Experimental Analysis of Thermoelectric Refrigerator

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Abstract— We take opportunity to present this project report on "EXPERIMENTAL ANALYSIS OF THERMOELECTRIC REFERIGERATOR", and put before readers some useful information regarding project. We have made a sincere attempt and taken new innovation other than conventional refrigerator. We have introduced a thermoelectric system for cooling formation other than a cabin based cooling. The basic refrigeration system taken into accounts is "portable refrigeration system" We have also made attempts to use different SMPS which can provide us the desired current we need. We have made quite study about all our components in literature study which include the information about PELTIER, SMPS, heat sink, thermocouple wire is acquired from various sources in field. This project has given us detailed glance of refrigeration systems. This project has introduced us and given us opportunity to work with the people who has practical knowledge about refrigeration system. We have carried out various operation such as welding, punching and finishing in making of this project. We have made an attempt to introduce every design detail related to the projected which you will find convenient to excess to. We are sure that information contained in this volume will certainly prove useful for better insight in the scope and dimension of this project in its true perspective. The task of completion of this project though being difficult was made quite simple, interesting and successful due to deep involvement and complete dedication of our group members.
Key words: Thermoelectric Refrigerator

I. INTRODUCTION

Due to the increasing demand for refrigeration in various fields led to production of more electricity and consequently more release of harmful gas like CO2 all over the world which is a contributing factor of global warming on climate change. Thermoelectric refrigeration is a new alternative method. The thermoelectric modules are made of semiconductor materials electrically connected in series configuration and thermally in parallel to create cold and hot surfaces. Although they are less efficient than the vapour compression system, they are very light, low in cost, silent in operation, and are environmentally friendly.

The objectives of this project is to design and develop a working thermoelectric refrigerator that utilizes the PELTIER effect to refrigerate and maintain a temperature between 5 0C to 25 0C. The design requirements are to cool the volume to a temperature within a short time and provide retention of at least next half an hour. And a thermo siphon cooling system is used for cooling the hot side of TEC module. It will be used in remote locations in the world where there is no grid electricity, and where electrical power supply is unreliable when a solar panel charger is added for battery charging.

A thermoelectric module thus uses a pair of fixed junctions into which electrical energy is applied causing one junction to become cold while the other becomes hot. Because thermoelectric cooling is a form of solid-state refrigeration, it has the advantage of being compact and long lasting. It uses no moving parts except for some fans, employs no fluids, and do not require bulky piping and mechanical compressors used in vapour-cycle cooling systems. Such sturdiness favour thermoelectric cooling over conventional refrigeration in certain situations. The compact size and weight requirements, as well as portability in the design, rule out the use of conventional refrigeration.

Thomas Seebeck in 1821 discovered that a continuously flowing current is created when two wires of dissimilar materials are joined together at the ends and heated at one end. This phenomenon is known as the Seebeck Effect. Later in 1834, Jean Charles Athanase Peltier a French watchmaker and physicist found that if two dissimilar metals are joined together and an electrical current is supplied it will produce heating and cooling at the ends and that phenomenon is known as Peltier effect and is shown in the figure 1.1. In 1838 Lenz showed that depending on the direction of current flow in the system, heat could be either removed from a junction to convert water into ice, or by reversing the direction of current heat can be generated to melt ice. The amount of heat absorbed or rejected at the junction is proportional to the electrical current intensity. The constant of proportionality is known as the Peltier coefficient.

Conventional cooling systems such as those used in refrigerators utilize a compressor and a working fluid to transfer heat. Thermal energy is absorbed and released as the working Fluid undergoes expansion and compression and changes phase from liquid to vapour and back, respectively. Semiconductor thermoelectric coolers (also known as Peltier coolers) offer Several advantages over conventional systems. They are entirely solid-state devices, with no moving parts; this makes them rugged, reliable, and quiet. They use no ozone- depleting chlorofluorocarbons, potentially offering a more environmentally responsible alternative to conventional refrigeration. They can be extremely compact, much more so than compressor-based systems. Precise temperature control ($< \pm 0.1$ °C) can be achieved with Peltier coolers. However, their efficiency is low compared to conventional refrigerators. Thus, they are used in niche applications where their unique advantages outweigh their low efficiency.

Although some large-scale applications have been considered (on submarines and surface vessels), Peltier coolers are generally used in applications where small size is needed and the cooling demands are not too great, such as for cooling electronic components.

The objectives of this study is design and develop a working thermoelectric refrigerator interior cooling volume of 5L that utilizes the Peltier effect to refrigerate and maintain a selected temperature from 5 °C to 25 °C. The design requirements are to cool this volume to temperature within a time period of 6 hrs. And provide retention of at least next

half an hour. The design requirement, options available and the final design of thermoelectric refrigerator for application are presented

II. METHODOLOGY

The project commenced with the idea to enhance the cooling effect of thermoelectric refrigeration system. So at first we decided the dimensions of the refrigerated space in which we would cool the load. The material selection and the insulation which we would provide it was also decided. We decided polyurethane as the insulation material. We fabricated a box made of mild steel whose dimensions are quoted below. After insulating the box with polyurethane we started to work on our setup.

We purchased 3 smps of a constant voltage of 12V and different amperage ratings of 2A, 5A and 12A respectively.

The connections were in the following sequence as follows-

1) Fan- To throw the heat from hot side of peltier.
2) Heat sink- To distribute the heat from the hot side on an enlarged area.
3) Peltier - To serve the purpose based on peltier effect.
4) Heat sink- To distribute cold temperature over the enlarged area.
5) Fan- To induce forced circulation of cold side.

A. Readings of single stage

The assembly was connected and then initial condition of water and ambient temperatures were noted. After switching on the supply we waited for 30 mins and then noted the final temperature of water. And finally the temperature drop. This was continued for all the remaining amperage readings.

B. Readings of Multistage

After noting down the readings of all the single stage we took 2 peltiers such that the hot side of the lower peltier was connected to the cold side of upper peltier. As we know peltier only maintains a constant temperature difference hence we were expecting a greater drop than what we actually got from single stage reading. We tried all the permutations and combinations to get the readings of multistage refrigeration whose peltiers were connected to different supply lines. The results were according to our expectations. We got a temperature drop more than what we got in a single stage refrigerator.

III. GRAPH

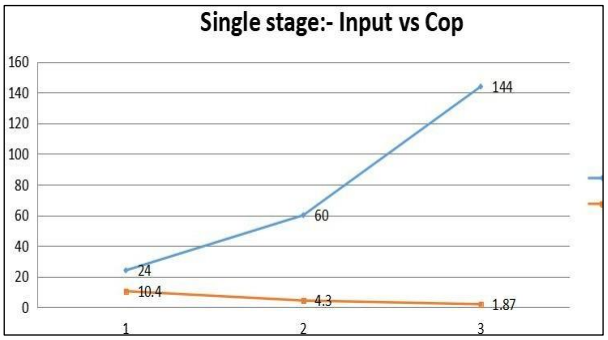

Fig. 1: (* IN 10^{-2})

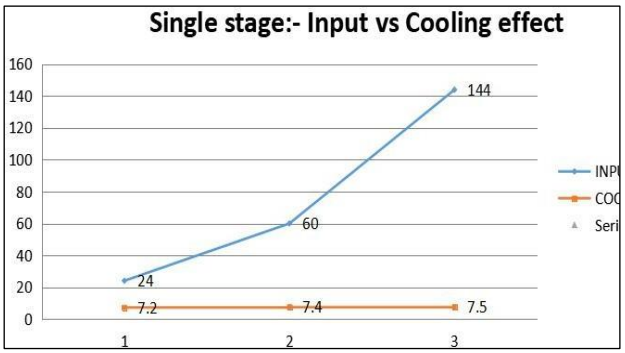

Fig. 2:

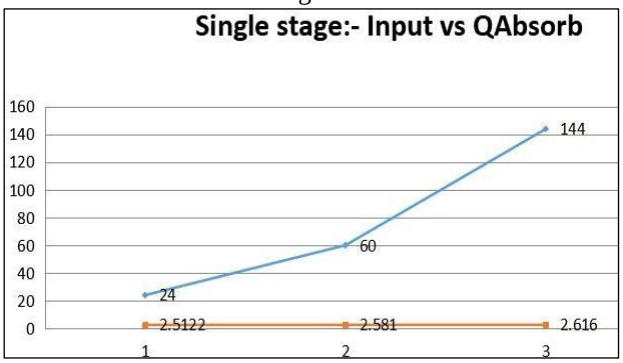

Fig. 3:

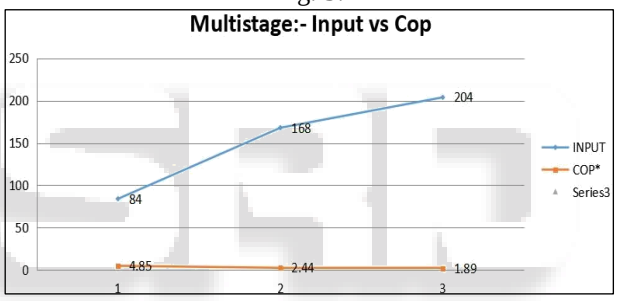

Fig. 4: (* IN 10^{-2})

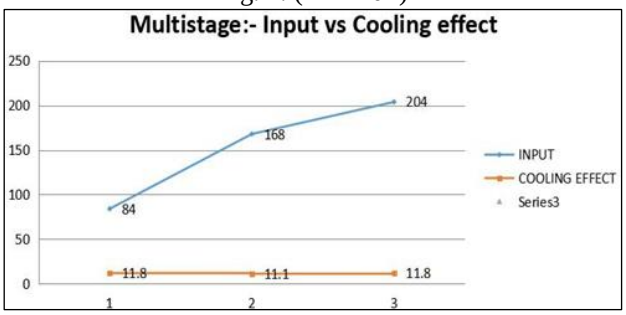

Fig. 5:

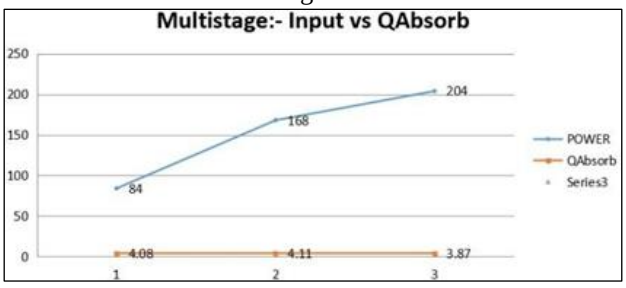

Fig. 6:

IV. RESULT

In single stage we have found a temperature drop of average 7.4 degree Celsius. In multistage we have found an average

drop of 11.2 degree Celsius. The total time required to cool the water in refrigerator takes 30 min. The system can sustain for long time without frequent maintenance.

A. SINGLE STAGE

POWER INPUT(W)	T_{amb} (°C)	T_{wi} (°C)	T_{wf} (°C)	TEMP DRO
24	31.4	36.7	29.5	7.2
60	31.3	36.8	29.4	7.4
144	31.3	36.6	29.1	7.5

B. MULTISTAGE

SMPS	POWER INPUT	T_{amb} (°C)	T_{wi} (°C)	T_{wf} (°C)	TEMP. DROP
5A & 12V# /2A & 12 V*	84	31.3	38.3	27.7	10.6
2A & 12V# /5A & 12 V*	84	31.2	38.6	26.9	11.7
12A & 12V# /5A & 12 V*	204	31.1	38.4	27.3	11.1
5A & 12V# /2A & 12 V*	204	30.1	38.2	27.1	11.1
2A & 12V# /12A & 12 V*	168	30.6	38.5	26.8	11.7
12A & 12V# /2A & 12 V*	168	30.4	38.7	26.9	11.8

UPPER PELTIER
*LOWER PELTIER

V. CONCLUSION

After conducting various experiments on 150ml of water with single stage and multi stage thermoelectric refrigerator on different power supplies by using three different SMPS of 2A, 5A and 12A, each of constant voltage of 12V we have concluded that the cooling effect increases when we use multistage refrigerator even though there is a slight drop in cop.

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