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# Experimental Study On Peltier Module-Based Compressor-Less Mini Solar Powered Refrigerator

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## Abstract

The solar energy provides wide range of flexibility in nature. In this study experimental investigation was performed on a solar powered refrigerator in which the 2 Peltier module was used to provide cooling to the system. The study was carried for the climatic condition of Dehradun at Graphic Era to be Deemed University. The setup was operated by solar energy during day time and at night an extra battery is provided to lower the temperature of the system. After operating the setup for 22min and 6sec the system temperature drops from 30.9˚C to 16.9˚C, with battery pack of 84W the system can continuously operates for 3.18hr.

**Keywords:** Solar Energy, Solar Powered Refrigerator, Compressor less, Peltier Module, Thermoelectric Cooling.

## 1. Introduction

Generation of electricity is the major source of economic development of country. From previous decades the interest of researchers has shifted from non-renewable sources to renewable sources of energy due to increase in pollution, population and limited in nature of non-renewable sources of energy. In last 18$^{th}$ century the generation of electricity from non-renewable sources like coal came into existence and later interest shifted towards alternative of coal like nuclear power plant etc. but they posses' high energy and can be disastrous to societies nearby them due to radioactive in nature. Chernobyl nuclear power plant of Kyiv, Ukraine is the living proof of the disaster. Now a days the researchers showing most of interest toward solar powered system as it depicts many advantages like free of cost

available, pollution free in nature and also the endless source of energy. So solar energy now a days are used in every field like for heating and cooling by the use of FPC[1], generation of electricity by using PV module[2], solar distillation[3], refrigeration as shown in Fig.1 etc.

Many authors investigated solar power, Peltier module for refrigeration some of the literature review of detailed work described below:

### 1.1 Solar Powered Cooling and Heating

Grignafinni et al.[5] performed a case study on solar powered cooling for modern, historic buildings. According to study the total energy of 465,450Kwh/year is required for both modern and historical buildings to cool. Adrian Kerr[6] performed a theoretical study for the climatic condition of Blenheim, New Zealand. Author suggested a cooling system of 35kW for the city with a payback period of 15-20 years. Yasiri t al.[7] performed theoretical investigation and suggested evacuated tube collector and parabolic solar collector for cooling and air conditioning purpose powered by solar for the purpose of buildings. Adenane et al.[8] performed a numerical investigation to verify the effect of operating parameters like temperature, condensation and evaporation pressure over solar powered refrigeration. The COP of the system was found to be 0.346 for pair of activated carbon/methanol while in case of zeolite/water it was found to be 0.0972. Salilih et al.[9] performed simulation investigation for two different cases: (1) Variation in working saturation temperature (2) Fixed working saturation temperature. For case 2 the performance parameters of refrigeration increase with increase in solar intensity but drops at evening while for case 1 the performance parameters drop like cooling capacity, power consumption etc. and concluded the system to be more sensitive for case 1. Sarbu et al.[10] performed theoretical investigation and states liquid desiccant system and absorption cooling system to be preferrable over solid desiccant system and adsorption cooling system due to ease of handling, and encourages the solar based cooling system as a wind-up statement. Ullah et al.[11] done theoretical investigation on different working pair, minimum and maximum working temperature, cooling capacity along COP for solar powered cooling system. Moria et al.[12] performed an experimental study over solar based compressor less refrigerator. In the setup Peltier module was used for cooling purpose. The temperature of cooling side of the module was found to be 10.6˚C while hotter side receives temperature of 65˚C. Ramadan et al.[13] performed experimental instigation on solar powered refrigeration system for the climatic condition of Egypt. The COP of the system varies around 0.47 to 0.52 respectively.

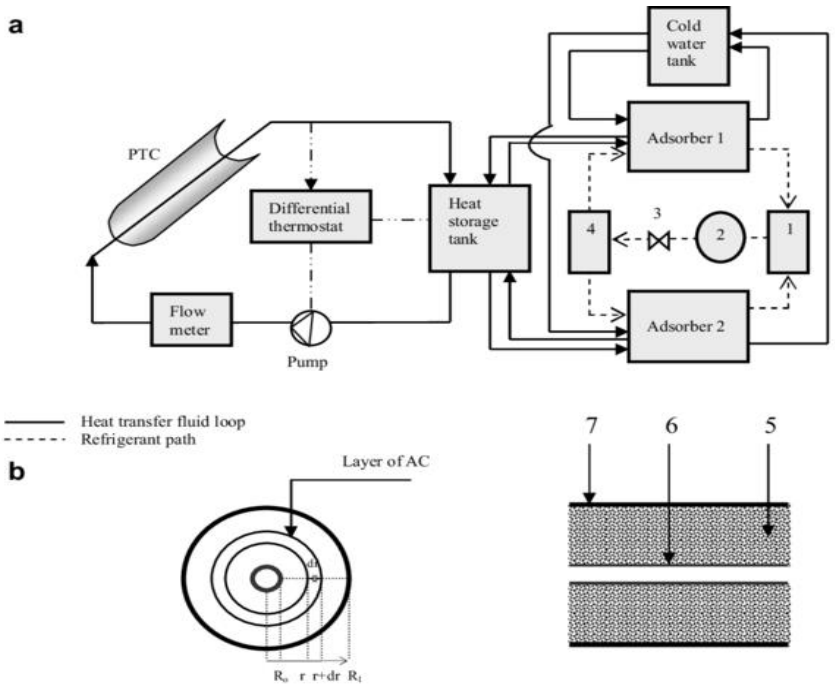


Fig.1 Block Diagram for Solar Powered Refrigeration Cycle 1. Condenser 2. Refrigerant Tank 3. Expansion valve 4. Evaporator 5. Adsorbent 6. Heat Exchanger 7. Insulation[4]

1.2 Solar Powered Cooling and Heating

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1.2 Thermoelectric Cooling

The Peltier effect is firstly invented by a scientist named J.C.A. Peltier in mid-18$^{th}$ century. Peltier effect states that when an electric current is passed through a two dissimilar material, then thermal energy is absorbed from one junction and rejected from other which produces cooling and heating of the material on alternate sides. Fig.2(a) shows systematic diagram of Peltier effect. This effect can be shown in Peltier module shown in Fig.2(b), which comprises of N and P type semiconductor materials.

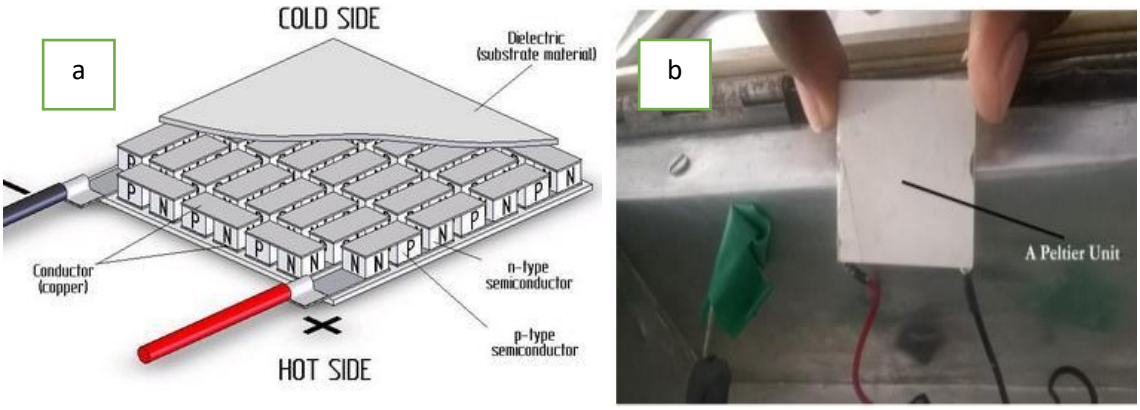


Fig.2 (a) Systematic Diagram of Peltier effect (b) Peltier Module (TIC 12073)

Sahu et al.[14] performed an experimental investigation by cooling based on Peltier module. The COP for the system was found to be 0.458 while the temperature drops of 12˚C was found for the Peltier module-based system. Anu Nair[15] performed a theoretical investigation on Peltier module-based cooling and sum up with various advantages of module as a cooling device.

On the basis of coined literature review it can be seen that a lot of work has been carried out on solar powered refrigeration system. However, there is further need for research in the field of the solar powered system. After reviewing the various literature, the author found that no work has been reported on experimental study om Peltier module-based compressor less mini solar powered refrigerator. So, in order to fill this gap, the simulation study has been carried out.

2. Setup Specification

A Peltier unit TIC 12073 was used for the study with power rating of 20 watts. A heat sink of specification 7.5cm X 8cm X 4.5 cm is used with two cooling fans with power consumption of 2.16W was used at hotter side to dissipate maximum heat. Thermocol and aluminum foil is used as insulating material at outer and inner side of the refrigerator to minimizes thermal losses to the surrounding from system. A solar panel from Exide company of 160W is used to operate the refrigerator along that a battery of 12V DC supply is also used for more cooling or as a secondary power source which can be charged by the solar panel. At last ON-OFF switch of 6Amp is provided to ON or cutoff the supply from panels to refrigerator according to requirement. Outer and inner dimension of the system can be shown in Table 1, and circuit diagram of the refrigerator setup can be seen in Fig.3.

Table 1 Dimensions of the Refrigerator

| | |
|---|---|
| Outer length (cm) | 30 |
| Outer Width (cm) | 20 |
| Outer Height (cm) | 21 |
| Inner length (cm) | 25.5 |
| Inner Width (cm) | 15.5 |
| Inner Height (cm) | 8 |
| Volume (L) | 3.162 |

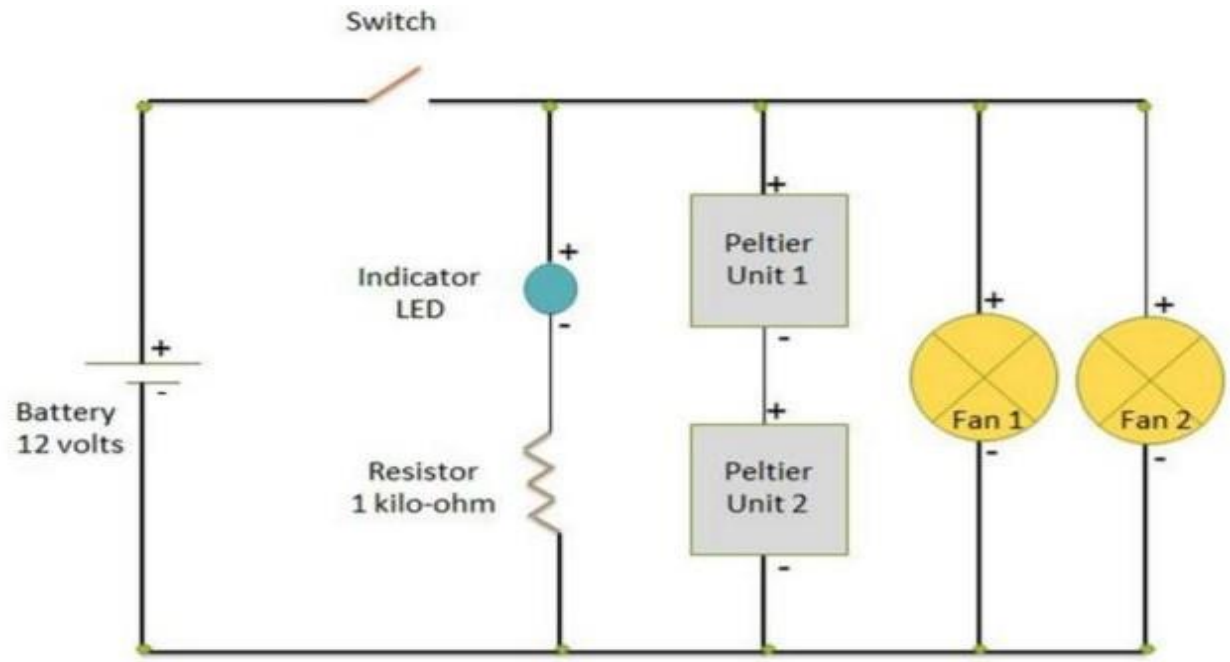


Fig.3 Circuit Diagram of the Experimental Study

**Results and Discussions**

Table 2 shows the complete data obtained from experiment; The initial temperature of the refrigerator was found to be 30.9˚C which was reduced to 16.9˚C for the time period of 22min 6sec and Fig.4 represents the complete change in temperature with respect to time.

Table 2 Data obtained from experiment

| Reading | Sample | Starting Time | Duration | Max time | Max Temp | Average Temp | Min time | Min Temp | Result | End Time |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 30.9°C | 26:02 | 00:12 | 26:02 | 30.9°C | 30.5°C | 26:14 | 29.7°C | Stable | 26:15 |
| 2 | 29.6°C | 26:15 | 00:07 | 26:15 | 29.6°C | 28.9°C | 26:21 | 28.4°C | Stable | 26:22 |
| 3 | 28.3°C | 26:22 | 00:08 | 26:22 | 28.3°C | 27.8°C | 26:30 | 27.2°C | Stable | 26:31 |
| 4 | 27.1°C | 26:31 | 00:18 | 26:32 | 27.1°C | 26.5°C | 26:44 | 26.1°C | Stable | 26:49 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 26.0℃ | 26:49 | 04:39 | 29:23 | 26.6℃ | 26.1℃ | 31:28 | 25.0℃ | Stable | 31:29 |
| 6 | 24.9℃ | 31:29 | 00:08 | 31:29 | 24.9℃ | 24.4℃ | 31:37 | 24.0℃ | Stable | 31:38 |
| 7 | 23.9℃ | 31:38 | 00:17 | 31:38 | 23.9℃ | 23.5℃ | 31:54 | 23.0℃ | Stable | 31:55 |
| 8 | 22.9℃ | 31:55 | 00:45 | 31:55 | 22.9℃ | 22.4℃ | 32:37 | 22.0℃ | Stable | 32:41 |
| 9 | 21.9℃ | 32:41 | 01:02 | 32:43 | 22.1℃ | 21.7℃ | 33:42 | 21.0℃ | Stable | 33:43 |
| 10 | 20.9℃ | 33:43 | 00:17 | 33:43 | 20.9℃ | 20.4℃ | 33:59 | 20.0℃ | Stable | 34:01 |
| 11 | 19.9℃ | 33:01 | 00:28 | 34:01 | 19.9℃ | 19.4℃ | 34:25 | 19.0℃ | Stable | 34:29 |
| 12 | 18.9℃ | 33:29 | 01:29 | 34:34 | 19.0℃ | 18.3℃ | 35:36 | 17.9℃ | Stable | 35:58 |
| 13 | 17.8℃ | 35:58 | 03:30 | 39:27 | 18.8℃ | 17.6℃ | 38:42 | 17.2℃ | Stable | 39:29 |
| 14 | 17.4℃ | 39:29 | 00:06 | 39:35 | 19.8℃ | 19.3℃ | 39:29 | 18.9℃ | Stable | 39:36 |
| 15 | 17.4℃ | 39.36 | 00:17 | 39:40 | 20.4℃ | 19.7℃ | 39:51 | 19.0℃ | Stable | 39:53 |
| 16 | 17.3℃ | 39:53 | 00:44 | 39:53 | 18.9℃ | 18.5℃ | 40:35 | 18.0℃ | Stable | 40:37 |
| 17 | 17.1℃ | 40:37 | 00:24 | 40:38 | 18.0℃ | 18.0℃ | 40:37 | 19.9℃ | Interval | 41:02 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 18 | 17.0℃ | 41:02 | 03:48 | 42:35 | 18.1℃ | 17.5℃ | 44:33 | 17.0 ℃ | Stable | 44:51 |
| 19 | 16.9℃ | 44:51 | 0.:17 | 48:05 | 17.5℃ | 16.9℃ | 46:34 | 16.6 ℃ | Stable | 48:08 |
| 20 | 16.9℃ | 48:08 | 00:00 | | | | | | Stop | 48:08 |

**Calculations**

1. Voltage supplied 12V DC
2. Voltage across Peltier module – 6V
3. Current drawn from battery – 2.2A
4. Power at one Peltier module = 6×2.2 = 13.2W
5. Power at Fridge with 2 Peltier module = 2×13.2= 26.4W/hr.
6. Capacity of battery 84W then operable time for Refrigerator = 84/26.4= 3.18hr.

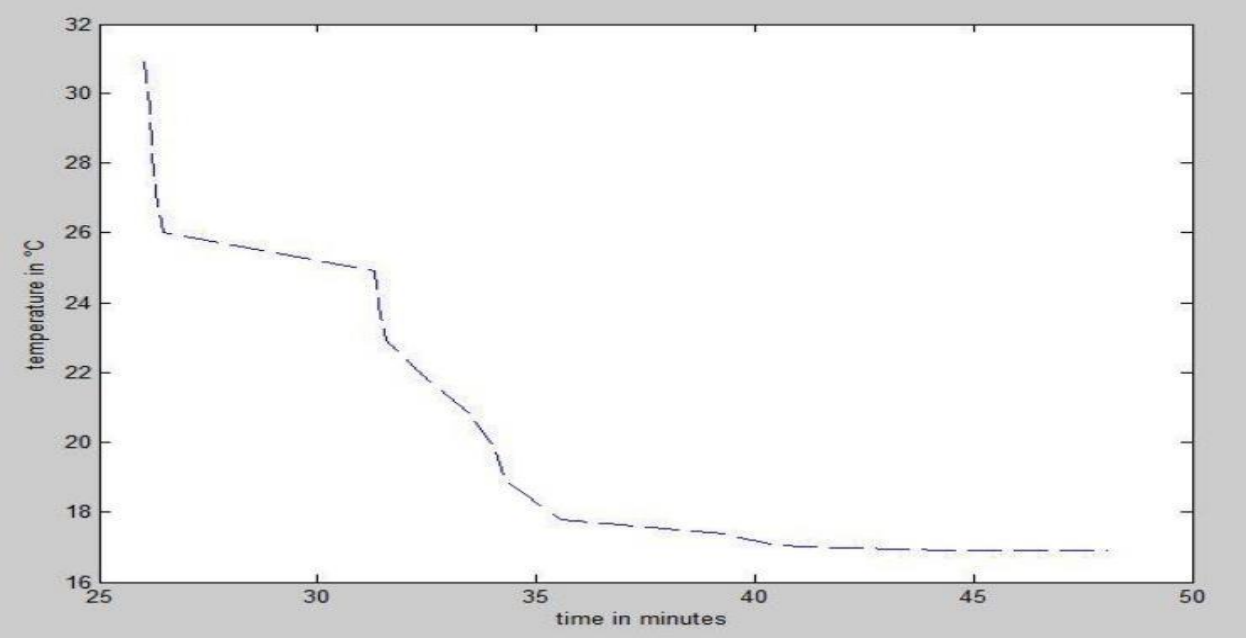

Fig.4 Variation in Temperature of Refrigerator w.r.t Time

**Conclusions**

On the completion of the experimental study some conclusions were derived from the study:

1. Peltier module can be used for the refrigeration process but further development in the field is needed for the large refrigerators.

2. The refrigerator can be operated for the time period of 3.18hr. with 2 Peltier module.
3. The refrigerator operation time can be increased by introducing bigger battery to the system.
4. The temperature difference of 14˚C is found for the operable time of 22min 6sec.
5. Min temperature during study was found to be 16.9˚C.

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