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Research Article

EXPERIMENTAL STUDY ON COMPARISON OF PELTIER MODULE TEC1 12706 AND TEC1 12715

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ABSTRACT
Peltier modules are widely used in industries for refrigeration applications. Although, plenty of researches have been done on Peltier module, based on either modelling or applications of Peltier module. Hence, users find it difficult to gather required information regarding Peltier module to design a refrigerator or other cooling systems which is an alternative for existing refrigeration technology. The current research work is based on TEC1-127 series such TEC1 12706 and TEC1 12715 to study their temperature characteristics in different atmospheric conditions (Open condition and closed condition) and explains the working setup of Peltier module. This work includes the results of tests that were conducted in order to identify the temperature characteristics of Peltier module with respect of time. The minimal temperature achieved was -7.2 °C within 6 minutes for TEC1 12715.

***Keywords**: Peltier Effect, TEC1- 12706 and TEC1 – 12715, Temperature, Time*

INTRODUCTION
The concept of thermoelectricity was discovered in the early years of the 19th century. In 1821, it was discovered that an electromotive force (e. m. f) is produced in a circuit that is made of two different materials by heating the junction (Jamakandi *et al.,* 2020).In 1821, a German scientist named Thomas Seebeck discovered that an electric current could flow continuously in a closed circuit made up of two dissimilar metals kept at two different temperatures. Seebeck, on the other hand, the scientific basis for his finding, supposing that flowing heat had the same impact as flowing electric current (Meher *et al.*, 2018)
Investigating the "Seebeck Effect" in 1834, a French watchmaker and part-time physicist, Jean Peltier, discovered an opposite phenomenon in which thermal energy could be absorbed at one dissimilar metal junction and discharged at the other when an electric current flowed within the closed circuit. After twenty years, William Thomson, later Lord Kelvin, published a concise description of the Seebeck and Peltier phenomena, as well as their interaction. However, at the time, these phenomena were still regarded as mere laboratory enigmas with little practical application (Tong, 2011).
Russian scientists began researching some of the older thermoelectric work in the 1930s in order to build power generators for use in isolated regions across the country. This Russian research in thermoelectricity finally drew international attention and led to the development of practical thermoelectric modules. Thermoelectric refrigerators of today rely on modern semi-conductor technology, in which doped semi-conductor material replaces the dissimilar metals used in early thermoelectric research (Onoroh *et al*., 2013)

Thermoelectric Module
A thermoelectric (TE) cooler is a semiconductor-based electronic component. On application of DC power with less voltage, heat is transferred through the thermoelectric module. Hence, a thermoelectric module is used for heating and cooling (Najafi and Woodbury, 2013; Venkatesan *et al.*, 2020). Therefore, it makes it applicable for applications of accurate temperature control.

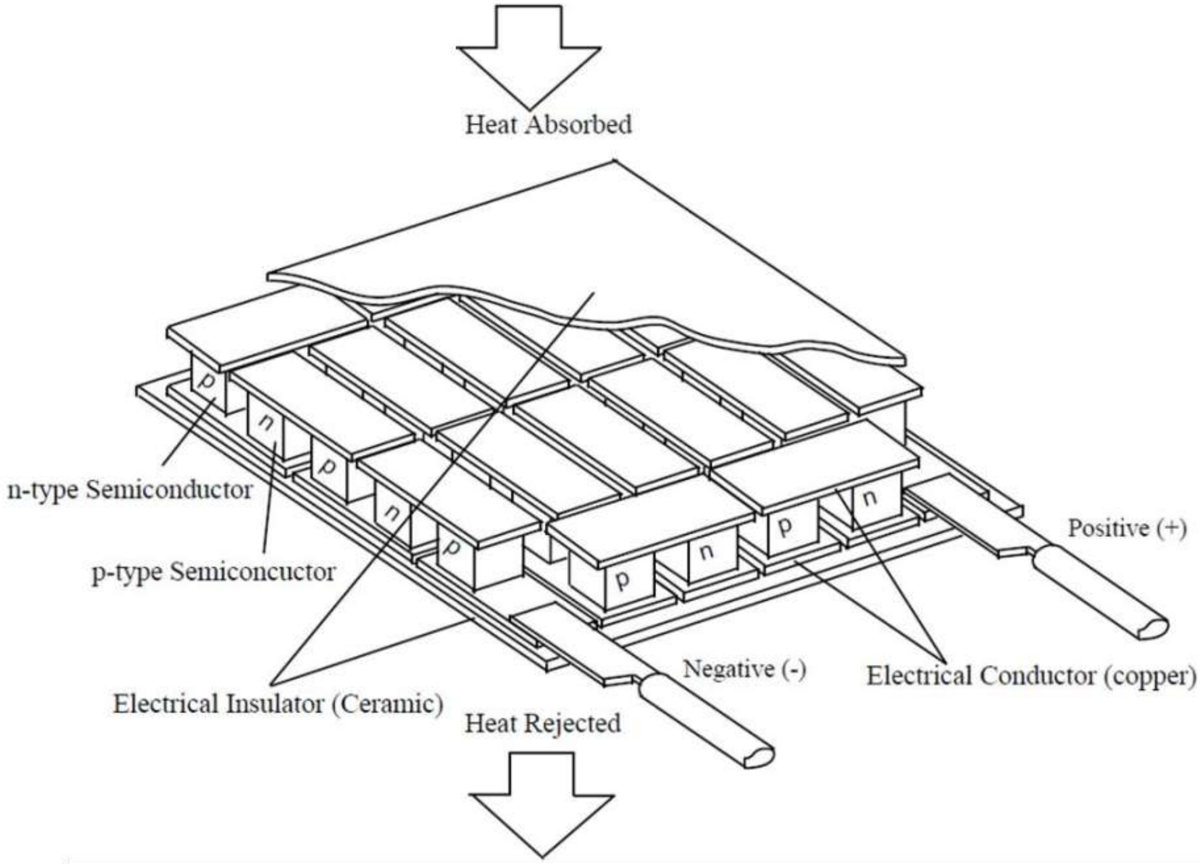

Figure 1: Construction of a typical Thermoelectric Module

A TEC comprises a p-type and n-type semiconductor and copper wires that are used to connect the semiconductors (Figure 1). The number of thermoelectric pairs in the module is based on the application. Bismuth Telluride is commonly used semiconductor. Materials such as Skutterudite were proved to provide improved results in certain conditions. A peltier module has two external ceramic plates that are separated by semiconductor pellets. When a current is passed through these micro-conductor pellets, one of the plates absorbs heat and dissipated by the other plate (Chen *et al.*, 2012).

Working of Peltier module

A Peltier module consists of two unique semiconductors, one n-type and one p-type, which are used because they need to have different electron densities. The alternating p and n-type semiconductor pillars are placed thermally in parallel to each other and electrically in series and then joined with a thermally conducting plate on each side, usually ceramic removing the need for a separate insulator (Jamakandi *et al.*, 2020), when a voltage is applied to the free ends of the two semiconductors there is a flow of DC current across the junction of the semiconductors causing a temperature difference. As the electrons travels from P type material to N type material, the electrons hop to the higher energy state hence absorbing thermal energy (cold side). Then as the electrons travel from N type material to P type material, the electrons drop to the lower energy state and hence, dissipating thermal energy (hot side)to the surrounding environment. The higher is the rate of dissipation of heat, the cooler it gets inside the chamber (cold side of Peltier module) and increasing the efficiency of the cooling module proportionally (Badgujar *et al.*, 2015).

This current research was conducted to determine the cold side temperature characteristics of TEC1 12706 and TEC1 12715 at the open and closed condition.
The manufacturer detailed specification of TEC1- 12706 and TEC1- 12715 is given in table 1

Table 1: Specification of TEC1 12706 and TEC1 12715

S. No	**Parameters**	**TEC1 12706**	**TEC1 12715**
1	Voltage	12 Volts	15Volts
2	Current	6 Amps	15Amps
3	Area	40 mmx 40 mm x 1mm	40 mm x 40 mm x1mm
4	Qmax	92.4 Watts	230Watts
5	Th	50 °C	< 90°C
6	ΔTmax	66	68°C

MATERIALS AND METHODS

Experimental set up

The experimental setup consists of components such as Peltier module, heat sink, fan and switched-mode power supply (SMPS). The Peltier module consists of 127 thermocouples and connected in series which is sandwiched between two ceramic plates. After applying electricity to the system, a ceramic plate works as a heated plate, while the other one works as a cooling plate. The direction of the current determines which plate is heated. The power was supplied to the Peltier modules using a DC power supply. To ensure the best performance of the Peltier module, the heat dissipated from the cold side to the hot side should be removed as much as possible. To dissipate this heat, a heat sink is attached to the hot side to the experimental set up. Heat sink consists of 12-volt dc fan and aluminum finned surface. The schematic diagram of experimental setup at open and closed condition is shown in Figure 2 and 3.
The cold side surface temperature and cooling time of the Peltier module (TEC1 12706 and 12715) were measured using a digital thermometer (K– type thermocouple) and stopwatch respectively and given in Table 3 and 4.

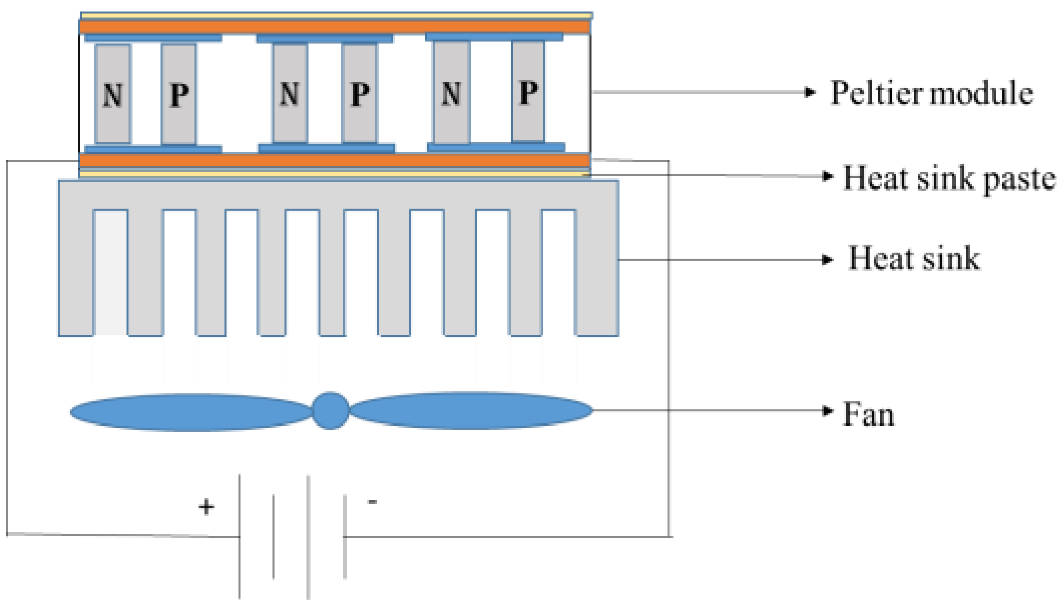

Figure 2: Schematic diagram for experimental setup at open condition

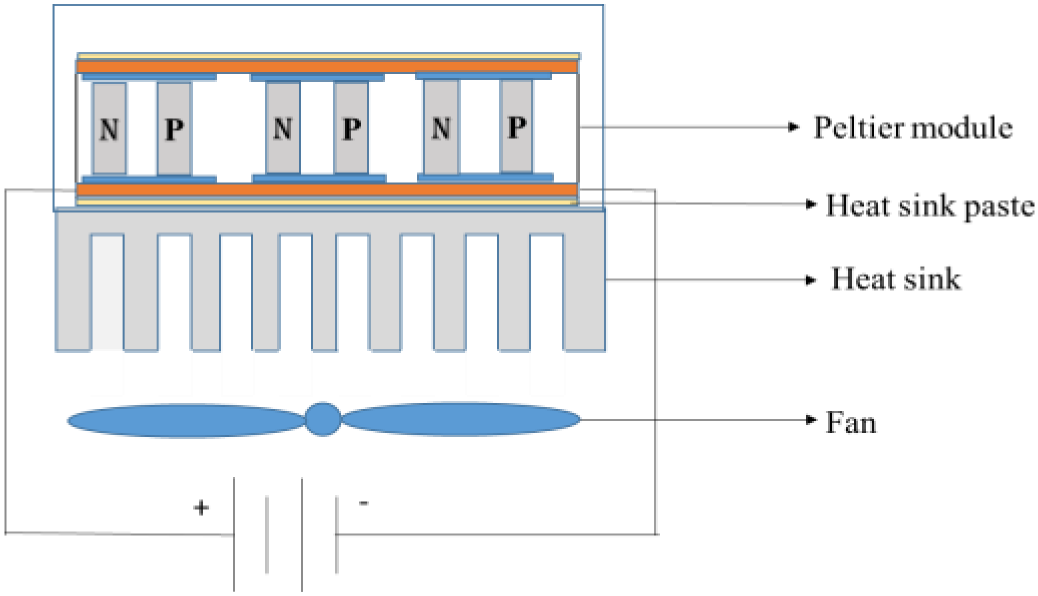

Figure 3: Schematic diagram for experimental setup at closed condition

RESULTS AND DISCUSSION

The aim of this study was to determine the cold side temperature characteristics of TEC1 12706 and TEC1 12715 at the open condition and closed condition are given in table 3 and table 4. The cold side temperature profile of TEC1 12706 and TEC1 12715 in the closed and open conditions were recorded for a period of 6 minutes with an interval of one minute. Table 3, depicts that there was highly significant ($p \leq 0.01$) reduction existed with respect to time for both TEC112706 and TEC1 12715 and also highly significance difference ($p \leq 0.01$) was observed between two conditions. From table 3 it was observed that, the Peltier module TEC1 12706 reached a temperature of 14.3 ºC and 12.1 ºC at 6 minutes in open condition and closed condition respectively. The lower temperature difference (ΔT) in open condition was due to heat ingress from the atmosphere and the heat transfer (cooling loss) to the atmosphere.The maximum efficiency was found in closed condition. Similar results observed by (Patil *et al.*, 2019) who stated that enclosed insulated cabinet was found to have maximum efficiency.

Table 3: Cold side temperature (ºC) characteristics of TEC1 12706 (Mean±SE)

Time (min)	**TEC1 12706**	
	Open condition	**Closed condition**
0	34.1± 0.04	33 ± 0.04
1	32.1 ±0.03	27.3 ± 0.03
2	29± 0.04	24.2± 0.03
3	22.1± 0.03	18.3 ± 0.02
4	19.3 ± 0.02	15.1 ± 0.02
5	15.2 ± 0.02	13 ± 0.01
6	14.3 ± 0.02	12.1 ± 0.01

Table 4: Cold side temperature (°C) characteristics of TEC1 12715 (Mean±SE)

Time (min)	TEC1 12715	
	Open condition	**Closed condition**
0	34.1± 0.04	33± 0.04
1	21± 0.02	20.1± 0.02
2	14.1 ± 0.02	13.8 ±0.02
3	8.3 ± 0.01	4± 0.05
4	2 ± 0.03	-1.6 ± 0.03
5	-1.2± 0.01	-4.1± 0.06
6	-3.1± 0.04	-7.2± 0.08

Table 4 shows the cold side temperature profile of Peltier module TEC1 12715 for every one minute interval. From the table 4, it was noted that the temperature difference was significantly increased with increasing time for both open condition and closed condition for Peltier module TEC1 12715. When comparing open and closed condition, the temperature of – 7.2 ºC was achieved in 6 minutes in closed condition, whereas -3.1ºC of temperature was attained in open condition due to heat ingress from the atmosphere. The maximum efficiency was found in closed condition.
From the table 3 and 4, it was observed that the module TEC1 12715 has attained very less temperature on cold side and has high temperature difference (ΔT) in both open and closed condition. The Peltier module TEC12715 was more efficient than TEC1 12706 with respect to time and temperature difference. Similar findings were observed by Utkarsh *et al.*, (2019) who stated that TEC1 12715 was more efficient when compared to TEC1 12706. Hence, the Peltier module TEC1 12715 can be used for development refrigerators and other cold storage applications.

CONCLUSION

Peltier modules are less bulky hence they are portable and user friendly. They are environment friendly as they do not contribute to any environmental hazards. Although Peltier modules have shorter lifetime but it had the reliability to overcome the major shortcomings of the conventional heating/cooling devices such as power consumption and portability. The same module is capable of both heating and cooling, therefore it served as a convenient option for various heating and cooling applications.
The Peltier module can able to achieve a lowest temperature which is below 0°C. So we can use this cold side temperature of the module to develop a cooling system for preserving and storing highly perishable food products and medicines. The Peltier modules are low on cost and ecofriendly. Through experiments, it has been concluded that a minimum of -7.2 °C temperature can be achieved with this kind of setup. Further improvements to design a Peltier module based refrigerator or cooling systems are possible.

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