Peltier Air Refrigeration System

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Abstract— Generally thermo electric refrigeration is defined as any process of heat removal. More specially, peltier effect is defined as the branch of science that deals with process of reducing and maintaining the temperature of a space or material bellow or above the temperature of the surroundings. Thermoelectric coolers (TECs) are solid state heat pumps that utilize the peltier effect. During operation, DC current flows through the TEC Causing heat to be transferred from one side of the TEC to the other, creating a cold and hot side. A single-stage TEC can achieve temperature differences up to 20°C, or can transfer heat at a rate of 125 W. To achieve greater temperature differences (up to 58°C), select a multistage (cascaded) TEC. To increase the amount of heat transferred, the TEC's modular design allow the use of multiple TECs mounted side-by-side.

Keywords: Peltier Air Refrigeration System, Thermoelectric coolers (TECs)

I. Introduction

From the ancient age man always prefers to have cold water for drinking purpose. Also in India, our country the weather is too hot. Particularly in summer season, the normal water temperature in open space is 35 to38^{0}C. The water is not suitable for drinking purpose. The required temperature is at the most 25^{0}C. Hence lowering down of the temperature is an essential task. In old age there was ample space available to keep the earthen container also the houses were sheltered by the trees and bushes which were enough to lower down the water container temperature. Because in most of the situations the temperature depends on the flow of air. Cooling of water in earthen pot is one of the earliest methods employed by men for cooling the water in their houses. It is a process of adiabatic saturation of air when cooling of surface water on container is made to evaporate to cool t with transfer of heat from water to the surroundings. The initial investment cost of such a system is low & the operation is simple & cheap. Simple evaporative cooling is achieved by direct contact of water particles & a moving air stream. The water may be sufficiently cooled by evaporative process to results a considerable degree of drinking comfort in climates of high dry-bulb temperatures associated with low relative humidity.

II. Objective

1) This project is needed for place where there is no electricity available.
2) The power of the battery is used for cooling goods placed in insulated chamber with the help of peltier cooler.
3) The objective of our project is to charge 12v DC battery with the help of solar cooler.
4) This technology can be used for small surfaces and also for small transportable fridges.
5) Peltier element provides a cold or warm surfaces depending upon polarity of electrical power.
6) Simple technology without moving parts enables a reliable system.

III. Construction

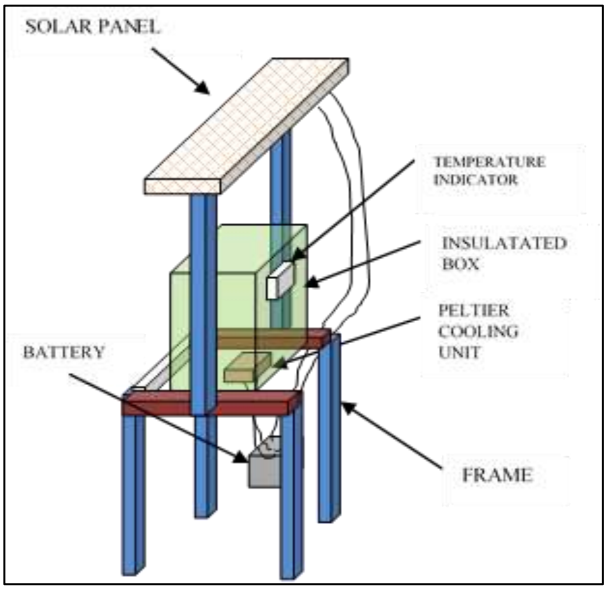


Fig. 1:

IV. Technical parameters

The primary objective of our research is to find new materials which could be used to make more efficient thermoelectric coolers. If more efficient devices could be made, there would be a number of new and exciting applications for Peltier coolers. The Peltier junction mentioned above consists of two materials, one with a positive thermopower and one with a negative thermopower. Since the charge carriers in p-type materials and n-type materials have opposite sign, their thermopowers have opposite sign. It is more than just the thermopower that determines the performance of a device. We need the electrical resistivity to be small so energy is not wasted in Joule heating. We also need the thermal conductivity to be small so heat we pump to the hot end stays there. For maximum device efficiency, we need to maximize each material's dimensionless Figure of Merit (ZT).

$$ZT = \frac{TS^2}{\rho\kappa}$$

S = thermopower (V/K)
ρ = electrical resistivity (Ωcm)
κ = thermal conductivity (W/cmK)
T = temperature (K)

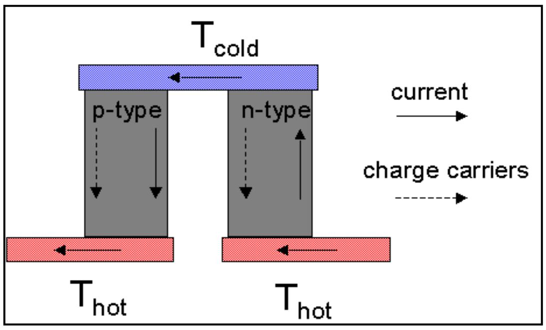


Fig. 2:

At present, the best materials are small band gap semiconductors; optimized Bi_2Te_3 has S = 220 μV/K and ZT = 1 at room temperature. However, a ZT greater than 3 is needed to compete with traditional cooling technologies. Our goal is to find new materials with ZT > 1 at or below room temperature.

V. Working

Fig. 3:

Solar peltier cooler and heater is a machine, which work on principle of conversion of solar energy in to electrical energy. Then electrical energy is used for cooling and heating purpose. We use 10 watt solar panel to charge battery. And power from battery is given to pettier module and heat sink fan.

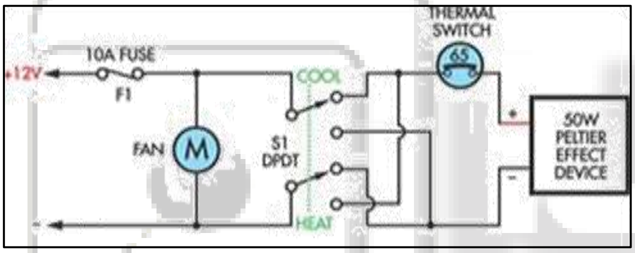
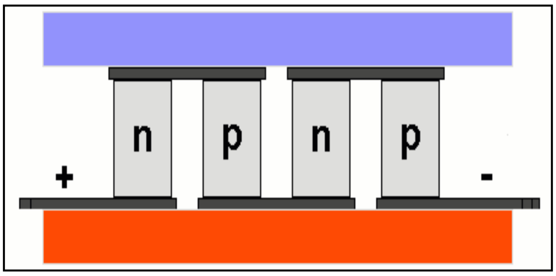


Fig. 4:

In above ckt 12 v dc supply is give to DPDT switch; this switch acts as polarity changer when positive terminal of battery is attached with positive terminal of pettier module and negative with negative the cooling effect is generated in insulated box and reveres effect is generated when polarity is changed with the help of DPDT switch.

The Peltier effect is explained the following way: electrons speed up or slow down under the influence of contact potential difference. In the first case the kinetic energy of the electrons increases, and then, turns into heat. In the second case the kinetic energy decreases and the joint temperature falls down. In case of usage of semiconductors of p- and n- types the effect becomes more vivid. On the scheme you can see how it works.

COLD JUNCTION



HOT JUNCTION

Fig. 5:

Combination of many pairs of p- and n-semiconductors allows to create cooling units - Peltier modules of relatively high power.

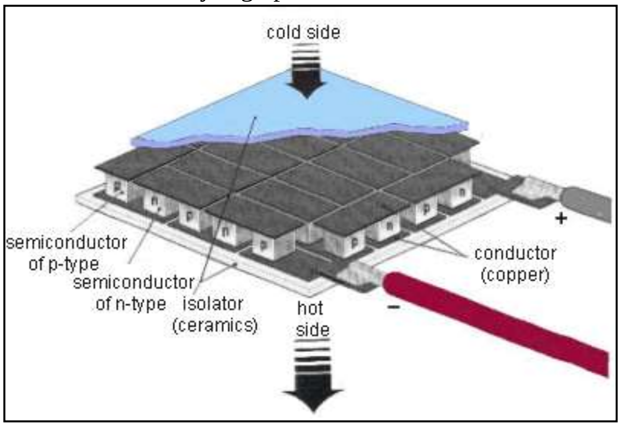


Fig. 6:

A Peltier module consists of semiconductors mounted successively, which form p-n- and n-p-junctions. Each junction has a thermal contact with radiators. When switching on the current of the definite polarity, there forms a temperature difference between the radiators: one of them warms up and works as a heat sink, the other works as a refrigerator. A typical module provides a temperature difference of several tens degrees Celsius. With forced cooling of the hot radiator, the second one can reach the temperatures below 0 Celsius. For more temperature difference the cascade connection is used.

VI. Calculation

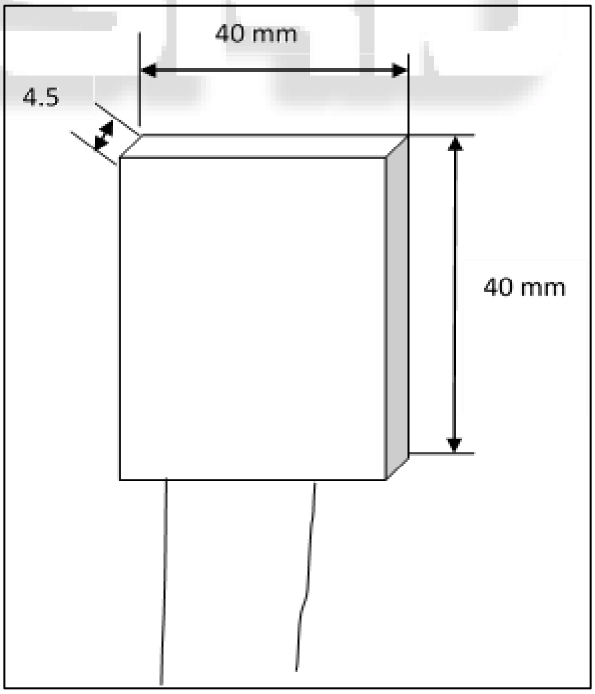


Fig. 7:

A = 0.04 x 0.04 = 0.0016 m^2
Q max =33.3 watt
V max = 14.8 v dc
I max =3.6 amp
T hot = 56 c
T cold = 8 c

T diff = 56 – 8 = 48 c
The heat load may consist of four types:

1) Active Heat load
2) Radiation
3) Convection
4) Conduction

A. *Active Heat Load*

The heat load is measured is Watts.
Active heat load

$$Qactive = V^2/R$$

where
Qactive T active heat load (W)
V = voltage applied to device being cooled (V)
R = device resistance (Q)
I = current through the device (A)

$$V = I \times R$$

14.8 = 3.6 x R
R =14.8/3.6 = 4.11ohms
Q active $=V^2/R = 14.8^2 /4.11 = 53.29$ watt

B. *Radiation*

Q radiation = radiation heat load (W)
F = shape factor (a worst case factor of 1 can be used)
e = emissivity (worst case value of 1 can be used)
s= Stefan-Boltzman constant (5,667 x $10^{-8}W/m^2K'$)
A = area of cooled surface (m2) = (1.6 x $10^{-3}m^2$)
T ambient= ambient temperature (Kelvin) = 274 + 30 = 304
Tc = TEe cold side ceramic temperature (Kelvin) = 274 + 8 =282

$$Q\ radiation = F.e.s.A(Tambient^4 - Tc^4) .$$

Q ,radiation= 1 x 1x 5,667 x 10^{-8}x 1.6 x 10^{-3}x $(304^4 - 282^4)$
Q ,radiation = 20.09 watt

C. *Convection*

$$Q\ convection = h.A(fair- Tc)$$

Where,
Q convection = convective heat load
h = convective heat transfer co-efficient (21.7 for air at 101.3kPa)
A = exposed surface area = (m^2)
Ta" = temperature of surrounding air =274 + 30 = 304
Tc = temperature of cold surface =274 + 8 =282

$$Q\ convection = h.A(fair- Tc)$$

Q convection = 21.7 x 1.6 x 10^{-3} (304 - 282)
Q convection = 7.6 watt
Conduction

$$Q\ conduction = k.A.\ \Delta T/L$$

where
Q conduction = conductive Heat load (W)
k = thermal conductivity of the material = 0.86W/mc
A = cross-sectional area of the material (m^2) = 1.6 x 10^{-3}
L = length of the heat path (m) = 0.04 m
ΔT = temperature difference across heat path (hot side - cold side) = 56 – 8 = 48^0C
Q conduction = 0.86 x 1.6 x 10^{-3} x 48 / 0.04
Q conduction = 16.5 watt.
TOTAL HEAT LOAD ON PELTIER PLATE
Q total = Active Heat load + Radiation + Convection + Conduction
Q total = 53.29+ 20.09 + 7.6 + 16.5
Q total = 97.48 WATT = 100 WATT
Q total = 100 WATT.

VII. FEATURES, ADVANTAGES & APPLICATIONS

A. *Features*

1) Fast Temperature Response.
2) Environmental Friendly.
3) Low Noise.
4) Can be used in any direction.

B. *Advantages*

1) Fast Temperature Response.
2) Small and lightweight.
3) No refrigerants required.
4) Heating and Cooling depending on current direction.

C. *Applications*

1) Electronics.
2) Medicine.
3) Consumer Goods.
4) Scientific & Laboratory Equipments.

VIII. CONCLUSION

1) Low Running Cost.
2) It is easy for the maintenance and service.
3) It requires very less skill for its operation.
4) Toxicity is zero.
5) It produces very low noise.
6) It is easy for portability.
7) It is extremely reliable and safe.

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