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Electric Power Generation from Waste Heat

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Abstract Waste heat is developed as a by-product in power generation, commercial procedures and electric machines, among others. Huge of spend warmed are designed by industry. Thermoelectric developer is one of the alternate sources for the growth of power. Thermoelectric developer is a device which transforms heat straight into electrical power, using a phenomenon called the "Seebeck effect". In this paper we will recommended a thermoelectric developer which will use invest warmed exhausted by the places for development of electric power. The suggested program will be depending on thermoelectric content known as bismuth telluride (Bi2Te3). This developer having no energy price because spend warmed is the opinions for this developer. In our suggested system we used voltmeters, ammeter and warmed wide range receptors to find the regards between the opinions warmed and the designed outcome power.

Keywords: *Seebeck effect, alternate, Electrical power, thermoelectric, invest heat*

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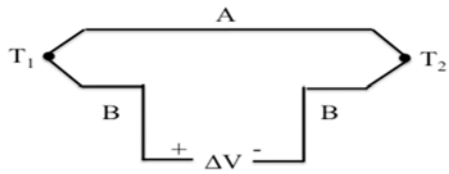
1. Introduction

A thermoelectric developer is an incredible system scenario that provides immediate power modification from warmed energy(heat) due to a warmed wide range mountain into electric power based on “Seebeck effect”. [1].

In 1821 Thomas Johann Seebeck, German physicist, first found the Seebeck impact. Seebeck first identified that a compass weblink deflected when placed in the position of a shut design identified of two different elements with a heated comprehensive extensive wide range distinction between the junctions. This statement provides immediate evidence that a current goes through the closed schedule inspired by the warmed wide range difference. A heat range distinction causes cost providers (electrons or holes) in the content to dissipate from the hot part to the cool part. Mobile cost providers move to the cool part and keep behind their oppositely billed and motionless nuclei at the hot part thus providing increase to a thermoelectric volts. The make up of cost providers on the amazing aspect gradually stops when an relative amount of cost providers move back to the hot aspect as a result of the power handled area designed by the cost separation. At this point, the content gets to stable state.

Only a rise in the heat range distinction can continue a accumulation of more charge providers on the cold side and thus lead to a rise in the thermoelectric volts. The voltage known as the thermoelectric emf, is created by a warm variety difference between two different elements (A and B) such as elements or semiconductors.



Seebeck effect: A temperature difference create a potential difference for the junction between materials A and B.

$$\Delta \mathbf{V} = (\alpha A - \alpha B)\, \Delta T \text{ [11]}$$

where, αA and αB are the Seebeck coefficients of components A and B, respectively.

Now the regards between the heated wide range and voltage as shown in Graph 1.

The features of Bi2Te3 are as under, [8].

Properties	
Molecular formula	Bi_2Te_3
Molar mass	800.761 g/mol
Appearance	grey powder
Density	7.7 g/cm^3
Melting point	585 °C

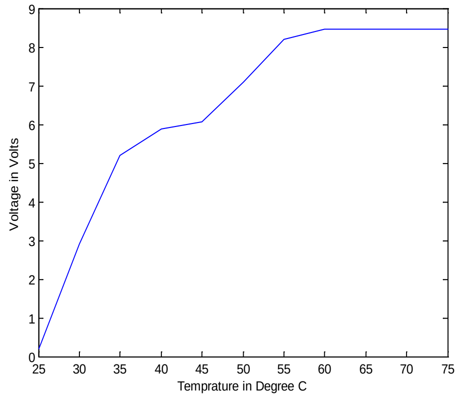
Performance of a thermoelectric content can be indicated with regards to the dimensionless figure out of benefit ZT.

$$ZT = \frac{\sigma S^2 T}{\lambda} \text{ [10]}$$

Where λ is thermal conductivity, T is the temperature, S is the seebeck coefficient, σ is the conductivity, thermoelectric content targeted on improving the see beck coefficient (s) and decreasing the heat conductivity λ to improve the electric conductivity σ.

Temperature vs Voltage:

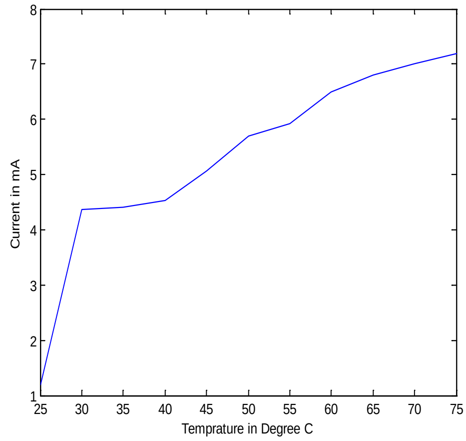
```
x=[25 30 35 40 45 50 55 60 65 70 75]
y=[0.2 2.9 5.2 5.89 6.07 7.1 8.2 8.46 8.46 8.46 8.46]
plot(x,y)
xlabel('Temprature in Degree C')
ylabel('Voltage in Volts')
```



Graph 1. show relation between temperature and voltage

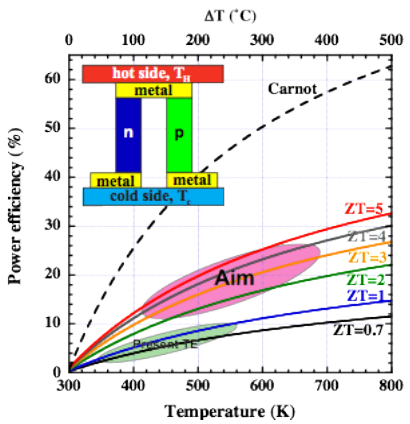
Temperature vs Current:

```
x=[25 30 35 40 45 50 55 60 65 70 75]
y=[1.20 4.37 4.40 4.54 5.06 5.70 5.93 6.50 6.80 7.00 7.20]
plot(x,y)
xlabel('Temprature in Degree C')
ylabel('Current in mA')
```



Graph 2. show relation between temperature and voltage

The value of ZT is if one then it will consider good. The value from 3 to 4 wide range for thermoelectric opponents with specific devices in performance such as mechanical generator. Up to 2012 the value ZT is reported 2.2.



2. Power Factor

The Seebeck coefficient is not the only broad variety that selects the strength of a content in a thermoelectric developer. Under a given warmed broad range difference, the ability of a content to produce useful power is quantified by its power factor,

$$POWER\ FACTOR = \sigma S^2$$

Components with excellent energy factor are able to produce more energy in a space-constrained program, but they are not actually effective.

3. Device Efficiency

The efficiency of a thermoelectric device for electricity generation is given by η, defined as

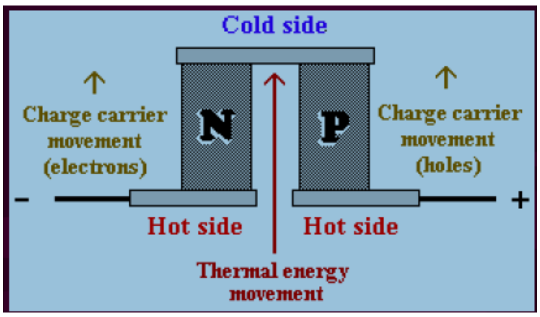
$$\eta = \frac{energy\ provided\ to\ the\ load}{heat\ energy\ absorbed\ at\ hot\ junction}$$

Which depends on the Seebeck coefficient S and electrical conductivity σ, in an actual thermoelectric device, two materials are used. The maximum efficiency η_{max} is then given by

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

Where T_H is the temperature at the hot junction and T_C is the temperature at the surface being cooled. $Z\overline{T}$ Is the modified dimensionless figure of merit, [9]

Semiconductor materials are the most efficient, and are combined in pairs of "p type" and "n type". The electrons flow from hot to cold in the "n type," While the electron holes flow from hot to cold in the "p type." This allows them to be combined electrically in series and thermally in parallel.

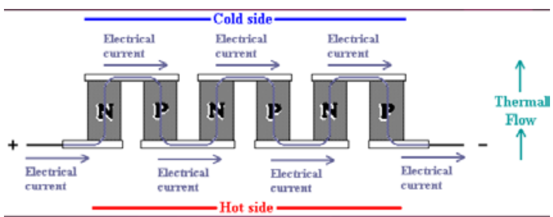


The electrons will move from the hot side to the cold side.

Because electrons on the hot side of a material are more energized than on the cold side.

If a complete circuit can be provided then electricity will flow.

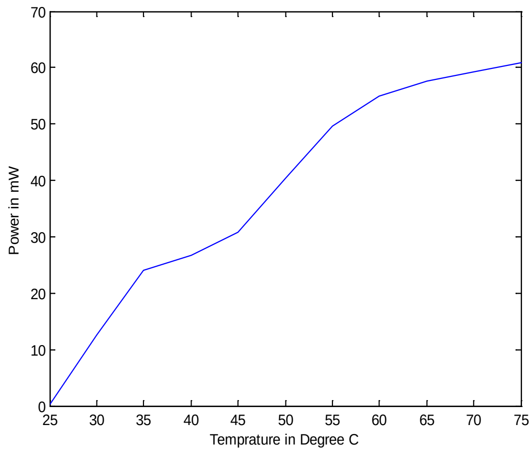
By combining these elements in series so we enhance existing and power output of thermoelectric developer.



The relation between the temperature and power output is shown in Graph 3.

Temperature vs power:

x=[25 30 35 40 45 50 55 60 65 70 75]
y=[0.24 12.67 24.01 26.74 30.71 40.47 49.60 55 57.52 59.22 60.9]
plot(x,y)
xlabel('Temprature in Degree C')
ylabel('Power in mW')



Graph 3. show relation between temperature and power

Thermoelectric generators can be applied in a variety of applications.

1.Many space probes, including the Mars Curiosity rover, generate electricity using a thermoelectric generator whose heat source is a radioactive element.

2.Human body is a heat source for TEG.

3.Cars and other automobiles produce waste heat (in the exhaust and in the cooling agents). Harvesting that heat energy, using a thermoelectric generator, can increase the fuel efficiency of the car.

4.In addition to in automobiles, waste heat is also generated many other places, such as in industrial processes and in cooking. Again, the waste heat can be reused to generate electricity. In fact, several companies have begun projects in installing large quantities of these thermoelectric devices.

5.Solar cells use only the high frequency part of the radiation, while the low frequency heat energy is wasted. Several patents about the use of thermoelectric devices in tandem with solar cells have been filed. The idea is to increase the efficiency of the combined solar/thermoelectric system to convert the solar radiation into useful electricity.

6.The power loss in the transmission line can be recovered by using TEG.

Thermoelectric developer provides several unique benefits over other technologies:

1.They have very small size.

2.They are easy, lightweight and safe;

3.They are really effective (typically exceed 100,000 hours of steady-state operation) and quiet in operation. Since they have no particular moving parts and need significantly less maintenance;

- Silent operation
- No moving parts

4.They are able of working at raised temperatures

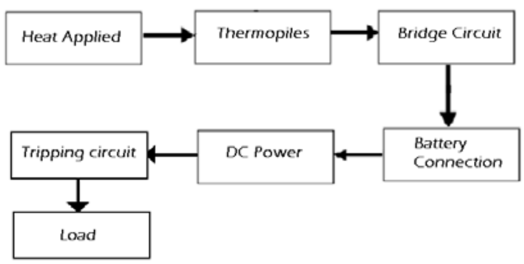
5.They are environmentally friendly;

6.They are appropriate for small-scale and far away programs common of non-urban source of energy, where there is limited or no power [2,3,4,5].

4. Problem Statement

Development can be evaluate by a country's power consumption in creating nations industry is the biggest customer of power. In developing countries about 22% of people having no access to electric power. As the globe has being affected by the power crises, so we have to discover out the possible remedy for this problem. One of the possible alternatives as to discover out the bottlenecks in the existing energy program to create it effective enough to fulfill up with the energy need of these days. As traditional fuels are depleting, so we have to modify to different resource for power production. To apply the substitute resources of energy, to compensate the gap between supply and demand of electrical power. The most substitute resource of power in universe is the sun, so we implement the warming effect of sun as a mean of growth of power by design known as thermoelectric developer. Moreover, low-grade warmed (heat resources approximately under 100°C) [6] is also available from natural sources such as geothermal tanks and solar panel technology. Restoring this warm into useful power would preserve a lot of money through enhancing performance and reducing power expenses as well as being useful to the surroundings [7]. For any heated engine, the recommendations of thermodynamics place essential limitations on the quality of useful energy which can be created**.** Due to the need for any creation process to eliminate warm, the portion of warm which may be transformed relies on the consumption and fatigue temperature, with lower temperature ranges being less efficient. However, since such a lot of warmed is easily available, now the problem is that to select one of the business economics technology and settings which generates the best using of warm. Now thermoelectric developer is the most economic technology for the utilization of this warm. Thermoelectric generator requires two types of cost that is device cost and operating cost. The operating cost is negligible because the input for this generator is waste heat which is available freely. Power loss in transmission line in the form of heat and we can recover this power loss by using thermoelectric generator placed on transmission line because it is the portable one.

5. Proposed Methodology



The opinions for this developer is spend warmed, which is available abundantly in nature. This warmed is used to the thermopiles (Bi2Te3) by using converging representation to focus the warmed on one factor of thermopiles to create the warmed wide variety difference which are responsible for the development of electric power. In DC generation the proper polarity connection is necessary so for this purpose we use bridge circuit to correct polarity instantly. Battery is used to store the extra generated power when we need then we use it. Tripping circuit which contains (solid state relay, operational amplifier and potentiometer) is used to provide protection to the generation section in case of fault on load side and also stops the battery from the release.

6. Conclusion

Thermoelectric developer is used to provide electric power which is designed from spend warmed produce by different equipments in industry, transmission line etc. In this paper we provided our suggested analysis in which we use a converging reflection for concentrating warmed on thermopiles. We took the Bi_2Te_3 thermopiles with dimensionless figure out of advantages of 1.5 and the results have confirmed that with the use of this converging representation we get an efficient result. when the load is connected to the generation section so we calculate the current with help of ammeter circuit. Graph 3, show the relation between the current and temperature.

From the graphs we observed that at room temperature the value of current and voltage is small, so that's why there is no significance power output. The number of thermopiles in our project is three(3) which provide two junctions, which are connected electrically in series and thermally in parallel. The voltage at the junction is (3.9 to 4.2) volts. At 75°C our system give maximum output , and the calculated efficiency of our system is 4.2%.

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