# REVIEW ON THERMOELECTRIC COOLING: MODELLING AND ITS APPLICATION

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**ABSTRACT**

*Increasing demand for cooling in field of air-conditioning, refrigeration, vaccine storage and food preservation lead to emission of more CFC gas and more consumption of electricity. Thermoelectric cooling is the new alternative because when it is supplied with dc supply it creates temperature difference as an output, without any environmental effect [1]. Effectively we are using TEC systems having advantages over the alternatives present till date, such as light in weight, high reliability, compact in size no mechanical moving parts and no working fluids. Peltier effect of thermoelectric cooling is the concept under which the cooling operation is going to be done. In this paper the study on the thermoelectric cooling using Peltier devices with the précised output, results has been obtained [3]. Also with hardware modelling of medication box to store medicines so as to maintain their potentiancy and effectiveness which will hold a major contribution in medical applications. As seen from the previous years, with the increase in the population the chances of the diseases and the accidents have been increased. It became necessary that the cure for this event, disease or an accident, must available on time when required. This paper deals with the concept that will help to store these lifesaving medicines in a more efficient way [5]. Different medicines need different temperatures for storage to maintain its potentiancy and effectiveness, some may need cold storage some may need probably high temperature. Considering all these in mind we have designed and fabricate thermoelectric cooling system having advantages over conventional cooling devices, such as compact size, light in weight, high reliability, no mechanical moving parts, no working fluids and eco-friendly. This model i.e. smart thermoelectric medication box holds tremendous advantages over available traditional alternatives.*

**Keyword:-** *SPV, Net Metering, Grid.*

## 1. INTRODUCTION

To prevent disease in an effective and proper manner it is necessary that the medicines must be stored as per the guidelines given on it. Some medicines may require hot temperature and some may require cold temperature and some may store at room temperature. Besides this storage it is also necessary that these medicines must be available anywhere means it can be easy to carry in a respective container and proper temperature is maintained in container [4].

During an emergency condition such as the injury occurred during the accident or during the immediately un-proper working of the body organ it becomes necessary to provide immediate medication to the person so as to save life, so the medicine should be available on time of incidence. The conventional ways for providing the cooling medium is only a refrigerator but the disadvantage of the is that it cannot be transported from one place to other place as it's size is somewhat bulky and a continuous electric supply is needed to run it besides this other major disadvantage of using the refrigerators are that, it uses chlorofluorocarbon (CFCs) as the main working fluid for cooling which when released to or come in contact with the atmosphere causes depletion of ozone layer.

Other small compartments are also available in ambulances and hospitals which are used to store such medicines but they also have disadvantage that the cooling medium is provided in them by using ice and salt, so it becomes difficult to maintain the constant temperature throughout the day [6]. So as to over the disadvantages mention above we are going to fabricate a new appliance/system that is "Smart Thermoelectric Medication Box".

## 2. PRESENT SCENARIO IN MEDICATION

The medicines are usually stored in the refrigerators, which provide cool medium for the storage of medication. Vaccine for polio are carried and stored in a fibre container containing a Thermocol with ice in it for its cooling. But this ice can't last for the longer time which creates a chance of medicine deterioration. Besides this the temperature control is also not possible to kept different medicines at their desired temperature. $20 million worth medicines are wasted annually due poor refrigeration, and up to 35% of vaccines are affected because of improper storage both as per the current estimation. There are Pharmaceuticals refrigerators which are lockable and have a thermometer (digital sensor readout) fitted with an audible alarm which measures minimum and maximum temperatures [3]. Ordinary domestic refrigerators must not be used. But today the use of common refrigerators is more than those which should be used.

## 3. OVERVIEW ON THERMOELECTRIC COOLING

### Seebeck Effect

Thermoelectric devices works on two effects Seebeck Effect When the temperature difference is created on the two either plates of the thermoelectric module, an electrical output will obtain. Suppose there are two conductors of dissimilar metals denoted as material A and B. The temperature at A is used as a reference (TC). The junction temperature at B i.e. this is used as temperature higher than temperature TC [7]. When heat is applied to junction B, a voltage (Eout) will appear across terminals of the device. Hence the electric current would flow continuously in this closed circuit. This voltage (V) as shown in Figure below known as the Seebeck EMF and it can be expressed as,

$$E_{out} = \alpha (T_H - T_C)$$

Where:
$\alpha = dE / dT = \alpha A - \alpha B$
$\alpha$ - The differential Seebeck coefficient
$E_{out}$ - The output voltage in volts.
$T_H$ and $T_C$ are the hot and cold thermocouple temperatures, respectively, in $^0$K.

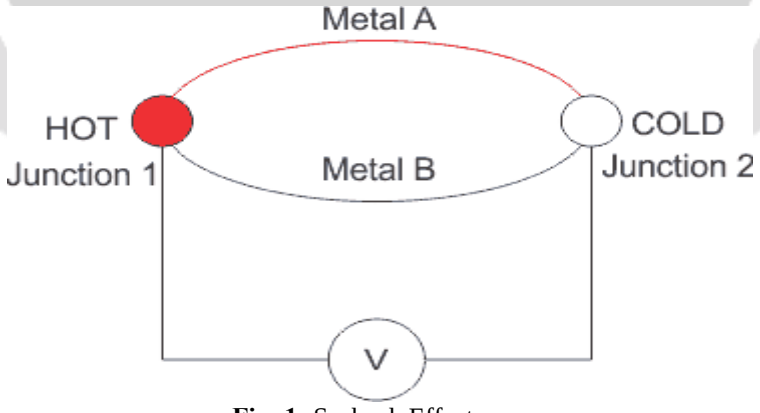


**Fig- 1:** Seebeck Effect

### Peltier Effect

Later on Peltier found there was an opposite phenomenon to the Seebeck Effect, whereby thermal energy could be absorbed at one dissimilar metal and discharged at the other when an electric current is allowed to flow within the module. If a voltage (Ein) is applied to terminals T1 and T2, an electrical current (I) will flow in the circuit. As a result of this, cooling effect (QC) will occur at metal A (where heat is absorbed), and a heating effect (QH) will occur at B (where heat is evolved). This effect may be reversed when the polarity of module will get changed [7]. The Peltier effect can be expressed mathematically as,

$$Q_C \text{ or } Q_H = \beta \times I$$
$$= (\alpha T) \times I$$

Where:
β - Differential Peltier coefficient between the two materials A and B in volts.
I - The electric current flow in amperes.
$Q_C$ and $Q_H$ are the rates of cooling and heating, respectively, in watts.

Case 1 - When High energy electrons move from right to left, Thermal current and electric current flow in opposite directions and $\beta < 0$ i.e Negative Peltier coefficient .

Case2 - When High energy holes move from left to right, Thermal current and electric current flow in same directions and $\beta > 0$ i.e Positive Peltier coefficient.

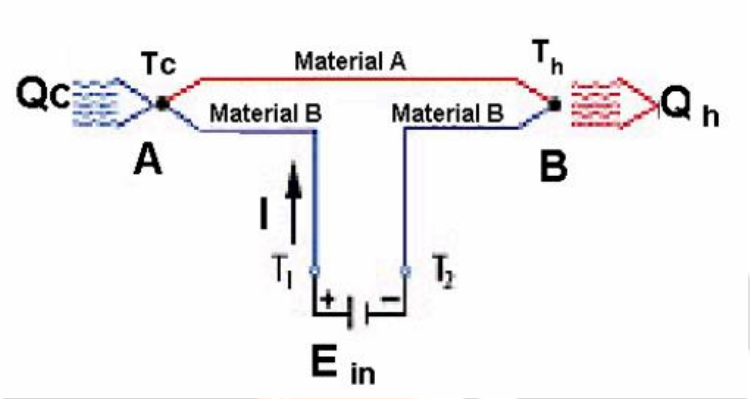


**Fig- 2:** Peltier effect

Thermoelectric cooling acts on the principle of Peltier effect, when a direct current is passed between two electrically dissimilar materials heat is absorbed or liberated at the junction. The direction of applied electric current of the two modules decides the direction of heat flow. A Peltier is a solid-state active heat pump which consist a number of p-n type semiconductor materials connected electrically in series and thermally in parallel and are sandwiched between two thermally conductive and electrically insulated substrate.

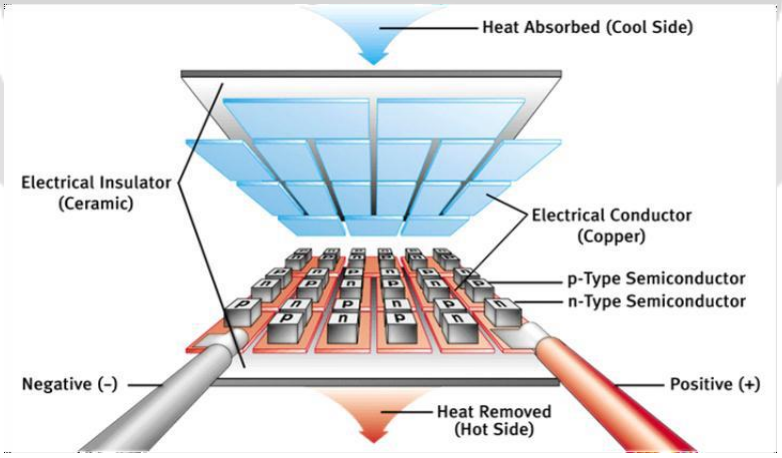


**Fig- 3:** TEC Principle of operation

The commonly material employed for commercially available thermoelectric cooler is based on Bismuth Telluride mixed crystal, having the highest figure-of-merit and most suitable in refrigeration. In addition to Bismuth Telluride, there are other thermoelectric materials including Lead Telluride (PbTe), Silicon Germanium (SiGe), and Bismuth-Antimony (Bi-Sb) alloys that may be used in specific situations. Thermoelectric coolers will either heat or cool depending upon the polarity of the applied DC power [5]. This feature eliminates the necessity of providing separate heating and cooling functions for a given enclosed space. Heat sink was used to enhance and increase the rate of heat transfer from the hot surface of thermoelectric module. Cooling fan was used to reject the heat from the hot side of module to ambient surroundings.

# 4. HARDWARE SPECIFICATION

## 4.1 Medication Box

The hardware specifications of the medication box are selected in such a way that, the maximum output would be,

**Table – 1:** Box Specifications

| Specification of Rectangular box | | |
|---|---|---|
| Parameters | | Value |
| Outer dimension(cm) | Height (H) | 23 cm |
| | Width (W) | 36 cm |
| | Length (L) | 48 cm |
| Inner dimension (cm) | Height (H) | 20 cm |
| | Width (W) | 30 cm |
| | Length (L) | 43 cm |

### 4.2 Thermoelectric Module

To increase the cooling efficiency of the medication box, two Peltier modules are used in this system. The technical specifications of the module are as given below,

- Model number: TEC1-12709.
- Voltage (V): 12V, Vmax (V): 15.4V, Imax (A): 9A.
- QMax (W): 138.6W.
- Dimensions: 40mm x 40mm x 3.6mm.

### 4.3 Battery:

COSMOS C-21, 12V. 8Ah

- Cycle use : 14.4 – 15.0 V ($25^0$c)
- Standby use : 13.6 – 13.8 V ($25^0$c)
- Initial current : less than 2.1 A

# 5. WORKING OF MODULE

Thermoelectric coolers operate on the basis of Peltier and Seebeck effect. The effect creates a temperature difference by transferring heat between two electrical junctions. A voltage is applied across joined conductors to create an electric current. When the current flows through the junctions of the two conductors, heat is removed at one junction and cooling occurs. Heat is deposited at the other junction and this phenomenon is called as Peltier effect [3].

The another phenomenon is that when we create the temperature difference on the two either plates of the device the phenomenon act inverse to the Peltier effect called as Seebeck and the electrical output get obtained at the terminals of the module[3]-[6].

The main application of the Peltier effect is cooling. However the Peltier effect can also be used for heating or control of temperature. In every case, a DC voltage is required.

The results obtained after the testing has been performed on the system are as given in the table below,

| COOLING | | HEATING | |
|---|---|---|---|
| TIME | TEMPREATURE | TIME | TEMPRATURE |
| 10 min | $20^0$c | 10 min | $40^0$c |
| 15 min | $10^0$c | 15 min | $60^0$c |

## 6. CONCLUSION

This paper reviews the developments in TEC system over the years. This study on the Thermoelectric cooling focusing on the TEC system is a novel cooling system which will be a better alternative for available systems. Our study in the field of storage of vaccines says that sometimes somewhere it is almost impossible to make availability of life saving medicines, in order to save lives. Hence it is better to have such hybrid and portable systems & devices to reduce total energy consumption.

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