



INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X

Impact factor: 4.295

(Volume3, Issue2)

Seebeck Effect to Generate an Electricity from Exhaust Gases of Automobile

Hrishikesh Kiran Sawant

Dnyanshree Institute of Engineering and Technology, Maharashtra

Vishawajeet R. Sawant

Dnyanshree Institute of Engineering and Technology, Maharashtra

Prakash R. Jadhav

Dnyanshree Institute of Engineering and Technology, Maharashtra

Pratik R. Pawar

Dnyanshree Institute of Engineering and Technology, Maharashtra

Prof. Vishal B. Dixit

Dnyanshree Institute of Engineering and Technology, Maharashtra

Abstract: In recent years the scientific and public awareness of environmental and energy issues has brought in major interests to the research of advanced technologies particularly in highly efficient internal combustion engines. Substantial thermal energy is available from the exhaust gas in modern automotive engines. The latest developments and technologies on waste heat recovery of exhaust gas from internal combustion engines include thermoelectric generators, Organic Rankine cycle, six-stroke cycle IC engine and new developments in turbocharger technology. Thermo-Electric Power Generator directly converts this Thermal energy into Electrical energy. So a number of moving and rotating part has been eliminated. Thermoelectric power generation offers a potential application in the direct exchange of waste-heat energy into electrical power. By this, it eliminated emission so we can believe this green technology. In this paper, a background on the basic concepts of thermoelectric power generation and its use in an automobile engine is reviewed and discussed.

Keywords: Waste-Heat Recovery, Thermoelectric Power Generator, Alternative Green Technology, Environmental Issue.

I. INTRODUCTION

Two-thirds of the energy from combustion in a vehicle is lost as waste heat, of which 40% is in the form of hot exhaust gas. The electric load of a vehicle is increasing due to improvements in driving performance and comfort. In order to satisfy the increasing demands of electricity in modern vehicles, bigger and heavy alternators are coupled to engines. These alternators which operate at an efficiency of 55 to 65% consume around 5% of the rated shaft power. And ultimately affects the fuel economy of the vehicle. One potential solution is the usage of the exhaust waste heat of combustion engines. This is possible by the waste heat recovery using a thermoelectric generator. A thermoelectric generator converts the temperature gradient into a useful voltage that can use for providing power for auxiliary systems such as air conditioner and minor car electronics. Even it can reduce the size of the alternator that consumes shaft power. If approximately 6% of exhaust heat could be converted into electrical power, it will save the approximately same quantity of driving energy. It will be possible to reduce fuel consumption by 10 %; hence AETEG system can be profitable in the automobile industry.

II. CONCEPT OF TEG

2.1. BASIC THEORY

Thermoelectric power generator works on "Seebeck effect". Seebeck effect was discovered by Thomas Seebeck in 1821. When a temperature difference is recognized between the hot and cold junctions of two dissimilar materials (metals or semiconductors) a voltage is generated, this voltage is called Seebeck voltage. Thermoelectric generators (TEG) are devices that convert temperature differences into usable electricity. TEGs are made from thermoelectric modules which are solid-state integrated circuits that employ three established thermoelectric effects known as the Peltier, Seebeck and Thomson effects. TEGs require heat as an energy source and can generate power as long as there is a heat source.

Based on this Seebeck effect, thermoelectric devices can act as electrical power generators. A schematic diagram of a simple thermoelectric power generator operating based on Seebeck effect. Heat is transferred at a rate of H from a high-temperature

heat source maintained at T_H to the hot junction, and it is rejected at a rate of $L Q$ to a low-temperature sink maintained at T_L from the cold junction. Based on Seebeck effect, the heat supplied at the hot junction causes an electric current to flow in the circuit and electrical power is produced. Using the first law of thermodynamics (energy conservation principle) the difference between H and $L Q$ is the electrical power output $e W$. It should be noted that this power cycle intimately resembles the power cycle of a heat engine (Carnot engine), thus in this respect a thermoelectric power generator can be considered as a unique heat engine

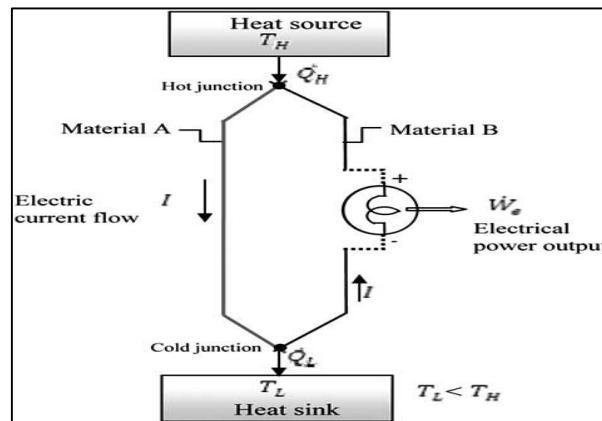


Fig 2.1. The concept of TEG.

2.2. COMPONENT OF TEG

- a) Thermal fin / Heatsink
- b) Thermoelectric Module
- c) Thermoelectric shield

THERMAL FIN / HEAT SINK

Thermal fins are made of aluminum metal. They increase the thermal gradient value. When we increase the Thermal gradient value it increases the Seebeck voltage generated by TEG.

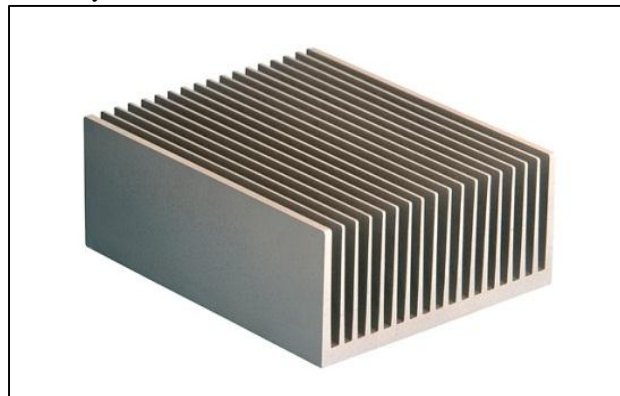


Fig 2.2. An aluminum Heat Sink or Thermal Fin.

THERMOELECTRIC MODULE

Thermoelectric or Peltier Cooling Modules (also known as a TEC or a TEM) come in a wide variety of types and sizes. While typically used for cooling, they can also be used for heating (by reversing the electric current flow) and even power generation if the temperature difference is provided at both ends.

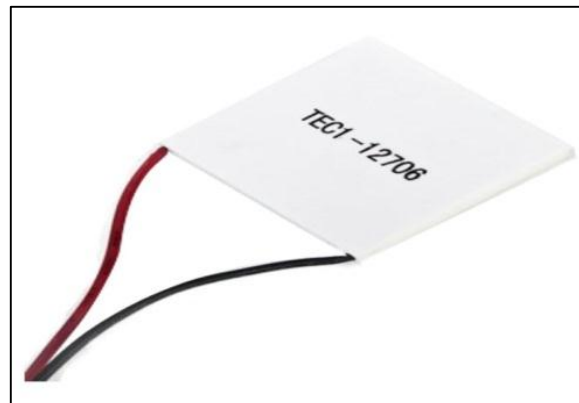


Fig 2.3. Thermoelectric module or Peltier Module.

THERMOELECTRIC SHIELD

It is a material which protects the modules damage due to high Temperature. Mostly Ceramics material is used. It also transfers temperature to the modules from the hot side.

2.3. ADVANTAGES AND DISADVANTAGES OF TEG

ADVANTAGES

1. They are extremely reliable and they have no mechanical moving parts and require considerably less maintenance.
2. They have mostly used for convert the waste heat so it is considered as a Green Technology.
3. A reliable source of energy.
4. Environmentally friendly.

DISADVANTAGES

1. The major drawback of the thermoelectric power generator is their relatively low conversion efficiency up to 5 % only.
2. Chances of getting failed are more.
3. Requires relatively constant heat source.
4. Slow technology Progression.
- 5.

III. USE OF TEG IN AUTOMOBILE ENGINE

3.1. OPERATION PRINCIPLE

In ATEGs, thermoelectric materials are packed between the hot side and the cold-side heat exchangers. The thermoelectric materials are made up of p-type and n-type semiconductors, while the heat exchangers are metal plates with high thermal conductivity. The temperature difference between the two surfaces of the thermoelectric module generates electricity using the Seebeck Effect. When hot exhaust from the engine passes through an exhaust ATEG, the charge carriers of the semiconductors within the generator diffuse from the hot-side heat exchanger to the cold-side exchanger. The build-up of charge carrier's results in a net charge, producing an electrostatic potential while the heat transfer drives a current. With exhaust temperatures, the temperature difference between exhaust gas on the hot side and coolant on the cold side is several hundred degrees. This temperature difference is capable of generating electricity. The compression assembly system aims to decrease the thermal contact resistance between the thermoelectric module and the heat exchanger surfaces. In coolant-based ATEGs, the cold side heat exchanger uses engine coolant as the cooling fluid, while in exhaust-based ATEGs, the cold-side heat exchanger uses ambient air as the cooling fluid.

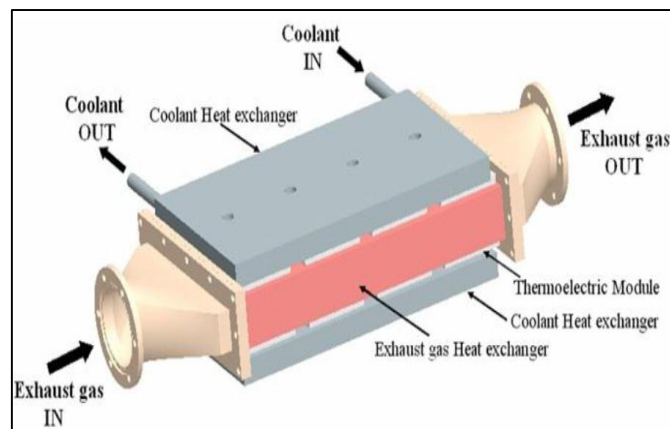


Fig. TEG at the exhaust pipe.

For generating electricity from exhaust gasses, we have to Design two Heat Exchanger for cold side and another one for the hot side of the thermoelectric generator. The gasses from the exhaust are at around 300-400 degree Celsius and surrounding temperature is 35 degree Celsius, But the requirement of the thermoelectric generator are different than actual condition so we have to design heat exchanger such that the maintain required temperature difference and generate electricity.

An automotive thermoelectric generator (ATEG) is a device that converts waste heat in an internal combustion engine (IC) into electricity using the Seebeck Effect. A typical ATEG consists of four main elements: A hot-side heat exchanger, a cold-side heat exchanger, thermoelectric materials, and a compression assembly system. ATEG can convert waste heat from an engine's coolant or exhaust into electricity. By reclaiming this otherwise lost energy, ATEGs decrease fuel consumed by the electric generator load on the engine. However, the cost of the unit and the extra fuel consumed due to its weight must be also considered. This could power the automobile.

3.2. WORKING

The main focus of energy conversion is on three conversion locations mainly exhaust gas pipe (EGP), exhaust gas recirculation (EGR) cooler, and retarder. The most significant factors for the waste heat quality are power density and temperature range. The EGP is the target of the most automobile waste heat recovery related research. The exhaust system contains a large portion of the total waste heat in the vehicle. The gas flow in exhaust gas pipe is relatively stable.

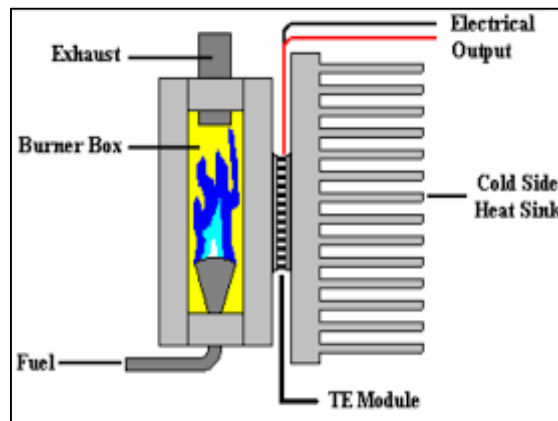


Fig 3.1. TEG utilizing the exhaust gas heat.

This temperature difference is capable of generating 100-500W of electricity. In the water coolant based system, though the temperature is lower, it may be high enough to produce significant electricity for use in the vehicle when TEGs are attached. The main advantage of EGR gas is a large temperature difference. Since EGR gas comes directly from the cylinders, its temperature is in the range of 820 K-1050 K, which is similar to that in the exhaust manifold. A considerable amount of heat. In the power plants and other industries, there are lots of flue gasses produced having significant amount heat. In the chimneys the temperature of flue gases would be around 373 K which is the hot junction & the ambient air is cold junction having temperature 308 K. So there is temperature difference of 353 K. Applying the same technique to this it will give output of 4.583 mV for one thermocouple loop so by adding these in series in large number we can generate large amount of electricity.

CONCLUSION

The electrical power generation of the thermoelectric generator is observed to be a strong function of flow rate and inlet exhaust temperature. The temperature difference between the hot and cold junctions of TEG increased as the engine speed or the coolant temperature increase. The output voltage, according to the Seebeck effect, also increased as the temperature difference increase. Therefore, the output power and thermal efficiency can be improved. The parametric evaluation of the longitudinal model indicates that TEG performance improves for configurations that have minimum TEG height and maximum TEG width. The high-efficiency heat exchanger is necessary to increase the amount of heat energy extracted from the exhaust gas. It is found that exhaust gas parameters and heat exchanger structure have a significant effect on the system power output and the pressure drop. The study also identified the potentials of the technologies when incorporated with other devices to maximize the potential energy efficiency of the vehicles.

REFERENCE

- [1] Baleswar Kumar Singh, Dr. Shrivastava. "Exhaust Gas Heat Recovery for I.C. Engine-A review", INT. journal of Science and Research Technology, 2014.
- [2] Prathmesh Ramade, Manoj Shelar, "Automobile Exhaust thermoelectric Generator Design and Performance analysis", int. journal of emerging technology and advanced engineering, 2014.
- [3] R K Rajput, "Heat and Mass Transfer", Third Edition, pub.-Tata Mc Graw-hill (2009)
- [4] Chen L, Li J, Sun F, Wu C. Performance optimization of a two stage semiconductor thermoelectric generator. Appl Energy 2005; 82: 300-312. 6. Www. Wikipidia.org.
- [5] Darren quick's thermoelectric report.