# Energy Generation from Waste Heat of Automobile

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**Abstract–** The use of combustion engines is on the rise due to the visible worldwide cycle of increased movement. I.C. engines are power-intensive devices with low efficiency since approximately 75% of the energy generated during combustion is lost as heat in the engine's coolant and exhaust. There is a pressing need to develop a strategy to stop the massive energy loss.In this work, a thermoelectric generator (TEG) intended for a four-stroke internal combustion engine is used to develop and build a waste heat recovery system. Using a TEG, the device transforms the exhaust manifold's waste heat into electrical energy. Generating electricity in present there is a shortage of fossil fuel, oil, gas, etc. burning of these fuels causes environmental problem like radio activity pollution, global warming etc. So that these (coal, oil, gas) are the limiting resources hence resulting new technology is needed for electricity generation, by using thermoelectric generators to generate power as a most promising technology and environmental free and several advantages in production. Thermoelectric generator can convert directly thermal (heat) energy into electrical energy. In this TEG there are no moving parts and it can not be produce any waste during power production hence it is consider as a green technology. Thermoelectric power generator convert direct waste heat in to generate electricity By this it eliminated emission so we can believe this green technology. Thermoelectric power generation offer a potential application in the direct exchange of waste-heat energy into electrical power where it is unnecessary to believe the cost of the thermal energy input. This method will have an maximum outcome. The application of this option green technology in converting waste-heat energy directly into electrical power can too improve the overall efficiencies of energy conversion systems. Heat source which is need for this conversion is less when contrast to conventional methods. By using this energy is used to charge the mobile electronics.
***Key Words***: *peltier , thermoelectric , power generator ,waste power etc .*

**Introduction-** Vehicles are one of the primary drivers of atmospheric greenhouse gases into the atmosphere, accounting for sixteen percent of total emissions. By 2050 as a there will be two billion light-duty vehicles on the road, up from the current 900 million, according to data published in Energy Technology Perspective (2015). The current 38% use of the world's oil supply for automotive purposes can rise significantly if the power industry shifts to greener technology utilising renewable energy. Among the major contributors to the greenhouse gas emissions to the environment, automobiles make a substantial contribution to the extent of 16.4% . According to the information reported in energy technology perspective 2015, the number of light duty vehicles in the roads is expected to go up from present 900 million to 2 billion by 2050 . With the global power sector moving towards clean technologies using renewable energy, the current 38% utilization of the global oil production for automotive use can increase to a significant extent.

Though the advancement of electric vehicle (EV) technology is making a steady progress on one side (expected to reach 56 million passenger cars on road from the present 2 million by 2030), still it is far from making any drastic reduction in the emissions level due to transportation sector unless a radical innovation is made in the battery technology. Policies such as better urban planning that can increase the use of collective transportation and innovative technologies that can reduce the individual’s vehicle need can make considerable contributions to the reduction of the CO2 emissions. However, this requires substantial investment, and hence it is difficult to implement worldwide particularly in low and middle income countries. Implementing innovative technologies for improving automobile engine efficiency or innovations in the field of hybrid/low emissions vehicles can improve the fuel efficiency and thereby emissions can be reduced to a greater extent. Several recent developments in the engine, transmission and few ancillary systems of the vehicles show promising results.

**Literature Review -**

L1) Research by Borate et al. (2021) In relation to motorcycle power, this paper controls exhaust gas usage. Many incredible ideas have been developed recently in the automotive industry, and even older ideas are being refined to meet and overcome the challenges of the modern era.

L2) Study by Yunus C et al. (2017) This project demonstrates a concept of using turbines to generate power in a stationary multiple cylinder diesel engine. The turbine is connected to a dynamo, which generates power; depending on the airflow, the turbine will start rotating, and then the dynamo will also start to rotate. In the automotive industry, many new and innovative concepts are being developed these days. These concepts use the power from vehicle exhaust to generate electricity that can be stored in batteries for later consumption.

L3) Research by Sabu et al. (2015) Here, we're modifying a vehicle to produce electricity through the usage of turbines. The automotive sector is now producing a lot of innovative and creative ideas. We are using vehicle exhaust to generate electricity that can be stored in a battery for later use. We are demonstrating the concept of utilising turbines to produce electricity in a moving vehicle with this project. Here, we're adding a turbine to the exhaust stream of the silencer. An engine is also housed in the vehicle's chassis. The turbine is attached to a dynamo, which generates electricity. The airflow will cause the turbine to start rotating, and the dynamo will follow suit.

L4) Study by Sidhu et al. (2017) The use of internal combustion engines is rising as a result of the present global trend towards more transportation. About 75% of the energy generated during combustion is wasted as heat in the engine's coolant and exhaust, making internal combustion engines inefficient devices with high energy consumption. There is a pressing need to develop a strategy to stop the massive energy loss.A thermoelectric generator (TEG) intended for four-stroke internal combustion engines is used in this research to develop and implement a waste heat recovery system. The system uses a TEG to transform the exhaust manifold's waste heat into electrical energy.

L5) Research by Prince et al. (2020) There are several irreversible processes in the engine that restrict its potential to reach a highly balanced efficiency. There is also a significant temperature differential due to the gases' quick expansion inside the engine's cylinder.The work that follows suggests a thermoelectric waste heat energy recovery device for automotive internal combustion engines. A thermoelectric generator (TEG) is employed in the study that follows to transform waste surface heat into electrical energy. For best waste heat utilisation, the TEG is installed directly on the car silencer. The energy from the TEG is amplified and then stored in the car's battery using a voltage boosting unit.

L6) Study by Lasankute et al. (2018) In this research work the modification of stationary diesel engine for producing power using turbine. Nowadays in automobile field many new innovating concepts are being developed. We are using the power from vehicle exhaust to generate the electricity which can be stored in battery for the later consumption. In this project, we are demonstrating a concept of generating power in a stationary single cylinder diesel engine by the usage of turbines.Here we are placing a turbine in the path of exhaust in the silencer. An engine is also placed in the chassis of the vehicle. The turbine is connected to a dynamo, which is used to generate power.

L7) Research by Kirdat et al. (2024) The automotive industry is focusing more and more on implementing sustainable methods to lessen its ecological imprint as the globe struggles with the issues posed by resource conservation and climate change. The removal of waste oil produced during regular maintenance and oil changes is one of the difficulties encountered. Waste oil has the ability to contaminate land and water, which makes it a serious environmental risk if improperly disposed. In this regard, the study investigates a novel and inventive approach that uses Peltier modules, often known as thermoelectric generators, to harness the thermal energy found in spent oil to produce power. **Methodology-**Thermoelectric generators (TEGs) are devices that convert heat directly into electricity. When applied to automobiles, TEGs can be used to harness wasteheat from exhaust systems, engine components, and other sources to generate electrical power, improving overall energy efficiency.

Use thermocouples, voltage meters, and data acquisition systems to measure temperature gradients, electrical output, and conversion efficiency.

Thermocouples: Widely used for measuring the temperature gradient across the TEG. They provide accurate readings of the hot and cold sides of the TEG module, which is crucial for evaluating performance.
Digital Multimeters: Standard devices for measuring the output voltage and current generated by the TEG.

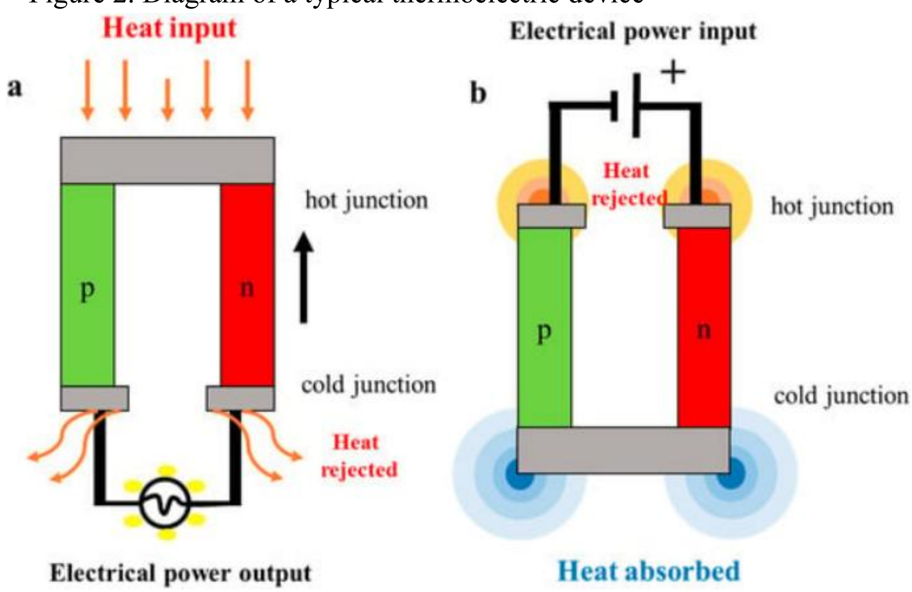
Heat Flux Sensors: These sensors are placed on the surfaces of the TEG to measure the rate of heat transfer, allowing for the calculation of conversion efficiency.

Load Resistors: By varying the resistance, one can measure the power output at different load conditions, which is essential for understanding the maximum power point of the TEG.

**Working Principle**- The way generators operate is by taking advantage of a temperature differential between their two sides. Consider this: Take a piece of metal, heat one end, and then cool the other end at the same time. The hot end's electrons will be more energetic than the colder end's electrons encircling the metal atoms.
Accordingly, the hot electrons will be bouncing around more quickly than those on the cool end, and they will also have a tendency to travel towards the cold end more quickly than the cold electrons will. Over time, the hot end will acquire a positive charge while the cold end will become increasingly negatively charged. This process, known as the thermoelectric effect, occurs when a temperature differential generates a voltage. Connecting numerous metal parts in series, as you would to create a larger battery, won't fix this problem since the wires used to connect them will create a voltage that is opposite to the voltages in the metal parts and will produce a voltage in the wrong direction.

In order to tackle this issue, scientists have used a substance that uses positively charged particles rather than electrons to conduct electricity. As with the metal's electrons, the positively charged particles will gravitate towards the cooler side. Therefore, if you connect a chain of them, the voltages will increase in series, enabling us to produce a significant amount of electricity. -The Seebeck effect is an electromagnetic field (EMF) created by a temperature differential across the junctions of two dissimilar conductors that form a closed loop. The two "pellets" of semiconductor material, typically composed of bismuth telluride ($Bi_2Te_3$), combine to form a single thermoelectric pair. P-type pellets are made by doping one of these pellets with acceptor impurities, whereas N-type pellets are made by doping the other with donor impurities. On one side, the two pellets are physically connected, often by a thin copper strip, and positioned between two ceramic outer plates that offer structural integrity and electrical isolation.

Figure 2. Diagram of a typical thermoelectric device



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If a temperature differential is maintained between the two sides of the thermoelectric couple (T1 and T2), thermal energy will flow through the device with this heat, producing an electrical voltage known as the Seebeck voltage, as illustrated in figure 1. The thermoelectric couple will produce a voltage (V) and electrical current if a resistive load is connected across its output terminals. Many of these thermoelectric couples are coupled thermally in parallel and electrically in series to create useful thermoelectric modules. Efficiency rapidly declines as the temperature gradient that powers the operation is eliminated. Scientists are searching for materials with a low heat conductivity and a high electrical conductivity in order to compensate for this [5]. One method is to slow down the passage of heat or allow electrons to move freely by using metal alloys that can be utilised to create a lattice of atoms of varying sizes. Similarly, some nanoparticle configurations have the ability to trap heat and slow it down. In general, heat moves more slowly when there are more joints and interfaces between the particles.
A single thermoelectric couple is constructed from two 'pellets' of semiconductor material usually made from Bismuth Telluride ($Bi_2Te_3$). One of these pellets is doped with acceptor impurity to create a P-type pellet; the other is doped with donor impurity to produce an N-type pellet. The two pellets are physically linked together on one side, usually with a small strip of copper, and mounted between two ceramic outer plates that provide electrical isolation and structural integrity. For thermoelectric power generation semiconductor material A and B joint together show in figure.1, if a temperature difference is maintained between two sides of the thermoelectric couple (T1 and T2), thermal energy will move through the device with this heat and an electrical voltage, called the Seebeck voltage, will be created. If a resistive load is connected across the thermoelectric couple's output terminals, electrical current will flow in the load and a voltage (V) will be generated at the load. Practical thermoelectric modules are constructed with several of these thermoelectric couples connected electrically in series and thermally in parallel.

**Experimental Set-up -** We think the efficiency of such a system would be in the range of 10.6% for QW of Si/SiGe, which accounts for 10 C temperature loss on both the hot and cold end of the thermoelectric for heat transfer. To determine the TEG with the maximum output at a particular temperature difference, we tested five different modules with different semi-conduct materials. The TEG module was clamped tightly between two containers, one of which was the hot side with a high temperature and the other was the cold side with a low temperature.

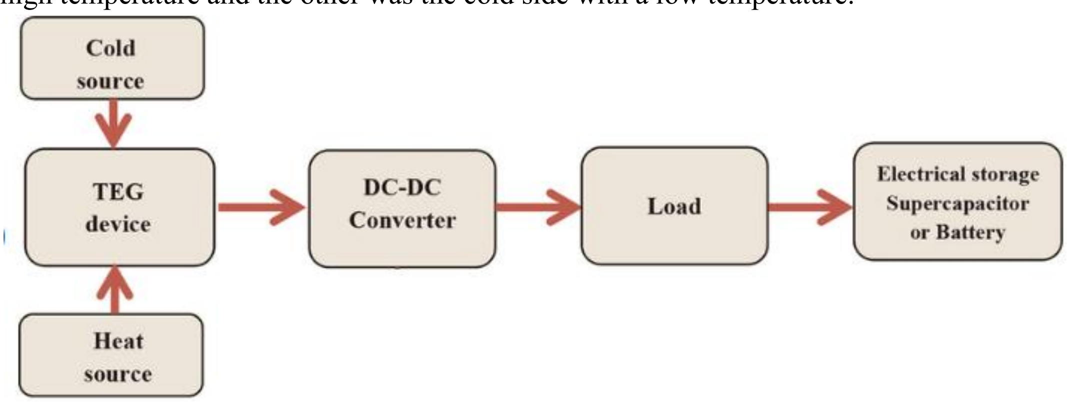


Figure 1. Block Daigram

**Components -**

1. Thermoelectric generator : Thermoelectric generator A thermoelectric generator is an electronic component based on semiconductors that uses the Seebeck effect to convert heat into electricity. The experimental setup uses two thermoelectric generators connected in series, with the bismuth telluride thermoelectric module having a hot side operating temperature of up to 150°C and a power output of 3.2 watts at a temperature difference of 100°C. Two TEG are connected thermally in parallel and electrically in series, resulting in an increasing voltage.

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1. Model: SP1848-27145

2. Operating Temperature: -40 to 150°C

3. Cable Length: approximately 20 cm

4. Seebeck effect

5. Raw material: bismuth telluride

6. Size: 40 x 40 x 3.4 mm

7. Merit (Z): 2.5 ~ 3.0 × 10-3W / °C

The module utilised in this work is based on bismuth telluride and is readily available at a reasonable cost. It comes in a variety of power and size options. 2. Heat source and heat sink: A heat source is an object that emits or generates heat. Copper heat source that was constructed for this investigation Heat is transferred to the thermoelectric generator via copper's high thermal conductivity and easy melting point, which make it suitable for welding at silencer bent pipes. Copper plates are therefore used as a heat source at the hot side of this experimental configuration. The TEGs' hot connections are attached to the copper plate required for the I.C. engine's bend pipe that transports the hot exhaust gases. With its smooth surface and measurements of 185 x 75 x 6 mm, this copper plate serves as a heat source. A heat sink is a device that uses thermal contact to collect and release heat from another item. 3. Aluminum heat sink: Aluminium heat sink designed for this investigation The aluminium heat sink employed in this experiment is the flat back variety. Numerous fins are cooled by an air cooling system. The aluminium heat sink's cold side is at room temperature, which is between 26 and 30°C. Figure 6 shows the aluminium heat sink fins, which have 25 fins and are distributed across an area of 70 x 80 mm with a thickness of 0.5 mm.In the experimental configuration, two heat sinks are used. Aluminium heat sinks are employed because of its high thermal conductivity, affordability, ease of availability, light weight, and TEG-attached flat back side. 4. Digital Thermometer: The temperature of the copper plate at the hot connection and the aluminium heat sink at the cold junction is measured by the two digital thermometers in this experimental setup. Digital thermometers with hot and cold sides have respective ranges of -50°C to 200°C and -99°C. There is a contact-type probe on both thermometers. (vi) Heat paste: This viscous fluid material has characteristics that are comparable to those of grease. It fills the micro-air gaps caused by the smooth or uneven surfaces, increasing the thermal conductivity of the thermal interface. The TEG's two joints are coated with heat paste to facilitate even heat transfer. Generally electrically insulating, it is thermally conducting.

5. I.C. Engine: A type of engine known as an internal combustion engine (IC) generates power by burning gasoline inside the engine itself, which powers a mechanical output. Common applications for IC engines include generators, cars, motorbikes, and other machines. 1. The engine cylinder receives a mixture of fuel (usually diesel or gasoline) and air. With an intake valve, this mixture is often managed. To provide the ideal air-fuel ratio, fuel injectors in contemporary engines spray fuel into the combustion chamber or into the intake manifold.

**Results -** The table-1 mentioned below shows speed variation with respect to increase in temperature.

| Temperature in ·c | Voltage in mV | Current in mA | Power in mW |
|---|---|---|---|
| 35 | 21.8 | 1 | 0.0218 |
| 45 | 443 | 1.9 | 0.8417 |
| 55 | 486 | 5.4 | 2.6244 |
| 65 | 508 | 13 | 6.6040 |
| 75 | 570 | 24.9 | 14.1930 |
| 85 | 645 | 36 | 23.2200 |
| 95 | 742 | 52 | 38.5840 |
| 105 | 848 | 76.8 | 65.1264 |
| 115 | 848 | 76.8 | 65.1264 |
| 115 | 1102 | 96.4 | 106.233 |
| 125 | 1348 | 121.4 | 163.647 |
| 135 | 1678 | 168 | 281.904 |
| 145 | 2080 | 206 | 428.480 |
| 150 | 2500 | 260 | 650.000 |

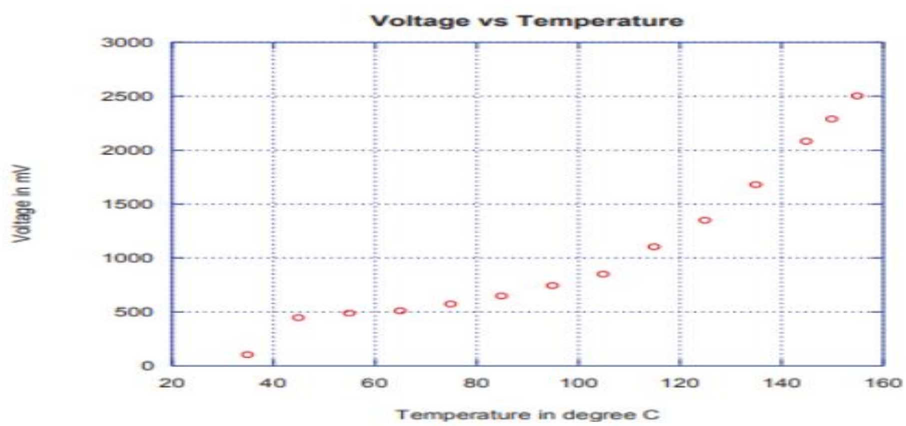


Figure9: Voltage VS Temperature

**Observations-**

- During the experiment the temperature was varied from 35o C to 155o C. We observed increased in power output with the increase in temperature. The variation of power, current and voltage produced by the TEG are plotted against the temperature in the figures 3, 4 and 5 respectively.

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**Conclusion -** Depending on the temperature differential attained, a thermoelectric Peltier module's efficiency will vary significantly. Furthermore, the Peltier's interaction with the other surfaces is a crucial consideration. Therefore, a surface that is insufficient or uneven will reduce efficiency. Additionally, using a thermal paste is a fantastic technique to produce additional electricity. Maximum energy dissipation between the surfaces will be guaranteed.

According to data sheets, certain SP1848-27145 thermoelectric modules can produce roughly:

Difference in temperature of 20 degrees: 0.97V and 225 mA
Difference in temperature at 40 degrees: 1.8V and 368 mA
60° Difference in temperature: 2.4V and 469 mA
80 degrees Difference in temperature: 3.6V and 558 mA

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