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EXPERIMENTAL PERFORMANCE ANALYSIS OF SOLAR THERMO-ELECTRIC REFRIGERATOR

Sanket P.Chaudhari[1], Harshit J. Desai[2],Gaurav L. Gadhesaria[3]

[1](M. Tech Scholar, Mechanical Engineering Department, CGPIT, UKA Tarsadia University, Bardoli, India)
[2](Assistant Professor, Mechanical Engineering Department, CGPIT, UKA TarsadiaUniversity, Bardoli, India)
[3](Assistant Professor, Mechanical Engineering Department, CGPIT, UKA TarsadiaUniversity, Bardoli, India)

Abstract: *In the recent years, we have many problems such as energy crises and environmental degradation due to the increasing CO2 emission and ozone layer depletion has become the primary concern. This project utilizes the solar energy for its operation. The solar-powered refrigerator is based on the principle of the thermo-electric module to create a hot side and cold side. The purpose of this project is to make a prototype of portable solar thermo-electric refrigerator to perform experimental performance analysis and to study the performance change when instead of single module two modules are used.*

Keywords: *Thermo-electric refrigeration, Solar energy, Co-efficient of performance, Prototype refrigerator*

I. INTRODUCTION

Solar thermo-electric refrigerator is a special type of refrigerator which utilizes solar energy instead of conventional electrical energy to power the thermo-electric module that has been used to cool the refrigerated space. The solar-powered refrigerator is based on the principle of the thermo-electric module to create a hot side and cold side. Solar PV module supplies the DC electrical energy to the battery and then to the thermo-electric module to generate cooling effects. A well-insulated rectangular container made of insulating material of glass wool is used as a cooling chamber. To enhance the cooling effect, heat sinks and electric fans are used to the hot side to cool down the thermo-electric modules. This project does not need any kind of refrigerant and mechanical device like compressor, evaporator for its operation.

Thermo-electric refrigeration based on the Peltier effect has important advantages compared to conventional vapor technology in spite of the fact that its COP is not as high a vapour compression technology. Some of these can be listed: free of refrigerant, the using of electrons as refrigerant, more compact system state, lower noise and vibrations, high quality temperature control and less maintenance requirements.

II. METHODOLOGY

A schematic diagram of a portable solar thermo-electric refrigerator, which mainly consists of a PV cell, charge controller, storage battery, fan & heat sink, multi-meter, pump and insulated box, is shown in figure.
Schematic diagram of the experimental setup is given in Figure 1.

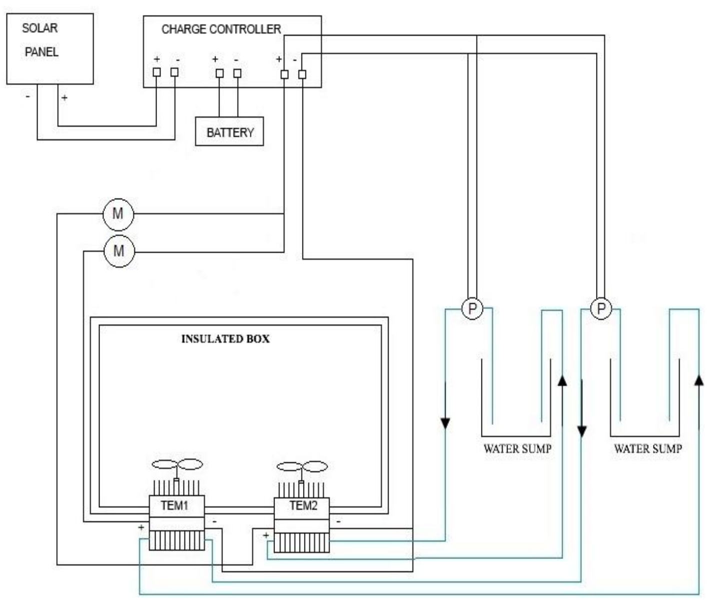

Figure 1 Schematic diagram of experimental setup

The PV module receives solar energy at daytime and converts it into electric power supply it to the battery through a charge controller. The storage battery is important in storing the excess energy produced by the PV module while it is powering the system. Besides, it can also work as power supply if the PV module is not producing sufficient power. The charge controller plays a role in controlling the amount of power stored in the battery. As thermo-electric modules receive power, one side of the module becomes cold and the other becomes hot. Both sides of the module are attached with heat sink, cold, heat sink is placed in insulated box and the hot heat sink is enclosed in an aluminium cabinet where cold water from the well is continuously supplied with the help of pump to extract the heat collected by the hot heat sink. Thermo-electric refrigerator having module (p-n) circuit, which has the principle of refrigerator. Due to this one side of circuit emit heat and rest side will extract the heat to get cooled by means of the p-n circuit.The heat sink is located above this module to remove a sufficient amount of heat. Heating surface, which rested as top face allocating with tube passing with cold water. Therefore, it extracted the heat and hot water should be coming out of the outlet. The performance of the thermo-electric module depends upon the supply of current. As the current is changed the effectiveness and performance are going to differ that can be measuredand used to calculate the performance change accordingly.
In this setup two thermo-electric modules are used so we can also check the performance change while single module is operating and while both modules are in operating condition.

III. RESULT AND DISCUSSION

The experimentation is performed changing the supply current and temperature differences are observed.
Experimental results for 1A current are given in Table 1.

Voltage	Time (min)	Temp（℃）
12 V	0	40
	5	32.1
	10	26.9
	15	24.7
	20	23.2
	25	21.8
	30	20.7

Table 1 Time vs Temperature for 1 A current

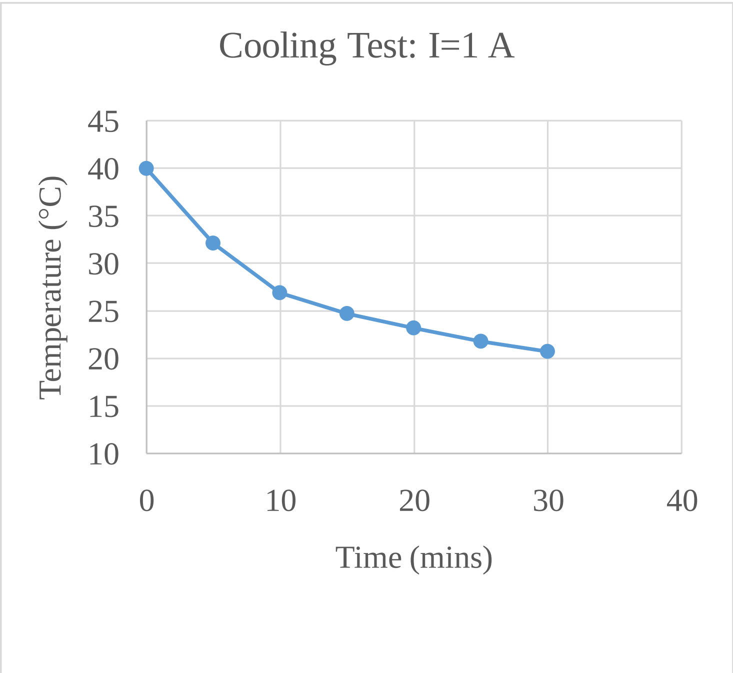

Figure 2 Time vs Temperature for 1 A current

Experimental results for 0.7A current are given in Table 2.

Voltage	Time (min)	Temp (℃)
14.16 V	0	32.4
	5	27.2
	10	25.2
	15	24.2
	20	23.2
	25	22.4
	30	22.1

Table 2 Time vs Temperature for 0.7 A current

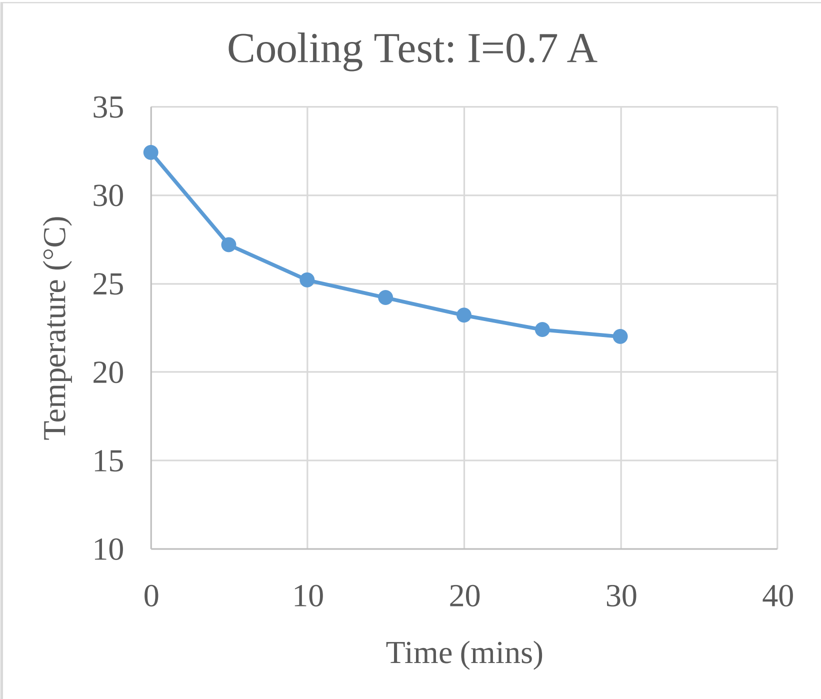

Figure 3 Time vs Temperature for 0.7 A current

Experimental results for 0.3A current are given in Table 3.

Table 3 Time vs Temperature for 0.3 A current

Voltage	Time(min)	Temp (℃)
17.66 V	0	40
	5	38.9
	10	38.5
	15	38.3
	20	38.1
	25	37.9
	30	37.7

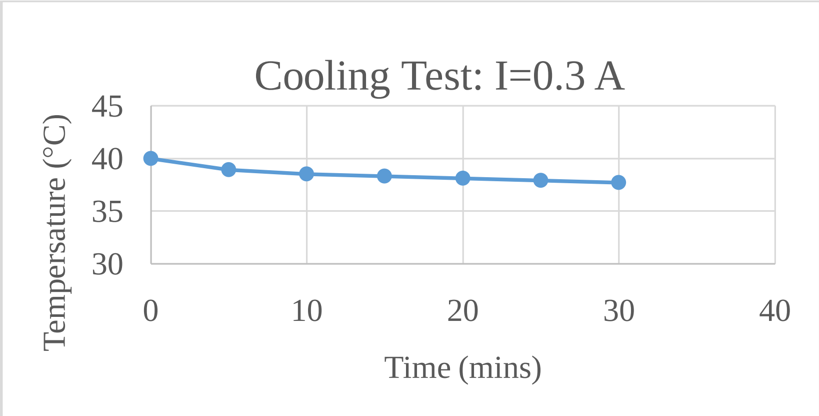

Figure 4 Time vs Temperature for 0.3 A current

0.5 ltr canned drink is used and different currents were supplied to modules to observe the performance change of the system.
Experimental results for different currents are given in Table 4.

Time	COP (1 A)	COP (0.3 A)	COP (0.7 A)
10	1.5	0.31	0.72
15	1.1	0.28	0.65
20	0.95	0.24	0.55
25	0.83	0.22	0.49

Table 4 Time vs Different COP at Different Ampere

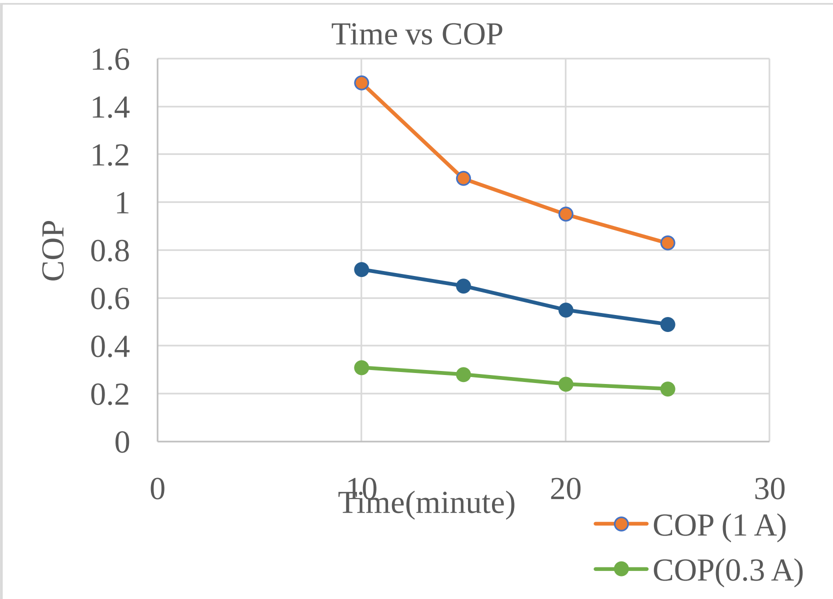

Figure 5 Time vs Different COP at Different Ampere

The comparison between single module and both module on performance is shown in Table 5.

Current	Voltage	Time(min)	Single TEM(℃)	Both TEM(℃)
5A	12V	0	40	40
		5	33.4	32.2
		10	29.3	28.3
		15	27.2	26.2
		20	25.8	24.3
		25	24.5	22.8
		30	23.3	21.1
		35	22.3	19.6
		40	21.2	18.4
		45	20.4	17.6
		50	19.6	16.9

Table 5 Single module vsBoth modules

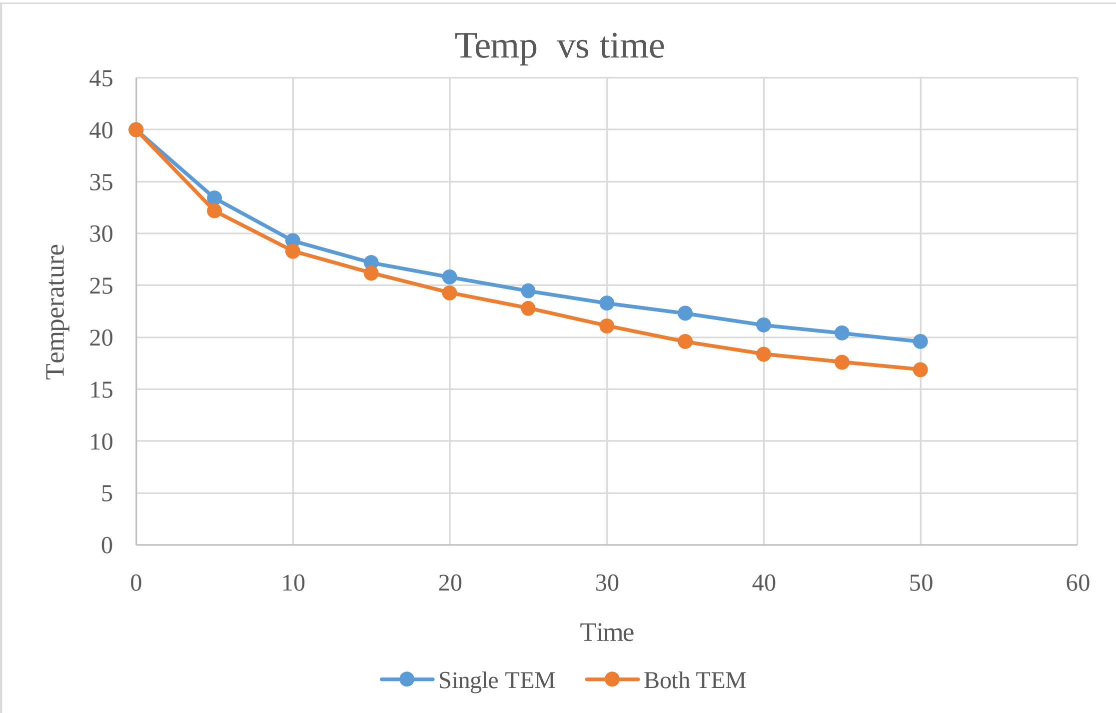

Figure 6 Single module vsBoth module

IV. CONCLUSION

In this work, a portable solar thermo-electric refrigerator unit was fabricated and tested for the cooling purpose. The refrigerator was designed based on the principle of TEM to create a hot side and cold side. The cold side of the TEM was utilized for refrigeration purposes whereas the rejected heat from the hot side of the module was eliminated using fans and heat sink with continuous water supply to abstract the heat.Several tests were carried out by the system to determine the minimum temperature that a refrigerated object could be reached. A canned drink with 0.5 ltr was used as the refrigerated object in these tests. Experiment and analysis on the system were conducted mainly under sunny outdoor conditions.It was found that the system performance was strongly dependent on the intensity of solar radiation and the temperature difference of hot and cold sides between the thermo-electric modules to overcome that problem two batteries are used to store DC power so that solar radiation change could not affect the performance of the system. The maximum temperature difference under outdoor conditions was found to be 23.1 (℃). Experimental results of developed TER system show that the performance of the system differs when the supplied current is changed and also found that the desired temperature reaching time is reduced when more thermo-electric modules are combined. A 23.1˚C Temperature reduction at no load and 21.1 ˚C at 0.5 ltr water inside the refrigeration space with respect to 40 ˚C ambient Temperature in 50 minutes for 5A current.

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