International Journal of Mechanical and Industrial Technology ISSN 2348-7593 (Online)
Vol. 3, Issue 2, pp: (23-32), Month: October 2015 - March 2016, Available at: www.researchpublish.com

Heat Energy Recovery System from Internal Combustion Engine by Using Thermo Electric Generator

Sujith Bobba[1], P.Rajesh[2]

[1]Assistant Professor, Mechanical engineering Department, MIC College of Technology, kanchikacherla, Krishna District, Andhra Pradesh, India

Abstract: **This paper demonstrates how to recover the waste heat energy form internal combustion engine automobiles, including gasoline vehicles. The key is to directly convert the heat energy from automotive exhaust gases to electrical energy using a thermoelectric generator, which is then regulated by a Booster circuit converter to charge a battery using maximum power point tracking. Hence, the electrical power stored in the battery can be enhanced. This is a two way power storing system i.e. Energy from TEG and electrical generator cum motor can be stored in the battery. Both analysis and experimental results demonstrate that the proposed system can work well under different working conditions, and is promising for automotive industry.**

Keywords**: thermoelectric generator, booster circuit.**

I. INTRODUCTION

Even a highly efficient combustion engine converts only about one-third of the energy in the fuel into mechanical power serving to actually drive the car. The rest is lost through heat discharged into the surroundings or, quite simply, leaves the vehicle as "waste heat". Until just a few years ago, however, such thermoelectric generators (TEGs) were unsuitable for use in the automobile due to their low level of efficiency. To generate electric power in the vehicle a Thermo electric generator is integrated in the exhaust gas manifold.

While the electric power such a system is able to generate is still relatively small at a maximum of 200 W, rapid progress in materials research already makes the ambitious objective of generating up to 1,000 W a realistic and by all means feasible proposition. This energy regeneration system also offers additional effects, such as providing the engine or the heating system with extra heat when starting the engine cold.

II. AUTOMOBILE APPLICATIONS

The utilization of waste heat energy from exhaust gas gases in reciprocating internal combustion engines (e.g. automobiles) is another novel application of electricity generation using thermoelectric power generators. For example, in a gasoline powered engine, approximately 30% of the primary gasoline fuel energy is dissipated as waste heat energy in the exhaust gases; waste heat energy discharged in the exhaust gas gases from a typical passenger car travelling at a regular speed is 20-30 Kw.

A schematic diagram showing this patent of converting waste heat into electrical power applied to an internal combustion engine, by means of thermo electric Generator installed near the heat source of the automobile.

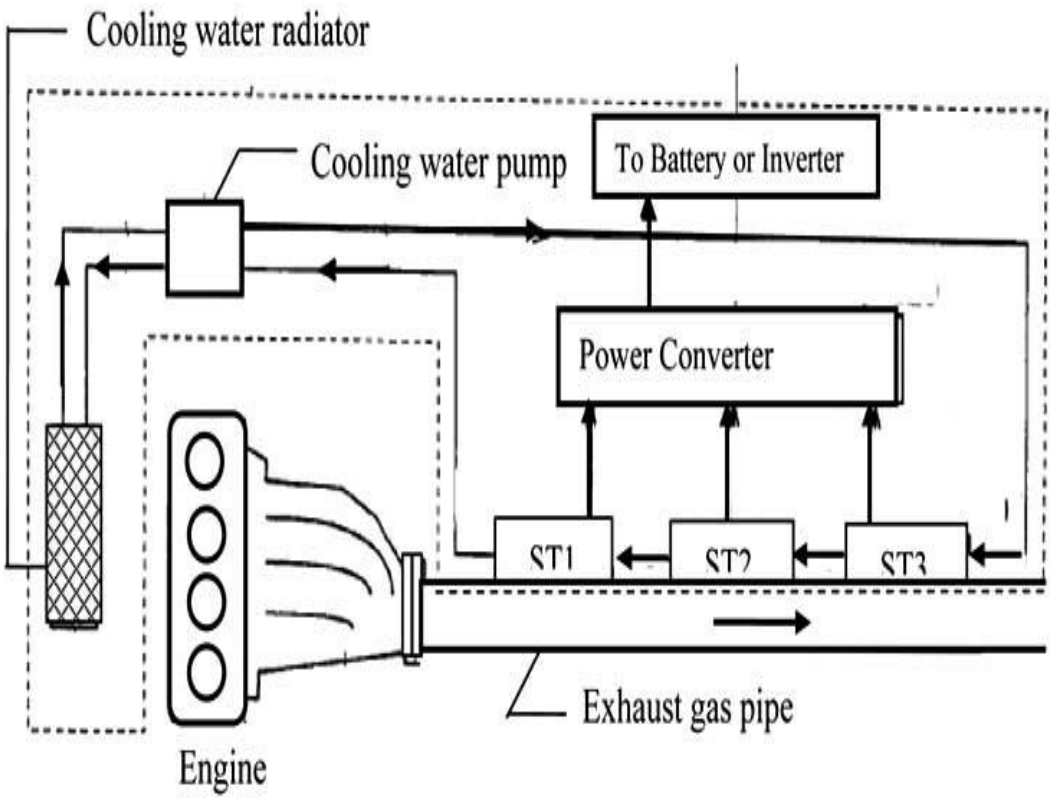


Fig-1: TE generator in an automobile

III. HYBRID ELECTRIC VEHICLE

In a traditional hybrid vehicle, you have a complete electric car. It includes an electric motor to provide all of the power to the wheels, as well as batteries to supply the motor with electricity. Then you have a completely separate gasoline engine powering a generator. The engine is very small perhaps 10 to 20 horsepower - - and it is designed to run at just one speed for maximum efficiency. The purpose of this small, efficient engine is to provide enough power for the car at its cruising speed.

IV. DESCRPTION OF THE EQIPMENT

A. Thermo Electric Material:

Thermo Electric Power:

TEG in conjunction with solar and wind, their combined output can provide all off your home's energy needs and depending on what state you live in

The advantages of using thermoelectric devices:

They are extremely reliable and silent in operation

They have no mechanical moving parts and require considerably less maintenance;

They are capable of operating at elevated temperatures;

Thermo electric principle of operation:

The typical thermoelectric module is manufactured using two thin ceramic wafers with a series of P and N doped bismuth-telluride semiconductor material sandwiched between them. The ceramic material on both sides of the thermoelectric adds rigidity and the necessary electrical insulation. The N type material has an excess of electrons, while the P type material has a deficit of electrons. One P and one N make up a couple. The thermoelectric couples are electrically in series and thermally in parallel. A thermoelectric module can contain one to several hundred couples.

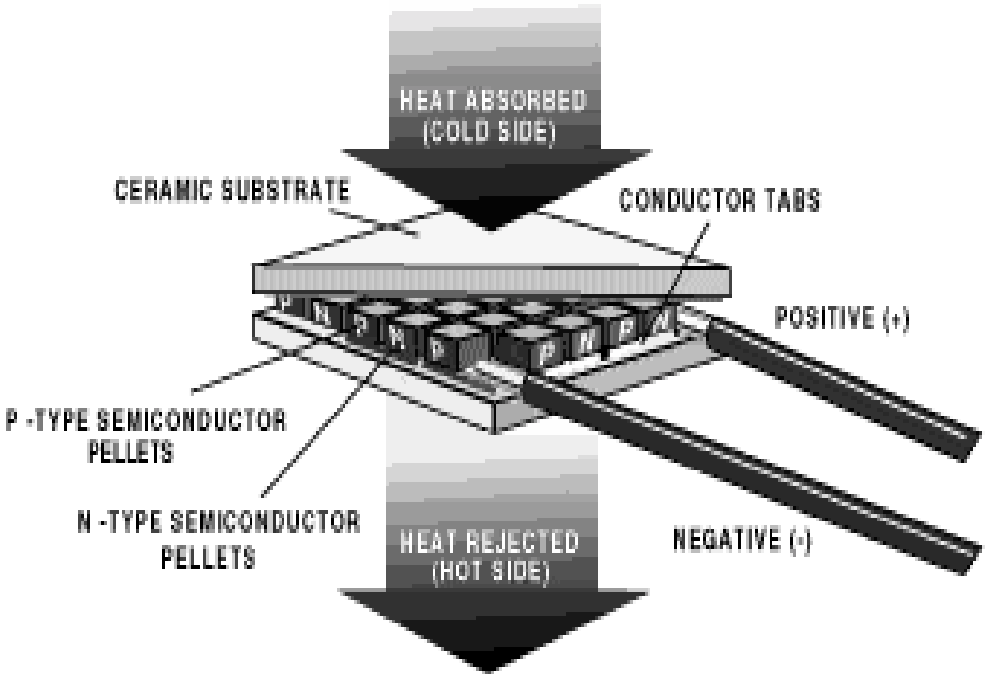
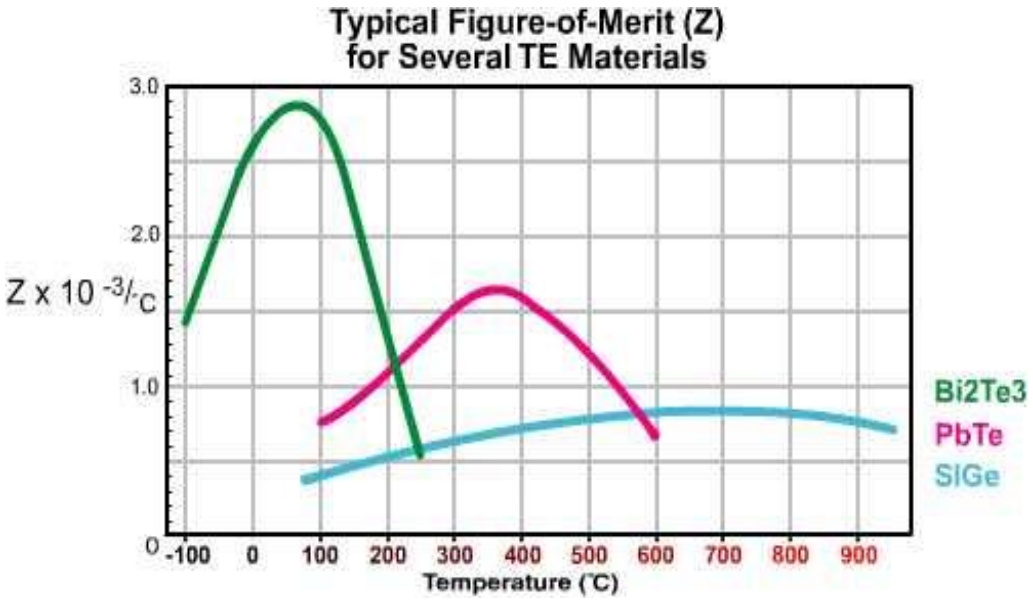


Figure-2: Principle of operation of peltier effect

Types of Thermo electric Materials:

Thermoelectric materials (those which are employed in commercial applications) can be conveniently divided into three groupings based on the temperature range of operation. Alloys based on Bismuth (Bi) in combinations with Antimony (An), Tellurium (Te) or Selenium (Se) are referred to as low temperature materials and can be used at temperatures up to around 450K. The intermediate temperature range - up to around 850K is the regime of materials based on alloys of Lead (Pb) while thermo-elements employed at the highest temperatures are fabricated from SiGe alloys and operate up to 1300K.



Graph-1: Performance of Thermoelectric Materials at Various Temperatures

B. Thermo-Electric Generator:

Based on this Seebeck effect, thermoelectric devices can act as electrical power generators. A schematic diagram of a simple thermoelectric power generator operating based on Seebeck effect.

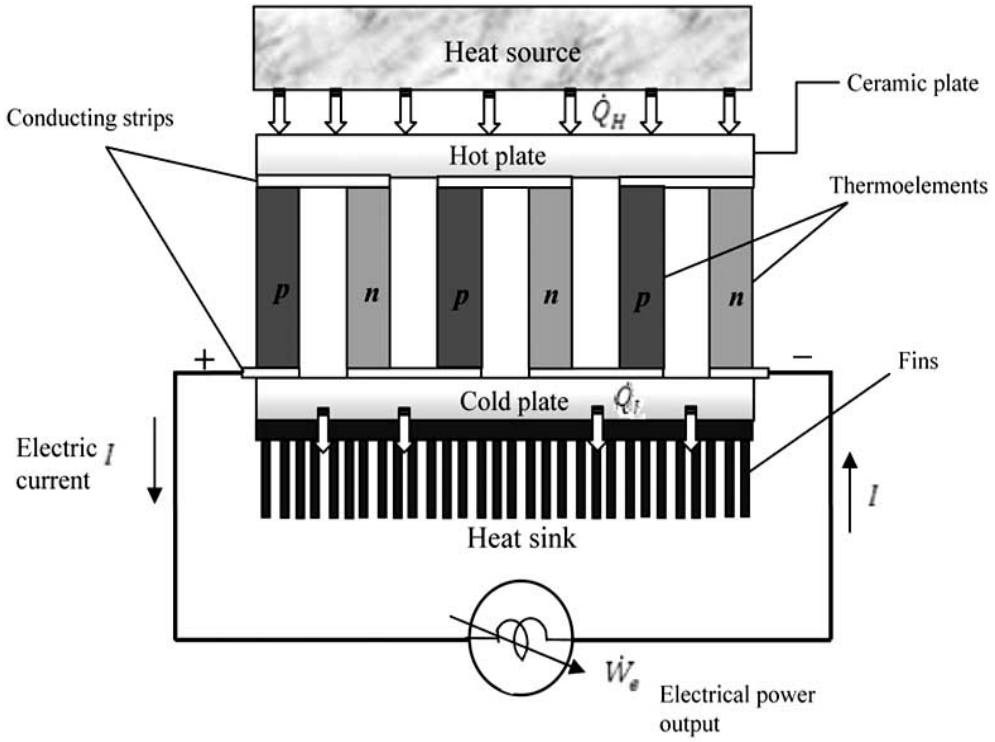


Figure-3: Working of thermoelectric generator

As shown in figure-3, heat is transferred at a rate of $Q_h$from a high-temperature heat source maintained at T_h to the hot junction, and it is rejected at a rate of Q_l to a low-temperature sink maintained at T_l from the cold junction. Based on Seebeck effect, the heat supplied at the hot junction causes an electric current to flow in the circuit and electrical power is produced. Using the first-law of thermodynamics (energy conservation principle) the difference between Q_h and Q_l is the electrical power output.It should be noted that this power cycle intimately resembles the power cycle of a heat engine (Carnot engine), thus in this respect a thermoelectric power generator can be considered as a unique heat engine.

Fig-4: Front and rear view of the TEG in the system

***Charge Carrier Diffusion*:**

In a system where both ends are kept at a constant temperature relative to each other (a constant heat current flows from one end to the other), there is a constant diffusion of carriers. If the rate of diffusion of hot and cold carriers were equal, there would be no net change in charge.

Booster Circuit:

This is based on the theory that inductor holds current and passes in opposite direction. This is a DC to DC converter and it has a poor efficiency of 60-80%. So we can't use it for a large project. We can use it for low power consuming models

like 12v and 3v models which requires 250mA current. We have to spend 650mA with 80% efficiency. In this circuit we are going to put DC pulse of around 2V through TEG and amplifying to 12V as output. We need to fallow the below for expected voltage range.

1. 6V to 12V @1A: 80 turns of 24swg wire in a 0.5mm ferrite core.
2. 6V to 12V @500mA: 60 turns of 36swg wire in a 0.5mm ferrite core.

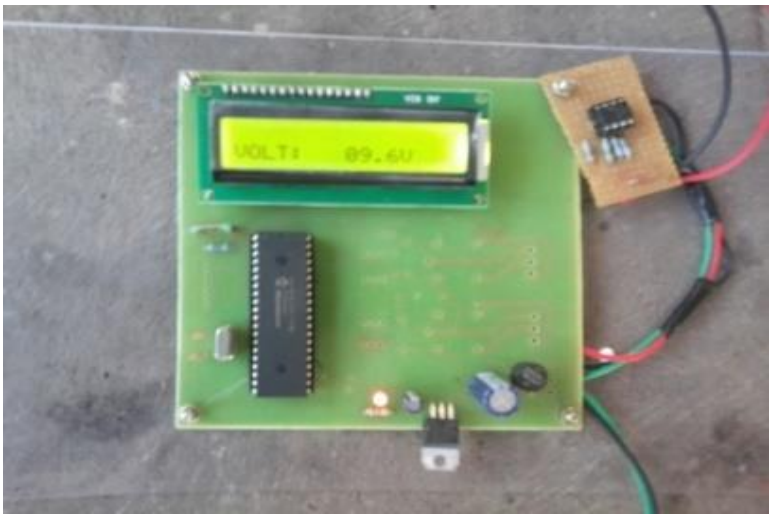


Fig-5: Booster Circuit

The main purpose of using the Booster Circuit is to amplify the voltage obtained from TEG. From TEG we can get a maximum of 2V and 500mA current. The Booster circuit will amplify the voltage to 12V and there is a digital display is provided in it which can display the amplified voltage.

C. ENGINE:

Construction:

In this project we use SPARK IGNITION engine of the type two stroke single cylinder of Cubic capacity 100cc. Engine has a piston that moves up and down in cylinder. A cylinder is a long round air pocket somewhat like a tin can with a bottom cut out. Cylinder has a piston which is slightly smaller in size than the cylinder the piston is a metal plug that slides up and down in the cylinder Bore diameter and stroke length of the engine are 50mm and 49mm respectively. The heat energy is converted in to mechanical energy by the expansion of gases against the piston attached to the crankshaft that can rotate. Burning or combustions always accomplished by the production of heat. When a gas is heated, it expands. If the volume remains constant, the pressure rises according to Charlie's law.

Fig-6: 2-stroke petrol Engine

Working:

There are only two strokes involved namely the compression stroke and the power stroke; they are usually called as upward stroke and downward stroke respectively.

Specifications of Two Stroke Petrol Engine:

Type: two strokes

Cooling System: Air Cooled

Bore/Stroke: 50 x 50 mm

Piston Displacement: 98.2 cc

Compression Ratio: 6.6: 1

Maximum Torque: 0.98kg-mat 5,500RPM

D. D.C Machine

D.C machine consists of the following components. They explained below one by one.

Construction:

Armature Core - The purpose of laminating the core is to reduce the eddy current loss.

Armature Winding - The armature conductors are connected in series-parallel; the conductors being connected in series so as to increase the voltage and in parallel paths so as to increase the current. The armature winding of a D.C machine is a closed circuit winding.

Commutator - A commutator is a mechanical rectifier which converts the alternating voltage generated in the armature winding into the direct voltage across the brushes. The commutator is made of copper segments insulated from each other by mica sheets and mounted on the shaft of the machine,

Brushes - The brush pressure is adjusted by means of adjustable springs. If brush pressure is very large, the friction produces heating of the commutator and the brushes. On the other hand, if it is too weak, the imperfect contact with the commutator may produce sparking.

Type of Armature Winding:

The armature windings are D.C machines are always of drum type. The armature conductors usually in the form of coils are placed in slots around the complete surface of drum-shaped or cylindrical armature core.

DC Motor:

A machine that converts DC power into mechanical power is known as D.C motor. Its operation is based on the principal that when current carrying conductor is placed in a magnetic field, the conductor experiences a mechanical force. The direction of this force is given by Fleming's left hand rule and magnitude is given by,

$F = B \times I \times L$ Newton

DC Generator:

An electric generator is a machine that converts mechanical energy in to electrical energy. An electric generator is based on the principle that whenever flux is cut by a conductor.

Fig-7: Motor cum Generator

Motor Cum Generator Specifications:

Voltage	12 Volts
Current	12 Amps
Winding	Shunt
Power	1 H.P
Field	Permanent magnet
Speed	250-350 rpm

E. BATTERY

Chemical changes during Discharging:

***At Cathode*:**

SO4 - 2e → SO4 (radical)

***At Anode**:*

$H^+H^+ + 2e \longrightarrow 2\,H$

$Pbo_2 + 2H \longrightarrow PbO + H_2O$

Sulphuric acid reacts with pbo to form Pbso4

$Pbo + H_2SO_4 \longrightarrow PbSO_4 + H_2O.$

Chemical Changes during Recharging:

***At Anode*:**

On reaching the anode, a sulphate ion (SO_4) given up its two extra electronics to become sulphate radical. These electrons given up at the anode move through the external circuit to the cathode where they are available to neutralize the positive ions (H^+H^+) arriving there.

At Cathode:

$PbSO_4 + 2\,H \longrightarrow Pb + H_2SO_4$

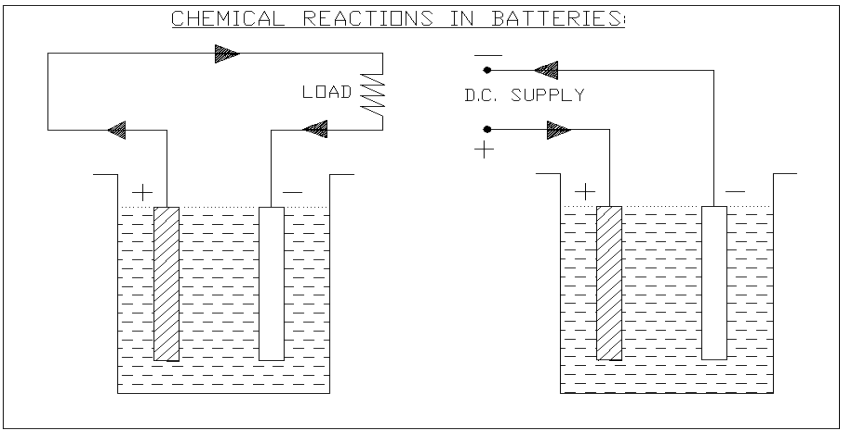


Fig-8: Diagrammatic Representation of reactions that are taking place in the Battery

V. PROPOSED SYSTEM

The working principle of hybrid vehicle basically involves two processes, the parallel system as shown in fig-9 involves when the vehicle is running by means of internal combustion engine and the series system as shown in fig-10 which involves when the vehicle is running by means of an electric motor. When the vehicle is driven at the outside of city the vehicle is powered by means of internal combustion engines. The power from the engine is taken from the pulley and then it rotates the wheel. During this process the vehicle is charged by means of a generator used. The power is generated

through generator is by connecting the generator shaft with the shaft of the wheel by means of chain. The battery will gets charged by another means called TEG. The TEG is attached to the silencer of the engine. During the working of the engine the silencer will gets heated to up through the exhaust gases evolved and TEG will absorb this heat. Due Thomson effect electrical energy is produced in it. The TEG is connected to battery through when the vehicle is driven inside the city, the vehicle is powered by means of a motor. The power to run the motor is supplied from the battery, as the battery is already charged when the vehicle running on the internal combustion engine. During this process the speed of the vehicle will be minimum and there is no smog forming pollutants produced during the vehicle runs. When the vehicle is powered by means of electric motor the power from the internal combustion engine will be disconnected from the shaft. In this process the TEG plays neutral role and no power is generated in it.

A. PARALLEL SYSTEM:

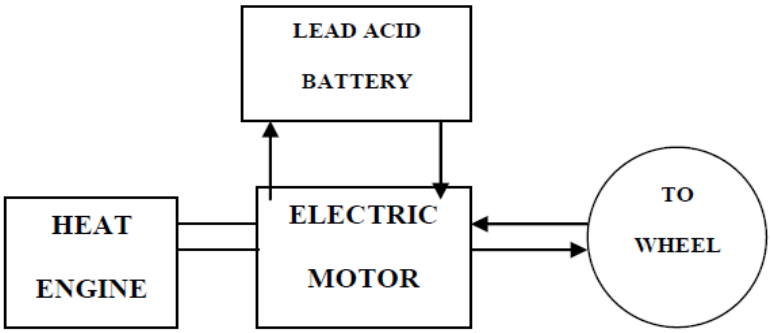


Fig-9: Systematic layout of Parallel system

B. SERIES SYSTEM:

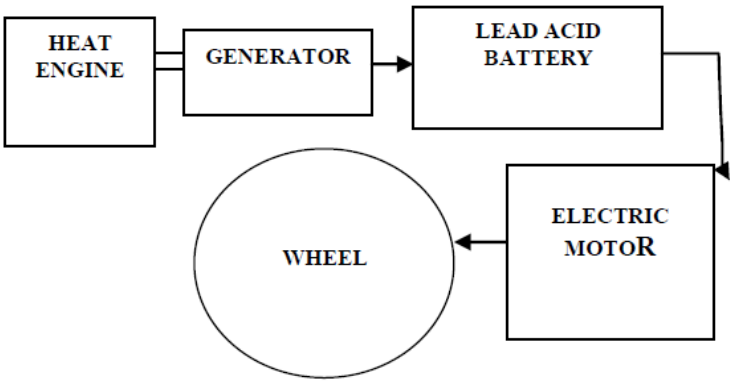


Fig-10: Systematic layout of series system

C. PROPOSED SYSTEM SETUP:

Fig-11: Expermental Setup of Proposed System

VI. ADVANTAGES AND DISADVANTAGES

A. ADVANTAGES:

1. Efficiency of the vehicle is improved.
2. Small modification is done in the vehicle
3. Battery efficiency and life time also increased
4. Noise and vibration produced are very low.
5. Fuel consumption can be reduced.

B. DISADVANTAGES:

1. Additional cost is required.
2. Additional space is required to install this arrangement in vehicles.
3. The speed of the vehicle is low while it is running with motor compared with an IC Engine

VII. RESULT

The final outcome of this paper is to extract heat energy from exhaust gases of an automobile and used to charge the battery of an hybrid vehicle to improve its performance. This is an eco-friendly since noise pollution can be minimized with the reduction in exhaust gas temperatures. The battery charge was greatly enhanced as it is getting energy from both Thermo Electric Generator and from Motor cum Generator. Thus, the overall efficiency of an automobile is increased with small modification in the system.

The Thermo Electric Generator used in this project is of mater Bismuth Tellurium (Bi_2Te_3) of size 7X7 cm. The output voltage obtained from this arrangement is observed to be around 12V for an engine operation of 6 minutes. By increasing the specifications of TEG and amplification in Booster Circuit the sensitivity of the system can be improved. As there are no moving parts in the TEG operation so there is no wear and tear of components and silent in operation.

Hence, the system is reliable.

VIII. CONCLUSION

An exhaust gas heat recovery power generation with hybrid vehicle has been implemented successfully. Thus the eco-friendly automobile working method can be implemented for domestic and commercial use at an affordable cost. Since this system requires less power input, it can also be used as portable refrigerator. The thermoelectric generator can be used in remote areas where power source is not possible to get.

REFERENCES

[1] Buist, Richard, Lau, Paul, “Thermoelectric Power Design and Selection from TE Cooling Module Specifications,” 16th International Conference on Thermo electrics (1997), Aug 26-29 1997, 551-554

[2] Rowe, D. M., Min, G. “Design Theory of Thermoelectric Modules for Electrical Power Generation,” IEE Proceedings: Science, Measurement and Technology, Vol. 143, No 6, November 1996, 351-356

[3] Nuwayhid, R. Y., Rowe, D. M., Min, G., “Low Cost Stove-Top Thermoelectric Generator for Regions with Unreliable Electricity Supply,” Renewable Energy, Vol. 28, 2003, 205-222

[4] Snyder, G. J. Toberer, E. S. “Complex Thermoelectric Materials” .NATURE MATERIALS, 2008, VOL 7; NUMBER 2, pages 105-114.

[5] Birkholz, U., et al. "Conversion of Waste Exhaust Heat in Automobile using FeSi2 Thermoelements". 7th International Conference on Thermoelectric Energy Conversion. 1988, pp. 124-128.

[6] R Venkatasubramanian, R., Sllvola, E., Colpltts and O’Quinn, “Thin-film thermoelectric devices with high room-temperature figures of merit,” Nature, Vol. 413(2001), pp.597-602.

[7] Miyazaki, Shirakawa and Tsukamoto, "Flash thin films of bismuth telluride," Proceedings of The 25th International Conference on Thermo electrics (2006).

[8] Rius(2008). “Electric Drive Design for Hybrid Electric Vehicle Optimum Fuel Efficiency”.

[9] Williams, Stephen (2010-08-25). "Honda Jazz Hybrid Will Get Paris Premiere". The New York Times.

[10] Solomon, G. M. Campbell, T. R. Feuer, G. R. Masters, J. Samkian, A. Paul “No Breathing in the Aisles - Diesel Exhaust Inside School Buses.” Natural Resources Defense Council, Coalition for Clean Air, Jan. 2001.

Cyber Reference:

[1] www.howstuffworks.com
[2] www.visionengineer.com

[3] www.tpup.com

[4] www.peltier-info.com