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Design and Analysis of Thermoelectric Generator module

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ABSTRACT: In contempt of increase in demand of electricity and depletion of fossil fuels, a thermoelectric generator module (TEG) can be used. TEG is a device that can be used to convert waste heat energy directly from the heat source into electricity at the junction of wires. It can also be used to provide the ample amount of electricity to the oil and gas industry to power remote monitoring system. Also, it is a latest technology in electronics and non-conventional energy.

In this analysis, we obtained high temperature difference due to more heat dissipation across the heat sink by varying the thickness of the substrate and also we increased the number of fins for proper cooling of the substrate at faster rate in normal conditions.

Keywords: TEG module, Thermal Grease, Heat sink, Semi-conductors

1. INTRODUCTION:

A decrease in supply of fossil fuels due to more utilization and losses are getting extinct. Hence use of alternative resources, TEG is one of such example and also a part of Green Technology with many good advantages. It works on Seebeck effect. It can be used in various applications such as Automobile Thermoelectric Generator (ATG), Radioisotope thermoelectric generator, electrical devices such as microprocessor, etc. Using TEG a great sum of heat would be recovered and converted into electricity, also it reduces load in automobile on ICE, alternate loads and decrease in fuel consumption. It has its own advantages:- Simple, compact, safe, lower weight, environmentally friendly.

"Seebeck effect" states that due to the temperature difference between the two dissimilar electrical conductors or semiconductors, it produces a voltage difference between the two substances. This conversion take place due to transfer of charges at the junction of electrical wires. We can also increase the efficiency and performance of the generators. In Seebeck, effect DC electricity is proportional to the thermal difference created across the thermoelectric module and the heat sink. With the increase in this temperature difference, an actual input of power produced can be increased.

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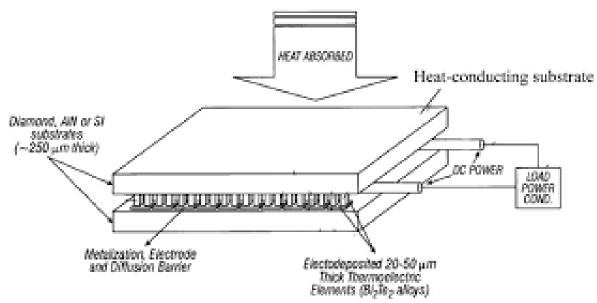

Fig.1: Thermoelectric Generator

2. OBJECTIVE:

Our main objective is to provide better output at low cost and decrease the pollution, also reduce the energy losses. Also, to replace the Green Technology with high cost depleting resources. We have also aimed to use the energy released from the refrigerators, automobile exhausts, and from the human body to produce more energy in the form of electricity by making waste energy as its heat source.

- To design and construct heat sink to obtain high efficiency, by raising its voltage.
- To maintain uniformity in heat flow from TEG module to heat sink and nullify the voids present in between the two module and sink when they both are kept attached to each other.
- To reduce scaling between source, module and sink.
- To find out various application of TEG.

3. PROBLEM DEFINATION:

Nowadays demand for power is increasing and there is no proper usage of depleting source of energies. It leads to increase in pollution, global warming and causing greenhouse effect in the environment which effect the depletion of ozone layer. The cost of electricity generation is increasing and there is shortage of supply with increase in tremendous demand. Also the fossil fuels are imported from Arabian countries with high cost. Hence there is a need for alternative technology to bring them under control. TEG is a source of generating electricity w/o any hazardous effect on environment and human life both .Its application has a drawback in big industries due expensive solar panels and large size of heat sinks.

Some of the problem statements are:-

- Different methods to charge smartphone anywhere at any time.
- Charging of automobile by using exhaust heat energy.
- Utilization of heat generated from human body during winter and summer in various applications.

4. METHODOLOGY:

A. 3D Modelling Of TEG Module

The TEG Module is designed according to proper design considerations .The three dimensional computer graphics deals with the generation of three dimensional model of a TEG Module using three dimensional software Autodesk Inventor. From the geometric modelling, the detail two dimensional drawings of the TEG Module can be created automatically.

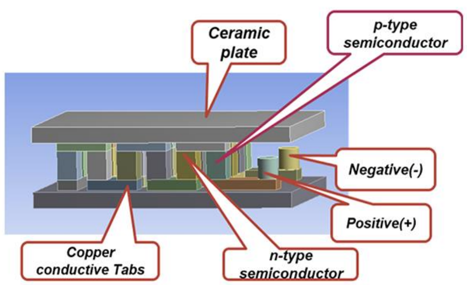

Fig.2: Overview of TEG model

B. Design Considerations

The main design consideration is to increase the efficiency of the module by creating high temperature difference along the elements. This can be achieved by using heat sink having high heat transfer rate. In normal elements there is decrease in temperature flux across the sink but we have optimized our results by decreasing the thickness on the hot side of module which leads to high heat dissipation and by increasing the thickness on the cold side of module for faster rate of cooling. In short we have taken the following considerations:-

1. Thickening of substrate on hot side of module.
2. Thinning of substrate on cold side of module.
3. Increase in the number of fins in heat sink.

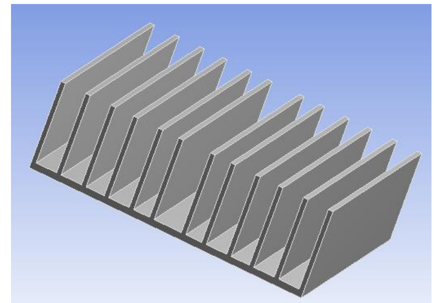

Fig.3: 3D Model of Heat Sink.

5. MATERIAL SELECTION:

While selecting the material for TEG, it must have low lattice thermal conductivity, high Seebeck effect and high electrical conductivity. There are two different materials present in actual thermoelectric. The selection is made by calculating the efficiency of thermoelectric device for electric generation and the figure of merit.

Efficiency for TEG device,

$$\eta_{\max} = \frac{T_H - T_C}{T_H} \frac{\sqrt{1+Z\bar{T}}-1}{\sqrt{1+Z\bar{T}}+\frac{T_C}{T_H}}$$

(Eq.1)

Figure of merit for TEG device,

$$ZT = \frac{\sigma S^2 T}{\kappa}$$

(Eq.2)

where,

k =Thermal conductivity,

S= Seebeck coefficient,

σ=Electrical conductivity,

TC=Temperature on cold side,

TH=Temperature on hot side.

Also the material is selected from the below ZT vs T graph,

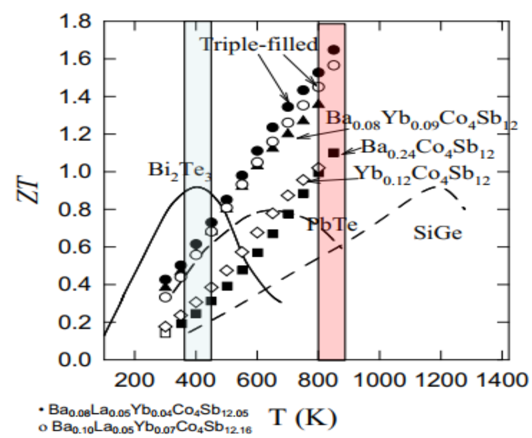

Fig.4: Figure of merit Vs Temperature (K).

The graph suggests that:

Table No. 1 Properties of materials obtained from ZT vs T (K) graph

Material	Seebeck Coefficient 'S'	Thermal Conductivity 'k'	Electrical Resistance	ZT
Insulator	High	Low	Very high	Too small
Metals	Low	Very High	Very low	Too small
Semi-conductors	Adequate	Low	Acceptable for doping	Adequate

From the above data we have selected 'Bi2Te3' material because of better mechanical properties, operating temperature 125ºC-525ºC,p-n leg type TE, Low value of 'k', ZT>1,easily available ,inexpensive, environment friendly.

Table No.2 Specifications of TEG Module

Sr.No	Specification	Values
1.	Model no.	TEG1-12610-5.1
2.	Seebeck Coefficient 'S'	250-350uV
3.	Thermal Conductivity 'k'	2.2-3 w/m .k
4.	Electrical Conductivity 'σ'	900-1200(rou)
5.	Max. Voltage	3.9 volts
6.	Max. Current	1.3 amp

6. RESULTS AND DISCUSSIONS:

A. Meshing of heat sink

The meshing is done to find out the geometry of the material, its nodes and number of cells. Here the default meshing is chosen and coarse meshing is done according to its manufacturing technique. The element size is taken as 2.5mm and minimum edge limit as 2.0mmm.

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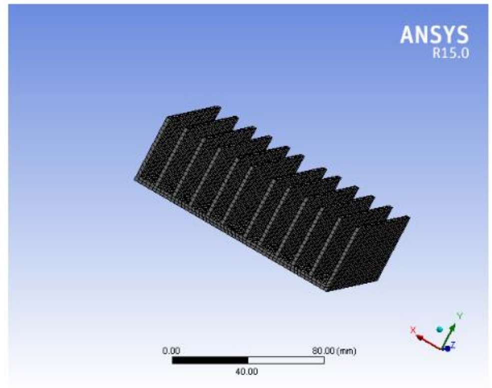

Fig.5: Meshing of heat sink

B. Temperature gradient of heat sink

After the temperature gradient is applied the maximum and minimum values of temperatures are identified on the heat sink (min-33ºC to max-35ºC).

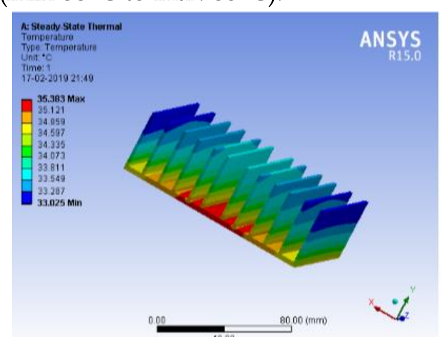

Fig.6: Temperature gradient of heat sink

C. Total heat flux of heat sink.

Considering the heat sink is cooled by forced convection with air. Assuming a heat transfer coefficient as 200 W/m2K.The heat transfer coefficient is obtained from Nusslet no. The air flow is taken as laminar with small fin spacing and less air velocity.

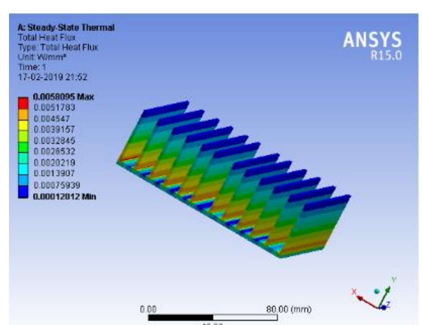

Fig.7: Total heat flux of heat sink

7. CONCLUSION:

In this analytical model, the thinning and thickening of substrates on the hot and cold side results in final increase in the efficiency and power output. To obtain better results thermal resistance must be taken into consideration. When we combined both TEG and heat sink an optimum rate of flow is shown which is balancing the medium of forced convection and TEG. Increasing the height has its own advantage but it is limited during the manufacturing processes. Out of folded, extruded, skived and bonded heat sinks the skived and the folded shown better results. The model is important for comprehensive understanding of heat conversion into electricity through TEG. The simulation is helpful for selecting the working parameters and the optimum conditions required for results. Also the parameters for selection of module is given so as to compare it easily with the other modules.

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9. REFERENCES:

[1] Sania LeBlanc, Thermoelectric generators: Linking material properties and systems engineering for waste heat recovery applications. Washington, DC 20052, USA. Science Direct, 2014.

[2] A K M, Muhammad Yazid Ameer, Investigation of aluminum heat sink design with thermoelectric generator, ser. Mater. Sci. Eng. 184 012062, Kuala Lumpur, Malaysia, 2017.

[3] Shripad Dhoopagunta, M.S.E, "A novel Analytical Modelling and Numerical Simulation of a Thermoelectric Generator", Western Michigan University, 2016.

[4] Diana Davila Pineda, Oliver Brand, and Gary.K.Fedder (2007) "Thermoelectric Energy Conversion: Basic Concepts and Device Applications," ser. Notes, Wiley-VCH Verlag GmbH.

[5] Chen, J., Lin, B.E, Lin, G, "Optimal Design of a muli-couple thermoelectric generator", J.Semiconductor Science and Technology 2(15), 184-188, 2000.

[6] TEC website. [Online]. Available: http:// www.Thermoelectric-generator.com.

[7] TEC Module website. Available: http:// www.rmtltd.ru/products/temodules.

[8] "Thermoelectric Cooling Temperature Controller data sheet," Meerstetters Engineering, Schulhausgasse 12 3113 Rubigen, Switzerland.