

# FABRICATION OF THERMOELECTRIC COOLER

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**Abstract:** In recent years, with the increase awareness towards environmental degradation due to the production, Use and discharge of ChloroFluoro Carbons (CFCs) and Hydro ChloroFluorocarbons (HCFCs) as heat carrier fluids in conventional refrigeration systems has become a subject of great concern and resulted in extensive research into development of refrigeration technologies. It is found by some researchers that Thermoelectric operated devices can be the best alternative in refrigeration technology due to their distinct advantages. Using thermoelectric effect in system the COP of the system also increases. A brief introduction of thermoelectricity, principal of thermoelectric cooling and thermoelectric materials has been presented in this paper. The literature review of some research paper has been seen in this paper. The purpose of this paper to review the process of fabrication of thermoelectric cooler using thermoelectric module technology. In this paper, we have also mention development on thermoelectric module based devices.

**KEYWORDS:** Thermoelectric module; Peltier effect; Thermoelectric Material

## 1. Introduction

The first important discovery relating to thermoelectricity occurred in 1823 when a German scientist, 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 application of a current at an interface between two dissimilar materials results in the absorption/release of heat as seen in Figure 1. 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. The principle of peltier effect is the inverse of the principle of seebeck effect.

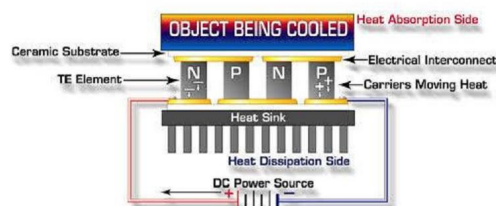


Fig 1. Principle of thermoelectric module

## 1.2 Thermoelectric phenomenon

The thermoelectric phenomenon deals with the conversion of thermal energy into electrical energy and vice-versa. When operating as an energy-generating device the thermoelectric device is termed a thermoelectric generator (TEG). The source of thermal energy manifests itself as a temperature difference across the TEG. When operating in a cooling or heating mode the thermoelectric device is termed a thermoelectric cooler (TEC). Similarly, the thermoelectric device produces heating or cooling that takes the form a heat flux which then induces a temperature difference across the TEC.

Thermoelectric devices are solid-state mechanisms that are capable of producing these three effects without any intermediary fluids or processes. For power generation applications thermoelectric devices are used in automobiles as exhaust gas waste heat recovery devices where thermal energy is scavenged along the exhaust line of a vehicle and converted into useful electricity.

## 1.3 Thermoelectric effect in P and N type materials

- As electrons move from p type material to n type material, electrons jump to a higher energy state absorbing energy, from the surrounding area. Similarly as electrons move from n-type material to p-type material, electrons fall to a lower energy state releasing energy to the surrounding area.
- The movement of electrons from higher energy state to lower energy state and vice-versa is responsible for increase or decrease of heat transfer rate.
- The relationship between the amount of current and heat absorbed/released at the junction of the two

dissimilar semiconductors is given by the Peltier coefficient ( $\pi = Q/I$ ).

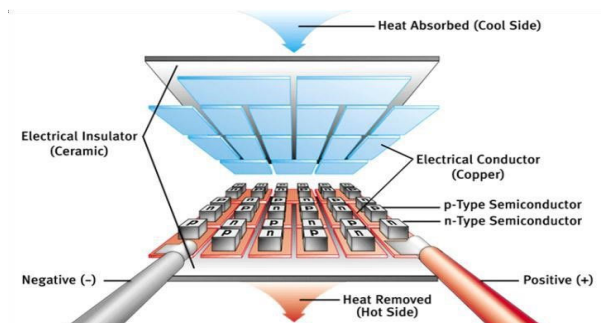


Fig.2 Semiconductor arrangement

## 1.4 Features of Thermoelectric Module

- Thermoelectric module is a device consist of precise arrangement of P and N type material sandwiched between ceramic plates (Electrical insulator).
- Two unique semiconductor are used because they need to have different electron densities.
- The semiconductors are placed thermally in parallel to each other and electrically in series and then joined with a thermally conducting plate on each side.
- 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.
- The side with the cooling plate absorbs heat which is then moved to the other side of the device where the heat sink is.

## 1.5 Design Considerations of TEC

1. Temperature to be maintained for the object that is to be cooled.
2. Heat to be removed from the cooled object.
3. Time required to attain the cooling after a DC power is applied.
4. Expected ambient temperature.
5. Space available for the module and hot side heat sink.
6. Expected temperature of hot side heat sink.
7. Power available for the TEC.
8. Controlling the temperature of the cooled object if necessary

## 1.5 Operating Modes

- When operating as an energy-generating device the thermoelectric device is termed a thermoelectric generator (TEG).
- When operating in a cooling or heating mode the thermoelectric device is termed a thermoelectric cooler (TEC).

## 2.1 Literature Survey:

Manoj Kumar et al [1] presented an experimental study of noval potential green refrigeration and air-conditioning technology. They are analysing the cause and effect of an existing air-condition system. Thermoelectric cooling provides a promising alternative R&AC technology due to their distinct advantages. The available literature shows that thermoelectric cooling systems are generally only around 5-15% as efficient compared to 4060% achieved by the conventional compression cooling system. Astrain, Vian& Dominguez [2] conducted an experimental investigation of the COP in the thermoelectric refrigeration by the optimization of heat dissipation. In thermoelectric refrigeration based on the principle of a thermo syphon with phase change is presented. In the experimental optimization phase, a prototype of thermos syphon with a thermal resistance of 0.1 10 K/W has been developed, dissipating the heat of a Peltier pellet with the size of 40\*40\*3.9 cm, Experimentally proved that the use of thermos syphon with phase change increases the coefficient of performance up to 32%. MatthieuCosnier et al[3] presented an experimental and numerical study of a thermoelectric air-cooling and air-heating system. They have reached a cooling power of 50W per module, with a COP between 1.5 and 2, by supplying an electrical intensity of 4A and maintaining the 5°C temperature difference between the hot and cold sides. SuwitJugsujinda et al [4] conducted a study on analyzing thermoelectric refrigerator performance. The refrigeration system of thermoelectric refrigerator (TER; 25 × 25 × 35 cm<sup>3</sup>) was fabricated by using a thermoelectric cooler (TEC; 4 × 4 cm<sup>2</sup>) and applied electrical power of 40 W. The TER was decreased from 30 °C to 20 °C for 1 hr and slowly decreasing temperature for 24 hrs. The maximum COP of TEC and TER were 3.0 and 0.65. Wei He et al[5] Conducted Numerical study of Theoretical and experimental investigation of a thermoelectric cooling and heating system driven by solar. In summer, the thermoelectric device works as a Peltier cooler when electrical power supplied by

PV/T modules is applied on it. The minimum temperature 17 degree C is achieved, with COP of the thermoelectric device higher than 0.45. Then compared simulation result and experimental data. Riff and Guoquan [6] conducted an experimental study of comparative investigation of thermoelectric air conditioners versus vapour compression and absorption air conditioners. Three types of domestic air conditioners are compared and compact air conditioner was fabricated. Riffat and Qiu[7] compared performances of thermoelectric and conventional vapour compression air-conditioners. Results show that the actual COPs of vapour compression and thermoelectric air-conditioners are in the range of 2.6-3.0 and 0.38-0.45, respectively. However, thermoelectric air conditioners have several advantageous features compared to their vapour-compression counterparts.

Shen, Xiao et al[8] investigated a novel thermoelectric radiant air-conditioning system (TERAC). The system employs thermoelectric modules as radiant panels for indoor cooling, as well as for space heating by easily reversing the input current. Based on the analysis of a commercial thermoelectric module they have obtained a maximum cooling COP of 1.77 when applying an electric current of 1.2A and maintaining cold side temperature at 20°C. Virjoghe, Diana et al [9] conducted a numerical investigation of thermoelectric System. The thermoelectric systems have attracted renewed interest as concerns with the efficient use of energy resources, and the minimization of environmental damage, have become important current issues. This paper presents of numerical simulation for several the thermoelectric materials. Numerical simulation is carried out by using a finite element package ANSYS. Maneewan et al[10] conducted an experimental investigation of thermal comfort study of compact thermoelectric air conditioner. In this paper analyse the cooling performance of compact thermoelectric air-conditioner. TEC1-12708 type thermoelectric modules used for heating and cooling application. The compact TE air conditioners COP was calculated to its optimum parameters. Then analyse the cop with respect to time and calculated cop at various considerations.

Manoj and Walke [11] conducted an experimental study of thermoelectric air cooling for cars. They are trying to overcome these demerits by replacing the existing HVAC system with newly emerging thermoelectric couple or cooler which works on peltier and seebeck effect. Yadav and Mehta [12] presented combined experimental and theoretical study of thermoelectric materials and application. The present study develops an optimization design method for thermoelectric refrigerator. This device is fabricated by combining the standard n and p-channel

solid-state thermoelectric cooler with a two-element device inserted into each of the two channels to eliminate the solid-state thermal conductivity. Huang. B et al [13] conducted an experimental study of design method of thermoelectric cooler. They are fabricated the thermoelectric cooler and analyse various considerations. The system simulation shows that there exists a cheapest heat sink for the design of a thermoelectric cooler. It is also shown that the system simulation coincides with experimental data of a thermoelectric cooler. MayankAwasthi [14] they designed and built a prototype thermoelectric cooler and perform an experiment. The thermoelectric module form melcor is used for the experiment. The test was conducted at different ambient 21 °C, 15 °C, 32 °C and 43 °C , The temperature vary from 15 °C to 5 °C with temperature variation within the TEC is less than 1 °C as this was the proto sample with improvement in prototyping we can achieve even lower temperature. Benziger B et al [15] for increasing the cooling rate parameter varied during the Experimentation are Voltage and Current. The temperatures at various locations of the Modules are measured with the help of calibrated K Type thermocouples and heat input can be supplied with the use of dimmer stat. Shigeo Yamaguchi et al [16] they proposed and fabricated an N- N type Peltier device composed of two small N-type Bi<sub>2</sub>Se<sub>0.37</sub>Te<sub>2.36</sub> thermoelectric bulk material. This structure includes an additional electric wire between the two N-type bulks. Then they introduced an application of the NN-type Peltier device as a stage on which a temperature difference can be induced by altering the current, targeting a rapid amplification system for deoxyribonucleic acid (a thermal cycler for the polymerase chain reaction). ChetanJangonda et al [17] they fabricated a prototype and concluded that the temperature vary from 15 °C to 5 °C. Temperature variation within the thermoelectric cooler is less than 1 °C as this was the proto sample with improvement in prototyping we can achieve even lower temperature.

Christian J.L. et al [18] study compares the thermodynamic performance of four smallcapacity portable coolers that employ different cooling technologies: thermoelectric, Stirling, and vapour compression using two different compressors (reciprocating and linear). The refrigeration systems were experimentally evaluated in a climatized chamber with controlled temperature and humidity. Tests were carried out at two different ambient temperatures (21 and 32°C) in order to obtain key performance parameters of the systems (e.g., power consumption, cooling capacity, internal air temperature, and the hot end and cold end temperatures). These performance parameters were compared using a thermodynamic approach. N. B. Totala et al [19] it had been shown from testing

results that the cooling system is capable of cooling & heating the air when recirculating the air with the help of blower. TEC cooling designed was able to cool an ambient air temperature from 32.5°C to 22.1°C. Cooling stabilizes within ten minutes once the blower is turned ON (with a velocity of 2.5 m/s). The system can attain a temperature difference of set target which was 6°C. A. K. Pathrikar et al [20] the paper describes efficient method to develop a portable thermoelectric refrigeration system for medical application using thermoelectric cooling effect. Thermoelectric modules are the key elements in this refrigerator for providing the thermoelectric cooling. The integrated use of microcontroller, temperature sensors, ADCs is mention.

### Conclusion:

- The available literature shows that thermoelectric cooling systems are generally only around 5–15% as efficient compared to 40–60% achieved by conventional compression cooling system.
- From the above data we can conclude that Thermoelectric cooling added a new dimension to cooling. It has major
- Impact over conventional cooling system. It is compact in size, no frictional elements are present, no coolant is required and weight of the system is low.
- From the review of the pertinent literature presented above, it can be inferred that thermoelectric technology using different modules used for cooling as well as heating application has considerable attention. Many researchers try to improve the COP of the thermoelectric air-conditioner using different material.

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