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Thermoelectric Generator Scheme For IOT

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Abstract

In the recent year Thermoelectric Modules (TEM) are widely used for cooling of different electronic devices. Thermoelectric module allows obtaining the additional and dropping of device temperature. The different way for manufacturing array of thermoelectric model by using integrated circuit technology are presented, So the fundamental dependent parameter of the thermoelectric model are thermal conductance, electrical resistance and seebeck coefficient, among the other factors. Paper introduces a method for calculating parameter from observable variables, which can be obtained from temperature, voltage, and electric current measurements made on a working TE device. The parameters are plotted against the temperature between the hot and cold side of the module.

Keywords: *Thermoelectric model, Thermoelectricity, Pettier cell, Thermodynamics*

INTRODUCTION

Thermoelectric module (TEM) is also known as pettier cell. TEM can be used for refrigeration or seek model for the electrical power generation for the refrigeration.

This device is useful for temperature calculation where the reliability of main objective. It is important for us to note that the phenomenon may be reversed where a change in the polarity (plus and minus) of the applied DC voltage will cause heat to be moved in the opposite direction [1].

A thermoelectric module may be used for both heating and cooling that is why, it is highly suitable for precise of temperature control applications.

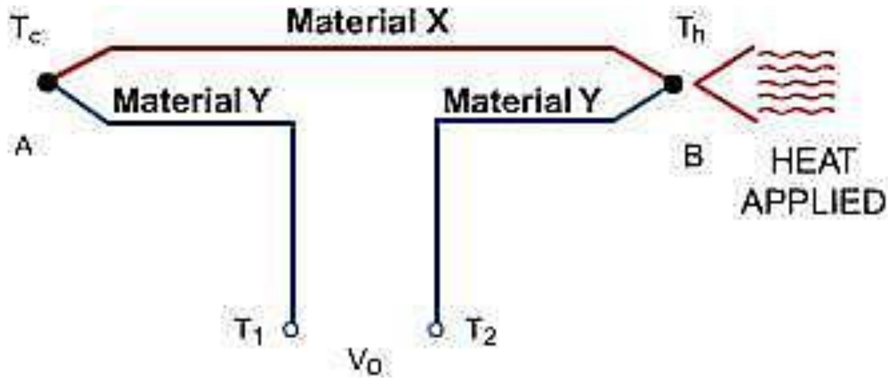
Thermoelectric coolers and mechanical refrigerators are governed by the same fundamental laws of thermodynamics and both refrigeration system, although considerably different in form, function in accordance with the same principles.

In a general refrigeration unit, the compressor is using to raises the pressure of a liquid and circulates through the system. In the evaporator or “freezer” area the refrigerant boils and, in the process of changing to a vapor, the refrigerant absorbs heat causing the freezer to become cold.

The Seebeck, Peltier, and Thomson Effects, are coefficient of basis functional thermoelectric modules. Without going into too much detail, for these fundamental thermoelectric effects [2].

Seebeck Effect

To obtain the Seebeck Effect let us take a simple example of thermocouple circuit as shown in Figure. The thermocouple conductors are two different metals which are denoted as Material x and Material y.



From a typical temperature measurement application, thermocouple A is used as a "reference" and is maintained at a relatively cool temperature of T_c. The thermocouple B is used to determine the temperature of interest (T_h) which, is the example, of higher than temperature T_c. When heat applied to thermocouple B, a voltage will appear along terminals Tl and T2. This voltage (V_o), which is known as the Seebeck emf, can be expressed as:

$V_o = axy \times (T_h - T_c)$

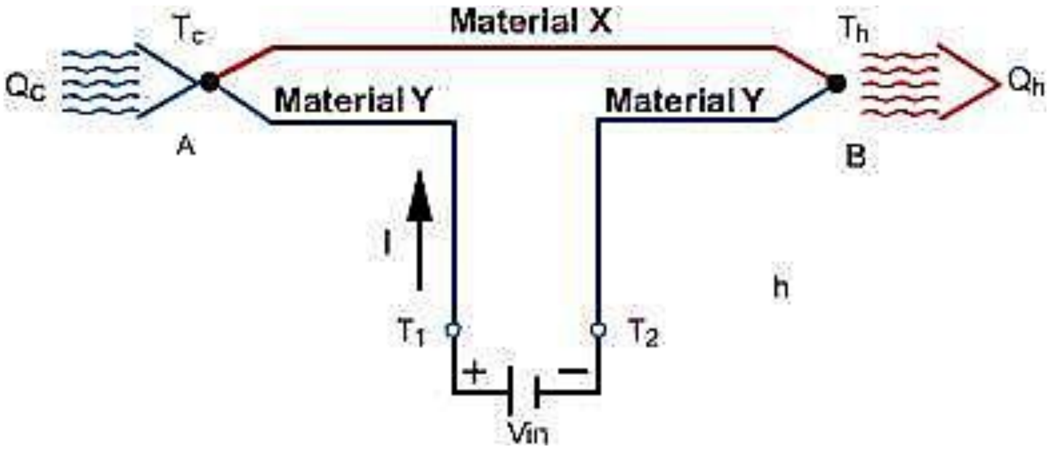
Where: V_o = output voltage in volts.
axy = differential Seebeck coefficient between the two materials, x and materials y, in volts/°K.

T_h And T_c = hot and cold thermocouple temperatures, donated in °K.

Peltier Effect

If we change our thermocouple circuit to obtain the configuration shown in Figure, That will be possible to seen an opposite phenomenon known as the Peltier Effect [3].

If a voltage (V_{in}) is applied to terminals Tl and T2 an electrical current (I) will flow in the circuit. A result of the current flow, a slight cooling effect (Q_c) will be present at thermocouple junction A where heat is absorbed and heating effect (Q_h) will be obtain at junction B where heat is expelled [4].



This effect may be reversed when there will a change in the direction of electric current flow will reverse the direction of heat flow. The Peltier effect can be expressed mathematically as:

Q_c Or $Q_h = pxy \times I$

Where: pxy = differential Peltier coefficient between the two materials, x and y, in volts.
I = electric current flow in amperes.
Q_c, Q_h = rate of cooling and heating, respectively, in watts.

The rest of the paper is follows as. Section II describes the methodology that tells us about the working of the proposed system. Section III and IV describes the applications and advantages of the system. Section V outlines the conclusion [5].

METHODOLOGY

The structure of thermoelectric modules is generally described as elements of n type and p type thermoelectric material is sandwiched between the two ceramic plates are connected in a series. The thermoelectric modules are placed on the external smooth surface of this tube fine exchanger. The modules are kept pressed against the surface through a second tubular heat exchanger but without fins in which a cold liquid circulates.

Several types of thermoelectric modules can be classified as.

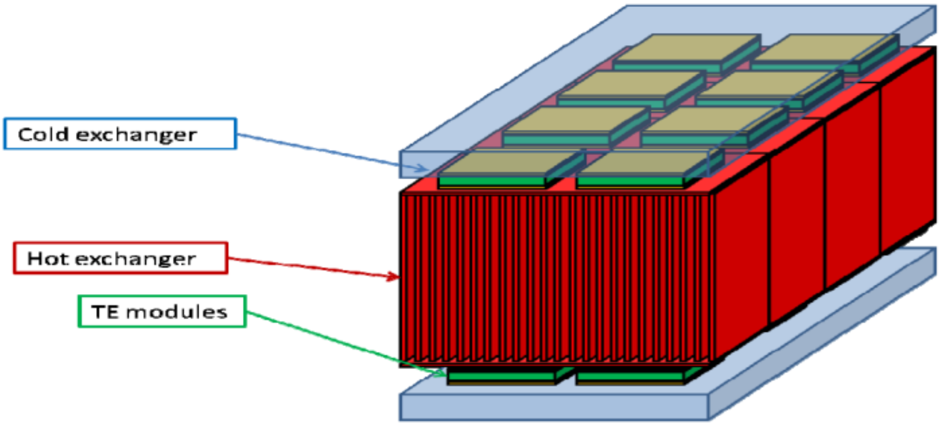


Figure 1: *Schematic diagram of the designed thermoelectric generator*

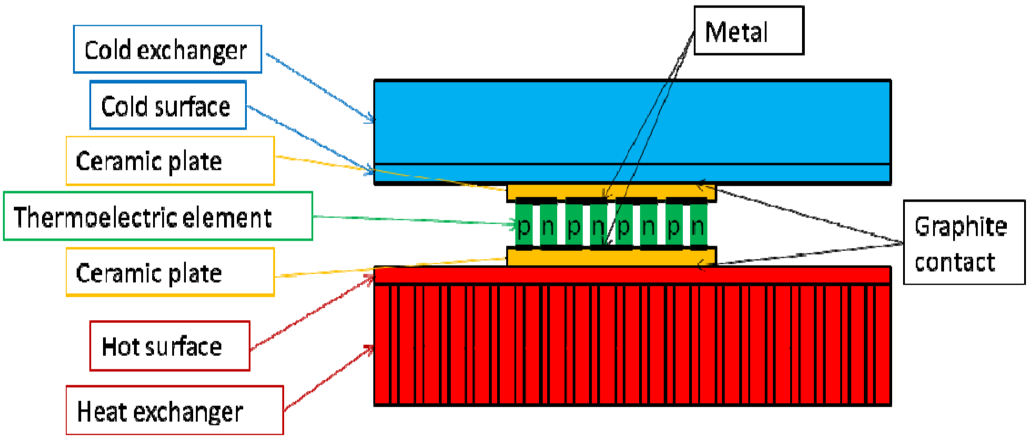


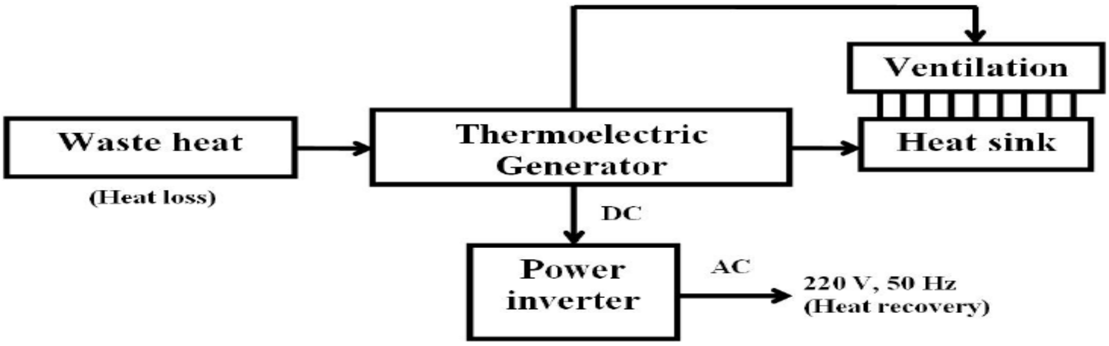
Figure 2: *Cross section of the TE module*

As already explained, the thermoelectric (TE) modules are sandwiched between hot and the cold fluid respectively and are electrically insulated through ceramic plates (see Fig. 2). The thermocouples are configured in such a manner that they are connected electrically in series, but thermally in parallel.

THERMOELECTRIC POWER GENERATOR DEVELOPMENT

System design

The thermoelectric power generation theory, the basic structure of the designed system is shown in below Figure. The developed system consisted of a thermoelectric generator with a heat exchanging unit and an inverter. Peltier cooler devices are used as the thermal cell for the thermoelectric generator. During the experiment, waste heat energy will be transferred to the hot side of the thermoelectric generator and the heat accumulated at the cold side is ventilated by a heat sink with cooling fan at the other end. The obtain direct current (DC) power was change into an alternating current (AC) power of 50 W at 220 V, 50 Hz.



Technical calculation

As shown in above Figure, a 50 W inverter with having high frequency at power switching conversion techniques in input operation range between 160-250 V DC and efficiency of 83.33% was developed. This result is required indirect current (DC) input for AC power conversion of 50 W/0.833 = 60 W. From the heat transfer experiment, the equilibrium temperature at the hot side (T_h) when a 100°C heat source was applied to the thermal cell under ventilation condition was 96 °C and cold side temperature (T_c) was 72°C. Therefore, the temperature difference was $T_h - T_c$ = 96-72 = 24°C. The average temperature (T_{avg}) between the hot side and the cold side is given by

$$T_{avg} = \frac{T_h T_c}{2} = \frac{96+72}{2} = 84^{\circ}C = (84+273.2)$$
$$= 357.2K$$

The Electrical and thermal characteristics of the TEC1- 12710 Peltier cooler device can tested and used as the thermal cell. Technical parameters at ΔT = 24 K were obtained as follows: approximately 1 V open circuit voltage, 0.45 A short circuit current, 0.0507 V/K Seebeck coefficient, 1.48 K/W thermal resistance or 0.67568 W/K thermal conductance, and 2.5Ω internal resistance.

All the information above was used to calculate the total number of thermal cells and the required heat source for generating 60-WDC power output. The following 3 major equations were used:

Maximum output power from a cell is

$$P_{max} = \frac{(S_M \times \Delta T)}{4 \times R_M} \quad (1)$$

Estimated number of cells needed is

$$N_T = \frac{P_o}{P_{max}} \quad (2)$$

Load resistance

$$R_L = \frac{V_o^2}{P_o} \quad (3)$$

APPLICATIONS

Applications for thermoelectric modules cover a wide spectrum of areas. TE coolers generally may be considered for applications that require heat removal ranging from milli watts up to several thousand watts. Most single-stage TE coolers, along with both high and low current modules, are efficient of pumping a maximum of 3 to 6 watts per square centimetre (20 to 40 watts per square inch) of module surface area. Multiple modules prepared thermally in parallel may be used to increase total heat pump performance. These added equipment used by military, medical, industrial, consumer, scientific/laboratory, and telecommunications organizations.

ADVANTAGES

TE coolers will often provide substantial advantages over alternative technologies. A TE module works electrically without any moving parts so they are virtually maintenance free. TE cooling system is much smaller and lighter, a variety of standard and special sizes and configurations are available to meet strict application requirements. It can be used in any orientation and in zero gravity environments. TE modules operate directly from a DC power source and can generate small amount of DC power. The TE Modules having a wide range of input voltages and currents.

CONCLUSION

The power module is drafted and manufactured for converting heat source directly into electricity. The thermoelectric module will generate DC electricity as long as there is a temperature changes over the module. Thermoelectric devices have maximum potential for many applications, in several industries and fields. Due to their high efficiency and greater power reserves, conventional compressor cooling systems maintain supremacy for conventional refrigerators and freezers. Thermoelectric generators can be deployed in power harvesting in automotive, were excess thermal waste-energy is found.

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