International Journal of Progressive Research in Science and Engineering
Volume-1, Issue-4, July-2020
www.ijprse.com

A Review on Thermoelectric (Peltier) Module

Nagesh Kudva [1], Veeresha R K[2], Muralidhara[3]

[1]Student, Department of Mechanical Engineering, N. M. A. M. Institute of Technology, Nitte, Karkala, Karnataka, India.

[2]Assistant Professor, Department of Mechanical Engineering, N. M. A. M. Institute of Technology, Nitte, Karkala, Karnataka, India.

[3]Professor, Department of Mechanical Engineering, N. M. A. M. Institute of Technology, Nitte, Karkala, Karnataka, India.

Corresponding Author: kudvanagesh12@gmail.com

Abstract: - In recent years, with the increase awareness towards environmental degradation due to the production, use and discharge of Chloro Fluoro Carbons (CFCs) and Hydro Chloro fluoro carbons (HCFCs) as heat carrier fluids in conventional refrigeration systems has become a subject of great concern and resulted in concept of thermoelectric (TE) energy that make it unique because of reversible energy conversion, e.g. from thermal to electrical and vice-versa. Seebeck and Peltier effects are base of all TE energy applications. Thermoelectricity has wide range of applications due to reversible energy conversion. In recent years, with technology development and global warming issues TE devices come into use in various applications because of its eco-friendly feature and distinct advantages. The thermoelectric energy has a vast range of applications in various fields like; electricity generation, refrigeration, air conditioning, particular heating/cooling, biomedical devices due to its simple construction and mechanism, compactness, require DC supply to run. This research paper thoroughly reviews the recent development and research work carried out by many researchers on thermoelectric energy applications in areas such as; power generation, refrigeration, electronic device cooling, medical field applications etc.

Key Words— *Thermoelectric effect, Thermoelectric energy, Peltier effect, Thermoelectric cooling, Thermoelectric refrigerator, Thermoelectric generator.*

I. Introduction

The world's energy demand is consistently expanding step by step and traditional wellsprings of energy have constrained stock. Likewise, traditional sources of energy have numerous issues of carbon outflow; it is the fundamental cause for an unusual weather change. The thermoelectric (TE) the device is very reasonable because of its sustainable power source feature (implies no carbon discharge) and it is eco-friendly. Emanations of ozone harming substances are expanding comprehensively on account of the ceaseless increment sought after for power, heating and cooling, refrigeration and cooling, and so forth. Just green advancements, for example, wind power, solar-oriented energy, and other sustainable power sources can control the outflow of ozone harming substances and assume a significant job in manageable turn of events. Numerous nations are attempting to control the outflow of carbon by framing new standards for enterprises. In the ongoing barely any years, thermoelectric hardware has come out with potential as option eco-accommodating applications. Uses of thermoelectric device reached out in different territories, for example, cooling or heating, refrigeration, ventilation, cooling, and so forth because of its eco-accommodating highlights and unmistakable points of interest. Thermoelectric energy can possibly change over heat energy into electrical energy and the other way around [1]. Because of solid state (no liquid/pivoting part) component of thermoelectric gadgets, it has an assortment of little applications for cooling of central processing units (CPU) and produce power in automobile from waste heat.

II. Working Principle

The thermoelectric semiconductor material frequently utilized in the present TE coolers is a composite of Bismuth Telluride that has been appropriately doped to give singular block or components having distinct N and P attributes. Thermoelectric materials regularly are manufactured by either directional crystallization from a melt or squeezed powder metallurgy. Each assembling strategy has its own specific preferred position, yet directionally developed materials are generally normal. In addition to Bismuth Telluride (Bi2Te3), there are other thermoelectric materials including Lead Telluride (PbTe), Silicon Germanium (SiGe), and Bismuth-Antimony (Bi-Sb) amalgams that might be utilized in explicit circumstances. Figure.1 [28] shows the relative execution or Figure-of-Merit of different materials over a range of temperatures. It very well may be seen from this diagram the presentation of Bismuth Telluride tops inside a temperature extend that is most appropriate for most cooling applications. When current (I) flow from N to P type and electrons (e) pass from P to N type semiconductor materials; electrons jump from low energy level (P type) to higher energy level (N type) absorbs heat from the surrounding and vice-versa. The thermoelectric module (TEM) is developed by two special semiconductor materials most generally Bismuth Telluride

(Bi2Te3) [3] as given in figure. 2, (one n-type and one p-type) utilized; in light of the fact that they should have disparate electron densities. These two p-type and n-type (Bismuth telluride) semiconductor dices are connected, electrically in arrangement and thermally in equal and sandwiched between

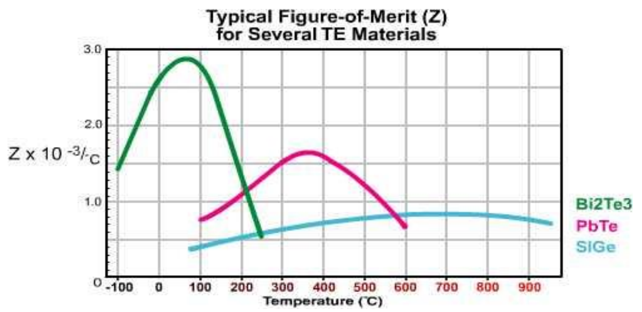

Fig.1. Figure-of-Merit of various materials [28]

the ceramic plates (electrical insulator). The p-type and n-type semiconductor dices are associated by copper tabs for the progression of power. At the point when the input is given at free ends of two semiconductors, temperature gradient produces over the junctures of semiconductors because of current stream. One side of the Peltier plate gets cooled and another side becomes hot.

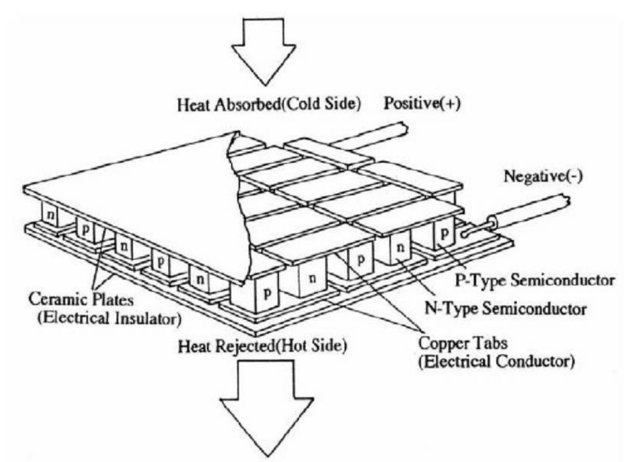

Fig.2. Construction of Thermoelectric Module [3]

III. Applications Of Thermoelectric Module

Thermoelectric modules are generally considered for applications that require heat expulsion extending from milliwatts up to a few thousand watts. Most single-stage TE coolers, including both high and low current modules, are equipped for siphoning a limit of 3 to 6 watts for every square centimeter of module surface region. Numerous modules mounted thermally in equal might be utilized to expand absolute warmth siphon execution. Huge thermoelectric frameworks in the kilowatt have been worked in the past for particular applications, for example, cooling inside submarines and railroad vehicles. Frameworks of this greatness are currently demonstrating very important in applications, for example, semiconductor fabricating lines. Peltier modules are included in the equipment used by military, medical, industrial, consumer, scientific/laboratory, and telecommunications organizations. Uses range from simple food and beverage coolers for an afternoon picnic to extremely sophisticated temperature control systems in missiles and space vehicles.

A. Thermoelectric Generator:

A thermoelectric generator (TEG) is also called the Seebeck generator, which changes over heat energy (temperature gradient) into electrical power straightforwardly without having any pivoting part/system. Kinikar et al. [3] detailed the utilizations of TEG for power plants for waste heat recuperation, automobile TEG to expand eco-friendliness. Liu et al. [5] have described numerous uses of TEG for car, aviation, mechanical, household, and slim film. This TEG produces electrical energy from waste heat from car, aviation, and industry. Mishra et al. [6] have surveyed the productivity of TEG, solar powered TEG's manufacture and execution, structure, and execution of a solar oriented warmth pipe TEG, inner heat loss, impacts of geometry, Electric power generated from the sunlight-based lake utilizing a mix of thermo-siphon and thermoelectric modules and concluded that the TE is preferable for generating electricity through sunlight yet low effectiveness of TEG was a disadvantage.

B. Thermoelectric Cooler:

Utilizing the Peltier module, a specific space can be cooled/kept up at a specific temperature. Nikam and Hole [8] looked into the utilization of the Peltier impact and described about combined use and direct utilization of the Peltier effect for refrigeration purposes. Combined utilization of Peltier effect with a vapour compression refrigeration framework (VCRS) is created and discovered that the COP expanded as contrast with the direct VCRS. Direct utilization of the Peltier impact is accomplished for refrigeration by Vian et al. [7] and Alaoui [9]. Narang et al. [10] proposed a prudent TE fridge in their examination and described that TE cooling is a successful method for the spaces with minimal in size. Figure. 3 shows the schematic diagram of thermoelectric cooler. Wang et.al [11] proposed the achievability of a compact solar oriented TE refrigeration framework for open air use. A few analysts revealed that the COP of two-phase/multi-stage TE modules is more than the single-stage TE cooler [12]-[13]. Utilization of TE cooler/cooler for clinical purposes, for

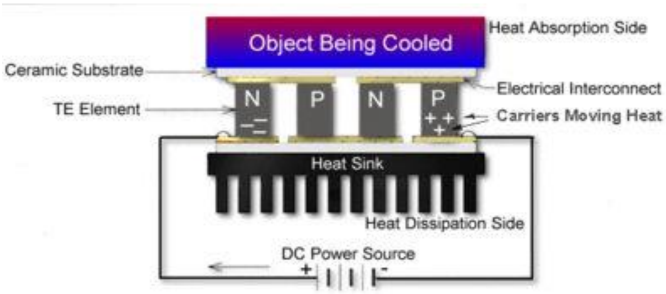

Fig.3. Schematic Diagram of Thermoelectric Cooler [28]

example, safeguarding and transportation of vaccines, blood serum, organic items. Also, for some, medical procedures had been accounted for by specialists [3], [5], [14].

C. For cooling Electrical Equipment:

Numerous high force electronic gadgets, for example, processors, power intensifiers, and PCs utilized in the server persistently run and offer support to clients; during the run, a lot of heat is delivered inside the framework and it must need to disperse from the framework to maintain a strategic distance from equipment failure and breakdown. Therefore, cooling is required to upgrade execution and life of electronic gadgets [5]. Cooling of these electronic gadgets is troublesome utilizing the conventional cooling frameworks; since, they are not conservative and have no space for their establishment. TE coolers have numerous preferences over customary cooling frameworks, for example, conservative in size, without vibration in light of the fact that no moving part, upkeep less, run utilizing DC gracefully. Zhao et al. [15] introduced a scaled down thermoelectric cooler (TEC) combined with a small-scale thermo-siphon cooling framework for cooling of CPU. Zhou and Ju [16] introduced a summed up hypothetical model for enhancement of TEC plan and amplified COP and limit of cooling. Huang et al. [17] structured and built up a TEC framework incorporated with gravity assisted heat pipe (GAHP) for electronic gadgets to improve heat dissemination from the hot side of TE module and came about that improvement in cooling limit by 73.54% and decrease in power utilization by 42.20% to deliver a similar measure of cooling of the electronic gadgets [17].

D. Other Applications:

There are numerous other uses of thermoelectricity and furthermore, it can possibly assist for advancement in view of its effortlessness, minimal in size, work on DC voltage, versatility, no pivoting component and so on. Different clinical uses of TE such wearable sensors for electroencephalography (EEG), electrocardiography (ECG), electromyography (EMG) and so forth, human implantable gadgets (like; cardiovascular pacemaker, heart defibrillator, neurological trigger and so on) are accounted by Chen and Wright [26]. Utilization of thermoelectricity is conceivable as dehumidifier by interfacing photovoltaic modules in array [19]. Peltier device was employed in the solar umbrella for cooling purpose [20]. The battery of the mobile can be charged and the lifetime of the battery can be increased by employing by thermoelectric generator [21],[22]. It can also be used for removing the moisture content present in the soil [24]. The temperature inside the lunch box can be maintained to the required temperature [23]. The Thermoelectric module can be used to cool the floor and the room [26].

IV. CONCLUSION

The uses of thermoelectric energy are summed up through this research work. Because of the uniqueness and simplicity of the TE rule for the reversible translation of energy; starting with one structure then onto the next structure makes it increasingly more helpful for different applications. Additionally, it has great future extension in light of ecological issues and mechanical progression. The main disadvantage it has low efficiency but combined utilization of thermoelectricity has the capacity to expand the performance of existing frameworks. TEGs can assume an incredible job in different fields, for example, power plants, heaters, electrical forces to produce power from waste heat recuperation. There are numerous chances of immediate and incorporated utilization of TE for refrigeration if module size increment or present stage change materials. Additionally, a versatile size cooler is proposed by scientists in their study. In electronic gadgets cooling and performance upgrade, TEC assumes a significant job because of its minimized size, working component, run utilizing DC flexibly. The rule of TE energy has variable applications for cars. In biomedical field, TE has extremely wide range applications, for example, different sensors, gear, medical procedure instruments. An immediate utilization of thermoelectricity is helpful for little and medium purpose and has low proficiency. But however, the efficiency could increase in the future. The combination of TE with many existing frameworks assumes a noteworthy job to improve their performance.

REFERENCES

[1]. R.A. Taylor and G. Solbrekken, “Comprensive system-level optimization of thermoelectric devices for electronic cooling applications” IEEE Transactions on Components and Packaging Technologies, Vol. 31, Issue 1, pp. 23-31, March 2008.

[2]. R. Radermacher and B. Yang, “Integrating Alternative and Conventional Cooling Technologies” ASHRAE Journal, Vol. 49, Issue 10, pp. 28-35, October 2007.

[3]. A. Kinikar, C. Jangonda, K. Patil, R. Bhokare and M. D. Gavali, “Review of Various Application of Thermoelectric Module” International Journal of Innovative Research in Science, Engineering and Technology, Vol. 5, Issue 3, pp. 3393-3400, March 2016.

[4]. R. P. Patil, P. Suryawanshi, A. Pawar and A. Pawar, “Thermoelectric refrigeration using Peltier effect” International journal of engineering sciences & research technology, Vol. 6, Issue 5, pp. 614-618, 2017.

[5]. C.X. Liu, X. F. Zheng, Y.Y. Yan, and Q. Wang, “A review of thermoelectric research –Recent developments and potentials for sustainable and renewable energy applications” Renewable and Sustainable Energy Reviews, Vol. 32(C), pp. 486–503, 2014.

[6]. A. Mishra, M. Singh and S. Nirapure, “Thermoelectric Generator: A Review” IOSR Journal of Mechanical and Civil Engineering, Vol. 12, Issue 3, Ver. III, pp. 40-45, May. - Jun. 2015.

[7]. J. G. Vian, D. Astrain and J. Albizua, “Computational model for refrigerators based on Peltier effect application” Applied Thermal Engineering., Vol. 25, Issues 17-18, pp. 3149–3162, Dec. 2005.

[8]. A. N. Nikam and Dr. Jitendra A. Hole, “A Review on use of Peltier Effects” Pratibha: International Journal of Science, Spirituality, Business and Technology (IJSSBT), Vol. 2, No. 2, pp. 6-12, May 2014.

[9]. C. Alaoui, “Peltier Thermoelectric Modules Modeling and Evaluation” International Journal of Engineering (IJE), Vol. 5, Issue 1, 2011.

[10]. K. Narang, A. Venugopal, K.Prakash and Mukund Joshi. “Cost-effective Refrigerator Using Thermoelectric Effect and Phase Change Materials” International Journal of Scientific & Engineering Research, Vol. 5, Issue 2, pp. 624-627, Feb. 2014.

[11]. R. Wang, Y. Dai and L. Ni, "Experimental investigation on a thermoelectric refrigerator driven by solar cells" Renewable Energy, Vol. 28, No. 6, pp. 949-959, May 2003.

[12]. G. Karimi, J. Culham and V. Kazerouni, "Performance analysis of multi-stage thermoelectric coolers" International Journal of Refrigeration, Vol. 34, No. 8, pp. 2129-2135, Dec. 2011.

[13]. J. Chen, Y. Zhou, H. Wang and J. T. Wang, "Comparison of the optimal performance of single- and two-stage thermoelectric refrigeration systems" Applied Energy, Vol. 73, No. 3-4, pp. 285-298, Nov.–Dec. 2002.

[14]. D. Zhao and G. Tan, "A review of thermoelectric cooling: Materials, modeling and applications" Applied Thermal Engineering, Vol. 66, No. 1–2, pp. 15-24, May 2014.

[15]. F. Y. Zhao, D. Liu, H. X. Yang and G.F. Tang, “Thermoelectric mini cooler coupled with micro thermosiphon for CPU cooling system” Energy, Vol. 83, pp. 29-36, Apr. 2015.

[16]. Y. Zhou and J. Yu, “Design optimization of thermoelectric cooling systems for applications in electronic devices” International Journal of Refrigeration, Vol. 35, pp. 1139-1144, 2012.

[17]. L. Huang, X. Sun, Y. Yang, H. Zhang, H. Si, S. Liao and X. Gu “Experimental research of a thermoelectric cooling system integrated with gravity assistant heat pipe for cooling electronic devices” The 8th International Conference on Applied Energy-(ICAE-2016), Energy Procedia, Vol. 105, pp. 4909 – 4914, May 2017.

[18]. N. Espinosa, M. Lazard, L. Aixala and H. Scherrer, “Modeling a thermoelectric generator applied to diesel automotive heat recovery” Journal of Electronic Materials, Vol. 39, Issue 9, pp. 1446–1455, Sept. 2010.

[19]. A. Chen and P. K. Wright, “Medical Applications of Thermoelectrics (chapter-26)” of ‘Modules, Systems, and Applications in Thermoelectrics’, Vol. 2 (reedited by D. M. Rowe), CRC Press, 2012.

[20]. N. Marati, Haarica.V, et al “Design and Development of Solar Umbrella Based on Peltier Effect” International Conference on Computing, Power and Communication Technologies (GUCON), pp. 853-856, 2019.

[21]. A. P. J. David “Thermoelectric Generator: Mobile Device Charger” International Conference on Recent Trends in Engineering and Technology, pp. 7-11, 2017.

[22]. A. K. R. Sombra, F. C. Sampaio, et al “Digital Temperature Control Project Using Peltier Modules to Improve the Maintenance of Battery Lifetime” IEEE International conference on industry application, pp. 1-7, 2016.

[23]. Akshata P. Y, Vikram S. Y and S. B. Deshmukh “Design Manufacturing and Experimental Analysis of Thermoelectric Lunch Box” International Journal of Engineering Research and Technology, Vol. 10, pp.757-761, 2017.

[24]. N. Dipova “Design and Development of Peltier Assisted Infrared Drying Based Soil Moisture Content Device” KSCE Journal of Civil Engineering, Vol. 23, pp. 29-36, 2019.

[25]. G. Ruzza, L. Guerriero, et al “A Low-Cost Chamber Prototype for Automatic Thermal Analysis of MEMS IMU Sensors in Tilt Measurements Perspective” Sensors, Vol. 19, 2019.

[26]. Harikrishnan.B and Sathil.P.T “Experimental Investigation and Thermal Analysis of Radiant Floor

Cooling System Incorporated with Peltier Effect" International Journal of Innovative Research in Science, Engineering and Technology, Vol. 6, pp. 9070-9078, 2017.

[27]. R Sathiya, R. R. S. Pavithra and C. Harini "IoT Based Hybrid Power Generation and Management using Solar and Peltier plate" International Journal of Pure and Applied Mathematics, Vol. 119, pp. 1017-1022, 2018.

[28]. Applied Thermoelectric solutions. Accessed March 08, 2020. https://thermoelectricsolutions.com