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STUDY AND DEVELOPMENT OF REFRIGERATION SYSTEM BY USING PELTIER MODULE

Yadav Harsh[1], Patel Abhishek [2], Moghariya Jainam[3], Trivedi Parth[4], Prof Amit Pandey[5]

[1,2,3,4]*Student, Department of Mechanical Engineering, LDRP Institute of Technology and Research, Gandhinagar, Gujrat, India*

[5]*Assistant Professor, Department of Mechanical Engineering, LDRP Institute of Technology and Research, Gandhinagar, Gujrat, India*

Abstract – *The conventional refrigeration system gives high COP but releases harmful gases which leads to global warming. This issue can be solved using Peltier devices which are used as element for cooling, heating, power generation and has its name for many researches as it has simple structure, less mechanical moving parts, no refrigerant needed, possible to manufacture in small sizes. This present review paper deals with the study of thermoelectric refrigeration system compared to conventional refrigeration system available in the market and presents various literature review of many researchers in the field of thermoelectric refrigeration.*

Key Words: **Thermoelectric Module, Peltier Effect, Thermoelectric refrigeration, Peltier Module, COP.**

1. INTRODUCTION

The Scientist, Jean Peltier and Thomas Seebeck in 19th Century first discovered about thermoelectric industry. Thomas Seebeck observed that for two dissimilar conductors as temperature difference is applied across the junction, electric current starts to flow. The heat which is absorbed is transferred from the semiconductor materials by electron transport to the other end of the junction and liberated as the electrons return to a lower energy level in the p-type material. This phenomenon is called the Peltier effect. In Seebeck effect the temperature difference between two different electrical conductors or semiconductors produces a voltage difference between the two substances. The conventional refrigeration system uses fluid known as refrigerant which absorbs heat from low temperature area and releases it to high temperature area undergoing phase transition. The conventional refrigeration system working on vapour Compression cycle uses compressor, condenser, Evaporator, Expansion valve, Receiver, Refrigerants (Ammonia (NH_3), Sulphur Dioxide (SO_2), Carbon Dioxide (CO_2)),etc. This system gives maximum overall efficiency and desired temperature output but releases harmful gases which is leading to ozone depletion and increase in global warming. Here, the refrigeration system based on thermoelectric module does not use any kind of refrigerant or compressor. Thus, overall contributes to betterment of the environment.

2. LITERATURE REVIEW

Karmini et al has done analysis and made a device with multi stage or single stage thermoelectric module. It has made considerations that the COP and heat resistance of heat sink are the main key parameter in the design of multi stage thermal electric coolers. It gave conclusion that multi stage thermoelectric refrigerator system allows use of heat sink with resistance which helps in enhancement of COP.

Chen al conducted the comparison performance of single stage and two stage TER system. The cycle model of single and two stage TER system was made and general expressions was derived for three important performance parameters as COP, Input Power & Rate of Refrigeration. It shows the maximum COP of double stage is more larger than single stage. It is preferred to use single stage thermoelectric refrigerator system when temperature range of heat sink to cooled side is smaller.

Saket Kumar, Ashutosh Gupta, Gaurav Yadav & Hemend Pal Sing conducted experiment on peltier module for refrigeration and heating using embedded system. Three model of Peltier module were used and temperature performance was checked according to the time when 12 V voltage supply and 2A DC current was used. The heating and cooling in Peltier module completely depends on the stress and contact terminal of the ceramic plate which acts similar to 2 electrodes. Power supply is one of the important factors in case of heating.

Prof. N. B. Totala, Prof. V. P. Desai, Rahul K. N. Singh, Debarshi Gangopadhyay, Mohd. Salman Mohd. Yaqub, Nikhil Sharad Jane conducted experiment on study and fabrication of thermoelectric air cooling and heating system using 4 peltier modules to achieve cooling with external power supply. From outcomes of the experiment, it was known that the cooling system can heat or cool the air when air is re-circulated with help of blower.

Afdhal Kurniawan Mainil, Azridjal Aziz , Muktafa Akmal, conducted test on portable thermoelectric cooler box performance with variation of input power and cooling Load. It was found that with the increase of input power that supplied to the system, the temperature at cool side of heat sink and cooler box decreases. This is due to

heat absorption at cool side of thermoelectric module. When the input power varies from low to high, with high input power lesser temperature of box is achieved which results in low COP.

F. Meng, L. Chen, F. Sun, developed model for commercial thermoelectric refrigerators with finned heat exchanger with the help of finite time thermodynamics. The outcome gives value of 2.33 W for maximum cooling load and 0.54 for coefficient of performance when 10 K is cooling temperature difference. When compared with other models, it is known that leakage of heat from air gap and heat convection of heat exchanger are two main factors which leads to decrease in overall performance and causes irreversibility in the model.

Gao Min & D.M. Rowe, investigated the coefficient of performance of thermoelectric refrigerator, the COP was found to be between 0.3-0.5 at 5°C with atmospheric temperature of 25°C. The outcome of the experiment shows that to increase COP there is need to improve thermal interfaces, module contact resistances and heat exchanger effectiveness.

D. Astrain made one device that dissipate heat from hot side of module. Two thermal electric commercial refrigerators are used for experiment, one of them with the device developed and other with the conventional fins dissipater. From this it has proved with help of experiment that use of thermo siphon with the change of phase they enhances the COP of thermoelectric cooler up to 32%.

Shen, Xiao done investigation on a novel thermoelectric radiant air conditioning system. The system allows modules as radiant panels for inner cooling and with reversing the polarity of input current for space heating. By analysis of commercial thermoelectric module they have gained maximum cooling COP of 1.77 when applying a current of 1.2A and obtained cold side temperature of 20 degree Celsius.

Xiaoqin Sun at el proposed a system in thermoelectric cooling for removal of heat generated in the peltier module. For improvement in performance of the system, a gravity assistant head pipe (GAHP) was used as heat sink in it. As a result, there was 73.54% improve in cooling capacity and there was reduction in electricity consumption by 42.20%.

Kaloyan Ivanov, Ivaylo Belovski, Anatoliy Aleksandrov, did research and analysis of the electromotive voltage generated by seebeck and peltier modules. From the experimental results it was found that peltier module generates 2 times more electric power than seebeck module which is due to bigger cross-section area of thermocouple branches from which it is made. It is also known from experimental results that module with more number of thermocouple gives higher output voltage and smaller output current.

3. WORKING PRINCIPLE

3.1 WORKING OF PELTIER MODULE

A peltier module is a square block with red and black leads attached with it for power. The red one is considered to be positive terminal and black one is considered as negative terminal. The side of the module with written specs (for example:- TEC1-12706) is one which gets cold and opposite side of it gets heated up. If you reverse the polarity of peltier device, the hot side of the thermoelectric module will end up being the cold side and cold side will become hot side. A peltier device consist of collection of "legs" which are composed of P and N Type semiconductor materials. Conductive sheets are placed at top and bottom of the matrix which are sandwiched between thermally conductive plates made of ceramic material. When current passing through it generates peltier effect. When the thermoelectric module is connected with a battery, current starts to flow and electrons being excited starts to flow. The heat is absorbed at cold junction by moving from low energy level in p-type semiconductor material to , high energy level in n-type semiconductor element. Similarly, the heat is removed at hot junction as electrons move from high energy level to low energy level. This phenomenon allows peltier module to function as heating and cooling by reversing the flow of current.

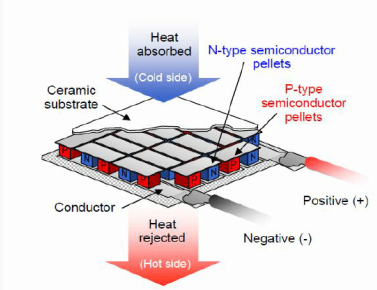

Fig 1. Cutaway of TEC

3.2 HEAT TRANSFER THROUGH PELTIER MODULE

In Peltier module, Q is the symbol to denote heat transfer in Watts. The value of Q shows heat generated by body to be cooled and also represents amount of heat the module transfers to the ambient environment. The absorption of heat from environment takes place in such way when current is applied to one or more pair of element of P-Type or N-Type which leads to decrease in temperature at junction ie cold side and provides cooling in it.

The Peltier heat absorption can be shown as Q=P (Peltier Coefficient) *I (current)*t (time).

4. ADVANTAGE OF PELTIER MODULE

1. Invulnerable to leakage of gas.

2. Peltier Module are light in weight and can be used with thickness as low as 1.95 mm.

3. Lifetime Operation up to 100,000 hours for constant temperature difference.

4. No Vibration or noise.

5. APPLICATION OF PELTIER MODULE

1. Peltier module are considered for spot cooling in medical equipment.

2. Portable Picnic Coolers, Residential Water Purifiers/coolers.

3. Used to lower temperature of GPU Chips and CPU in High End computers.

4. For temperature control system in Space vehicles and Missiles.

5. Used in thermal cycling devices for DNA and blood analyzers.

6. Used as deep cooling for cooling CCD (Charged Couple Device) or sensors.

6. COST ANALYSIS

The conventional refrigeration system mainly uses compressor, evaporator and refrigerants as its main parts. Here, the cost of refrigerant used in it is high. Such refrigeration system have more wear and tear, noise compared to thermoelectric refrigeration system. Thermoelectric modules without any need for any refrigerants requires less maintenance too. Overall, thermoelectric modules are cheaper than conventional air conditioners.

7. CONCLUSION

In this paper, detailed literature review was done to understand real time application and performance of thermoelectric based refrigeration system. The study also shows that thermoelectric system is a novel refrigeration system which can be good alternative for conventional refrigeration system. There is huge scope of improvement and research in designing of heat sink, thermoelectric materials, its fabrication. The main issue is about its low efficiency but combined utilization of thermoelectricity has capacity to perform well in existing framework. In coming years thermoelectricity has much more potential to create energy saving and impactful solutions for commercial and industrial field.

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