ORIGINAL RESEARCH PAPER

Mechanical Engineering

SMART AND PORTABLE THERMOELECTRIC HEATING/COOLING DERIVED FOODWARE

KEY WORDS: Peltier, Thermoelectric Heating/cooling , Iot, App-controlled Foodware

Dr. Vijay Kumar	Department Of Mechanical Engineering, IIMT College Of Engineering, Greater Noida
Aseem Saxena*	Department Of Mechanical Engineering, IIMT College Of Engineering, Greater Noida *Corresponding Author
Ashutosh Kr Prajapati	Department Of Mechanical Engineering, IIMT College Of Engineering, Greater Noida
Anurag Yadav	Department Of Mechanical Engineering, IIMT College Of Engineering, Greater Noida
Anuj Rawal	Department Of Mechanical Engineering, IIMT College Of Engineering, Greater Noida

ABSTRACT

In this automation scenario when everyone is serious about glaciers melting & ozonelayer depletion so it's important to do which helps in overcoming this problem. Many type of refrigerator are made using refrigerant which to extent affect our environment. Then it strikes to make a refrigerating system in which there is no use of refrigerant so there is an option of vapour absorption system. Now the problem occurs about its shape refrigeration system with absorption system is heavy & bulky. The idea generation for the project had come in order to face and tackle the food and beverage storage's problem of inefficiency and inability of keeping the preferred temperatures (Adiabatic nature). Most of the storage container and devices in the market are largely unable to comply with their statement stated— 'Adiabatic nature' or 'keeping the temperature same', which is also reasonable. We know 'Adiabatic' state is only a theoretical approach to understand and study the nature of Thermodynamics and heat transfer, hence it is not possible in practical world. That's where the principle of internal heat generation and manipulation comes to save the day. If the subject is heated or cooled just before the required time, it will subsequently decrease the energy losses and produce the required temperature at the right time. But despite using high energy consuming resistance coils to produce heat and refrigeration system to produce cooling. We use Peltier effect to produce either heating/cooling as per the user's requirement. The JIT (just in time) philosophy of our product increases accountability to meet the user's needs efficiently while reducing the heat loss/gain incurred during the process of pre-heating/pre-cooling of food. There have been a lot of advancements made to cups over the years, but no one's made anything for the "modern man," until the **Acup 12: an app-controlled, temperature adjustable Foodware** period, carrying medicines and making the temp of the food stuff stable at what they were kept. Without any harm to our environment.

1. INTRODUCTION

World demand for food containers is forecast to rise **4.5** percent annually to **$139 billion** in **2017**. While the US remains by far the world's largest user of food containers, the most significant growth will occur in **India and China**.

This shows the growth factor in this industry and the future necessity as food production rate is declining as many farmers and producers boycotting the agriculture industry due to less economic benefits, so decreasing the food wastage is also one of major emerging concern.

We've come across the idea of building a small, lightweight and portable product offering real time food temperature modulation just before consumption which also helps in decreasing heat losses of hot food after cooking and prevents food spoilage[1].

1.1 THERMOELECTRIC EFFECT

The thermoelectric effect is the direct conversion of temperature differences to electric voltage and vice versa. A thermoelectric device creates voltage when there is a different temperature on each side. Conversely, when a voltage is applied to it, it creates a temperature difference. At the atomic scale, an applied temperature gradient causes charge carriers in the material to diffuse from the hot side to the cold side. The term "thermoelectric effect" encompasses three separately identified effects: the **Seebeck** effect, **Peltier** effect, and **Thomson** effect.

1.2 THE SEEBECK EFFECT

The Seebeck effect is the conversion of heat directly into electricity at the junction of dissimilar electrical conductors. It is named for the Baltic German physicist Thomas Johann Seebeck.

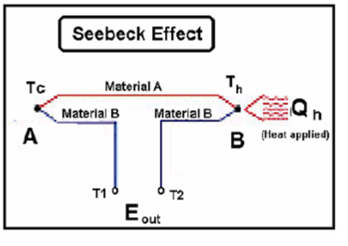


Figure 1 : The Seebeck effect

As shown in Figure 1, the conductors are two dissimilar metals denoted as material A and material B. The junction temperature at A is used as a reference and is maintained at a relatively cool temperature (TC). The junction temperature at B is used as temperature higher than temperature TC. With heat 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 is known as the Seebeck EMF, 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 (thermoelectric

power coefficient) between the two materials, A and B, positive when the direction of electric current is same as the direction of thermal current, unit is V/K.
- Eout is the output voltage in volts.
- TH and TC are the hot and cold junction temperatures, respectively, in Kelvin.

1.3 THE PELTIER EFFECT

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 flowed within the closed circuit[2].

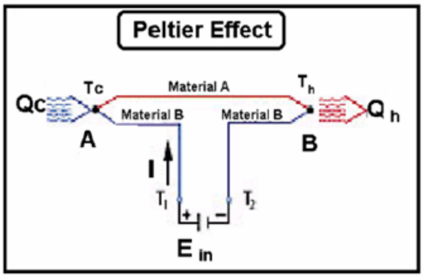


Figure 2: Peltier effect

In Figure 2, the circuit is 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 ofthe current flow, a slight 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). Note that this effect may be reversed whereby a change in the direction of electric current flow will reverse the direction of heat flow.

Joule heating, having a magnitude of I^2 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 causes a net reduction of the available cooling. The Peltier effect can be expressed mathematically as:

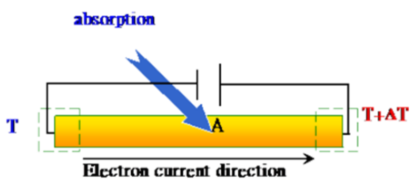


Figure 3: The Thomson effect

2. LITERATURE REVIEW

PELTIER MODULE

Peltier Module is the component which works on Peltier effect and Seaback effect. At and electrified junction of two different types of materials which act as pure conductor, then presence of heating and cooling is called Peltier Effect. If we are considering two different conductors A & B, when current is to flow through the junction of these conductors, the few amount of heat may be generated at the point of junction[4]. This generated heat is called Peltier Heat and it is said to heat generated per unit time Q, and equal to

$$Q = (\Pi_A + \Pi_B)$$

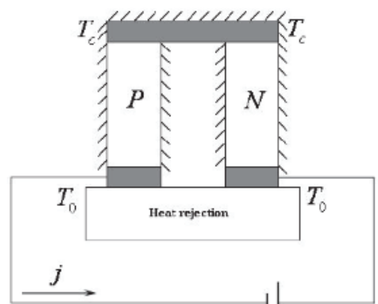
Where,
Q = *Total Heat at junction of Conductors*
πA = Peltier coefficient of conductor A
πB = Peltier coefficient of conductor A
I = Current flowing through A & B

The heating & cooling through Peltier Module is completely depends upon the point of contact and the material you are using. In our experiment we are using copper metal because copper has very good thermal conductivity. Peltier heating or cooling are the work of build-in contact electric and valence forces on movingcharges and the generation (or recombination) in space charge region. The device which works on this principle issome time called thermoelectric module also. Due to the Peltier effect it called Peltier Module. The main problem in this module is the difference of temperature created on the layers of module. The junction temperature is different and layer temperature is slightly difference. We cannot evaluate the exact temperature of the layer. It depends upon the ΔT.

$$\Delta T = T1 - T2$$

Where, T1 is temperature of one side and T2 is temperature of other side. Experimentally it is depend upon the Heat Sink which is connected to the hot side plate. If Heat Sink is keep cool then the lowest temperature will be achieve is -2°C and if we keep hot plate open then the temperature achieve in the hot side is 85°C. But there is problem during heating. If we give power supply more than this temperature then it will burn and device will be damage. So for heating we can use it till 85°C. Peltier effect from the new Physics point of view.

It has two types of semiconductors mounted. P type semiconductor branch has positive Seebeck coefficient "α" and in N type semiconductor has negative coefficient of "α". These two branches of semiconductors are joined by a good conductor like metal. On supplying D.C. current, the junction between n and p junction will be cooled and if a body touch with it then **t** will get cooled. In fig.1 Tc and To if the temperature of cold side and hot side respectively. Tc will be always less than To.



In Fig. 1 the schematic diagram of thermoelectric module is shown.

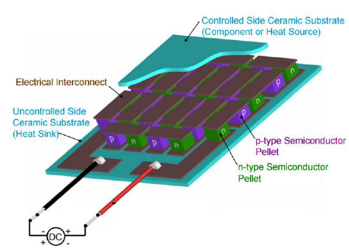


Fig. Fabrication of Peltier

Thermoelectric Cooling or Peltier cooling is one of the best cooling techniques for local use like chillers, Printed Circuit Boards, DC Machines, Power Plant, etc. It has no any movable part and it is completely gases free. It does not need any type of coolant gases or any type of compressors. The heat balance equation considered from equation[5,6,7]

$$div\vec{q} = \frac{j^2}{\sigma} + \alpha\vec{j}\Delta T$$

We can calculate the maximum temperature difference which can be gain in special adiabatic process[8,9]

$$\Delta T_{max} = T_o - T_{min}(x=0) = T_o\left(1 + \frac{1-\sqrt{1+2ZT_o}}{ZT_o}\right)$$

3. DRAWING / MATHEMATICAL FORMULATION

To find the maximum cooling power, differentiating Q1, with respect to I and equating it to 0

$$\frac{dQ_1}{dI} = 0$$

By, solving above equation, we can get current required for maximum cooling power,

$$I_{max} = \frac{(\alpha_p - \alpha_n) * T_1}{R_p + R_n}$$

Value of maximum cooling power, corresponding to. I *max*

$$Q_{max} = \frac{\alpha^2 * T_1^2}{2 * R} - K * (T_2 - T_1)$$

$$Here, \quad \alpha = \alpha_p - \alpha_n$$

$$K = K_p + K_n$$

$$R = R_p + R_n$$

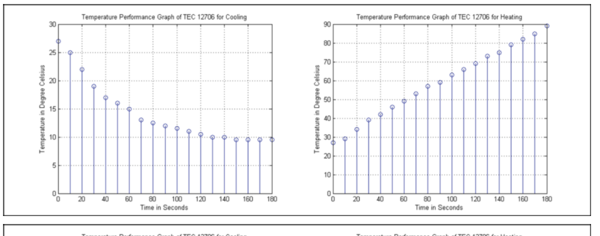
We can calculate the maximum temperature difference which can be gain in special adiabatic process.

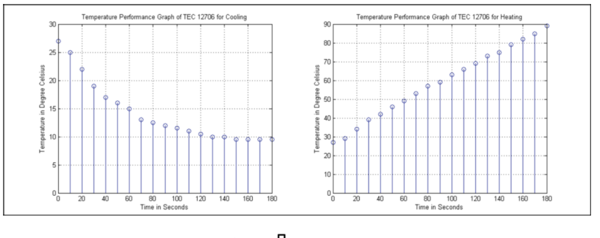
$$\Delta T_{max} = T_o - T_{min}(x=0) = T_o\left(1 + \frac{1-\sqrt{1+2ZT_o}}{ZT_o}\right)$$

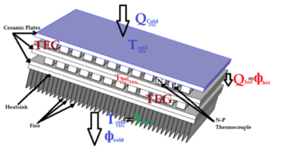
The coefficient of performance COP is the ratio between the cooling capacity Q1 and the electrical power consumption W,

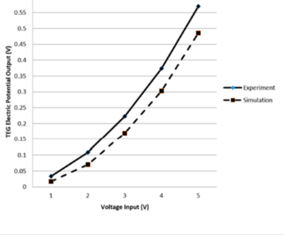
$$COP = \frac{Q_1}{W}$$

$$\therefore COP = \frac{\left((\alpha_p - \alpha_n)IT_1 - (T_2 - T_1) * (K_p + K_n) - \frac{I^2(R_p + R_n)}{2}\right)}{\left((\alpha_p - \alpha_n).I.(T_2 - T_1) + I^2.(R_p + R_n)\right)}$$









4. CONCLUSION

- As per the calculation and heat transfer rate required, Peltier module TEC-12706 is selected for cooling and heat generation.
- And TEC1089E-SV is selected as the circuit driving IC.

REFERENCES

1. Marc H., Thermoelectric Modules: Principles and Research, InterPACK July-6-8, 2011, Portland
2. Kaseb S., El-hairy G, Electronics Cooling, Mechanical Power Engineering Department, Faculty of Engineering, Cairo University, Egypt
3. H. Julian Goldsmid, Bismuth Telluride and Its Alloys as Materials for Thermoelectric Generation, Materials 2014, 7, 2577-2592.
4. S. Riffat, S.A. Omer, Xiaoli Ma, A novel thermoelectric refrigeration system employing heat pipes and a phase change, Renewable Energy 23 (2001) 313–323
5. R. Chein, Y. Chen, "Performances of thermoelectric cooler integrated with microchannel heat sinks", International Journal of Refrigeration 28 (2005) 828–839
6. S. Riffat, X. ma, Improving the coefficient of performance of thermoelectric cooling systems, international journal of energy research Int. J. Energy Res. 2004; 28:753–768
8. J. Vian, D. Astrain, "Development of a heat exchanger for the cold side of a thermoelectric module", Applied Thermal Engineering 28 (2008) 1514–1521
9. Kaseb S., El-hairy G, Electronics Cooling, Mechanical Power Engineering Department, Faculty of Engineering, Cairo University, Egypt
10. Thermoelectric cooling FAQ, Tellurex Corporation.
11. www.hyperphysics.phy-astr.gsu.edu/ (assessed on September, 2015)