Conversion of Exhaust Heat from An IC Engine To Electric Power

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Abstract: The application of low temperature thermal resources, especially for power generation has been the subject of interest in recent years. Most of the current commercialized thermal power- generation technologies convert thermal energy to electric energy indirectly. That is converting mechanical work before producing electricity. A thermoelectric generator can directly transform thermal energy into electricity through the Seebeck effect. This method has many advantages such as compactness, quietness, and reliability because there are no moving parts. Laboratory experiments have been conducted to measure the output power at different conditions: different connection modes between Thermoelectric generator modules, different mechanical structures and different temperature differences between hot and cold sides. The thermoelectric generator apparatus fitted to a 4s-diesel engine has been tested and the data have been presented.

Keywords: Thermo Electric Generator (TEG), Seeback Effect, Exhaust Heat.

I. Introduction

The Seebeck effect is a phenomenon in which a temperature difference between two dissimilar electrical conductors or semiconductors produce a voltage difference between the two materials. A Thermoelectric generator or TEG (also called a Seebeck generator) is a solid- state device that converts heat (temperature differences) directly into electrical energy through a phenomenon called the Seebeck effect.

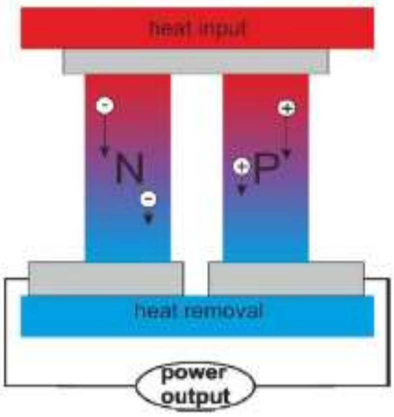

Fig.1. Seebeck Effect

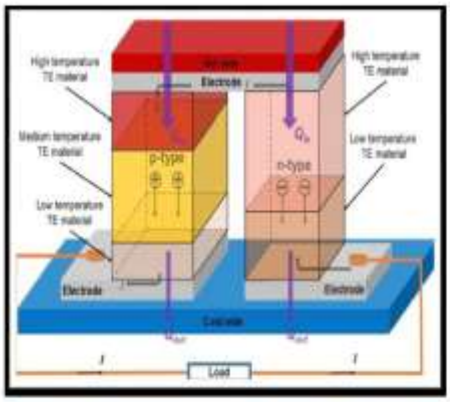

Fig. 2. Anatomy of TEG

Thermoelectric generators could be used to convert waste heat into additional electrical power and in automobiles as automotive thermoelectric generators (ATGs) to increase fuel efficiency. Thermoelectric power generators consist of three major components: thermoelectric materials, thermoelectric modules and thermoelectric system that interface with the heat source. 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 and the other side stays cold, which helps to generate a large voltage.

A thermoelectric module is a circuit containing thermoelectric materials that generate electricity from heat directly. 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 percent is in the form of hot exhaust gas. The power from vehicle exhaust is used to generate the electricity which can be stored in battery for the later consumption.

A thermoelectric generator, also called a Seebeck generator, is 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). Thermoelectric generators function like heat engines, but are less bulky and have no moving parts. However, Thermoelectric generators 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. Literature Survey

Thomas Jon Seebeck has invented that a temperature formed between two dissimilar conductors produces a voltage and current. At the heart of the thermoelectric generator effect is the fact that a temperature difference in a conducting material results in heat flow between one side to another side.

Liu et al. have built a power generator using TEG modules, which indicated that the cost of the TEG system developed was lower than those of photovoltaic (PV) and wind power systems in terms of equivalent energy generated.
Belanger and Gosselin have presented a model and optimized the internal structure of a thermoelectric generator sandwiched in a cross-flow heat exchanger.
Gou et al. have studied the influence of heat transfer irreversibility on thermoelectric generation performance. Expanding the heat sink surface area and enhancing cold-side heat transfer capacity in a proper range can enhance performance of the TEG system.
Casano and Piva have reported an experimental investigation of the performance of a power generation device in which they used multiple Peltier modules in the Seebeck mode and analyzed the thermoelectric generator based on the experimental data for the 'open' and 'closed' circuit voltage, electric power output and conversion efficiency as a function of temperature.
Yu and Zhao have presented a detailed numerical model of thermoelectric generator with the parallel-plate heat exchanger, focused on analyzing the fluid temperature change along the fluid passage and the temperature difference across the thermoelectric modules (TEG).

III. OBJECTIVES

1. To understand the working principle of thermoelectric generator.
2. Maintain the heat transfer from hot side to cold side because of uniform charging mobile battery.
3. To produce electricity from exhaust heat and utilize this electricity to charge the battery.

IV. METHODOLOGY

01.Planning: By referring several literatures review we got many ideas, hence finalized our topic as, "CONVERSION OF EXHAUST HEAT FROM AN IC ENGINE TO ELECTRIC POWER".
02.Fabrication of basic components: For our project we required some components to fabricate like aluminum block, heat sink, etc.
We measured the exhaust pipe according that we fabricated the aluminum block by machining.
03.Assembling: After finishing fabrication work, we started the assembling the components manually.
04.Conduction of experiment: To conduct our experiment fill the fuel tank and start the engine, after running for some time the exhaust pipe change in temperature and heat transfer take space through aluminum block to TEG model, hence by temperature difference we get the electricity.
05.Introspection of Results: By the experimentation we got some results for different temperatures. From all the results we plotted a graph of temperature vs voltage.

V. RESULTS

Temperature reading in ºC	Multimeter reading in Volts
40	0.22
77	1.05
92	1.74
105	2.33
126	3.46
136	4.06
146	4.57
160	5.04
170	5.52
182	6.09
194	6.53
206	7.02
222	7.65
234	8.12
257	9.05
294	10.05
314	11.39
346	12.71

Table.1. Result

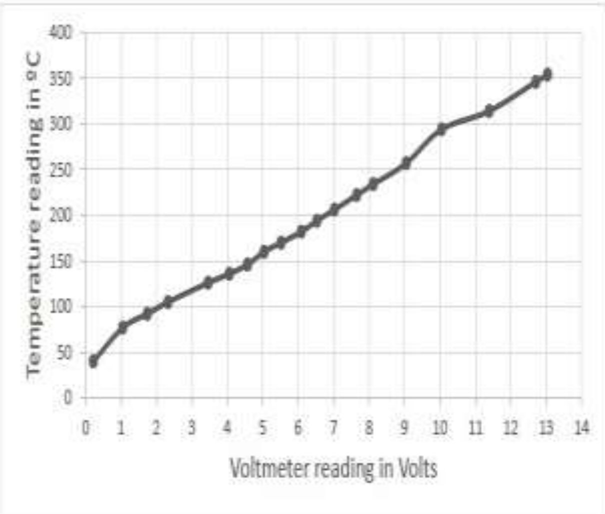

Fig. 2. Temperature vs Potential Difference

VI. CONCLUSION:

1. It can be concluded that a proper difference in temperature applied between two sides of module improves the electrical performance.
2. The performance of the thermoelectric generator under mismatch conditions. The experimental data are presented to highlight the effect on the electrical performance.
3. From the experimental procedure we observed that in series connection voltage is more than parallel connection.

VII. SCOPE OF FUTURE WORK:

1. Connection of more TEG modules on the setup.
2. Utilization of liquid cooling on the TEG module setup instead of air cooling.

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