperature of the water varies due to power supply according to time is clearly shown in the graph. At a moment come when the temperature is being constant. Graph 1 shows the performance of Peltier Module TEC1-12715 with System. And Graph 2 shows the performance of the Peltier Module alone.



Graph 1. Performance graph of TEC1-12715 with Water Cooling System



Graph 2. Performance Graph of TEC1-12715

II. Material and Methodology The goal was to supply power to the thermoelectric modules using an ac source by converting it into dc power. The modules in turn will cool a container wherein water will be filled and tests be done. A circuit consisting of transformers, 5 in number, was designed to convert the available ac power to dc. There are five output terminals each having a maximum capacity of 10 amps at 12-volt dc current. This is achieved due to the circuit having five transformers connected separately. For extensive testing it was required that we should be able to vary the power input to the module to study it properly. This was made possible by the knobs attached to each of the terminals, which help us to vary the voltage from two to 12 in steps of two. The modules are connected to the terminals of the transformer circuit as shown above. Switches are introduced in between the path to enable controlled cooling. A container had to be fabricated of a material, which would easily conduct heat. Other requirements of the container include that it should be strong enough to bear the pressure of water that will be filled inside it, it should be easier to handle and, more importantly, it should have a flat surface for the modules to be mounted on. To achieve these objectives, we bought a thermocol box. At the bottom of the box, where the modules were to be attached, five slots were cut to place plates of such a material that can transfer the cold temperature of TE modules easily to the water inside the box. We chose copper as the material of the plates as it has one of the best thermal conductivities, is relatively cheaper than other high conductivity metals and is soft enough to be fabricated easily. To this container, at one of the bottom corners, is fixed a small pipe to act as an outlet for water. A regulator is attached to the plastic pipe. To meet the requirements of the project the dimensions of the container were to be decided to ensure highest efficiency. We were looking for area that was only large enough to just fix the modules along with heat sinks. Similarly, the thickness of the copper should also be appropriate, thin enough to allow the process of heat transfer easily and thick enough for the surface to be rigid and flat. This was achieved by selecting a copper sheet of 0.5 mm for the bottom plates, where the modules were to be mounted. The base surface measures 8 inch by 10 inches. Moreover, thermocol would acts a very good insulator, thus protecting the inside space from the hotter atmosphere, effectively. Thermoelectric modules work best when the heat developed on the opposite side of the cold plate is dissipated from it effectively. Moreover, there is a chance that the module is damaged due to excessive heat accumulation. To dissipate this heat a heat sink is to be attached to the hot side of the module. The heat sink we have used is the one, which is used typically in CPU’s of the computers. It consists of two parts; one is a 12-volt dc fan and the other an aluminium finned surface. Both the parts are held together using four long screws. Five of such heat sinks were used to dissipate the heat from the five modules that were going to be used. Since the fan is a dc type and the power available is in ac, we had to make use of a converter for the fans to work. This was an ‘LED Driver’, which converts the available 220-volt ac into 12-volt dc with one amp as maximum current. So, five such drivers were used to run the five fans. The air gaps present in the interface of the module and heat sink, module, and container hamper the efficiency of the module, as air is not a very good conductor of heat. This hurdle was dealt with by applying a thermal paste between the surfaces. After the thermal paste is applied the two surfaces are wrung together to ensure proper thermal contact.

IV. CONCLUSION

Peltier Module TEC1-12715 has been used and experimentally verify the temperature is performed according to time when we supply 12V, 2A DC. We have observed that the temperature of 4 Litres of water dropped in between 5 degrees to 6 degrees in 12 min approx. This Peltier module is a very important electronics device for better power savings. This has low power and high output. So, in general life, we can use this device in series for more efficient results. Peltier modules, ready to be designed into commercial electronic products, is a relatively new phenomenon. There are numerous advantages offered, including faster response, improved temperature stability and greater flexibility to control the temperature of critical devices such as ICs, laser diodes or sensors. Many new and innovative applications for Peltier modules are expected to emerge as designers gain familiarity with the products and design techniques.

Thermoelectric refrigeration is a noiseless method of doing so and, above it eco-friendly. The various tests that we have conducted made us to believe that TE modules are best suited for minor applications and efficient for the same too. As can be seen in the third test, its effects come to surface clearly after some time. There still can be an improvement in the performance of the module if heat sinks required are made and manufactured according to the dimensions of the module. The one's we are using now, CPU fans, are reliable but not perfect. Another room for improvement can be find in the making of the container in which efforts can be made to increase the ratio of area of the container covered by the modules to the area that is not. Overall, there is room for the module to perform even better than it is doing now. It holds the future of refrigeration needs for all small applications.

V. REFERENCES

[1]. Kumar, Saket & Ashutosh, Gupta. (2015). Peltier module for refrigeration and heating using embedded system. 10.1109/RDCAPE.2015.7281416.

[2]. Y. G. Gurevich, G. N. Logvinov, O. A. Fragoso and J. L. del Rio, "Lowest temperature at thermoelectric cooling," 2007 4th International Conference on Electrical and Electronics Engineering, 2007, pp. 369-372, DOI: 10.1109/ICEEE.2007.4345042.

[3]. International Journal of Emerging Technology and Advanced Engineering Volume 3, Special Issue 3: ICERTSD 2013, Feb 2013, pages 362-367. http://www.ijetae.com/files/conference%20icertsd2013/ijetae_icertsd_0213_56.pdf

[4]. International Journal of Engineering and Innovative Technology (IJEIT) Volume 2, Issue 7, January 2013. Http://www.ijeit.com/archive/13/volume-2-issue-7--january-- 2013.html

[5]. Middle-East Journal of Scientific Research 13 (Mathematical Applications in Engineering): 103-108, 2013 ISSN 1990- 9233.https://www.idosi.org/mejsr/mejsr13(mae)13/16.pdf

[6]. A Heat Transfer Textbook by John H. Lienhard IV and John H. Lienhard Vhttp://www.mie.uth.gr/labs/ltte/grk/pubs/ahtt.pdf

[7]. Consideration For Design Of Thermoelectric Refrigeration System, Research Article, International Journal of Advanced Engineering Research and Studies, E-ISSN 2249–8974.http://www.technicaljournalsonline.com/ijaers/vol%20i/ijaers %20vol%20i%20issue%20ii%20january%20march%202012/ijaers %20102.pdf

[8]. Article in ieee transactions on advanced packaging · june 2009 pages 423-430. Ieeexplore.ieee.org/abstract/document/4530752/

[9]. Journal of Environmental Research and Development Vol. 6 No. 4, April-June 2012. Https://www.jerad.org/ppapers/dnload.php?Vl=6&is=4&st=1059

[10]. International Journal of Scientific & Engineering Research, Volume 5, Issue 2, February-2014, page 624-627. Http://www.ijser.org/researchpaper%5ccost-effective-RefrigeratorUsing-Thermoelectric-Effect.pdf