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EXPERIMENTAL STUDY OF MINI THERMOELECTRIC REFRIGERATOR

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ABSTRACT

This paper studies a refrigeration system by using thermoelectric effect (peltier), a module for controlling the temperature within an enclosed structure that is provided in the system. It consists of controller system, transducers, cooling fan and sensing element. The desired temperature which was about 5°C for 10 litres of loads as similar as normal refrigerators, the various parameters of this module are of cooling fan voltage (CFV), Peltier Voltage (PV) and ambient temperature (T_a). The results show that the COP was increasing from 0.14 to 0.47 with the gradual decrease of temperature in the cooling region from 303 K to 284 K. The thermoelectric effect of refrigerator increased with a higher amount of heat rejected from the heat sink.

KEYWORDS: Thermoelectric, Peltier, Controller System, Cooling Fan & Ambient Temperature

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Original Article

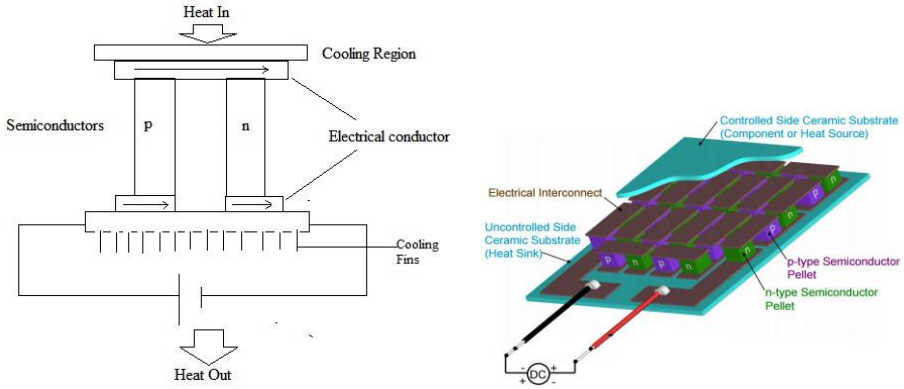
1. INTRODUCTION

Refrigerators are mainlyused in kitchens to keeping the refrigeration space cold; slow down the activities of microbial organisms such as bacteria and fungi. Our food and drinks could be preserved over longer periods. They are also used for medical and scientific purposes to preserve blood and vaccines. The major issues of refrigeration and air conditioning system are the emissions of CFCs and HCFCs; these are man-made greenhouse gases developed for the operating refrigerator and air-conditioning system, foam blowing agents, aerosols, fire protection and solvents. These gases, which are of Fluorine (F) type family gases causes ozone depletion and climate changes [1]. Global Warming Potential (GWP) was developed by the impacts of different gases such as CFCs and HFCs. It measures the emissions of 1 ton of gases that will absorb over a given period of time. GWP warms the earth more compared to that of CO_2emissions over that time period. The time period usually used for GWPs is 100 years. GWPs provide a common unit of measure, which allows analysts to add up emissions estimates of different gases (e.g., to compile a national GHG inventory), and allows policymakers to compare emissions reduction opportunities across sectors and gases Chloro Fluoro Carbons (CFCs) and Hydro Fluoro Carbons (HFCs are the high-GWP gases [2,3].

Peltier effect defined that 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. This effect is also called as Thermoelectric (TE) effect. Applying this effect in refrigerator is known as the Peltier refrigerator. Thermoelectric (TE) cooling uses the peltier effect to create a heat flux between the junctions of two different types of materials such as bismuth chalcogenides, silicon germanium, lead telluride and its alloys. [2,3]. DC voltage (12V) was applied on the module of one face will be cooled while the opposite face simultaneously is heated then vice versa. [4]. Hybrid prototype which includes vapour compression and Thermo Electric (TE) cooling were constructed with different compartments of serial units**.** These units were used to cool the water, cool drinks, vegetables and fruits and it has different power requirements.

Consumption of power, cool effect, sounds and vibration tests were conducted in compliance with different standards [5, 6]. The reverse phenomenon of the peltier effect; the current flowing through the junction connecting two materials will emit or absorb heat per unit time at the junction to balance the difference in the chemical potential of the two materials it is said to be as seebeck effect [7]. Waste heat recovery in air conditioners have been experimentally studied [8].

2. MODEL OF THERMOELECTRIC REFRIGERATOR



(a) **(b)**

Figure 1: (a) Model of Thermoelectric (TE) Refrigerator System using Peltier Effect (b) Thermoelectric Effect Design.

The thermoelectric effect module is composed of a p-type and n-type semiconductor material with the electrical conductor as shown in figure 1 (a), which are connected with the electrical current; it produce a cooling effect in one face by heat rejection and other face heat deposited observed heating effect. The thermoelectric effect design is shown in figure 1 (b); it enables the refrigerator to produce freezing effect. Cooling fans acts as a heat exchanger to reject heat from the refrigerator system. Power supply was about 12V battery power (DC) source. Cooling Fan as shown in figure 2 is a device which is used to carry the heat from one side to another. It cools the particular area by pulling the hot air away from that particular area. In thermo electric refrigeration process, the fan is used on both sides of the module. Cooling fan takes away the heat from the one side and discharges it to the surrounding atmosphere. In thermoelectric refrigeration, fins are also attached to the fans for more efficient cooling. Basically, the fans used are similar to ones that are found in CPU of computer.

Figure 2: Cooling Fan used in the Thermoelectric Refrigeration System.

Peltier plate as shown in figure 3 is a solid-state heat pump; each features an array of alternating n- and p- type semiconductors, was soldered between two ceramic plates with one end in series and other in parallel. Bismuth telluride, antimony telluride, and bismuth selenide were the semiconducting materials used. Cooling effect is directly proportional to the number of coolers used. Typically, multiple thermoelectric coolers are connected side by side and then placed between

two metal plates.

Figure 3: Peltier Plate.

Cooling fins' as shown in figure 4 has projections that increase the surface area from which heat can be radiated away from the refrigerator. The fins project outwards makes the contact with the atmosphere to emit the heat from the refrigeration system.

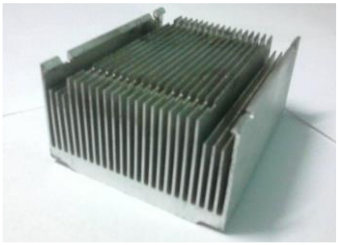


Figure 4: Cooling Fins.

Circuit controller is a device which works as a power supply. It converts A.C. to D.C. which helps to decrease the temp of the chamber by controlling the palter device and cooling fans, as shown in figure 5.

Figure 5: Circuit Controller.

Thermocol is a polymer made from the polymerisation of styrene, and it is also called as polystyrene. It is in the form of solid or foamed. It has the properties of poor barrier to atmospheric oxygen and moisture and has very less melting point, as shown in figure 6.

Figure 6: Thermocol.

3. EXPERIMENTAL DESIGN OF THERMOELECTRIC MODULE

Thermo Electric (TE) module refrigeration system is planned with a capacity of 10Litres of cooling region. It is designed in such as way to maintain the temperature inside the region between 15°C to 10°C for a long run, operated by means of 12 volt battery. It extend the application of less power generation and distribution and as an alternative energy source like the solar, wind and battery sources. The dimensions as follows 12mm plywood thickness**,** 500mm height**,** 300mm width**,** 250mm depth**,** upper chamber dimensions (150*300*250) mm and lower chamber dimensions (350*300*250) mm.

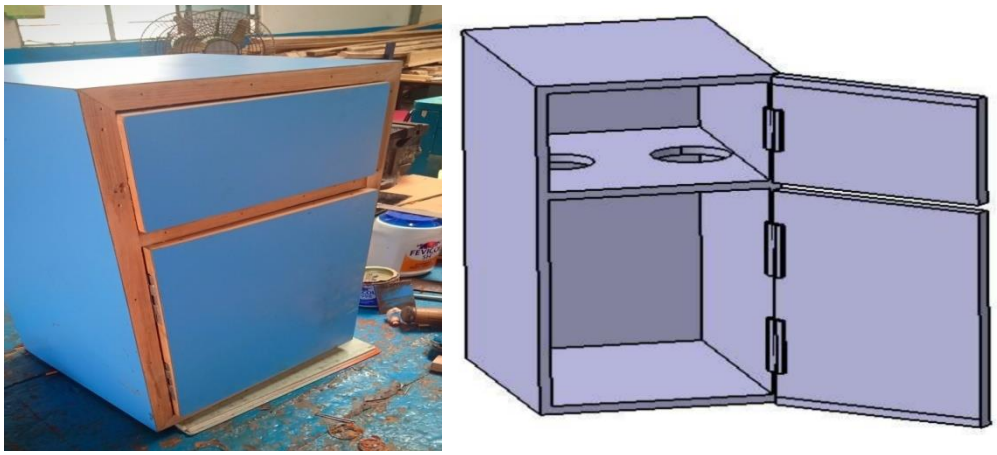


Figure 7: (a) 3 Dimensional Model of Mini Refrigerator System using Peltier Effect
(b) Experimental Setup of Mini Refrigerator using Peltier Effect.

3.1 Experimental Procedure

The experiment starts from ambient temperature T_a, 30.4°C. At different interval of time, temperature is measured and tabulated in the table 1. Thermometer is used to measure the temperature as a function of time. Heat absorbed by the peltier module on cooling region is Q_L and heat rejected by the peltier module on the heat region which is Q_M. Both are calculated with the ambient temperature, T_a and energy supply, W. Thereafter, coefficient of performance of refrigerator, COP is determined.

Total Energy Supply, $W = Q_M - Q_L$,

Coefficient of performance (COP) calculations, $COP = Q_L / W$

3.2 Performance Calculation

Heat absorbed by the Peltier module on cooling region, Q_L

$T_C = 17.9^O$ C = 290.9 K, $T_H = 63^O$ C = 336 K

I = 2A, $T_H - T_C = 45.1^O$ C

$Q_L = = -9.03\ J$

Heat rejected by the Peltier module on the heat region, Q_M

$Q_M = 8.07\ J$

Total Energy Supply

$W = Q_M - Q_L$

$W = 8.07 – (-9.03) =$ ***17.1 J***

COP calculations

$COP = Q_L / W$

$COP = 9.03 / 17.1 =$ ***0.528***

Table 1: Temperature as Time Function

S. No	Time, min	Temperature, °C	Coefficient of Performance, COP
01.	0	30.4	0.14
02.	5	25.3	0.22
03.	10	22.1	0.25
04.	15	21.8	0.29
05.	20	20.6	0.31
06.	25	18.2	0.33
07.	30	17.5	0.36
08.	35	16.7	0.40
09.	40	14.9	0.41
10.	45	13.3	0.44
11.	50	12.5	0.45
12.	55	11.2	0.47

4. RESULTS & DISCUSSIONSS

The thermoelectric effect depends on the three important factors which are peltier voltage (PV), cooling fan voltage (CV) and ambient temperature (T_a). It increases the cooling effect of the refrigeration system. Coefficient of performance of refrigerator, COP was found to be from 0.14 – 0.47 which is shown in figure 8.

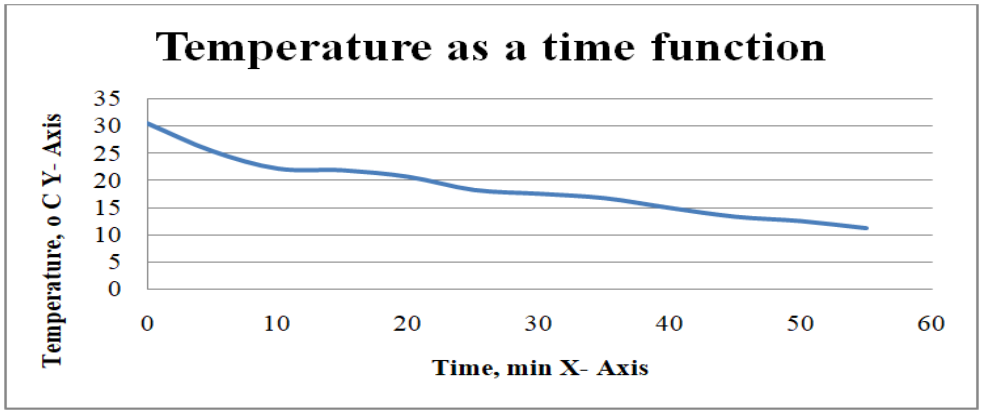


Figure 8: Time vs Temperature.

The heat absorbed by the thermoelectric effect on cooling region is $Q_L = -7.04$ J, and heat rejected on the heat region, $Q_M = 8.07$ J and then the total energy supply, W= 15.11 J. By using the above values, the COP is calculated and tabulated in the table 1. Figure 8 shows the variation of coefficient of performance with respect to time. It was seen COP gradually increased with the increase in the rate of heat rejected from the system.

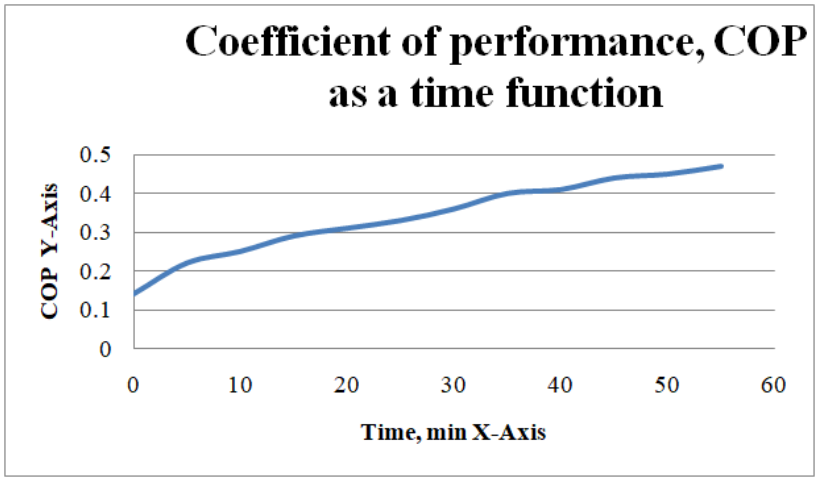


Figure 9: Time vs Coefficient of Performance, COP.

5. CONCLUSIONS

From the experimental study on this system, following conclusions are drawn.

- The maximum temperature reached by the cooling region was about 11.4ºC and the heat region of 63ºC.
- Peltier voltage and cooling fan voltage are the important factors that cause cooling effect. Circuit controller is also considered as a minor contributor to the above effect.
- Research on thermoelectric materials like super lattice structures, quantum wires and quantum wells and thin films using SiGe/Simight enhances the thermoelectric cooler's coefficient of performance.
- Promote wide range of applications in defence, pharmacy, research laboratory and telecommunications. In domestic purpose, preservation of foods and cool drinks.
- The main advantages are zero emissions of green house gases and less vibration of the parts. A limitation is that it exhibits lower coefficient of performance for the high capacity systems.

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