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THERMOELECTRIC POWER GENERATION BY BIKE SILENCER

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Abstract - A number of irreversible processes in the engine limit its capability to achieve a highly balanced efficiency. Also, the rapid expansion of gases inside the engine's cylinder produces a high temperature difference.in the following study a thermoelectric waste heat energy recovery system is proposed for the internal combustion engines used in automobiles. In the following study a Thermoelectric Generator (TEG) is used convert the waste surface heat to electrical energy. The TEG is directly mounted on the automobile silencer for optimum utilization of the waste heat. A voltage boosting unit is used to amplify the energy obtained from the TEG and further stored in the automobile's battery. The experimental results suggest that the proposed system can work well under different working conditions, and is a promising technology to be practically implemented in automotive industry. The further study also suggests that output energy obtained could be increased by connecting a number of TEGs in series, resulting in voltage addition leading to additional power output. In addition energy produced from this system could be used to power any auxiliary devices in an automobile.

Key Words: Thermoelectric Generator; Voltage Amplifier; Internal Combustion Engine; Temperature Gradient

1.0 INTRODUCTION

Viewing from the socio-economic perspective, as the level of energy consumption is directly proportional to the economic development and total number of population in a country, the growing rate of population in the world today indicates that the energy demand is likely to increase Currently fossil fuels are the main source of fuel for electricity generation. However, the reserves of fossil fuels are depleting, while in the recent years cost of per unit electricity is also increasing. Thus the, non-conventional methods (green energies) are more attractive alternatives because of its nature to bide with pollution free environment. The global demand of energy is elaborated graphically in Fig 1. The traditional nonconventional methods have many disadvantages associated with it. To name a few, the Solar cells, most commonly used in applications such as household are unable to function in the absence of sunlight and have major issues with energy storage facilities. Wind and hydro electric energy on the other hand have their own drawback and restricted by their nature of use. In recent years the scientific and public awareness on environmental and energy issues has drawn major attention towards the research on advanced technologies particularly in the field of internal combustion engines. Substantial thermal energy is available from the exhaust gas in modern automotive engines. 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 latest developments and technologies on waste heat recovery of exhaust gas from internal combustion engines (ICE) include thermoelectric generators (TEG), Organic Rankine cycle (ORC), six-stroke cycle IC engine and new developments in turbocharger technologies.

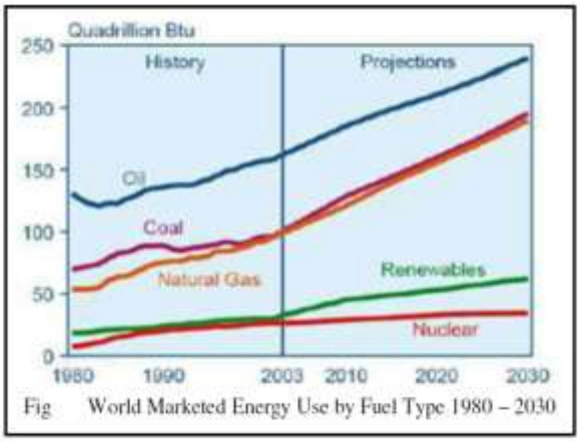


Fig 1: Estimated Global Energy Use for All Resources from 1980-2030

A thermoelectric generator (TEG) also called a Seebeck generator, a solid state device that converts heat flux (temperature differences) directly into electrical energy through a phenomenon called the Seebeck effect (a form of thermoelectric effect). The Seeback effect is demonstared in Fig 2. The thermoelectric power cycle, charge carriers (electrons) serving as the working fluid, follows the fundamental laws of thermodynamics and intimately resembles the power cycle of a conventional heat engine. 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. At the same time TEG is a suitable device for space research, Satellites and even unmanned facilities due to its compact size and high efficiency. Amongst their multiple uses, the thermoelectric devices can also be used in vehicles for production of electricity using the waste heat from engine. To name a few advantages of thermoelectric generators, they are. Compact in size and have low weight. Potential applications of TEG can be Jet Engines, IC Engines, Furnace covers, Hot water tubes, Refrigerators, Computers/ Laptops and others. Being one of the promising devices for automotive waste heat recovery, thermoelectric generators (TEG) sets to be one of the most important devices in the near futurethe.

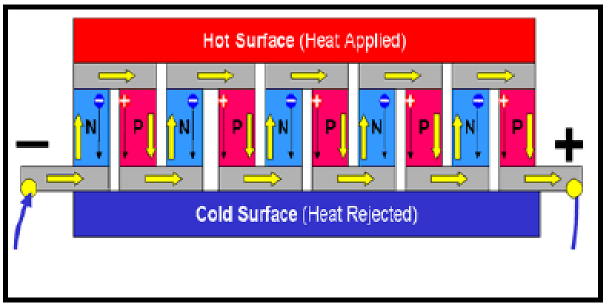


Fig. 2: Schematic Diagram for Seeback effect

In the following study, a TEG is used to generate electrical energy using the temperature of exhaust gases. The effectiveness of the TEG is improved by designing a cooling system for the same. Further practical experiments were conducted on a motor cycle to obtain the results in practical scenario.

2.0 Material and Method

The Schematic diagram of the mounting method for the device is shown in Fig 3. A TEG (TEC12706) was used in the following experiment. The working principle of the device can be given as with an increase in temperature there is an increase in the voltage and vice versa. As the heat transfer is uniform the second face of the TEG remains cold resulting in electron flow creating a potential difference and voltage is developed at the output side. A material 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 Seebeck coefficient (S). The efficiency of a given material to produce a thermoelectric power is governed by its "figure of merit" given as

$zT = S2\sigma T/\kappa$ (1)

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). The efficiency of a thermoelectric module is greatly affected by the geometry of its design. Thus selection of material from the above available is a crucial decision for the efficiency of the TEG. While all materials have a nonzero thermoelectric effect, in most materials it is too small to be useful. However, low-cost materials that have a sufficiently strong thermoelectric effect (and other required properties) could be used in applications including power generation and refrigeration. A commonly used thermoelectric material in such applications is bismuth telluride (Bi_2Te_3). The general workflow diagram of the following system is given in Fig. 4

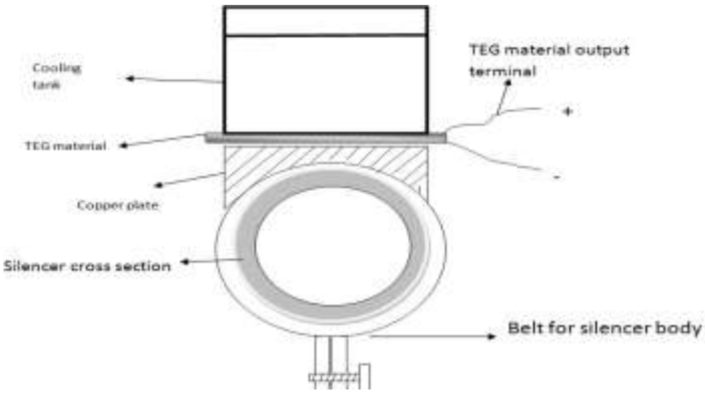


Fig 3: Schematic Diagram for Device Mounting

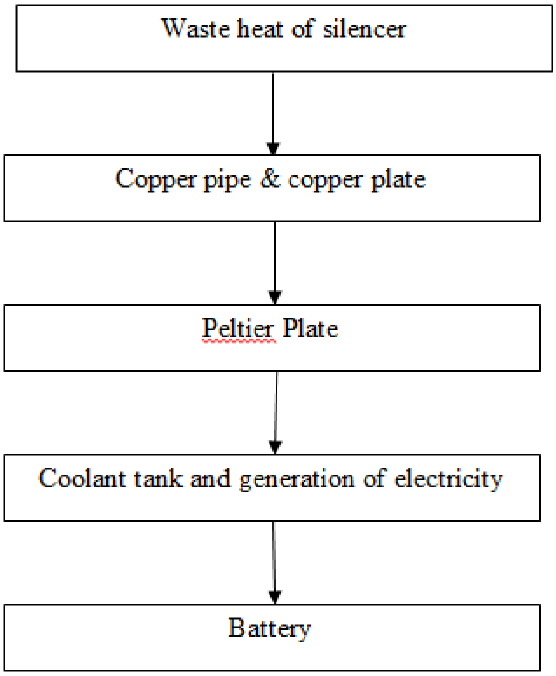


Fig. 4: Work Flow diagram of the system

3.0 Results and Discussion

It was observed that the vibration in the bike results in heat loss and ineffective heat transfer to the TEG system. Thus the design of the system was modified and an improved design was suggested. The schematic design of the modified design is given in Fig. 5.

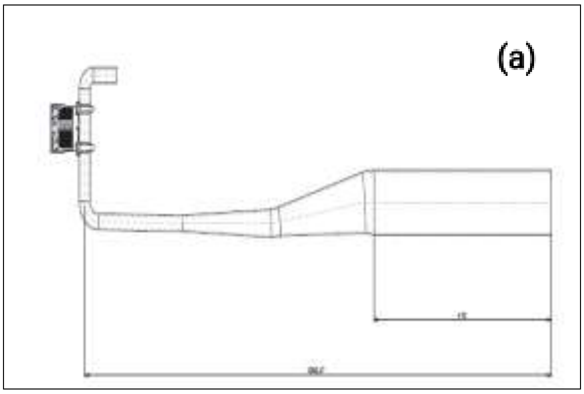


Fig. 5: (a) Mounting on Exhaust System

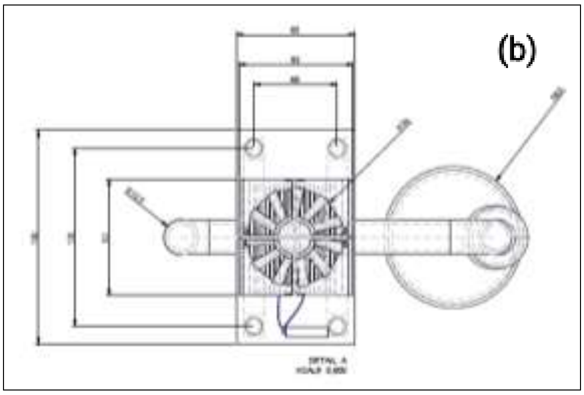
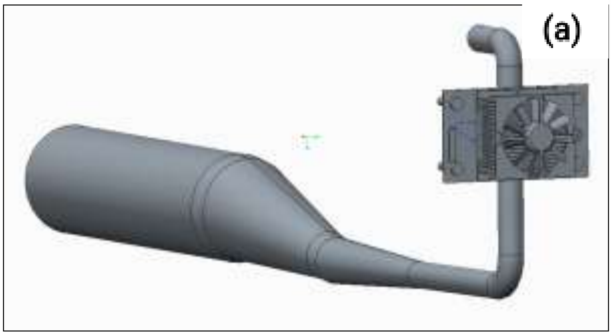
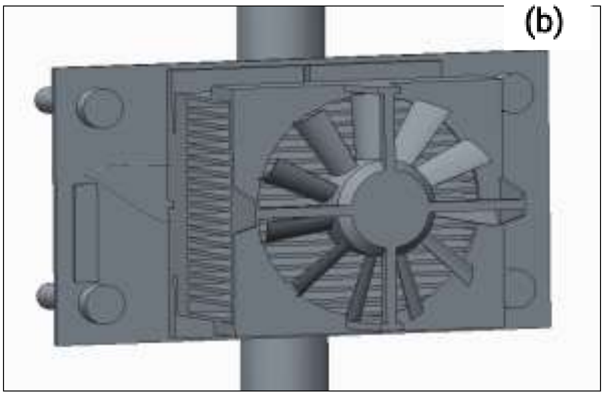


Fig. 5: (a) Mounting on Exhaust System (b) Front View of the System Mounting

The final mounting design was designed in the CAD software and was further simulated in other software. The final CAD diagram is shown in Fig. 6





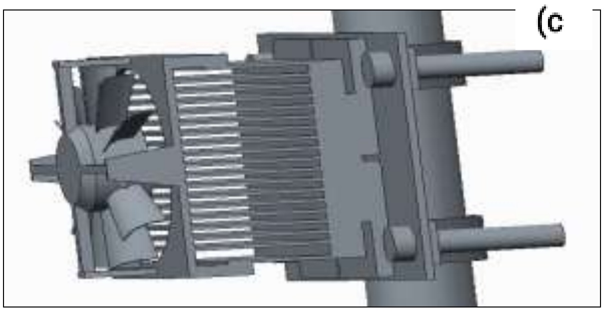


Fig. 6: CAD diagram of the Set-up (a) Mounting on the Exhaust System (b) Close-up view (c) Axillary View

The attachment was mounted on the exhaust system of an engine. The engine was them run at a constant speed of 1000 rpm. The heat from the exhaust system was transferred to a copper plate. The heat from the copper plate was simultaneously transferred to the peltier plate and the heat sink resulting in the cooling of peltier plate. This generated a thermal gradient which resulted in generation of electricity by the TEG.

The experiments were conducted on 8 runs which showed that as the temperature increased there was an increase in the generated voltage up to a particular point beyond which there was a decrease in voltage. The trend of voltage generation with increase in temperature is represented in Fig. 7 and the detailed voltage generation is mentioned in Table. 1. The maximum voltage was obtained at 175 °C beyond which the voltage started dropping.

4.0 WORKING PROJECT

When we attach our working setup on exhaust silencer then we start bike. After driving the bike exhaust silencer heated and this heat transfer to the copper plate. Heat of copper plat convey to peltier plate and heat sink simultaneously cooling the peltier plate. So TEG produce electricity through peltier plate.

4.1 Observation

Table 1: Voltage generation with increase in temperature.

Temperature (°C)	Voltage (V)
25	0
50	0.5
75	0.78
100	0.96
125	1.03
150	1.26
175	1.58
200	1.32

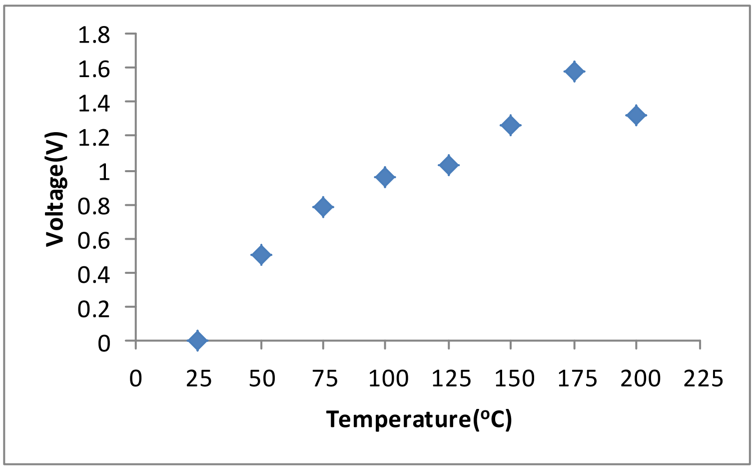


Fig.7: Voltage vs. Temperature Graph

5.0 FUTURE SCOPE

By using proper heat sink material help to increase the output voltage.

1. Using long proper heat sink material is to avoid the heat in between the gap of fins.
2. By addition of the more TEG in SERIES is to increase the voltage

6.0 CONCLUSIONS

The maximum potential difference generated by the TEG was 1.58V. The generated potential difference was utilized in running auxiliary devices mounted on the motor cycle. The potential difference generated was sufficient to run the auxiliary device. TEG setup was able to successfully recover energy from the exhaust system of the engine. The potential difference generated was not sufficient to charge a battery. The utilization of multiple TEGs in series could result in generation of higher potential difference which needs to be studied further.

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