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Research Article

Thermo Electric Generator (Future renewable energy source)

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Abstract

Electricity has become a necessity for everyone. Electricity is no longer a luxury; it has become a necessity in our everyday lives. It's very difficult to live without electricity for an extended period of time. We know that how electrical energy being generated in India by several method such as diesel, steam, Hydro etc. power plant have generated electrical energy as per requirement. But different method of generation has different merits and demerits like costly, bulky and expensive. Now a days facing fuel cost, we required the low cost, high efficient and easy to use renewable energy to the home or emergency purposes mostly when power cut occur. Advantage of Thermoelectric generators Electrical power will be user friendly, clean and fresh and increases interest in renewable energy. It can use waste heat energy produce by machinery works and other process that produce thermal energy.

Here we discussed about the new ideas of electrical generation, called thermoelectric generators. Thermoelectric generators could be used in power plants in order to convert waste heat into additional electrical power and in automobiles as automotive thermoelectric generators (ATGs) to increase fuel efficiency.

Keywords: Thermocouple, See back effect, Peltier effect, Heat sink, Working, Construction

Introduction of Thermo Electric Generator

Thermoelectric generators are device that convert temperature differences in to electrical energy with the use of see back effect and Peltier effect. In 1821, Thomas Johann See back discovered that a thermal gradient formed between two dissimilar conductors can produce electricity. Temperature in conducting material results in heat flow; this result in the diffusion of charge carriers. The flow of charge carriers between the hot and cold regions in turn creates a voltage difference. Peltier effect was named after Jean Charles Athanase Peltier, the physicist who discovered the effect in 1834. Peltier discovered that when current is made to flow through a circuit consisting of two different types of conductors, a heating or cooling effect is observed at the junctions between the two materials. This change in temperature at the junction is called the Peltier effect. The simplest form of the thermoelectric generators consists of n-type and p-type thermocouple joined electrically in series and thermally in parallel. The voltage across the thermocouple generated due to hot and cold junction temperature difference. Thus the voltage of the thermocouple is directly proportional to the temperature gradient. There is various type of thermocouple with their different temperature Range like as J, K, T, N, E, B, R, S etc. Thermoelectric power sources are flexible and capable to operate at the elevated temperatures. All the thermoelectric materials are non-toxic and non-radioactive which is one of the chief characteristic of ecofriendly system. A benefit of this type has no moving parts, pollution free and its operation easy.

Main components

Thermocouple

Thermocouple is widely used as "temperature sensor". It has two dissimilar points which joined together as a

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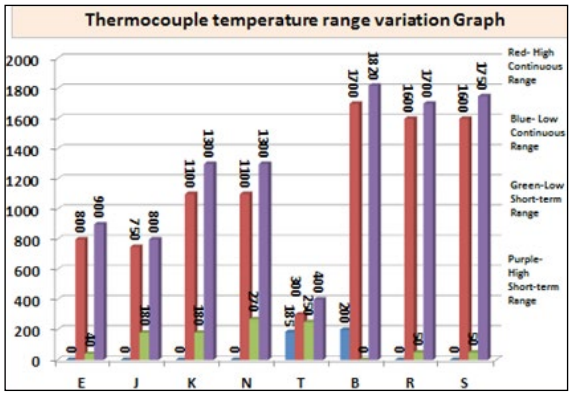
junction. This junction created a temperature dependent voltage as a result of thermoelectric effect. This voltage is directly proportional to the amount of temperature difference between junctions. Thermocouples are found in various types. Commercial type is inexpensive, easily use and provide wide range of temperatures. But limitation is accuracy for temperature measurement. Thermocouples are self-powered and require no external form of excitation. There are many types of thermocouples with its Material alloy range but few are as follows and given below:-

- Nickel-alloy thermocouples(Type-E,J,K,M,N,T)
- Platinum/rhodium-alloy thermocouples (Type-B, R, S)
- Tungsten/rhenium-alloy thermocouples (Type- C, D, G)
- Other-alloy thermocouples(Chromel-gold/iron, Type –P, Platinum/Molybdenum, Iridium/Rhodium and skutterudite)

Thermocouple Group's	Type	Temperature Range				color codes
		Continuous		Short term		
		Low	High	Low	High	as per IEC
Nickel-alloy thermocouples	E	0	800+	-40	900+	
	J	0	750+	-180	800+	
	K	0	1100+	-180	1300+	
	N	0	1100+	-270	1300+	
	T	-185	300	-250	400+	
Platinum/rhodium-alloy thermocouples	B	200+	1700+	0	1820+	No standard
	R	0	1600+	-50	1700+	
	S	0	1600+	-50	1750+	No standard

a) Comparission between some types of thermocouple



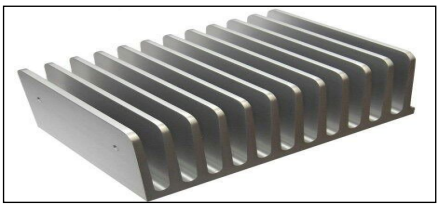
b) Different types of thermocouple temperature range showing in graph

C) How to measured temperature from thermocouple:- Thermocouple connected to a multimeter displaying room temperature in °C

- In modern technology we are provided different types of Digital multimeter mostly Fluke has a option for directtemperature measurement.
- Testing a temperature with ordinary multimeterThe first is to check for a short on the terminals and the second, to make sure that voltage tracks with the temperature. The first test can be performed with any quality multimeter. Put the meter in ohms or continuity mode; on a good thermocouple, you should see a low resistance reading.

Heat Sink

Heat Sink- A heat sink (also commonly spelled heat sink) is a passive heat exchanger that transfers the heat generated by an electronic or a mechanical device to a fluid medium, often air or a liquid coolant, where it is dissipated away from the device, thereby allowing regulation of the device's temperature at optimal levels.



Materials used for thermoelectric generator

- Ceramic Plate made from aluminum.
- Hot and cold plates usually connected with highly conductive material like as copper.
- Commercial materials: - these materials are further divided in to the three categories.

(a) Low temperature material (around 450K, Material used- alloy Bi combination with Sb,Se,Te)
(b) Medium temperature material (between 450K to 850K, Material used-alloy of Pb)
(c) High temperature material (up to 1300K, Material used-alloy of Si and Ge)

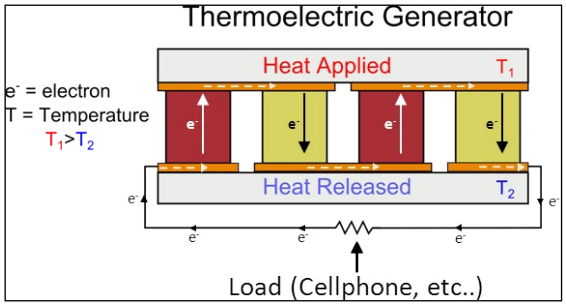
- Novel materials reduce lattice thermal conductivity without the typical negative effects on electrical conductivity from the simultaneous increased scattering of electrons.

- The most common material used for this generator is Lead telluride. Lead telluride is a compound made of lead and tellurium having small amount of bismuth or sodium.

Working principle of thermo electric generator

Thermoelectric generators based on seeback effect that when the junctions of the two different materials (such as Semiconductor material) have maintained at different temperature, the emf is produced. Seeback effect– An Electrical current can flow in closed circuit path between two dissimilar metals if the junctions of the metal operated on different temperature. Thermoelectric material carry both charge and heat for this we have a one example of gas charged particles. Gas molecule at the hot end move faster than those of cold end. The faster hot molecules

will diffuse further than the cold molecules so there net buildup of molecules at the cold end on high density. This density gradient will diffuse the molecules back to the hot end. The Heat source such as natural gas or propane gas is used for power generation. The heat source is kept at high temperature as compare to heat sink. The sides of generating device are insulated so, the heat flows along the length only. The applied heat to the hot junction causes the electrons in the n type block and the holes in the p type block to flow away from the heat junction and thereby producing an electrical potential difference. The circuit is completed by connecting a load resistance, R_L. The current will start flowing through this load resistance, R_L.



Voltage of the generator = V in volts and equal to V = α ΔT where α is Seeback coefficient and ΔT is the temperature difference between hot and cold junction.

Let the R is the internal resistance of the generator and Load resistance (R_L) then the current flowing through the generator should be

$$I = \frac{V}{R + R_L} \quad (1)$$

Substitute the value of voltage in equation (1) we have

$$I = \frac{\alpha \Delta T}{R + R_L} \quad (2)$$

We know that the power flow in external circuit due to heat source $P_L = I^2 R_L$. Substitute the value of Current

$$Power,\ P_L = \left(\frac{\alpha \Delta T}{R + R_L}\right)^2 R_L \quad (3)$$

The Maximum power will be possible only when $R = R_L$
So, maximum power is given by

$$P_{max} = \frac{(\alpha \Delta T)^2}{4R} \quad (4)$$

Thus on Maximum power generated depends on internal resistance, seeback coefficient and temperature difference ΔT.ΔT can be increased by increasing the temperature difference between heat source and heat sink. For maximum power, ΔT and α^2 / R value should be in high.

$$Efficiency = \frac{Power\ developed,\ P_L}{heat\ flow,\ Q}$$

$$Efficiency = \frac{I^2 R_L}{Q}$$

$$Efficiency = \frac{\left(\frac{\alpha \Delta T}{R + R_L}\right)^2 R_L}{Q}$$

Efficiency of TEG Efficiency of TEG is defined as the ratio of the Power developed at the load side and heat flow at the input side.

Construction of Thermo electric generator

Thermoelectric materials

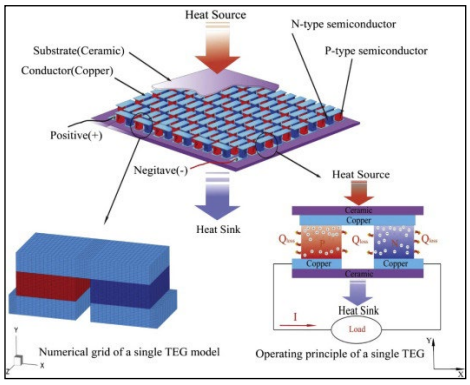
Thermoelectric materials must have both high electrical conductivity (σ) and low thermal conductivity (κ). Having low thermal conductivity ensures that when one side is made hot, the other side stays cold, which helps to generate a large voltage while in a temperature gradient. The measure of the magnitude of electrons flow in response to a temperature difference across that material is given by the Seebeck coefficient (S). The efficiency of a given material to produce a thermoelectric power is governed by its "figure of merit" $zT = S^2\sigma T/\kappa$. the main three semiconductors known to have both low thermal conductivity and high power factor were bismuth telluride (Bi_2Te_3), lead telluride (PbTe), and silicon germanium (SiGe). These materials have very rare elements which make them very expensive compounds.

Thermoelectric module

A thermoelectric module consists of two dissimilar thermoelectric materials joined together: an n-type (negatively charged); and a p-type (positively charged) semiconductors. A

Direct electric current will flow in the circuit when temperature difference builds up. Generally, the current magnitude is directly proportional to the temperature difference. Thermoelectric modules work in very tough mechanical and thermal conditions. The reason behind this was build up very high temperature gradient and thermal stress for over long time.

Thus the thermoelectric modules must be designed with high mechanical and thermal strength. These two materials must be connected in thermally in parallel, but electrically in series.



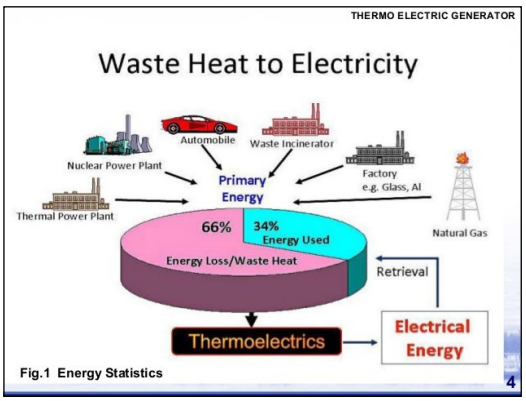
Thermoelectric system

The system needs a large temperature gradient, which is not easy in real-world applications. The cold side must be cooled by air or water. Heat exchangers are used on both sides of the modules to supply this heating and cooling.

Uses and Applications of Thermo Electric Generator

TEG has variety of applications but few are as below:-

- Thermoelectric Generators are primarily used as remote and off-grid power generators for unmanned sites. They are the most reliable power generator in such situations as they do not have moving parts (thus virtually maintenance free), work day and night, perform under all weather conditions, and can work without battery backup.
- Solar Photovoltaic systems are also implemented in remote sites; Solar PV may not be a suitable solution where solar radiation is low, i.e. areas at higher latitudes with snow or no sunshine, areas with lots of cloud or tree canopy cover, dusty deserts, forests, etc.
- 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.
- Gentherm Global Power Technologies (GPT) formerly known as Global Thermoelectric (Canada) has Hybrid Solar-TEG solutions where the Thermoelectric Generator backs up the Solar-PV, such that if the Solar panel is down and the backup battery backup goes into deep discharge then a sensor starts the TEG as a backup power source until the Solar is up again. The TEG heat can be produced by a low pressure flame fueled by Propane or Natural Gas.
- Generate electricity using a radioisotope thermoelectric generator whose heat source is a radioactive element.
- Solar cells use only the high frequency part of the radiation, while the low frequency heat energy is wasted. The idea is to increase the efficiency of the combined solar/thermoelectric system to convert the solar radiation into useful electricity.
- Microprocessors generate waste heat.
- Many types of industries released waste heat. This heat can be used for generate electrical energy. So that the environment should be less polluted, eco-friendly and reduce Global Warming.
- Common source of heat loss shown as below in diagram.



This heat can be useful for power generation.

- This generator also useful in cooling purpose. This type of cooling has the advantage of low maintenance, long life higher reliability and no moving parts. Other uses thermoelectric phone charger, stove, watches etc.

Advantages and Disadvantages Thermo Electric Generator

Advantage of thermoelectric generator

- Environmentally friendly.
- Recycles wasted heat energy.
- Reliable source of energy.
- Lowers production cost.

Disadvantage of thermoelectric generator

- Limited Applications.
- Requires relatively constant heat source.
- Slow technology Progression.
- Lack of customer/ industry education about thermoelectric generators.
- Low energy conversion efficiency rate.

Conclusion

Now a day there is need for going through the thought of how to save the earth from different types of heating hazardous, which can be used for power generation i.e. thermoelectric generator. Advantage of this made the environment eco-friendly, Green and healthy for growing life.

Currently, a large amount of waste heat is discharged from industry including power utilities and manufacturing

plants. Most of the researchers have been tried for waste heat converting into the energy.

Research on thermoelectric generators might be needed to focus on finding suitable thermoelectric materials that can withstand higher temperatures of various industrial heat sources at a feasible cost with good performance.

It has numerous advantages over disadvantages such as introduction of nanotechnology, development of Waste energy conversion to electrical energy beneficial to present energy crisis and lead to various applications in future.

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