THERMOELECTRIC

REFRIGERATION

SYSTEM

Thermoelectric Effect

When two dissimilar metals are connected with each other in two junctions ad hold in two different temperatures as show in figure (1), this arrangement was called thermocouple or thermoelectric refrigeration system. The following five phenomena take place:

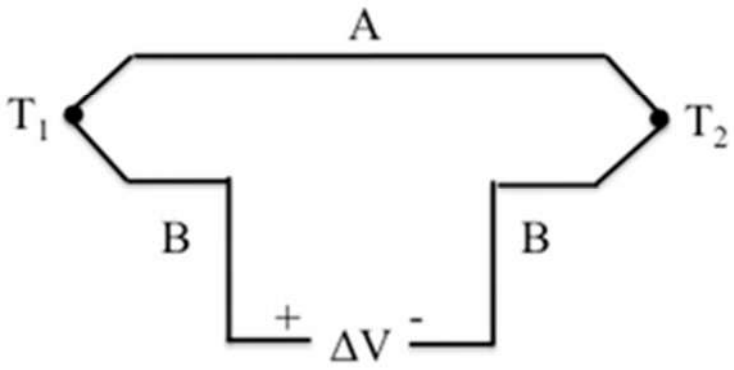


figure (1)

1- ***The Seebeck effect***: In 1821 the German physicist T.J. Seebeck reported that when two dissimilar metal wire are connected with each other in a loop to form two junctions, maintained at two different temperatures, a voltage potential or electromotive force (E=emf) will be generated and the current will flow through the loop circuit. The current will be proportional to the difference in temperature between the junctions and the metals used. The higher the temperature difference, the higher is the electromotive force (emf) and the current flow in the loop. The magnitude of the emf is in the order of few millivolts. The emf output was found to be

$$\Delta E \propto \Delta T$$

Where the ΔE and ΔT are the emf output and temperature different of the junction.

The proportionality constant of Eq. is denoted by:

$$\alpha_{ab} = \Delta E/\Delta T$$

and is called *Seebeck coefficient* or the *thermoelectric power*. It is to be noted that $\alpha_{ab}(= \alpha_a - \alpha_b)$ is the coefficient for a pair of different metals (A and B or P and N or p and n).

2- Peltier effect : In 1834, a Frenchmen, J. Peltier observed the reverse Seebeck effect, i.e., cooling and heating of two junctions of dissimilar materials when direct current is passed through them, the heat transfer rate being proportional to the current, if external voltage is supply to thermocouple o junction become hotter than other. He found that

$$q \propto I$$

Where q and I are the cooling or heating rate and the current

The proportionality constant of Eq. is called as *Peltier coefficient*, π_{ab} (= volt) i.e.,

$$q = \pi_{ab} I$$

where $\pi_{ab} = \pi_a - \pi_b$ is the coefficient for two different metals.

3- *Thomson effect* : In 1857, William Thomson (Lord Kelvin) proved when current flows through a conductor of a thermocouple that has an initial temperature gradient in it, then heat transfer rate per unit length is proportional to the product of current and the temperature

$$\frac{\delta q}{dx} = \tau I \, (dT/dx)$$

where τ being *Thomson coefficient* (Volt/K) and $\delta q/dx$, the *Thomson heat transfer*.

Zemansky [1] using *first* and *second laws* of thermodynamics obtained the relation between *Seeback* and *Peltier* coefficients as:

$$\pi_{ab} = \alpha_{ab} T$$

it is found:

$$q = \alpha_{ab} IT$$

4- Joulean effect: when the electric current flow through thermoelectric material (conductor), there is a dissipated of electric energy (it gets heated due to its electrical losses). According to the Joule

$$q = I^2 * R$$

Where I and R are the current and electric resistance

5- Conduction effect if the end of any element are maintenance at different temperature, there is a heat transfer from the hot end to the cold end and related by

$$q_{cond} = U(T_h - T_l)$$

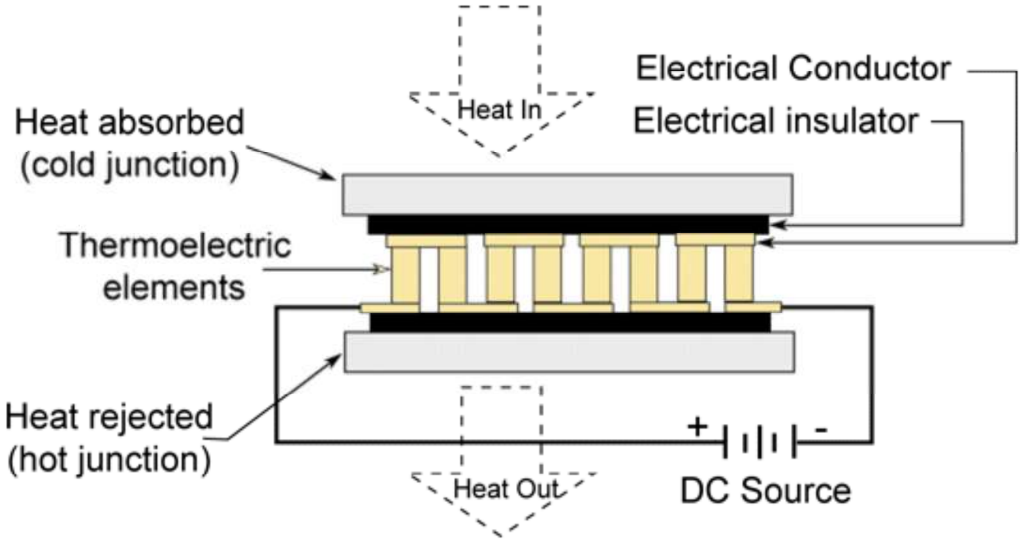
where U being overall conductance and T_h, T_l are the high and low temperatures, respectively. If there is only one conductor of cross-sectional area A, conductivity k and length L, the overall conductance is given by:

$$U = kA/L$$

<u>Thermoelectric effect application</u>

<u>1-Thermocouple:</u> depended on Seebeck effect is tools using to measure the temperature of solid body such as temperature of pipe whether inside or outside surface.

<u>2-Thermoelectric refrigeration system:</u> depend on Peltier effect is system using to absorb the heat from surrounding to cooling it, or can be using to supply the heat to the surrounding to heating it.



Advantages of Thermoelectric refrigeration system

1- Small Size and Weight
2- No Moving Parts
3- Ability to Heat and Cool With the Same module
4- Environmentally Friendly
5- Electrically "Quiet" Operation

Disadvantages of Thermoelectric refrigeration system

1- Low COP
2- High cost

Application of Thermoelectric refrigeration system

1- Electronics Cooling
2- Cooling of biological specimens
3- Dew Point Hygrometers construction
4- Constant Temperature Baths

The main differences between thermoelectric refrigeration system and vapor compression refrigeration system

Vapour compression system	*Thermoelectric system*
1. Refrigerant flows through the circuit.	1. Electrons flow through the circuit.
2. The difference in the enthalpy levels of the refrigerant is maintained by using compressor.	2. The difference in electron energy levels is maintained by using suitable semiconductor.
3. There are losses due to gas leakage past the piston and valves in a reciprocating compressor.	3. Loss occurs due to thermal conductivity of materials, which results in a backward flow of heat, through the thermocouple.
4. There is friction loss in pipes.	4. There is I^2R loss in conductors.
5. Pumping capacity is limited due to headclearance in a reciprocating compressor.	5. The relative Seebeck coefficient is limited due to the entropy difference of the electrons in the two materials in contact.
6. The heating and cooling functions of the condenser and evaporator can be interchanged by reversing the direction of refrigerant flow.	6. The heating and cooling functions can be interchanged by reversing the direction of electric current.