

REVIEW ON PERFORMANCE AND ANALYSIS OF THERMOELECTRIC COOLING IN VARIOUS APPLICATIONS

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ABSTRACT

This review is based on thermoelectric cooling and its various application. Thermoelectric cooling have great advantage over convectional cooling system. TEC are compact in size, robust in construction, no coolant required, no mechanical moving components are present and total weight of the system is less. When a current is passed through two conductors either heating or cooling will takes place. On the basis of peltier effect TEC works. When the voltage is given to two ends of a dissimilar metal a temperature difference will takes place and this temperature difference will cause heat to flow. N and P types of semiconductor are used. Oxides, silicides, skutterutide, half heauler, chalcogenides etc. these are most used thermoelectric materials. They should have high electrical conductivity, low thermal conductivity. They should be stable within filter medium and should not oxidize when exposed to air. We have seen TEC is used in various places such as TEC used in portable active solar still , space cooling system with use of pcm, FGM used for thermoelectric cooling ,external cooling jackets in fire fighter application and TEC of electronic equipment with help of heat pipe liquid block (nanofluids as coolant) .

I. INTRODUCTION

Thermoelectric cooling is method used for cooling purpose in various application. It has good impact over conventional cooling system. Thermoelectric coolers are compact in size, no coolant is used in the system, no frictional element present in system and weight of system is very less. The changing state between cooling device and heating device is easily controlled. Depending upon the requirement Thermoelectric coolers are used in various application such as cooling of electronic equipment, thermoelectric refrigeration, space cooling with use of PCM, Portable active solar still etc. TEC are heat pumps that operate on Peltier effect. Research suggest that heating or cooling effect occurs when electric current passes through two conductors. When a voltage is applied to two ends of dissimilar material it will create difference. The temperature difference causes heat to flow according to peltier effect. A basic Thermoelectric cooler will consist of semiconductor elements(p-type & n-type) that work as two dissimilar conductors arranged in specific order. The layer of elements is soldered between two ceramics plates, they are placed electrically in series structure and thermally in parallel structure. When the Direct current passes through one pair or multiple pairs of elements from 'n' to 'p' the temperature will

decrease at that junction, resulting the absorption of heat from the surrounding. The heat is carried out through the transportation of electron and it will move from high state to low state. The pumping capacity of a cooler is directly proportional to no. of pairs of 'n' and 'p' type (couples).

The 'n' and 'p' type semiconductor usually Bismuth Telluride are the most used material to achieve the Peltier effect because they are used for carrying out the heat. They also controls the charge carrier type in the system.

II. WORKING PRINCIPLE

The Thermoelectric cooling works on Peltier Effect. The Peltier Effect States that when voltage is applied between two ends of electrode, which is connected to semiconducting material creates the temperature difference which will cause Material to diffuse from hot side to cold side. When current is flowing through two junctions then surface may heated up or cooled down as per the requirement.

III. SEMICONDUCTORS

There are two types of semiconductor used in the setup. P-type and N-type are those two types of semiconductor. These two semiconductors come in Extrinsic Semiconductor type. When extrinsic semiconductor is doped then, doping agent is introduced in it and it has different electrical properties than pure semiconductor.

3.1 P-Type

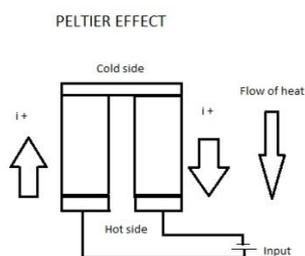
These semiconductors are in opposite of n type semiconductor. These type of semiconductor have more hole type concentration than electron type concentration. The P is named as positive charge of hole. In these semiconductors holes are majority carrier and electron are minority carrier. P-type of semiconductor is formed by an intrinsic semiconductor with acceptor impurities. Silicon is used as a common dopant for p type semiconductor.

3.2 N-Type

These type of semiconductor have bigger electron concentration than that hole type concentration. The word N comes due to negative charge of electron. In this type Electrons are majority carriers and holes are minority carriers. These semiconductors are formed by doping an intrinsic semiconductor with donor impurity. A basic dopant is phosphorus.

IV. PELTIER EFFECT

Heating and cooling at electrical carrying junction of two different conductor is known as peltier effect. This effect was discovered by scientist named Jean Charles Athanase Peltier in 1834. When current is flowed through two conductor then heat may be generated or removed. The peltier coefficient is heat carried per unit charge. The current must be continuous across the junction and the heat flow will develop a discontinuity are different. This can be considered as the reverse effect to the Seebeck effect. If a simple TE circuit is closed then the Seebeck effect will allow a current, which in turn with the help of the Peltier effect. Transfer of heat is from the hot to the cold junction. There is a close relationship between peltier effect and seebeck effect. The peltier effect used in Refrigeration purpose in many places.



Concept of Peltier Effect

V. THERMOELECTRIC MATERIALS

1. Lead telluride (PbTe)
2. Oxide material
3. Zinc Antimonides
4. Half-Heusler Alloy
5. Skutterudites

VI. GENERAL MECHANICAL PROPERTIES OF TE MATERIALS

Material	Youngs modulus	Fracture strength	Hardness	Fracture toughness
Skutterudite	133-140	35-85	-	1.1-1.8
Oxides	85-210	-	2.5-11.75	2.69-4.78
Antimonide	74	65	1.56	0.69
PbTe-based	54-55	28	0.98-1.27	-

VII. TE MATERIAL SHOULD HAVE

1. High Electrical conductivity
2. Low Thermal conductivity
3. High Seebeck effect
4. Should not oxidize when exposed to air
5. Stable within filter medium
6. High efficiency

VIII. APPLICATIONS

1. Thermoelectric refrigeration
2. Electronic cooling
3. Automobile cooling
4. Air conditioning appliances
5. Portable active solar still
6. Space cooling with PCM
7. Solar space power system
8. Fire fighter application

IX. REVIEW OF SOME RESEACHERS

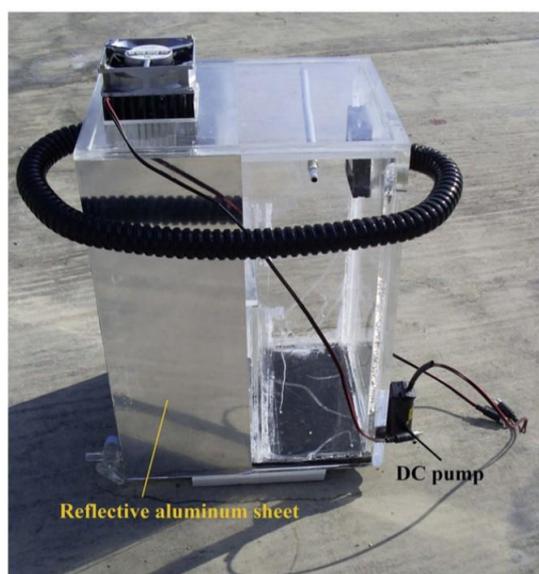
[1] Javad Abolfazli Esfahani et al [1] :-

Researcher made a portable active solar still. He made effort to increase the productivity of still as compared to other convectional stills. Some techniques have been used to improve the performance to solar still. It consist of solar collector, a black wool covering is provided to wall of solar still. water sprinkling device along with thermoelectric cooler is added to improve performance of still. Plexiglas is used on the wall of portable solar still to make it unbreakable. He carried out this experiment in nine summer and winter days in iran. But result took from both seasons were having a significant difference. The temperature of air and intensity of solar radiation was more in summer as compared to winter season. So atmospheric condition affects on productivity of a portable solar still. The efficiency of a portable solar still was in more in summer as compared to winter. The portability function gives significant impact on solar still as compared to other conventional type of solar stills. The cost of still is less as compared to other solar stills.

9.1 Materials Used

1. 12 V power source
2. Dc pump
3. Fan
4. Thermoelectric cooler
5. Plexiglas
6. 4L capacity for cooled water
7. Solar collector
8. Copper tubes
9. Water sprinkle system
10. Black wool carriage

9.2 Experimentation



As this is a portable still so some characteristics should be considered while modelling it. So the total weight of the system should be less, as it is portable. The device should be unbreakable. As it is a cooler so the material should not get affected by moisture. It have a power source which will carry a load of pump, fan and the cooler. Solar still should be compatible with the solar panels. As we have to make device unbreakable researcher made walls of Plexiglas. There are two section to store the water. 4 litre capacity for each for raw water and condensed water. Two zones are present in the system. In evaporation zone radiation of sun with the help of solar panels is used to increase the temperature of raw water. Then as the temperature of water increases the vapours are formed. Sprinkler tube is used in evaporating zone to sprinkle water droplets. According to vapour compression cycle this vapours are condensed with the thermoelectric cooler and condensed water is carried out in other side which is known as condensing zone. This is how we get cooled water with above experiment.

9.3 Result and Discussion

The experiment shows that intensity of solar radiation have a major impact on a productivity of a portable solar still. When experiment was carried out in 9 days ,at 2-3 pm researcher got constant intensity of radiation along with increasing ambient temperature and decreasing velocity of air is obtained. This region got the maximum productivity of portable active solar still.

[2] **Gang tan et al [2] :-** In this research researcher made thermoelectric space cooling system with the use of phase change material. Integrated thermoelectric cooling system with PCM is used for space cooling purpose. The function of Phase change material is to store cold thermal energy in night as cold side and it is used to reduce temperature of thermoelectric module in day period. A model based on thermoelectric space cooling system with PCM using numeric calculations is based on two working type. One is the removal of heat to surrounding with the help of air water heat exchanger and other one is to pass heat to shell and tube. Use of Phase change material increases the efficiency of the system. The experimental value claims that there is significant increase in the value of coefficient of performance of system by large amount. A model can made for office based on numerical calculations which have daytime cooling requirements. In this system cooling power output, coefficient of performance along with the cost plays an important role.

9.4 Result and Discussion

The efficiency of the system increases with the overall increase in COP by 56%. The daytime cooling requirement of thermoelectric module can be fulfilled by this experiment.

[3] Michael Gasik et al [3]:- The research paper present the functionally graduated material used for thermoelectric cooling of solar space power system. This system is designed to use natural resources such as intensive solar radiation approaching earth. The mirror arrangement is placed in the system which is at space. Sun radiation will fall on mirror , then arrangement of mirror and laser amplifier. It will directed to ground system in form of laser radiation. This system needs constant temperature range. The cooling system have no moving parts as thermoelectric cooling based on peltier effect is used. We can directly apply to do cooling. The excessive and low grade heat is rejected to surrounding. This system is widely used in space system .this system is compact in structure and it performs noiseless operation. The functionally graduated material have good temperature dependent properties. So with help of researchers theory we can optimise FGM with thermoelectric cooler based on peltier effect for solar space power system.

9.5 Result and Discussion

From the above paper we understood that there are two types of material used in solar space power system are homogeneous and semiconductors FGM. The coefficient of performance of system is very low as 0.85. this system perform noiseless process so it is used in many solar space stations.

[4] Andrew B. Kustas et al [4] :- This research paper presents the application of thermoelectric cooling in fire fighter. Fire-fighter have suffered physiological strain due to working environment. Some strain is produced due to presence in high temperature environment doing physical activity. Many fire fighter die because of external environment leads to increase internal body temperature as heat flows from high to low. Researcher suggested that external thermoelectric cooler provided with each fire fighter , so in presence of high temperature environment the external temperature will affect in less quantity and internal body temperature will remain normal. The TEC will be in portable form. The thermoelectric cooler is in form of closed loop system carrying water. This will reduce the temperature and maintain body temperature. The use of this cooler is easy and efficiency is good.

9.6 Result and Discussion

When the value of COP is greater than 1 then we can achieve heat removal rate of 250 w. successful heat removal rate for 160w having COP 0.6 has been achieved during test.

[5] Nandy Putra et al [5] :- The research paper represents the thermoelectric cooling of a electrical equipment with the help of nanofluids with heat pipe liquid block. As the technology is increasing the size of microprocessor is also increasing. It will give higher heat flux. In computer, central processing unit(CPU) is the heart of computer. CPU contains 1 billion transistors and each transistor dissipate heat. The temperature should be less for performing operations smoothly. When the load of CPU increases the rate of heat dissipation also increases. The TEC along with heat pipe liquid block having coolant as alumina-water and titana-water nanofluids used to decrease temperature of CPU. Coolant reduces thermal resistance in wall and coolant.

9.7 Result and Discussion

For maintaining the temperature of central processing unit the heat pipe liquid block with coolant alumina-water, titana-water is used along with thermoelectric cooler.

X. CONCLUSION

From the above data we can conclude that Thermoelectric cooling added a new dimension to cooling. It has major impact over conventional cooling system. It is compact in size, no frictional element are present, no coolant is required and weight of the system is low. This works on peltier effect. Bismuth Telluride is the most common Thermoelectric material used in TEC system. Improved cooling performance , ability to work for a long period of time , it can use in space and low operating cost make TEC a contender.

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