Development of Mini Refrigerator Using Hybrid Technology

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***Abstract*: Mini Refrigerator plays an important role for preservation of food and medicine. Refrigeration is a process of cooling a substance. In this work, we develop mini refrigerator using hybrid technology, The peltier effect and seebeck effect are used to produce cooling effect. The seebeck effect produce some amount of power through exhaust gases. The power is utilized to produce cooling effect in the peltier device. The current differential temperature time and co-efficient of performance where analysed (TEC) cold plate. Temperature was decrease from 33℃ to 13℃ or 7hrs 30min, and continuously decreasing to -7.4 c for 24 hrs & 50 c. The maximum Cop of TER is 0.2204.**

Key words: Mini Refrigerator, Seebeck effect, Peltier effect, COP_R

I. INTRODUCTION

The purpose of hybrid refrigeration system is to produce refrigeration without compressor and also without electric current. In order to utilize the waste heat produced by the automobiles, industries. If this heat is not utilized it is dissipated, the following waste heat recovery is performed by See beck effect. Thermoelectric cooling, also called "The Peltier Cooling" is a solid-state method of heat transfer through dissimilar semiconductor materials, this is done to have a refrigeration system.The increasing need for smaller and more portable electrically powered equipment has produced a need for low maintenance, smaller and more portable cooling. To satisfy this need, we can use solid-state thermoelectric devices in computers, portable refrigerators and cool boxes.

The Peltier and Seebeck Effect demonstrator shows how one of these devices work and tests its performance when connected in a choice of two modes:

- Heat to electricity for power generation when used in Seebeck mode – often used for thermoelectric generation and given the acronym 'TEG'.
- As an electrically powered heat pump when used in Peltier mode. Often used in thermoelectric cooling and given the acronym 'TEC'.

Importance for thermoelectric modules cover a wide spectrum of product areas. These include equipment used by military, medical, industrial, consumer, scientific/laboratory, and telecommunications organizations. The following uses can be done with this hybrid technology.

II. EXPERIMENTAL SETUP

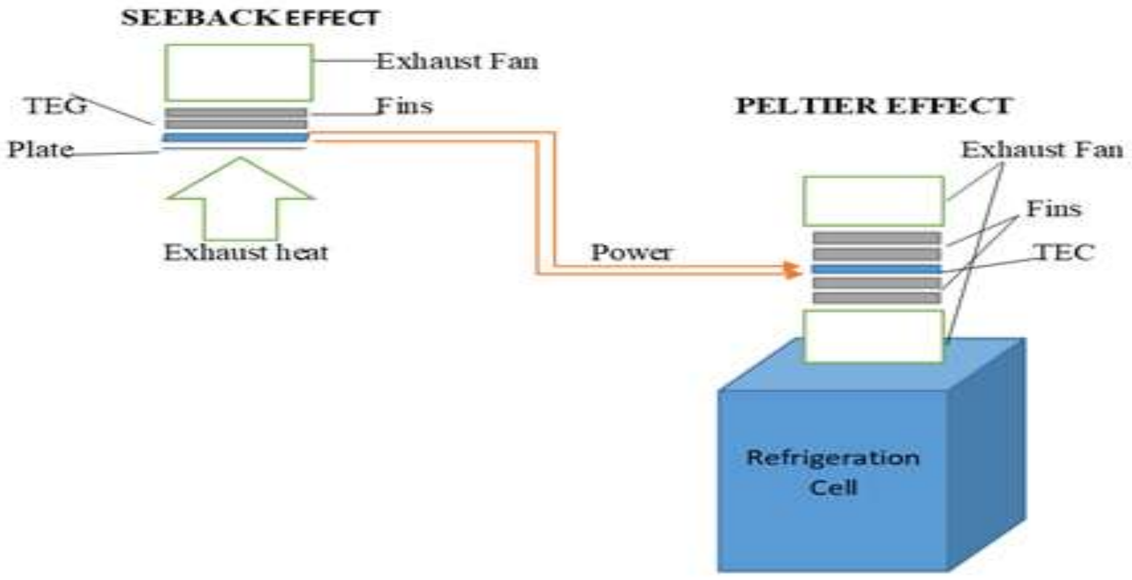

Fig 3.1Schematic of development of hybrid refrigeration system

3.1 Design of Thermo Electric Refrigerator

3.1.1 Thermo electric generator (TEG)

A thermoelectric generator (TEG), also called a Seebeck generator, is a solid state device that converts heat flux (temperature differences) directly into electrical energy through a phenomenon called the Seebeck effect (a form of thermoelectric effect). Thermoelectric generators function like heat engines, but are less bulky and have no moving parts. However, TEGs are typically more expensive and less efficient.

3.1.2 Design Procedure

In designing a thermoelectric cooling system, one of the most critical processes is to reach an understanding of the thermal load. With this vital information, we can able to choose the best TE device or heat exchangers for the job. Each of the thermoelectric cooling system has a unique

capacity for moving heat. In order to achieve the performance objectives estimate of the amount of heat must be removed from the thermal load is calculated. Once the module is selected, thermosiphon system for heat dissipation from the hot side of the module is designed based on the amount of heat that has to be removed.

3.1.3 System Design

Our known design values are:

Q = 25 Watt heat load

T_A= 30°C maximum ambient air temperature

T_C= 10°C required temperature of the cabin

Then identify the hot side temperature (T_H) and the resultant temperature differential across the module (ΔT). The temperature at the hot side will be equal to the sum of ambient temperature (T_A), the rise in temperature across the heat sink from rejecting the heat load (Q) and the TE module power (V x I). T_H = T_A + (V x I + Q) R_Q Where, R_Q is the thermal resistance of heat sink in℃ temperature rise per Watt dissipated. In this design, we will keep the rise of temperature of the heat sink to not more than about 15℃ above ambient. This would give us a thermoelectric module hot side temperature of about 45°C. T_H = 30+ 15 = 45°C The temperature differential across the thermoelectric module can be calculated as follows: ΔT = T_H – T_C = 45 – 8= 37°C.

Fig 3.2 TEC-12705 refrigeration unit

III. RESULT AND DISCUSSION

4.1 Thermo electric generator calculation

Thermo electric generator-TEG (Power produced in volts)

Time (seconds)	Voltage produced (V)	Temperature(°C)
90	1	70
180	1.20	78
270	1.40	81
360	1.63	89
450	1.72	94
540	1.72	106
630	1.80	110
720	1.84	112
810	1.91	116
900	1.96	118
990	2.01	121

4.2 Experimental Investigation

An experimental and performance analysis on fabricated thermo electric refrigerator was conducted. The cold end of the thermoelectric module was used in the system to cool the refrigerator cabin and a digital thermo meter is used to measure the temperature. The hot end is attached to a heat sink for heat rejection. In order to validate the performance of the system cool down experiment was conducted on the system.

4.3 Cool down test

For analyzing the performance of system, water load is considered is considered as the active heat load to the system. Water at 33˚C was filled in the container before switching ON the system. The temperature at every 20min.intervel was tabulated. The readings were recorded for 450 mins. Even though the conventional system is mainly designed for maintain a fixed temperature, the above cool down experiment was proved that the system can be adapted for sensible cooling also. The lower steady temperature was attained around 13 ˚C at a time of 450 minutes. It took about 7 hours and 30 minutes to attain the same from 33 ˚C (ambient temperature).The cabin temperature drop was at an average rate of 2.67 ˚C per hour.

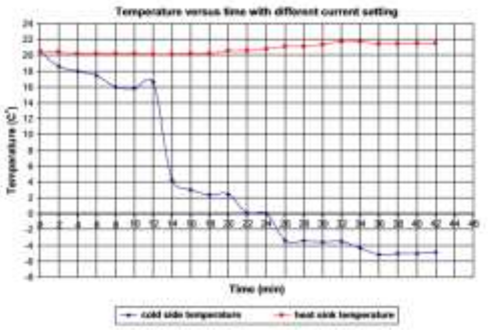

Fig 4.1 Voltage vs Time (TEG)

4.4 Performance of the thermoelectric refrigerator

The active heat load is expressed as the equivalent cooling power that the unit will need to provide when the sample at ambient temperature is placed in the container. It was decided that two liter of water at room temperature took as the test sample .When the designed thermoelectric refrigerator was tested, it was found that the inner temperature of the refrigeration area was reduced from 33.1 ˚C to 13.2 ˚C in approximately 450min. Coefficient of performance of the refrigerator (COPR) was calculated. Water is used in place of vaccine for taking measurements and calculation. In these calculations, the properties of water are (density = 1 kg/L and CP = 4187 J/kg).V = 2.0 L.

Coefficient of performance of the refrigerator (COPR) was calculated,

$$COP_R = \frac{Q_{cooling}}{W_{in}}$$

Q = m $C_p \Delta$ T

Mass of water, m = density x volume = 2 kg

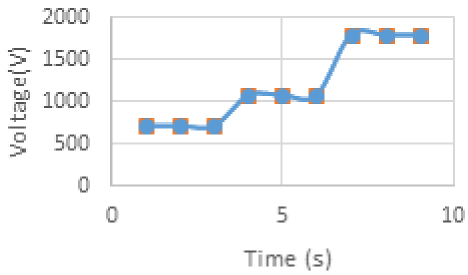

Fig 4.2 Temperature vs Time (TEC)

Total heat removed from the heat sink =166642.6J

$Q_{cooling} = \frac{Q}{\Delta T}$

$= \frac{166642.6}{450 \times 60}$

= 6.17 w

Power given to the system for working,

W_{IN} = V x I + fan input

= 12 x 2 + 2

= 28 w

Coefficient of performance of this refrigeration system is given by,

$$\textbf{COP} = \frac{Q_{cooling}}{W_{in}}$$

$$= \frac{6.17}{28}$$

$$= 0.2204$$

COP of this refrigerator system is lower than conventional refrigerator. This is because the efficiency of thermoelectric modules is usually four times lesser than that of vapour compression system. And the heat leakage is also detected through doors; this too reduces the efficiency of the system.

IV. CONCLUSION

The mini Refrigerator has been fabricated successfully using hybrid technology. The exhaust gases are used to produce electrical energy with seebeck device. Then the power is used to run the peltier effect and produce cooling chamber. It can produce cooling effect upto 13℃. It can be used for medical preservative and food preservation. Less power consumption, portable, and reliable are the feature of the mini Refrigerator.

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