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Design and Objective of Thermo-Electric Generator

Sana Ullah Khan, Muhammad Iftikhar Khan, Feroz Shah, Sadiq Ali, Arshad Ali khan

***Abstract*—** Waste heat is created as an outgrowth in many process such as driving vehicles, running, cooking, electricity generation, working on computer etc. if we perform any task in the result decay warmth is created. Now large amount of spend warmed is create by the industries. Thermoelectric generator is one of the system of the power generation. Thermoelectric generator is a system which change warmed straight forwardly into electricity by utilizing a procedure called the "Seebeck impact". In this paper i will suggested a thermoelectric generator which will utilize waste spend heat sap by the place for development of electric power. This recommended system depend on thermopiles and is called as bismuth telluride (Bi_2Te_3). Every system have two types of cost such as device and running or maintenance cost. But this system have no running cost because decay heat is the input source for this system. In our proposed design we use the digital circuit of thermometer, voltmeter, ampere meter to find the graph between decay warmth and generated power. By obtaining these graph we can easily calculate the efficiency of our proposed system.

***Keywords*—** Waste heat, Straight forwardly, Seebeck impact, Thermopiles, No running cost.

I. INTRODUCTION

Thermoelectric developer is one of the alternate and renewable source for the utilization of the decay warmth present in huge amount in the surrounding. Thermo-electric developer consists of thermoelectric contents known as Bismuth Telluride (Bi_2Te_3), utilize the seebeck impact which change decay warmth into electric power [1].

Seebeck impact:

German Physicist Thomas Johann Seebeck in 1821, initial invented the Seebeck conclusion. Seebeck initial noticed that the compass needle redirected when set in the region of a shut circle framed of two different metals with a temperature contrast between the intersections. This perception gives direct evidence that a current flow through the Shut circuit forced by the temperature contrast. A temperature contrast causes charge bearers (electron or hole) in the element to circulate from the warm side to the cool side. Versatile carrier transporters shift to the chill side and leave their adversely carrier which stable cores to the warm side along these lines offering ascend to a thermo-electric voltage. This development of carrier transporters on the cool side in the long run stops when an equivalent measure of charge bearers float backward to the warm side as a consequence of the electric field made by the carrier partition. Now at this phase, the substantial achieves unfaltering repeat. Just an expansion in temperature contrast is responsible to promote a development of extra carrier transporters to the cool spot and along these lines top to an expansion in the thermo-electric voltage. Now this voltage, is known as the thermo-electric emf, is produced by change in the temperature of two distinct elements i.e A and B for example, metal or semiconductor [2].

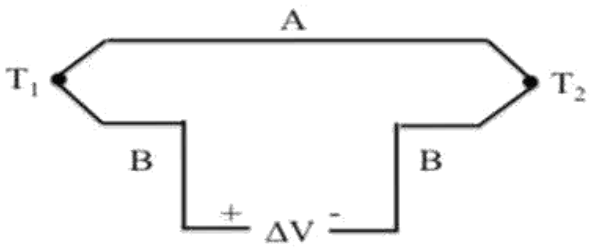

Fig 1. Seebeck Impact: Temperature Contrast Responsible to Generate Voltage at the joint of two Material A and B

$$\Delta V = (\alpha A - \alpha B)\,\Delta T \quad (1)$$

In equation (1), αA and αB are the Seebeck coefficients of different elements.

The graph 2 show the relation between the temperature contrast and generated voltage.

Bismuth Telluride Characteristics:

The characteristics of bismuth telluride are shown in table [3].

Sana Ullah Khan is a postgraduate student in Electrical Engineering Department University of Engineering and Technology Peshawar, Pakistan. Contact : +92-345-4840366, engrsanaullah51@gmail.com

Muhammad Iftikhar Khan is a Assistant Professor in Electrical Engineering Department Univeristy of Engineering and Technology Peshawar, Pakistan.

Feroz Shah is a Assistant Professor in Mechanical Engineerng Department University of Engineering and Technology Peshawar, Pakistan.

Sadiq Ali is a Lecturer in Electrical Engineering Department University of Engineering and Technology Peshawar, Pakistan.

Arshad Ali Khan is a Lecturer in Mechanical Engineering Department University of Engineering and Technology Peshawar, Pakistan.

TABLE I. CHARACTERISTICS OF BISMUTH TELLURIDE

Properties	
Thermopiles	Bismuth Telluride
Formula	$Bi_2 Te_3$
Molar Mass	800.8 g / mole
Power Density	0.055 mW/cm^2
Melting Point	585 ^{0}C
Appearance	Gray Powder
Density	7.7 g/cm^3

II. PROBLEM STATEMENT

Energy is concerned with the capability of a physical system to perform work. Energy assets is not the similar concept as "sort of energy". Sorts of strength mean kinetic strength, chemical strength and so on. "Strength Resources "is around method of capturing strength so we can create electric power. Now the main energy resources are fossil fuel, atomic power, hydroelectric power and solar energy. Solar penal convert the high frequency sun light into electric power, but the low frequency rays are present in the environment in the form of decay warmth. Decay warm is a warm which create as outgrowth in industry, electrical and many generation processes, among others. In All of them industry produce huge measure of decay warmth. Besides this, minimum-value warmth (warmth fount generally below 100 C^0) [4], is also present in common fount that is from geothermal reservoirs and sun vitality. For any heat engine, the principles of thermo-dynamics put essential restraint on the measure of useful force which is obtained. Table show the decay warmth and fuel performance for both diesel and petrol engines [5].

TABLE II. FUEL EFFICIENCY AND WASTE HEAT GENERATION

Engine type	Shaft Power	Cooling	Exhaust	Miscellaneous
	Percentage of fuel heating value			
SI (petrol)	25-28	17-26	34-45	5-15
CI (Diesel)	34-38	16-35	22-35	3-8

In electrical point of view the decay heat is also is generated in high transmission and distribution lines. The measure of the decay heat depend upon the voltage level if the voltage is low then decay heat is more and vice versa.

From the equations,

$$P = VI \quad (2)$$

Equation (2) , power flow in transmission or distribution line and

$$P = I^2 R \quad (3)$$

Equation (3), power loss in transmission or distribution line in form of heat.

As the world has confronting the power emergencies, so we need to discover the conceivable solution for this issue. One of the conceivable arrangements as to discover the bottlenecks in the current force framework to make it sufficiently productive to take care of the vitality demand of today. As traditional powers are draining so we need to change to interchange asset for power generation. Therefore thermoelectric developer is one of the alternate and renewable source for the utilization of the decay warmth present in huge amount in the surrounding. This developer has a benefit of being exceptionally straight forward having no rotating components, demanding little support and are along these lines ready to be utilized for well springs of warmth for which the universal Rankine cycle would be unsuitable, for example, which situated in distant or unfriendly situations [4]. For instance, in zone utilizations, thinking is given to their small weight and constancy in compression with warmth turbine [1]. Thermoelectric developer will save sufficient money through enhancing performance and will minimizing the fuel price and mover over being advantageous to the surrounding [6].

III. EQUIPMENT PERFORMANCE

Performance of the thermo-electric generator for electric power era is shown by η , and is describe below.

$$\eta = \frac{\text{Energy Provided to the Load}}{\text{Heat Energy absorbed at hot Junction}}$$

The greatest performance η_{max} is then given by,

$$\eta_{max} = \frac{T_H - T_C}{T_H} \frac{\sqrt{1+Z\bar{T}} - 1}{\sqrt{1+Z\bar{T}} + \frac{T_C}{T_H}}, \quad (4)$$

In equation (4), the temperature of the warm intersection point is express by T_H and the temperature of the chill side is express by T_C.

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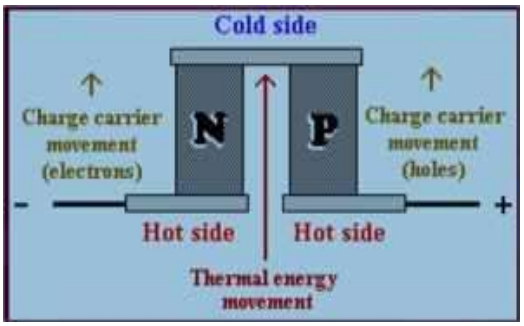


Fig 2. Single Thermoelectric Material

Fig shows that the electrons moves from blazing to chilled side. Since the electron excited more on the blazing side then the chilled one. The flow of electricity start by providing the entire circuit.

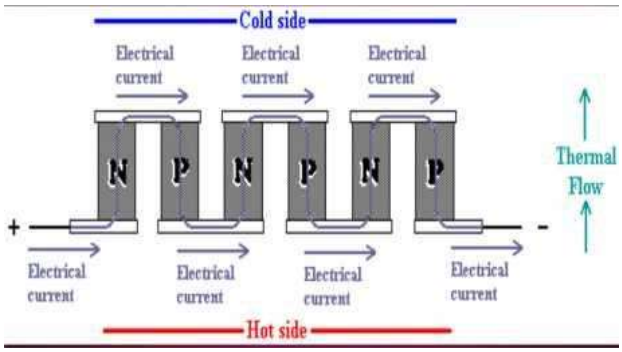


Fig 3. Series of Thermoelectric Material

Fig shows that thermoelectric material are arranged electrically in series arrangement and thermally in parallel arrangement.

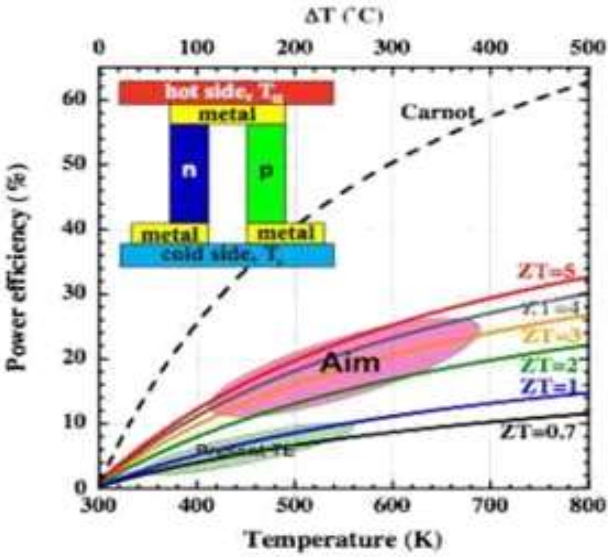
The reformed dimensionless character of credibility is ZT [6], and the performance of the equipment is based on ZT.

$$ZT = \frac{\sigma S^2 T}{\lambda} \tag{5}$$

In the equation (5) λ show the thermal conductivity, T show the temperature change, S show seebeck coordinate, σ show the electrical conductivity, thermo-electric substance focused on enhancing the seebeck collateral (s) and diminishing the warmth conductivity λ to enhance the electric conductivity σ [7]. Therefore the thermoelectric material are targeted to make thinner crystal, because of which the thermal conductivity is reduced and at low temperature more power will be generated.

That is why the dimensionless figure of credibility play important role in the performance of the thermoelectric generator.

If ZT=1, so this value is consider good. Now the value of ZT from 4-5 of thermo-electric substance will compete the mechanical generator in performance.



Graph 1. Show Dimensionless figure of Merit of Thermoelectric Material

IV. POWER FACTOR

Seebeck collateral is not by any means the only wide assortment that chooses the quality of a substance in a thermo-electric generator. Under specific heat expansive extent distinction, now capacity of substance which create valuable potential is measured with the help of power factor.

$$POWER\ FACTOR = \sigma S^2 \tag{6}$$

Components with excellent energy element can deliver extra vitality in a space-compelled plane, however these components are not really powerful. By consolidating these components in above arrangement so we upgrade existing and potential of thermoelectric generator.

TABLE III. OBTAIN DATA AT VARYING TEMPERATURE POINTS

Temperature in degree C	Voltage in volts	Current in mA	Power in mW
25	0.22	1.2	0.264
36	5.5	4.41	24.25
42	5.96	4.8	28.60
47	6.23	5.22	32.52
53	7.5	5.85	43.87
59	8.44	6.43	54.26
64	8.46	6.73	56.93
69	8.46	6.96	58.88
74	8.46	7.08	59.89
79	8.46	7.2	60.99

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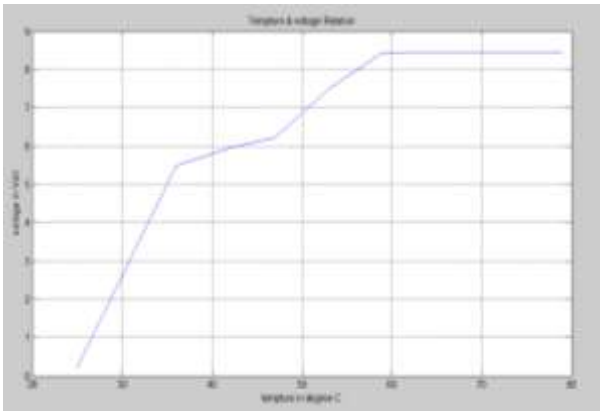
Table show the generated voltage, current and power at varying temperature and graphical results related to data is given below,

V. Graphical Results

The relation between temperature, voltage, current and power are shown in graphs below.
These graph are drawn in MATLAB

a. Voltage Temperature Graph

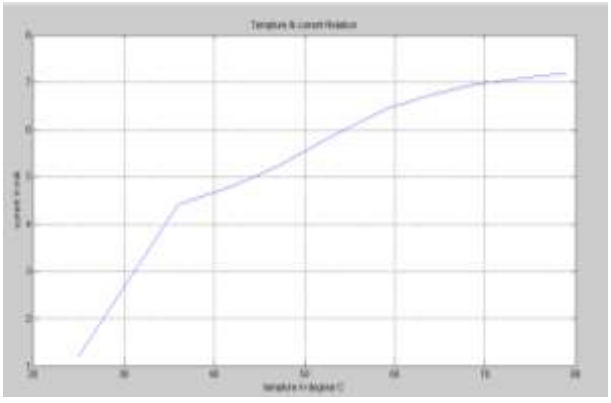
```
x=[25 36 42 47 53 59 64 69 74 79];
y=[0.22 5.5 5.96 6.23 7.5 8.44 8.46 8.46 8.46 8.46];
plot(x,y);
title('Tempture & voltage Relation');
xlabel('tempture in degree C');
ylabel('voltage in Volt');
grid on;
```



Graph 2. Show Voltage Temperature relationship

b. Current Temperature Graph:

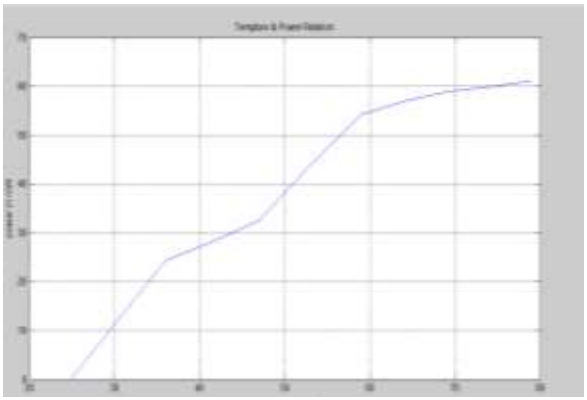
```
x=[25 36 42 47 53 59 64 69 74 79];
y=[1.2 4.41 4.8 5.22 5.85 6.43 6.73 6.96 7.08 7.2];
plot(x,y);
title('Tempture & current Relation');
xlabel('tempture in degree C');
ylabel('current in mA');
grid on;
```



Graph 3. Show Current Temperature relationship

c. Power Temperature Graph:

```
x=[25 36 42 47 53 59 64 69 74 79];
y=[0.26 24.25 28.6 32.5 43.87 54.2 56.93 58.88 59.89 60.99];
plot(x,y);
title('Tempture & Power Relation');
xlabel('tempture in degree C');
ylabel('power in mW');
grid on;
```



Graph 4. Show Power Temperature relationship

VI. Applications

Thermoelectric developers is related to a gathering of utilizations.

- Frequent space tests, containing the Mars Curiosity meanderer, produce power utilizing a thermo-electric developer whose warmth hotspot is a hot component [8].
- Now the animal body can also be used as a warmth hotspot for TEG [6].
- Trucks, buses and diverse autos create waste warmth (in form of sap gases create by the engines) Procuring this warmth vitality, by utilizing a thermo-electric developer, which rise the fuel capability of vehicles [9].
- Along with vehicles, waste warmth is additionally produced numerous different spots, for example, in modern procedures and in cooking. Once more, the waste warmth can be reused to produce power. Indeed, a few organizations have started ventures in introducing extensive amounts of these thermoelectric components [9].
- Sun controlled penal utilize only tremendous repeat segment of the light rays, although the minor repeat warmth does not use. A couple licenses round the utilization of thermo-electric contraptions with pair to sun situated penal has been recorded. Now this concept grow the effectiveness of the united sun controlled, thermo-electric arrangement to change over the sun based emission into significant power [9].

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- Thermoelectric developer is small in size therefore it can be placed on H.V transmission lines to generate electric power which is sufficient for online monitoring of transmission line through GSM, because the input voltage is 3 to 5 v.

VII. ADVANTAGES

Thermoelectric generator provide many particular recognitions over more technologies:

- The hardware of this developer is compact and hence it is a portable one.
- They are clear, light weight and protected.
- This developer is absolutely impressive (experimentally top 100,100 hour of constant action) and noiseless in action. Science it have no special rotating segments and demand extremely minor care;
- Noiseless in application or use
- Nil rotating segment
- This developer is efficient to work at high temperatures.
- This developer is favorable to the surrounding [8,9,10, 11].

VIII. PROPOSED METHDOLOGY

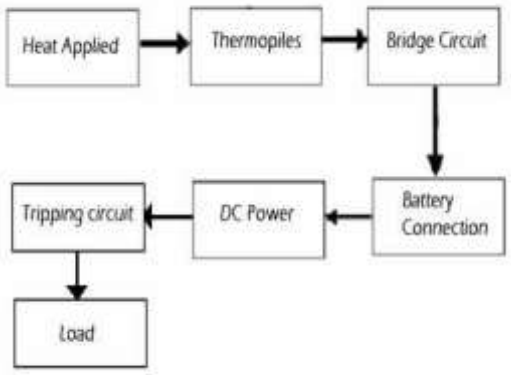

Fig 4. Block Diagram of Thermoelectric Generator

The contribution for this generator is decay warmth, which is accessible richly in surrounding environment. This warmth is connected to the thermopiles (Bi2Te3) by utilizing merging mirror to center the warmth on one side of thermopiles to have the temperature effect which are in charge of the generation of electric force. The bridge circuit is utilized to adjust the extremity naturally. Battery is utilized to store the produced power. Toppling circuit gives insurance to the generation section if there should arise a fault and keeps the battery from the discharge.

Duration operation we obtained the following graphs that are temperature vs power, temperature vs voltage and temperature vs current with the help of digital ammeter, voltmeter and thermometer, the value of temperature is measured by a heat sensor which is placed in the generation section.

CONCLUSION

Thermo-electric generator is utilize to produce electrical power from decay warm which is generated by various equipment's in factories, vehicles, cooking process, electrical transmission and distribution system etc. In this paper i present my recommended research in which i utilize a focalize reflector for establishing decay warm on thermopiles. I take the Bi2Te3 thermopiles with dimensionless figure out of benefits of 1.5 and the conclusion have proved that with the utilization of this focalizing representation we get a competent result. By connecting the load to the generation section therefore with the help of ammeter we calculate the current and voltage with voltmeter. The value of generated power as absorbed from graph is increased by increasing temperature on thermopiles at room temperature the generated power is low. The number of thermopiles is used in this suggested program is 3 which are thermally in parallel arrangement and electrical in series arrangement. Therefore the total generated on two junction is 8.46V and 7.2 mA at 79 degree C. The maximum output and calculated efficiency at 79 0C is 5%.

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Sana Ullah Khan is a Postgraduate Student in Electrical Engineering Department University of Engineering and Technology Peshawar, Pakistan
Contact: +92-345-4840366
Email: engrsanaullah51@gmail.com.

Muhammad Iftikhar Khan is a Assistant Professor in Electrical Engineering Department University of Engineering and Technology Peshawar, Pakistan.

Feroz Shah is a Assistant Professor in Mechanical Engineering Department University of Engineering and Technology Peshawar, Pakistan.

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