Thermo-electric Power Generator from Waste Heat

Adiesh koul[1], Ajay Gaikwad[2], Akshay Gaikwad[3], Shubham Babar[4], Prashant Mahale[5]

[1] *Student, Department of Mechanical Engineering, D.Y.Patil College of Engineering, Maharashtra, India*
[2] *Student, Department of Mechanical Engineering, D.Y.Patil College of Engineering, Maharashtra, India*
[3] *Student, Department of Mechanical Engineering, D.Y.Patil College of Engineering, Maharashtra, India*
[4] *Student, Department of Mechanical Engineering, D.Y.Patil College of Engineering, Maharashtra, India*

ABSTRACT

The current worldwide trend of increasing transportation is responsible for increasing the use of internal combustion engines. I.C engines, the devices with a high energy usage and low efficiency because roughly 65% of the energy produced during combustion is lost in the exhaust and in the coolant of the engine in the form of heat. Asa huge amount of energy is lost, there is urgent need to design a advice to trap this loss.This paper proposes and implements a waste heat recovery system using a thermoelectric generator (TEG) designed for four strokes I.C. engine. The system converts the waste heat from the exhaust manifold into electrical energy using a TEG. The output is then boosted by a Joule Thief converter to run the required load or to charge a battery. The experimental results demonstrate that the proposed system recovers considerable amount of waste heat which can be used to power some auxiliaryautomobile devices.

Keyword: - Thermoelectric Generator, Seebeck Effect, Waste Heat Recovery, Thermoelectric Module, Thermocouple, Thermal fin.

I. INTRODUCTION

There is no system which converts total input energy into output energy practically, there are some losses. In the universe there is no system which is 100% proficient, due to losses system effectiveness decreases in real practices. Automobile sector are an example of high energy usage with low competence. It has 35% efficiency and roughly 65% of the energy produced during combustion is lost in the exhaust or engine coolant in the form of heat. If this energy is tapped and transformed into functional energy, the overall efficiency of an engine can be improved. Thermoelectrictechnology can be used to generate electrical power from waste heat. Thermoelectric generator utilizes the See beck effect which was first observed in 1821. Thermoelectricgenerator practically came into existence in 1960 which were developed appreciably and since then number of manufacturers are now marketing thermoelectric modules for power generation, heating and cooling applications. Constant research and advances in thermoelectric materials and manufacturing techniques, enables the technology to make an increasing effort to address the growing low power energy sources typically used in energy harvesting and scavenging systems. Thermoelectric generator can be used to generate a small amount of electrical power, typically in the microwatt (μW) range, if a temperature difference is maintained between two terminals of a thermoelectric generator.

The hotness of exhaust gas pipe of an engine is very high when exhaust gases are flowing through it. Thermoelectric generator is model for such applications as they are small, with no moving parts and relatively efficient at this temperature. Thermoelectric generator is basically solid-state devices that are used to convert thermal energy from temperature gradient to electrical energy. By using waste thermal energy through IC engines exhaust to charge the battery instead of using an alternator the overall fuel economy can be increased by 10%. Peltier module structure has two types of semiconductor elements arranged in tandem sandwiched between copper substrate when electricity is passed through the module, electrons move in one element and positive holes move in the other element,

this is called the "Peltier effect." This allows one side of the substrate to absorb heat and the other to radiate heat, so the hot and cold sides to be switched depending on the current

1.1 Literature Review

Q. Cao et.al. - "Performance enhancement of heat pipe assisted thermoelectric generator forautomobile exhaust heat recovery"

They had performed an experiment using heat pipes assisted thermoelectric generator for automobile waste heat recovery. Because of the low thermal resistance ofthe heat pipe, it is widely applied to exhaust waste heat. Heat pipes will make the TEMsurface temperature be closer to the exhaust temperature when fins are employed in the gas flow channel. A thermoelectric generator including 36 TEMs for automobile exhaust waste heat recovery is proposed. Several factors of the heat pipe application were testedbefore it was put into application on the HP-TEG system construction. Comparative study of the TEG with or without heat pipes was analysed. This improvement of powergeneration efficiency with the rising of exhaust temperature was found out. The maximum power generation efficiency of 2.58% was reached with exhaust temperatureof 300C and mass flow rate of 80 Kg/h. For the pressure drop was relatively lower thanthe allowable pressure drop of engine exhaust, indicated the acceptability of HP-TEG be used in automobile without affecting the normal operation of the engine. With reference to this research paper, the design considerations are taken into account. Estimated number of modules has also been taken for available space constraint from this paper. Insulation parameters regarding the concentration of heat at a single space isalso found. The temperature gradient should be high enough so that maximum voltage could be produced and this is possible by the use of fins which will improve the heat transfer rate.

D. Patilet.al. - "Thermoelectric materials and heat exchangers for power generation.

Attempted to review the materials which are efficient for the thermoelectric generation and heat exchangers with internal structures. Highly doped semiconductors showed good thermal resistance which are important characteristic for the TEG. The thermoelectric material which are based on bismuth telluride, lead telluride and silicon germaniums are used in the TEG's according to their temperature capability. The outputpower of the TEG's are built upon the type of economic TEM's, temperature differencebetween the heat sink and the heat source and the physical properties of the working fluid. The temperature dissemination of the exhaust heat exchanger is very crucial for thermoelectric generator as the heat exchanger provides primary heat to the TEG's and their conversion efficiency and capacity depends on shape, material and type of heat exchanger. Irregular thermal stresses make the contact between the TEM and the heat dissipating surface rough and can lead to the permanent damage to the TEM's. With reference to this research paper, material that could work under the specified temperature limit of below 250C is bismuth telluride and is readily available in commercial module form. The lower temperature kept for bismuth telluride -50C thus,the working temperature should be maintained between these limits of temperature.

1.2 Problem Statement

There is need of waste heat recovery because we are facing the problem of energy crisis in terms of conventional sources of energy. By using waste heat, we can save not only conventional sources of energy but also, we can enhance the efficiency of these sources of energy. In the case of heat recovery, we are saving some amount of energy which we can use not only for ourself but also for upcoming generation.

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1.3 Objectives

The main focus of this experimental setup for conversion of waste heat energy (from Exhaust of Two-Wheeler) into electricity using thermoelectric generator (TEG). Advantages of thermoelectric generators outside of such specialized applications is that they can potentially be integrated into existing technologies to boost efficiency and reduce environmental impact by producing usable power from waste heat.

1.4 Methodology

Phase I

We started our work with literature survey. Searched many research papers from various articles and published journal papers. Then we collected all the topic related data from these research papers and studied them in detailed manner along with the standard reference books and academic books.

Phase II

Worked on diff. Mechanisms that can be useful for our project. We have done a rough 2D sketch of model in Catia. After the final analysis and material selection we explore the market to purchase the required components with required specifications. In this process we approximately estimated the cost required to purchase the components and for machining.

Phase III

Tested the different designs that we had in mind for our project (chose the number of Peltier plates, the shape that would absorb the maximum heat of the exhaust pipe) and did the wiring of the Peltier plate, the temperature control unit.

Phase IV

Selected the best design for our Project and the model was manufactured the project was then used to take observations and note down the readings of various variables in our project, the project ran successfully and the data was gathered.

Phase V

Collecting the various data required for all the variables, we made different observations about the temperature gradient, the voltage collected at various temperatures, the time taken to attain a certain voltage and plotted the required graph for various variables.

2. DESIGN

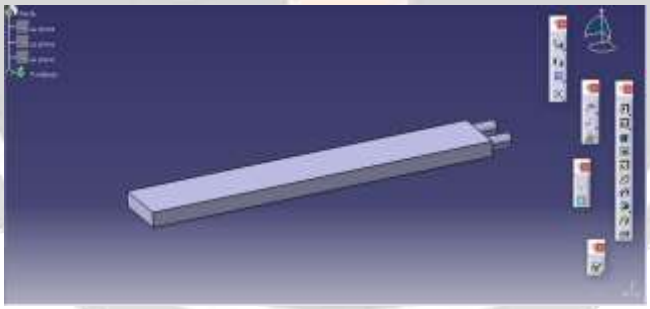


Fig – 1 Aluminium Cooling Plate

It is a Heavy Aluminium build which consists of Internal flow channel extrusion forming within it for coolant to flow and provide effective cooling. The aluminum heat sink has a 1.1mm thickness. Aluminum heat sink is used because it has high thermal conductivity.

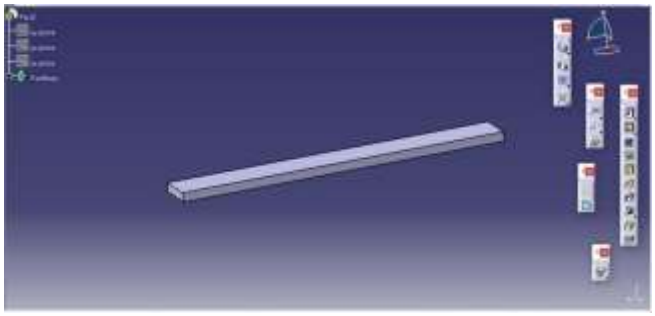


Fig – 2 Aluminium Plate

It is a Heavy Aluminium build which is used to sandwich the Peltier plates within them. the aluminium Plate has a 1mm thickness. Aluminium plate is used because it has high thermal conductivity which will help the temperature to rise easily on the hot side and reduce easily on the cold side.

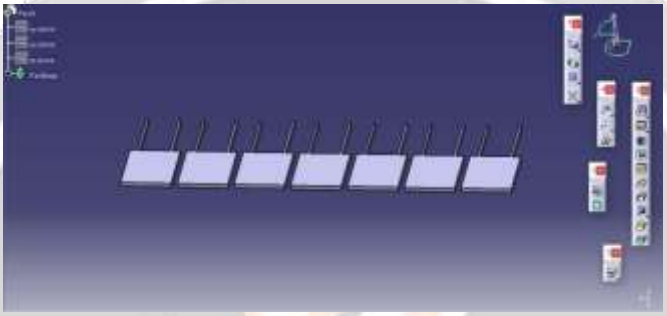


Fig – 3 Peltier Plate

It is a Heavy Aluminium build which is used to sandwich the Peltier plates within them. the aluminium Plate has a 1mm thickness. Aluminium plate is used because it has high thermal conductivity which will help the temperature to rise easily on the hot side and reduce easily on the cold side.

Fig – 4 Cooling Tank

It is plastic container, which is used to hold water for the cooling process. It consists of a motor which is used to continuously supply cold water for cooling purposes to maintain the temperature difference.

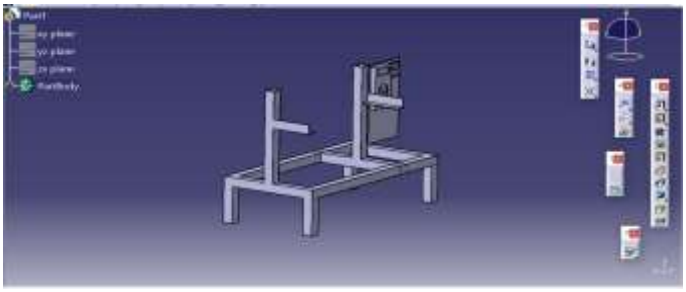


Fig – 5 Frame

It is a MS frame used as it is low cost. It is used as a replacement for the exhaust pipe. It is designed in such a way so that all the components are easily placed on it. On the right side there is a flat plate holding the temperature control unit, the multimeter and the temperature sensor.

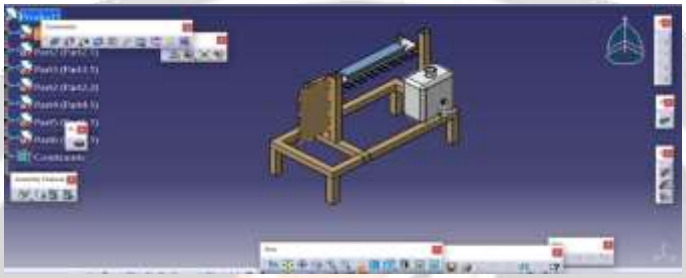


Fig – 7 Assembly

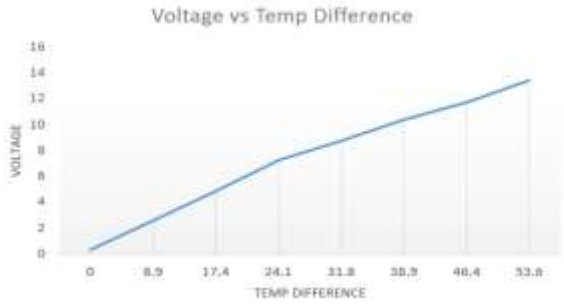
The 7 Peltier plates are sandwiched between the Aluminium plates. On one side of the Aluminium plate heater is installed and on the other side Aluminium cooling plate is installed so as to maintain the temperature difference. The supply for Aluminium cooling plate is taken form a cooling tank which is at the rear left side of the assembly. The right side of the assembly consist of a flat plate which consists of the temperature control unit, the multimeter and the temperature sensor.

3. TESTING AND ANALYSIS

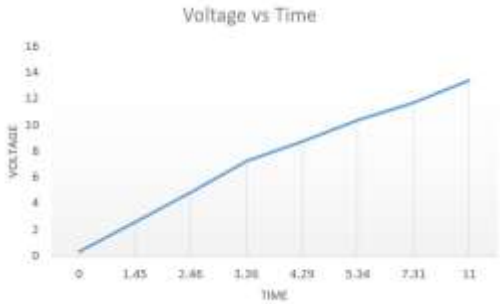
3.1 At Surrounding Temperature

S. No.	**Temperature**			**Voltage**	**Time**
	Hot (°C)	**Cold (°C)**	**∆T (°C)**	**(Volt)**	**(Min)**
1.	31	31	0	0.3	0
2.	41	32.1	8.9	2.59	1.45
3.	51	33.6	17.4	4.83	2.46
4.	61	36.9	24.1	7.26	3.36
5.	71	39.2	31.8	8.76	4.29
6.	81	42.1	38.9	10.37	5.34
7.	91	44.6	46.4	11.74	7.31
8.	101	47.4	53.6	13.38	11.00

Table – 1 Reading at Surrounding Temp



Graph – 1 Voltage Vs Temperature Difference Graph

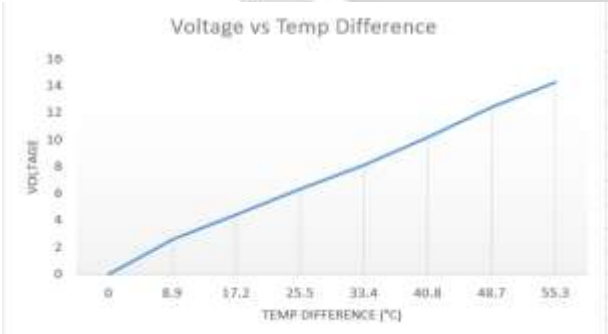


Graph – 2 Voltage Vs Time Graph

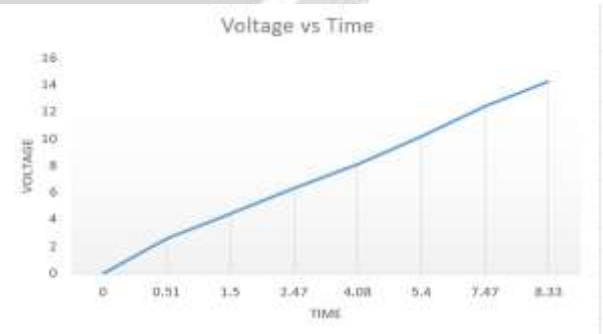
3.2 At Room Temperature

S. No.	Temperature			Voltage	Time
	Hot (°C)	Cold (°C)	ΔT (°C)	(Volt)	(Min)
1.	32	32	0	0	0
2.	42	33.1	8.9	2.61	0.51
3.	52	34.8	17.2	4.41	1.50
4.	62	36.5	25.5	6.36	2.47
5.	72	38.6	33.4	8.08	4.08
6.	82	41.2	40.8	10.16	5.40
7.	92	43.3	48.7	12.38	7.47
8.	102	46.7	55.3	14.25	8.33

Table – 2 Readings taken at Room Temp



Graph – 3 Voltage Vs Temperature Difference Graph



Graph – 4 Voltage Vs Time Graph

4. CONCLUSIONS

Present method for electricity generation is converting thermal energy into mechanical energy by turbine then into electricity by using generator. Burning of these fuels causes environmental problem like radio activity pollution, global warming. hence (coal, oil, gas) are the limiting resources resulting new technology is needed. The project paper is tested and implemented. The system gives the best economical pollution free, required energy solution tothe people.

Power generators have been built using TEG modules and tested. The power of the module could reach about 500 W (predicted using experimental data in Reference Paper) with a temperature difference of about 200°C between hot and cold sides.

This work can be used for many applications in urban and rural areas where power availability is less or totally absence. By making this system generates and charge 12v which is capable torecharge a mobile. it avoiding dependency of grid supply. This is a Promising technology for solving power crisis to an affordable extent.

5. REFERENCES

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[3]. Design and Machine Elements by V. B. Bhandari