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Electricity Generation From Waste Thermal Energy Source Using Peltier Module

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ABSTRACT

Devices like automobiles, stoves, ovens, boilers, kilns and heaters dissipate large amount of waste heat. Since most of this waste heat goes un-used, the efficiency of these devices is drastically reduced. A lot of research is being conducted on the recovery of the waste heat, among which Thermoelectric Generators (TEG) is one of the popular method. TEG is a semiconductor device that produces electric potential difference when a thermal gradient develops on it. This paper deals with the study of performance of a TEG module for different hot surface temperatures. Performance characteristics used here are voltage, current and power developed by the TEG. One side of the TEG was kept on a hotplate where uniform heat flux was supplied to that. And the other side was cooled by supplying cold water. The results show that the output power increases significantly with increase in the temperature of the hot surface. The benefit of this generation system is that electricity produced is green with no emission.

Keywords : *Thermo electric generator, Peltier module, Green energy.*

1. Introduction:

The aim is to develop a low cost, efficient and userfriendly thermoelectric generation system that will generate sufficient electrical energy for backup in case of power cut. The generation system is aimed to utilise solar heat as well as waste heat sources like steam boilers, large engines, kilns. Today's renewable energy market is not suited to common people. The cost of the system, bulky design repels people from utilizing photovoltaic solar panels for electricity generation. The thermoelectric generator model will be overcoming these challenges, being portable yet affordable so that it will be in reach of common people.

2. Literature Review:

The scope of electricity generation from peltier by utilising waste thermal energy sources was discussed in Thermoelectric waste recovery [1]. With the help of conceptual structure of [2] which highlighted the linkages between the effects of temperature difference on voltage generated.

In this book Thermoelectric: Design and Materials [3], in their work on improving the voltage and current generation by series and parallel combination. In principle of thermal collection [4] which is used for reference for designing the model prototype for better collection of solar energy.

3. Problem Statement:

The conventional solar panel systems are costly, heavy and bulky and hence are not portable. The size of a typical 30Watt solar panel is 426*680*80 mm weighting around 3.5kg, making them highly inconvenient for transportation or attaching to electric vehicles or solar powered vehicles as they require large space which is a constraint in an automobile design.

The main challenge that comes in designing a thermoelectric generator is the efficiency of the generator which is very low. Thermoelectric module works on See-beck effect which requires a minimal temperature difference between two sides named as hot panel and cold panel. If the temperature difference is maintained ideally the efficiency of the thermoelectric module is improved and one get rated output voltage. One has to design a cooling system comprising of a heat sink and a fan which acts heat exhauster and helps in maintaining the temperature between the two sides of the thermoelectric module. After this stage one need to regulate the voltage as the output module is non uniform and contain ripples.

4. Working:

The thermoelectric effect is the direct conversion of heat into electricity. According to Joules Law, a current-carrying conductor produces heat proportional to the product of the resistance of the conductor and the square of the current passing through it. In the 1820s, Thomas J. Seebeck tested this law by interpreting it differently. He brought two dissimilar metals where the junctions at which the metals touch are of different temperatures. He noticed that a voltage developedbetween the junctions proportional to the difference in the heat. The current generated due to the difference in temperature at the junction of two different metals is known as the Seebeck Effect. The Seebeck Effect produces measurable amounts of voltage and current.

5. Peltier Module:

Two important thermoelectric materials are Bismuth Telluride (Bi2Te3) at room temperature 9K (acting as the cold side) and Lead Telluride (PbTe), which is at 500K to 600K (acting as the hot side). These thermoelectric materials have a metric of measure that helps to evaluate the thermoelectric properties of the material; this measure is known as the figure of merit. The figure of merit for Bismuth Telluride (Bi2Te3) and Lead Telluride (PbTe) is one at the aforementioned temperatures. To be a viable source of credible power, the figure of merit must be 2 to 3.There are numerous other factors that also need to be considered in the selection of a thermoelectric material. Ideally, a thermoelectric material must have a wide temperature gradient. If it does not have a wide temperature gradient, it will be susceptible to heat-induced stress, which might lead to the fracture of the material. The mechanical properties of the materials must be considered, and the coefficient of thermal expansion of the n-type and p-type materials must be matched reasonably well as shown in Fig.1.

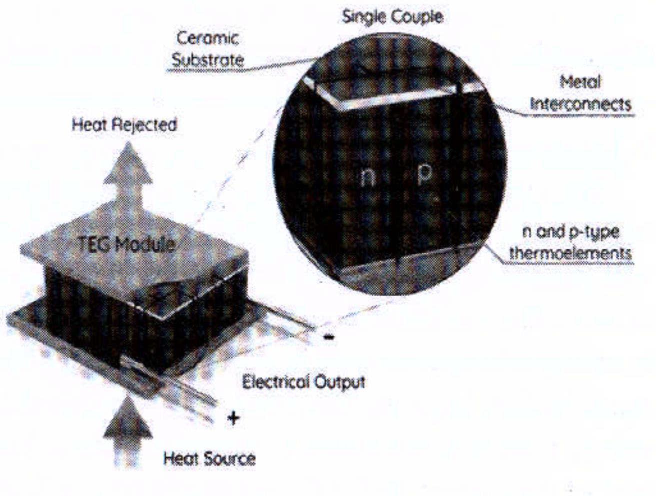


Fig. 1 Thermoelectric module

6. Fresnel Lens:

A fresnel lens is a type of composite compact lens. Since plastic Fresnel lenses can be made larger than glass lenses, as well as being much cheaper and lighter, they are used to concentrate sunlight for heating in solar cookers, in solar forges, and in solar collectors used to heat water for domestic use. They can also be used to generate steam or to power a Stirling engine.

Fresnel lenses can concentrate sunlight onto solar cells with a ratio of almost 500:1. This allows the active solar-cell surface to be reduced, lowering cost and allowing the use of more efficient cells that would otherwise be too expensive.

7. Experimental Setup:

1. The uppermost part of the prototype is a Fresnel lens, which will be responsible for concentrating the sun rays and focusing it on the copper plate for even temperature and heat distribution.
2. The top surface of the peltier module is in contact with the copper sheet for getting hotter side.
3. The peltier module is affixed in an aero-gel sheet. The purpose of using aero-gel sheet is to prevent excessive heat transfer from hot copper plate to cold water.
4. The bottom or cold side of the peltier module comes in contact with the brine solution. The brine solution extracts heat from cold side at a higher rate than normal water.
5. The bottom part is water tank for holding the brine solution. This water tank also contains the peltier cooler for cooling brine solution continuously for maintaining temperature difference. The exploded design as shown in Fig.2. and test setup in Fig.3.

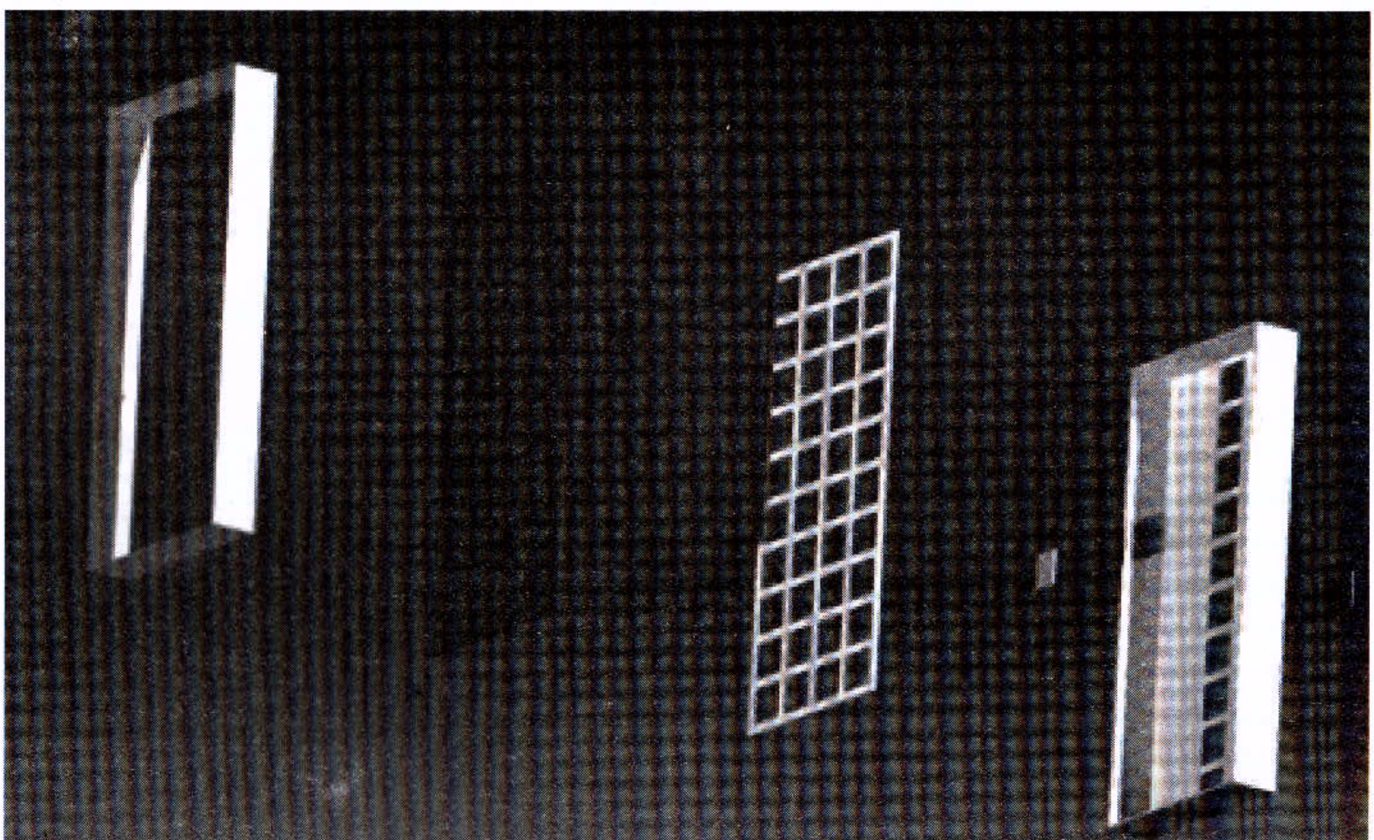
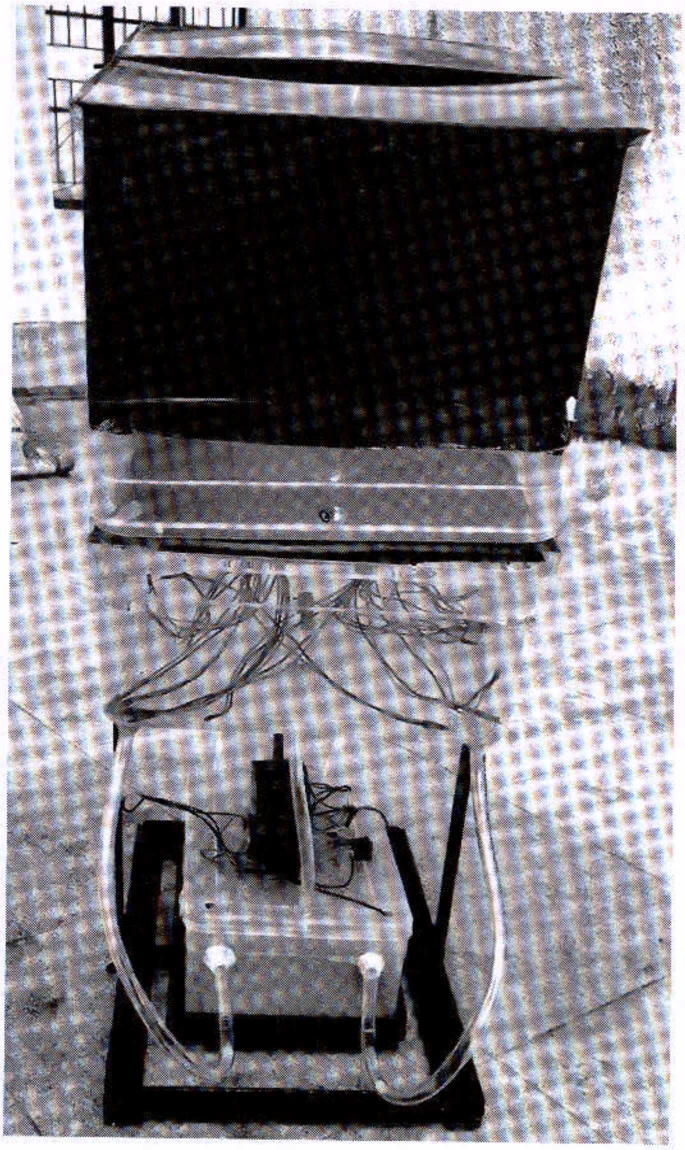


Fig. 2 Exploded view of peltier module design



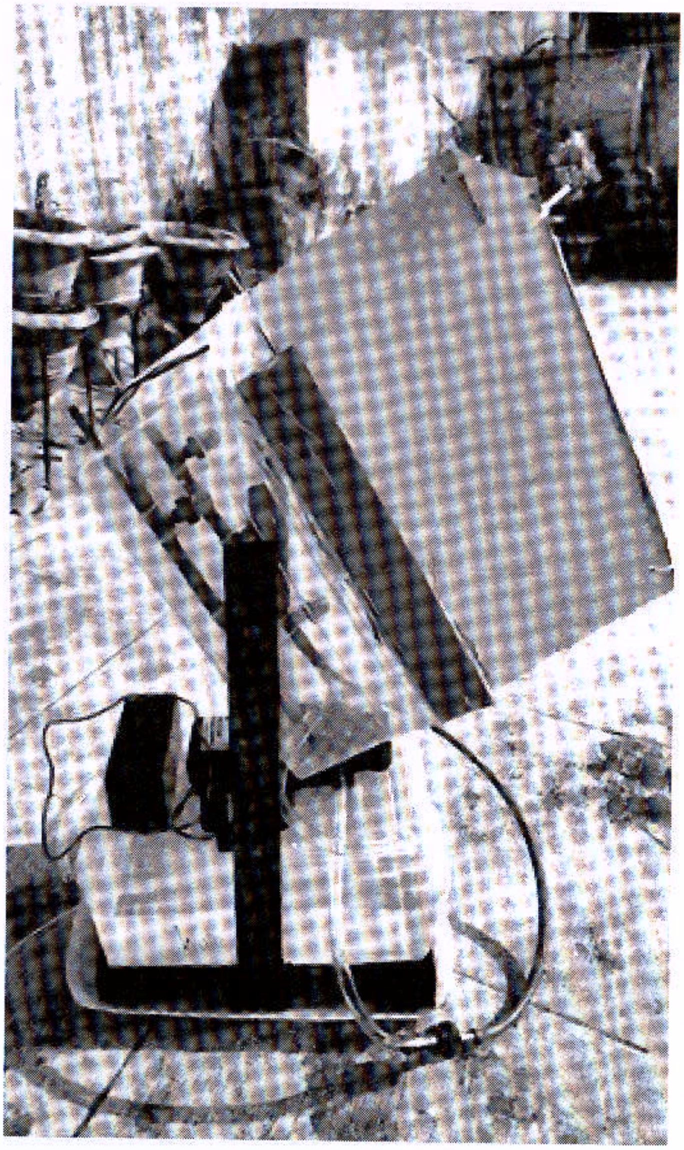


Fig. 3 Actual Prototype using Peltier Module

8. Results:

The following outcome was observed for a Peltier module of size 5 cm x 3 cm which is thermoelectric bismuth tellurid. The maximum temperature difference was 328 ^{o}C and it produced an output of 200 mA and 2.51 V as given in Table 1. These thermo electric generators having low conversion efficiency, higher temperature differences are required to produce higher efficiency.

The sudden drop in voltage generation is due to environmental factors and drop in temperature difference as shown in Fig.3.

Table 1 Exeperimental results

Amperes Gen (mA)	Voltage Gen (Volts)	Warm Side Temperature (Celsius)	Cold Side Temperature (Celsius)	Temperature Difference (Celsius)
2.5	0.45	220	40	180
50.2	0.9	280	46	234
141.2	2.45	367	63	304
120	1.94	325	50	275
200	2.51	380	52	328
190	2.23	330	44	286
170	2.09	367	56	311

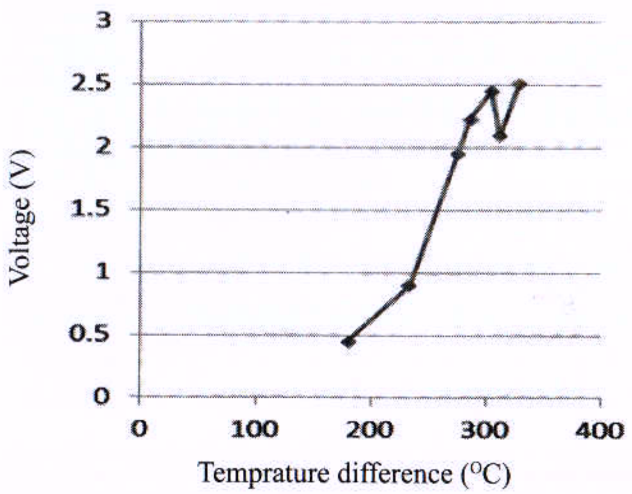


Fig. 3 Peltier module voltage versus temprature difference

Power generated in milli Watts (mW)

Power = Current (mA) X Voltage (V)

Minimum power generated = 2.5 X 0.45 =**1.13 mW**

Maximum power generated = 200 X 2.51=**502 mW**

Merits

1. Can be installed on different devices, EV's.
2. Low cost.
3. Compact design
4. Recycles waste heat energy.

Demerits

1. Low energy conservation efficiency rate.
2. Slow technology progression
3. Requires relatively constant heat source.

9. Conclusion

Thermoelectric module is a good way of utilizing CHP or co-generation. This will greatly contribute in increasing the efficiency of co-generation plants, since most of the waste heat gets utilized. The amount of electricity generated depends on the characteristics of the heat source, heat sink and design of the thermoelectric generator. The experimental data shows the electricity generation using solar thermal that is heat is concentrated on thermoelectric generator hot side. However this proves to be less efficient way of electricity generation since the heat transfer on the thermoelectric module is not uniform, but the effectiveness and efficiency of generation increases as one switch to utilizing waste heat such as automotive exhaust, gas stoves, hot water pipelines etc.

References

1. C. Yu, K.T. Chau, 2009, Thermoelectric automotive waste heat energy recovery using maximum power point tracking, Energy Conversion and Management, 50 (6) : 1506-1512.
2. G. Rohit, D. Manaswini, Vinod Kotebavi, and Nagaraja S R, 2017, Performance of study of thermoelectric generator, AIP conference proceding, 1859 (1): 020094.
3. HoSung Lee, 2016, Thermoelectrics: Design and Materials, John Wiley and Sons Ltd.
4. S.P. Sukhatme and J.K. Nayak, 2008, Solar Energy: Principles of Thermal Collection and Storage, Tata Mc Graw Hill Education.