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Design and Development of Eco-Friendly Water Dispenser with Purification

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***Abstract*: In the present scenario, with the increase in awareness towards environmental degradation due to the production, use and disposal of Chloro-Fluoro-Carbons (CFCs), Hydro Cholo-Fluoro-Carbon (HCFs), as refrigerant conventional cooling System. Thermoelectric dispensers are compact in size, robust in construction, no coolant require, no mechanical moving components are present and total weight of the system is less, noiseless. This paper presents the total Coefficient of Performance (CoP) of a thermoelectric module in combined heating and cooling modes, obtained through experiments and thermodynamics mathematical model. This paper aims toward developing a system which will provide cooling and heating effect simultaneously. Thermoelectric cooling and heating system does not require working fluids. This device can be used to cool water without use of refrigerants and simultaneously heating can be achieved from the hot side of thermoelectric module to heat the water, this is due to heat absorption and rejection using peltier element. This compact design is very useful in elimination of CFC and it would replace conventional refrigeration system. In RO system, there are pre carbon filter, post carbon filter & sediment filter through which water gets filtered and divide into two containers with the help of T section.**

***Keywords*: RO system, Peltier effect, thermoelectric cooling and heating, forced convection, heat pump, CFC elimination.**

1. Introduction

A water dispenser, known as water cooler (if used for cooling only), is a machine that cools or heats up and dispenses water with a refrigeration unit. We are very pleased to be able to put forward our idea "Thermoelectric heating and cooling system for drinking ", which is equipped with TEC plug-ins (Peltier modules) between the water blocks. The system uses the principle of the Peltier effect, when current flows through the connection between two materials, heat will be removed or absorbed. TEC consists of p-type and n-type semiconductors connected in series and covered with a silicon-bismuth coating. When the polarity changes, the direction of heat transfer also changes. It cools on one side and the other side heats up at the same time. The main goal of the project is to produce hot and cold water without the use of refrigerants and induction coils. Eliminate CFC emissions. It is environmentally friendly, and the service life of the thermoelectric module exceeds 2 million hours.

2. Objectives

1. To eliminate the emission of CFC (Chlorofluorocarbon) from water dispensers, this could ultimately reduce global warming and also reduce power consumption.
2. To provide a system with less a long-life time.
3. Minimization of cost of the system.
4. To reduce the size and weight of the system.
5. Increasing the cooling rate with maintaining temperature difference.

3. Working

Thermoelectric modules are solid state heat pumps that operate on the Peltier effect, the theory that there is a heating or cooling effect when electric current passes through two conductors' voltage applied to the free ends of two dissimilar materials creates a temperature difference. With this temperature difference, Peltier cooling will cause heat to move from one end to the other. A typical thermoelectric module will consist of an array of p- and n- type semiconductor elements that act as the two dissimilar conductors. The array of elements is soldered between two ceramic plates, electrically in series and thermally in parallel. As a dc current passes through one or more pairs of elements from n- to p-, there is a decrease in temperature at the junction ("cold side") resulting in the absorption of heat from the environment. The heat is carried through the cooler by electron transport and released on the opposite ("hot") side as the electrons move from a high to low energy state. The heat pumping capacity of a cooler is proportional to the current and the number of pairs of p and n elements. N and P type semiconductors (usually Bismuth Telluride) are the preferred materials used to achieve the Peltier effect because they can be easily optimized for pumping heat and due to the ability to control the type of charge carrier within the conductor.

4. Experimental Analysis

The model was fabricated and the measurements were taken at the room temperature. The table below shows the temperature change of water with respect to time. The initial temperature of water was measured to be 34℃ at room temperature. The TEC modules were powered using 12V 5Amp

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dc power supply. The sample test of 2.5L of water on two containers was tested and the change in temperature for every 5 min was measure for a period of 30 min. The change in temperature with respect to the time is plotted in a graph shown below.

The table 1 shows the rise of temperature on the hot side & cold side. The temperature of water rises from 34℃ to 50℃. The table 2 shows the fall of temperature on the cold side heat exchanger. The temperature of water falls from 34℃ to 21℃.

Table 1
Hot side readings

Time (min)	T_h (℃)
0	34
5	37
10	39
15	41
20	44
25	46
30	50

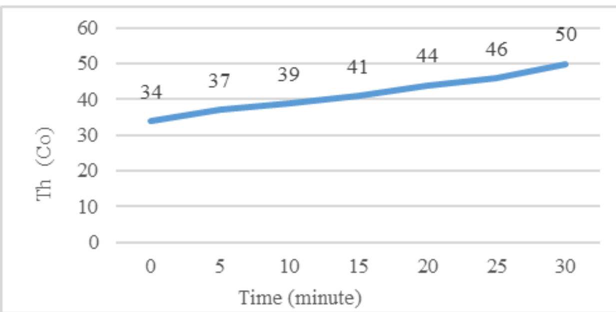

Fig. 1. Graph of hot side reading

Table 2
Cold side readings

Time (min)	T_c (℃)
0	34
5	32
10	31
15	28
20	26
25	24
30	21

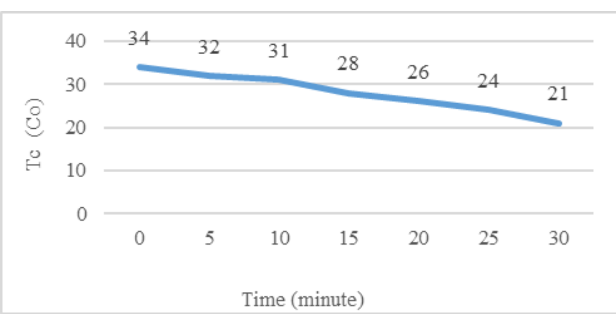

Fig. 2. Graph of cold side reading

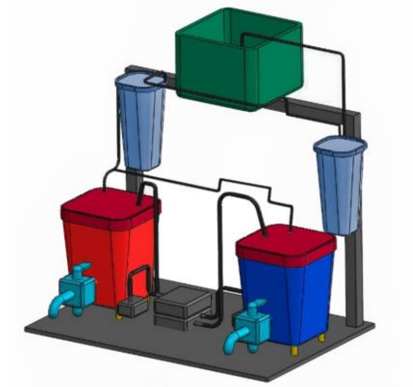
Fig. 3. Solid work model of the project


Fig. 4. Image of model

5. Calculation

Thermoelectric module is a solid-state heat pump that works based on peltier effect, ohmic heating and conduction between its surface.

The heat pumped on the hot surface Q_h of module & the heat flows through the cold surface Q_c is presented by equation given below

$$Q_h = S_{te} I T_c + \frac{1}{2} I^2 R - \frac{(T_h - Tc)}{R_{te}}$$
$$Qc = S_{te} I T_c - \frac{1}{2} I^2 R - \frac{(T_h - Tc)}{R_{te}}$$

Where,
s_{te} = thermoelectric Seebeck coefficient
T_h & T_c= temperature at hot side & cold side of module
I = electric current flowing through module
r = electric electrical resistance
R_{te} = module thermal resistance
$T_h - T_c$ = temperature difference between two surface of module

Thermoelectric thermal resistance (R_{te})

$$R_{te} = \frac{\alpha}{2k_{te}Nc}$$

Where,
α = ratio of elements length to area
k_{te} = material thermal conductivity
N_C = number of the p-n elements
Thermoelectric seebeck coefficient is given by $S_{te} = 2S_mN_c$

Where,
S_m = seebeck coefficient of material
Electrical resistance r is equal to $R = 2\rho_m\alpha N_c$

Where,
ρ_m = material electrical resistivity
The coefficient of performance of the module in heating & cooling modes is given by below equation

$$CoP_h = \frac{Q_h}{vI}$$

$$CoP_c = \frac{Q_c}{vI}$$

Where,
V = Supplied voltage
I = Electric current

Total coefficient of performance is calculated by the formula,

$$CoP_t = CoP_h + CoP_C$$

Where,
CoP_t= Total coefficient of performance
CoP_h =Coefficient of performance of hot side
CoP_C = Coefficient of performance of cold side

Mathematical calculation as per readings,
Temperature at hot side T_h = 50˚ C
Temperature at cold side (Tc) = 21˚ C

So, Temperature difference can be considered as,
T= $(T_h - Tc)$ = (50-21) = 29˚C

COP can be calculated by dividing the amount of heat absorbed at the cold side to the input power.

COP = QL/Energy supplied (W)

Heat absorption is calculated as below,

QL = - [SITc $- I^2$R $-$ k $(T_h - T_c)$] = 69.1935

From the first law of thermodynamics, the Energy supplied is:
Energy supplied, W = QH - QL
=SI $(T_h - T_c)$ + I^2 R
=53.9877
The Coefficient of Performance (COP) is obtained by the following empirical equation.

COP = QL/Energy supplied

$$= \frac{[\text{SITc} - I^2\text{R} - \text{k}\,(T_h - T_c)]}{\text{SI}\,(T_h - T_c) + I^2\,\text{R}}$$

$$= \frac{69.1935}{53.9877}$$

COP =1.28

6. Conclusion

The thermoelectric system is pollution free system to produce heating and cooling. It does not require CFC and other elements which generates pollution. Only the limitation of the system is the temperature achieved through thermoelectric system is limited. Especially in cooling side rate of decrease in temperature is lower than heating side but one can improve the rate of cooling by using heat exchanger or temperature controller. The system is compact and reduce in size, weight and price of water dispenser. Ultimately thermoelectric system holds the future of refrigeration for a pollution free environment.

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