Use of Waste Energy to Convert useful Energy by Thermoelectric Power Generator

Vaishali Singh
Student
Department of Mechanical Engineering
United College of Engineering and Management, Naini, Allahabad

Shrey Bhatt
Student
Department of Mechanical Engineering
United College of Engineering and Management, Naini, Allahabad

Sumit Prakash
Student
Department of Mechanical Engineering
United College of Engineering and Management, Naini, Allahabad

Preeti
Student
Department of Mechanical Engineering
United College of Engineering and Management, Naini, Allahabad

Shubham Singh Tiwari
Student
Department of Mechanical Engineering
United College of Engineering and Management, Naini, Allahabad

Abstract

In our country India, there is a significant crisis of energy we are mostly dependent on coal for our energy utilization. Thus, there is a need to conserve energy and measures should be taken to reduce the wastage of energy. Our project mainly focuses on utilizing the waste energy and convert it into useful energy (in particular electricity). Our project is the model where waste energy (heat energy) can be used to introduce electrical energy. Various ways where heat energy is wasted. Automobile, Power plant, etc

Keywords- Electric Generator, Thermoelectric Power Generator, Thermoelectric Materials

I. INTRODUCTION

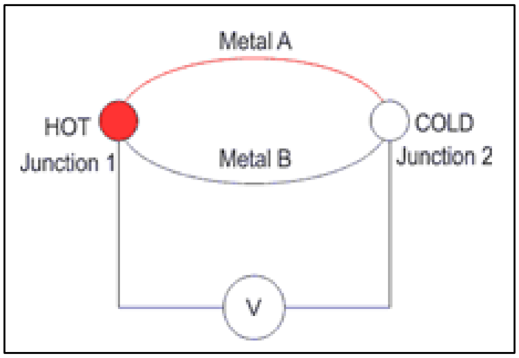
.A thermoelectric generator, or TEG (also called a See beck generator) is a solid state device that converts heat (temperature differences) directly into electrical energy through a phenomenon called the See beck effect (a form of thermoelectric effect). Thermoelectric generators function like heat engines, but are less bulky and have no moving parts. However, TEGs are typically more expensive and less efficient.

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. Another application is radioisotope thermoelectric generators which are used in space probes, which has the same mechanism but use radioisotopes to generate the required heat difference.

II. PRINCIPLE OF WORKING

Thermoelectric generator works on the principle of Seebeck effect.

A. Seebeck Effect



Seebeck discovered that when heat is applied to the junctions of two dissimilar metals, an emf is generated which can be measured at the other junction. The two dissimilar metals form an electric circuit, and a current flows as a result of generated emf. The emf produced is a function of difference in temperature and is given by equation:-

$$E=S*(T_1-T_2)$$

Where E= emf generated.
S= seebeck coefficient.
T_1, T_2=temperature of hot and cold side

III. THERMOELECTRIC POWER GENERATORS CONSIST OF THREE MAJOR COMPONENTS

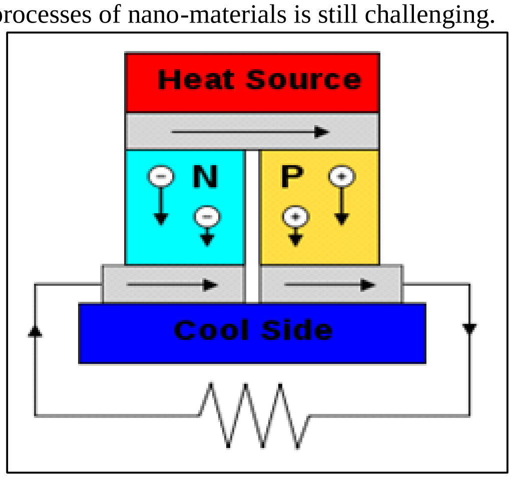
- Thermoelectric materials.
- Thermoelectric modules.
- Thermoelectric systems that interface with the heat source

A. Thermoelectric Materials

Thermoelectric materials generate power directly from heat by converting temperature differences into electric voltage. These materials must have both high electrical conductivity (σ) and low thermal conductivity (κ) to be good thermoelectric materials. 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 See beck coefficient (S). The efficiency of a given material to produce a thermoelectric power is governed by its " figure of merit" $zT=S^2\sigma T/\kappa$.

For many years, 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.

Today, the thermal conductivity of semiconductors can be lowered without affecting their high electrical properties using nanotechnology. This can be achieved by creating nanoscale features such as particles, wires or interfaces in bulk semiconductor materials. However, the manufacturing processes of nano-materials is still challenging.



A thermoelectric circuit composed of materials of different Seebeck coefficient (p-doped and n-doped semiconductors), configured as a thermoelectric generator. If the load resistor at the bottom is replaced with a voltmeter the circuit then functions as a temperature-sensing thermocouple.

B. Thermoelectric Module

A thermoelectric module is a circuit containing thermoelectric materials that generate electricity from heat directly. A thermoelectric module consists of two dissimilar thermoelectric materials joining in their ends: an n-type (negatively charged); and a p-type (positively charged) semiconductors. A direct electric current will flow in the circuit when there is a temperature difference between the two materials. Generally, the current magnitude has a proportional relationship with the temperature difference. (i.e., the more the temperature difference, the higher the current.)

In application, thermoelectric modules in power generation work in very tough mechanical and thermal conditions. Because they operate in very high temperature gradient, the modules are subject to large thermally induced stresses and strains for long periods of time. They also are subject to mechanical fatigue caused by large number of thermal cycles.

Thus, the junctions and materials must be selected so that they survive these tough mechanical and thermal conditions. Also, the module must be designed such that the two thermoelectric materials are thermally in parallel, but electrically in series. The efficiency of thermoelectric modules are greatly affected by its geometrical design.

C. Thermoelectric System

Using thermoelectric modules, a thermoelectric system generates power by taking in heat from a source such as hot exhaust flue. In order to do that, 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.

There are many challenges in designing a reliable TEG system that operates at high temperatures. Achieving high efficiency in the system requires extensive engineering design in order to balance between the heat flow through the modules and maximizing the temperature gradient across them. To do this, designing heat exchanger technologies in the system is one of the most important aspects of TEG engineering. In addition, the system requires minimizing the thermal losses due to the interfaces between materials at several places. Another challenging constraint is avoiding large pressure drops between the heating and cooling sources.

After the DC power from the TE modules passes through an inverter, the TEG produces AC power, which in turn, requires an integrated power electronics system to deliver it to the customer.

D. Materials for TEG

Only a few known materials to date are identified as thermoelectric materials. Most thermoelectric materials today have a ZT value of around unity, such as in Bismuth Telluride (Bi_2Te_3) at room temperature and lead telluride (PbTe) at 500-700K. However, in order to be competitive with other power generation systems, TEG materials should have ZT of 2-3 range. Most research in thermoelectric materials has focused on increasing the Seebeck coefficient (S) and reducing the thermal conductivity, especially by manipulating the nanostructure of the thermoelectric materials. Because the thermal and electrical conductivity correlate with the charge carriers, new means must be introduced in order to conciliate the contradiction between high electrical conductivity and low thermal conductivity as indicated.

When selecting materials for thermoelectric generation, a number of other factors need to be considered. During operation, ideally the thermoelectric generator has a large temperature gradient across it. Thermal expansion will then introduce stress in the device which may cause fracture of the thermoelectric legs, or separation from the coupling material. The mechanical properties of the materials must be considered and the coefficient of thermal expansion of the n and p-type material must be matched reasonably well. In segmented thermoelectric generators, the material's compatibility must also be considered. The material parameters determining s (as well as zT) are temperature dependent, so the compatibility factor may change from the hot side to the cold side of the device, even in one segment. This behavior is referred to as self-compatibility and may become important in devices design for low temperature operation.

In general, thermoelectric materials can be categorized into conventional and new materials:

IV. MATERIALS USED

- Ceramic plates usually made from alumina.
- Two Chambers (1^{st} Hot & 2^{nd} Cold)
- Motor with Fan(2 volt)
- DC to AC Converter Circuit
- Bulb(3 watt)
- Rechargeable Battery(6 volt)
- Cardboard

V. WORKING OF PROJECT

Temperature difference is created across the two sides of peltier plate, one side hot and the other side cold. This temperature difference allows the peltier plate to develop emf. This emf results in a flow of current which drives the fan. A battery is also provided which is charged using the current generated and it could be used for further electrical purposes.

VI. ADVANTAGES OF THERMOELECTRIC GENERATOR

- Effective use of waste energy.
- Extremely reliable and silent operation.
- No moving parts.
- Require much less maintenance.
- Simple, compact and safe.
- Very small and almost weightless.
- Capable of operating at high temperatures.

- Suitable where there is little or no electricity.
- Environmentally friendly.

VII. FUTURE SCOPE

- It can be classified in micro and macro scale depending upon conversion of potential energy into electric power.
- Future developments in these applications tend to move towards the Nano technology.
- To develop more new thermoelectric unit geometries and configurations.
- To focus on finding the most appropriate thermoelectric materials that could handle higher temperatures from various industrial sources of heat at a feasible cost with acceptable performance.

VIII. CONCLUSION

Thermoelectric power generator mainly converts heat energy to electrical energy. We mainly choose this project to use all waste full heat and convert it to electric energy and help in controlling energy crisis. We can use this heat from power plants, wasteful heat from chimneys and lubrication. We can use heat incident on the car coming from sun light and use it to run exhaust in car and avoid suffocation problem. Wasteful heat are released from industry in various form from different sources like liquid, gases etc.

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