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# GENERATION OF ELECTRICITY USING EXHAUST GASES


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**ABSTRACT** This paper deals with the generation of electricity from heat of the exhaust gases using thermoelectric Generator (TEG). Thus produced electricity is stored in a battery for later consumption. A thermoelectric generator, also called a Seebeck generator, is a solid state device that converts heat flux directly into electrical energy (a form of thermoelectric effect). Thermoelectric generators function like heat engines, but are less bulky and have no moving parts. A cylindrical pipe is provided in between the exhaust manifold and the catalytic convertor .On this pipe, thermoelectric generators are mounted. When the exhaust gases flow through this pipe as the engine is turned on, the pipe gets heated. This heat is converted into electricity by these TEGs. The TEGs are mounted in such a way that their hot side is in contact with the pipe and a coolant is provided to the cold side. Due to the temperature difference provided the electrons and holes of the thermoelectric semiconductors will try to move towards the junction. The flow of these electrons produces a voltage in the circuit. Since all the TEGs are connected in series the EMF produced by each TEG sums up. The voltage thus produced is stored in external batteries and used for further purposes.


**KEYWORDS** : electricity, exhaust gases, thermoelectric, seebeck

## INTRODUCTION

In recent years the scientific and public awareness on environmental and energy issues has brought in major interests to the research of advanced technologies particularly in highly efficient internal combustion engines. Viewing from the socioeconomic perspective, it is essential to conserve the energy that is available. Conservation of energy is carried out in two ways,

- Reduced / Limited usage
- Recycling of waste energy

Since the needs and demands cannot be compromised, it is impossible to reduce/limit the usage. So recycling is the only method to conserve energy.

- Industrial Flue Gases
- Automobile exhaust etc…

There are about 1.2 billion automobiles in the world. Almost all of the are running on fossil fuels and consists IC engines. Every IC engine releases exhaust gases after the fuel is burnt.

Construction Thermoelectric power generators consist of three major components: thermoelectric materials, thermoelectric modules and thermoelectric systems that interface with the heat source.

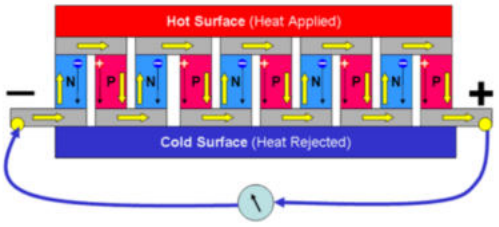



**Figure.1 Construction of TEG**

**Working:**

TEG works on the principle of seebeck effect, produces an electric current when dissimilar metals are exposed to a variance in temperature. The voltage produced is proportional to the temperature distance across between the two metal junctions.

**Benefits:**

Thermoelectric power generation provides reliable, renewable energy for a variety of industries and applications. Benefits include:
(1) Easy installation
(2) Safe storage (safe or safer than most existing batteries)
(3) Can operate in any geographic location
(4) Cost effective
(5) Low maintenance
(6) Can be produced in bulk

**Materials for TEG:**

Only a few known materials to date are identified as thermoelectric materials. Most thermoelectric materials today have a ZT, the figure of merit, value of around unity, such as in Bismuth Telluride (Bi2Te3) 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.

**SPECIFICATOINS:**

Model: TEG1-SP1848-27145.
Operating Range: -40 degrees to 120 degrees. Dimensions: -
Hot side: 40mm*40mm,
Cold side: 40mm*40mm,
Height: 3.6mm.

Model number side is exposed to coolant and its opposite side to heat. The semiconductors used in the TEG are Bismuth and Tellurium.

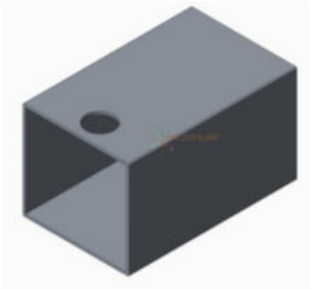
Note: Grease is applied on both sides (hot & cold) of the TEG.

**DESIGN: Casing:-**It is the main component which is connected to exhaust of IC engine. It is a cylindrical shell with elliptical cross-section. TEG's are installed on the casing, with hot side of TEG facing

the casing. It transfers the heat of exhaust gas to the TEG. Material used was aluminum

**Casing**

**Coolant Well: -** It is attached on top of the TEG. It is provided with inlet and an outlet pipe for the coolant to flow.



**Coolant well**

Pipes:- Two pipes of diameters 28mm and 40mm are provided one to connect the exhaust port and the casing and to the other to the casing outlet respectively. Both the pipes are threaded externally. Various fabrication methods have been used in this work: Shearing, milling, screw threading, lathe and MIG welding.

## MATERIALS AND METHODOLOGY

Single Cylinder Diesel Engine: A single cylinder 4 stroke diesel engine is used as the heat source. The equipment is connected to the exhaust port of the engine. Thus when the engine is started and kept running the exhaust gases flow through the casing.

**Figure.2 Single Cylinder Diesel Engine**

The specifications of the engine used are:

**Table 1 Engine Specifications**

| | |
|---|---|
| Make | Kirloskar |
| Bore | 80 mm |
| Stroke length | 110mm |
| Speed | 1500rpm |
| Brake power | 3.68KW |
| Compression ratio | 16:1 |

**Multimeter:**

Multimeter is used to measure the voltage and current developed in the circuit.

**Figure. 3 Multimeter**

**Generation of heat from the engine:**

The Engine is started and the acceleration is to be given, so that the amount of heat leaving the exhaust will be increased. Loads are gradually applied on the engine so that the exhaust temperature increases. The exhaust gas temperatures of the single cylinder 4-stroke diesel engine for various loads is given in the below table. Due to this heat, the surface of the exhaust pipe and the silencer will be heated to very high temperatures. These hot surfaces will try to liberate the heat to the atmosphere, which acts as a Heat Sink.

**Table 2 Temperatures for various loads**

| S.no | load | temperature |
|---|---|---|
| 1 | 2 | 100 |
| 2 | 4 | 124 |
| 3 | 6 | 159 |
| 4 | 8 | 191 |
| 5 | 10 | 228 |

**Coolant system:**

A coolant system is provided on the cold side of the TEG. A coolant well is provided on the surface of the cold side. The well is provided with inlet and outlet for the coolant to flow. A coolant reservoir is provided at some height above the equipment and a pipe is connected from the reservoir to the inlet of the coolant well. Another pipe is connected to the outlet of the coolant well to remove the heated coolant. The coolant flow is regulated such that the coolant stays enough time in the coolant well before getting heated due to the heat.

Generation of electricity from the TEG's:- Since the coolant temperature is less than that of the silencer surface, a temperature difference is created and hence the surface tries to attain the equilibrium state through the heat transformation process. As the coolant flow continues the temperature difference is constantly maintained between the hot and cold side of the TEG.

As the surface of the silencer gets more and more heated the heat transfer rate will increase due to the increase in the temperature difference. The TEG module is placed between the Heat Source (Hot Component Surface) and the Heat Sink (Coolant tank). The module is made of semiconducting materials. Hence by the principle of Seebeck Effect, the temperature difference can be directly converted into voltage by using some thermoelectric materials. Based on this effect, when the surface heat of the component is passed on to the coolant, the electrons and holes of the thermo electric semiconductors will try to move towards the junction and make the flow of electric current to be possible.

The emf generated for various temperature differences for the TEG SP1848-27415 is shown in the following table:

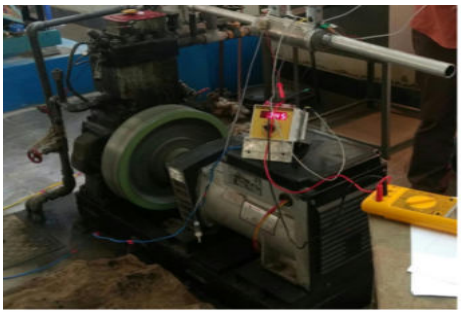


**Figure.4 Experimental setup**

## RESULTS AND DISCUSSION

**Table.3 Output Vs Temperature**

| Temperature difference | Voltage (V) | Current(mA) |
|---|---|---|
| 20 | 0.97 | 225 |
| 40 | 1.8 | 368 |
| 60 | 2.4 | 469 |
| 80 | 3.6 | 558 |

The voltage generated can be increased by placing more number of modules and connecting them with one another in series to meet the demand of the required voltage. This voltage can then be supplied to the suitable electrical appliances.

Voltages obtained for various loads are noted and tabulated.

**Table.4 Output Vs Temperature**

| S.No | Load kw | Exhaust temperature | Hotside temperature | Coolant Temperate | Voltage |
|---|---|---|---|---|---|
| 1 | No load | 100 | 82 | 10 | 2.76 |
| 2 | 0.6 | 124 | 91 | 13 | 3.62 |
| 3 | 1.2 | 143 | 103 | 18 | 4.91 |
| 4 | 1.8 | 164 | 112 | 21 | 5.6 |

## CONCLUSIONS

From the experiments it was observed that there is a need to converter exhaust gas into electricity. As the load increase the exhaust temperature increased from 1000C to 228 0C that was about 56% more than starting of engine. The more temperature difference from hot surface to coolant surface resulted grater voltage and current. Finally it is concluded that the production of electricity from exhaust gases depends on temperature difference and number of TEG modules.

## SCOPE:

As the energy resources are in the continued state of depletion, the world will look towards conserving the remaining sources and recycling the current energy. The main aim of the project is to reduce dependency on non-renewable sources. Many countries are taking measures to prevent the use of non renewable energy sources (fossil fuels). So by using TEGs, dependency on fossil fuels decreases to at least some extent. Efficiency of an IC engine is less, as only 30% of the fuel consumed is being properly utilised and the remaining portion is going out as waste in the form of exhaust gases. So if the flew gases coming out from the exhaust are used to produce electricity, some of the energy can be recycled. The same concept can be applied for industrial purposes where more amount of flew gases are emitted and more heat is available, electricity can be produced on a large scale.

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