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Original Research Paper

Engineering

DEVELOP A PORTABLE MINI REFERIGERATOR USING PELTIER MODUL

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ABSTRACT The global increasing demand in field of refrigeration air-conditioning, food preservation, vaccine storages, medical services, and cooling of electronic devices, led to production of more electricity and consequently more release of CO2 all over the world which is contributing factor in global warming and climate change. Thermoelectric refrigeration is a new alternative because it can convert waste electricity into useful cooling and is expected to play an important role in meeting today's energy challenges. Therefore, thermoelectric refrigeration is greatly needed, particularly for developing countries where long life and low maintenance are needed. The objective of this study is to design and develop a working thermoelectric refrigerator with an interior cooling volume of 5 litres 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 required temperature within a time period of 6 hrs and provide retention for at least next half an hour. The design requirement, options available and the final design of thermoelectric refrigerator for application are presented.

KEYWORDS :

1.Introduction

Refrigeration is defined as the process of cooling of bodies or fluids to temperatures lower than those available in the surroundings at a particular time and place. Thermoelectric refrigeration is one of the techniques used for producing refrigeration effect. Thermoelectric refrigeration is based on the Peltier Effect. The Peltier Effect is one of the thermoelectric effects; the other two are known as the Seebeck Effect and Thomson Effect. The last two effects act on a single conductor whereas the Peltier Effect is a typical junction phenomenon. There are many products using thermoelectric coolers, including CCD cameras (charge coupled device), laser diodes, microprocessors, blood analyzers and portable and picnic coolers etc. TER is also a good option for food preservation applications & cooling of pharmaceutical products.

2.Theory and Principles of Thermoelectric Devices

2.1 Seebeck Effect

Suppose there are two conductors of dissimilar metals denoted as material A and B. The junction temperature at A is used as a reference and is maintained at a relatively cool temperature (TC).The junction temperature at Bi.eTH is used as temperature higher than temperature TC. When heat is applied to junction B, a voltage (Eout) will appear across terminals T1 and T2 and hence an electric current would flow continuously in this closed circuit. This voltage as shown in Figure known as the Seebeck EMF and it can be expressed as:

$$E_{out} = \alpha\,(T_H - T_C)$$

Where:

- $\alpha = dE/dT = \alpha A - \alpha B$
- α is the differential Seebeck coefficient or (thermo electric power coefficient) between the two materials, A and B, positive when the direction of electric current is same as the direction of thermal current, in volts per degree Kelvin.
- Eout is the output voltage in volts.

2.2 Peltier Effect

Later on Peltier found there was an opposite phenomenon to the Seebeck Effect, whereby thermal energy could be absorbed at one dissimilar metal junction and discharged at the other junction when an electric current is allowed to flow within the closed circuit. The thermocouple circuit has been modified to obtain a different configuration that illustrates the Peltier Effect, a phenomenon opposite that of the Seebeck Effect. If a voltage (Ein) is applied to terminals T1 and T2, an electrical current (I) will flow in the circuit. As a result of this, as light cooling effect (QC) will occur at thermocouple junction A (where heat is absorbed), and a heating effect (QH) will occur at junction B (where heat is expelled). This effect may be reversed when a change in the direction of electric current flow will reverse the direction of heat flow. Joule heating, having a magnitude of I2 x R (where R is the electrical resistance), also occurs in the conductors as a result of current flow. This Joule heating effect acts in opposition to the Peltier Effect and causesa net reduction of the available cooling. The Peltier effect can be expressed mathematically as

$$Q_C \text{ or } Q_H = \beta \times I = (\alpha T) \times I$$

Where:

β is the differential Peltier coefficient between the two materials A and B in volts.

I is the electric current flow in amperes.

QC and QH are the rates of cooling and heating, respectively, in watts. Case 1. When High energy electrons move from right to left, Thermal current and electric current flow in opposite directions and β 0 i.e Positive Peltier coefficient

3. Working of the project

3.1 Fridge

- The Fridge is provided power supply form a 12 volts battery.
- To start the fridge , the switch on the fridge is turned on.
- Now four Peltier thermoelectric devices which are insulated from the cooling side and arranges in the fridges generates cooling effect on inner side and the heat is dissipated on outer side.
- On the heat side of the Peltier unit , a heat sink along with the fan works to dissipate the heat from the Peltier unit in the outer environment .
- The Peltier Thermoelectric Device will be so arranged in a box

with proper insulation system and heat sink so that efficient cooling takes place at all the time.

3.1.1 Coefficient of Performance

Let the mass of the air inside the box be M_w

Let Specific heat Capacity of Air at constant pressure be c_p

M_w = Volume of air in the box * Density of Air at 300K = 0.0274*1.225 =0.0335 Kg

Calculation of COP of Fridge

1. Input power= Product of voltage and current =(12V * 9A) = 108 Watts
2. Initial Temperature = 305K
3. Final temperature = 290K
4. Total amount of heat removed = Total cooling effect produced
5. Total amount of heat removed = $\mathbf{M_{w*}c_{p*}}$change in temperature = 0.0335*1.005*15 = 0.50 KJ=500 J
6. Input Work = Input Power * Time(in Seconds) = 108W * 17 Seconds = 1836 J
7. Coefficient of performance = refrigeration effect / input work = 500/1836 = .272

4. Conclusion and Future Scope

4.1 Conclusion

The objective of the project is to achieve the long term cooling in case of power failure for refrigerator.A TER Cooling system is has been designed and developed to provide active cooling with help of single stage 12 V TE module is used to provide adequate cooling. First the cooling load calculations for this TER compartment considered under study were presented. Simulation tests in laboratory have validated the theoretical design parameters and established the feasibility of providing cooling with single stage thermoelectric cooler was tested in the environmental chamber. As TER not available in open market which we can retain cooling at case of power outage due to high current carrying capacity. The retention time achieved was 52 min with the designed module in this project. In order to achieve the higher retention time, another alternative was incorporate. This consists the additional heater on heat sink. The highest retention time achieved was 57 mins.

4.2 Future Scope

With recent development taking place in field of thermoelectric and nanoscience different thermoelectric material with figure of merit ZT more than 1 with high temperature difference to be explored this will further help to reduce the temperature, current below and can also perform better at higher ambient conditions. To improve the power retention in this thermoelectric cooler sandwich heater needs to be explored with quick switching mechanism from thermoelectric cell off state of heater to on state, so that temperature drop in thermoelectric cell can be reduced.

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