Fabrication and Analysis of Thermo Electric Generator For Power Generator

AravindKaruppaiah.C[1], Ganesh.S[2], Dileepan.T[3], Jayabharathi.S[4]

Student, Department of Mechanical Engineering, Sri Manakula Vinayagar Engineering College, Madagadipet, Puducherry- 605 107, India[1, 2, 3]

Assistant Professor, Department of Mechanical Engineering, Sri Manakula Vinayagar Engineering College, Madagadipet, Puducherry- 605 107, India[4]

Abstract: The Thermo Electric Generator can be used to produce power using the exhaust waste heat from IC engines (automobiles). This power can be used to charge the battery of automobiles (two-wheelers). This system of charging the battery reduces the fuel consumption and battery life is also increased.
   The project describes the design and analysis of TEG with the material used. The factors affecting the efficiency of TEG are studied. The properties of the material, efficiency of TEG and the heat transfer in TEG are also studied using ANSYS.
   The objective of the project is to produce power from the waste sources. To reduce the heat let into the atmosphere. To reduce the fuel consumption of automobiles. To increase the life of the battery used in automobiles.

Keywords-   TEG, battery, fuel consumption

I.   INTRODUCTION

A.   Thermo Electric Generator

   The thermo electric generator (TEG) is the system used to generate power from low temperatures that is less than 1000K as heat input. It is best method for recovery of exhaust heat. It can be used in many fields such as automobiles, boilers   wood stoves etc. The efficiency of a TEG depends on the thermo electric materials. The main research of the world is to use the renewable energy. The main advantage of TEG is that it uses green energy. The TEG is mainly based on the principle of Seebeck effect. The efficiency of a thermo electric generator is about 5%. A heat source provides the high temperature, and the heat flows through a thermoelectric converter to a heat sink, which is maintained at a temperature below that of the source. The temperature differential across the converter

produces direct current (DC) to a load (R_L) having a terminal voltage (V) and a terminal current (I). There is no intermediate energy conversion process. For this reason, thermoelectric power generation is classified as direct power conversion. The amount of electrical power generated is given by $I^2 R_L$, or VI.

   A unique aspect of thermoelectric energy conversion is that the direction of energy flow is reversible. So, for instance, if the load resistor is removed and a DC power supply is substituted, the thermoelectric device can be used to draw heat from the "heat source" element and lower its temperature. In this configuration, the reversed energy-conversion process of thermoelectric devices is invoked, using electrical power to pump heat and produce refrigeration.
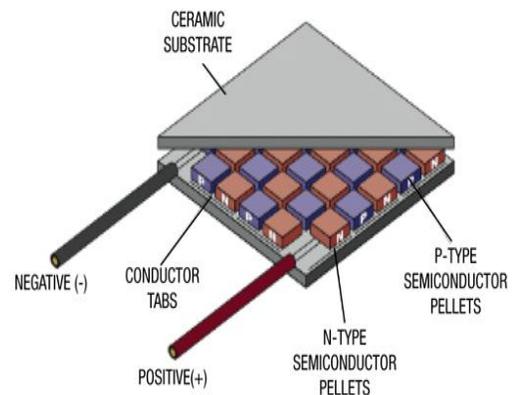

Fig.2 experimental setup

B. Thermo Electric Material

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. Although the above mentioned materials still remain the cornerstone for commercial and practical applications in thermoelectric power generation, significant advances have been made in synthesizing new materials and fabricating material structures with improved thermoelectric performance. Efforts have focused primarily on improving the material's figure-of-merit, and hence the conversion efficiency, by reducing the lattice thermal conductivity.

C. Battery Charging System

The existing system of charging the battery for automobiles consumes 10 % of the fuel, and hence the efficiency of the engine is reduced. This system is to be replaced by TEG system of charging the battery which is light in weight and battery life also can be increased.

FACTORS AFFCTING THE EFFICENCY OF TEG

➢ Thermo Electric Material
➢ Hot source
➢ Cold source
➢ Heat transfer

II. EXPERIMENTAL SETUP

The experimental setup for testing is shown

EXHAUST GAS HEAT RECOVERY POWER GENERATION SYSTEM :-
1.FUELTANK
2.IGNITION INLET TUBE
3.EXHAUST GAS
4.ENGINE
5.WHEEL
6.STAND
7.CARBURATOR
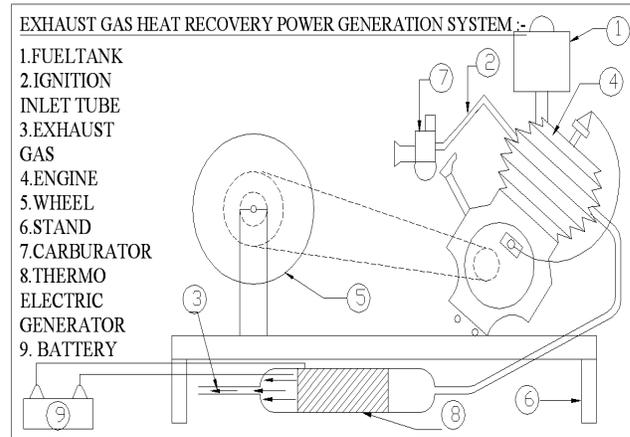8.THERMO ELECTRIC GENERATOR
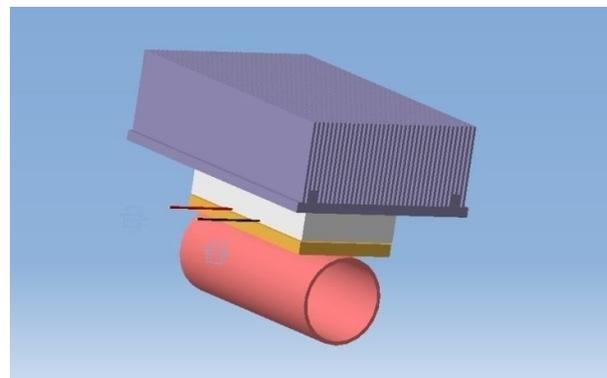9. BATTERY

Fig.2 experimental setup

Fig.3 TEG assembly model

TE-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.
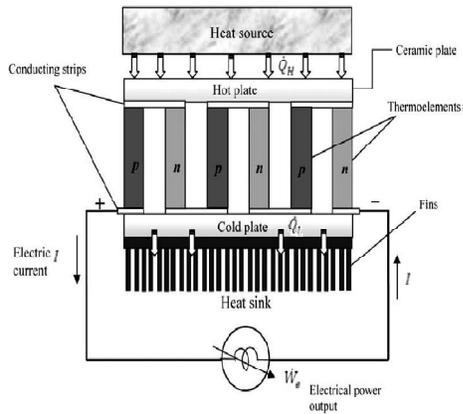
Fig.4 principle of TEG

As shown in figure, 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 we. 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.

Charge carriers in the materials (electrons in metals, electrons and holes in semiconductors, ions in ionic conductors) will diffuse when one end of a conductor is at a different temperature than the other. Hot carriers diffuse from the hot end to the cold end, since there is a lower density of hot carriers at the cold end of the conductor. Cold carriers diffuse from the cold end to the hot end for the same reason.

If the conductor were left to reach equilibrium, this process would result in heat being distributed evenly throughout the conductor. The movement of heat (in the form of hot charge carriers) from one end to the other is called a heat current. As charge carriers are moving, it is also an electrical current.

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. However, the diffusing charges are scattered by impurities, imperfections, and lattice vibrations. If the scattering is energy dependent, the hot and cold carriers will diffuse at different rates. This will create a higher density of carriers at one end of the material, and the distance between the positive and negative charges produces a potential difference; an electrostatic voltage.

This electric field, however, will oppose the uneven scattering of carriers, and equilibrium will be reached where the net number of carriers diffusing in one direction is cancelled by the net number of carriers moving in the opposite direction from the electrostatic field. This means the thermo power of a material depends greatly on impurities, imperfections, and structural changes (which often vary themselves with temperature and electric field), and the thermo power of a material is a collection of many different effects.

III.   THERMO ELECTRIC MATERIAL

The thermo electric material used in this project is silicon and germanium. The material is selected on the basis of power factor , figure of merit and melting point.The performance of thermoelectric materials can be expressed as

$$Z = \alpha^2 / kR,$$

Where Z is the thermoelectric material figure-of-merit, α is the Seebeck coefficient given by

$$\alpha = -\frac{\Delta V}{\Delta T},$$

Where,

R is the electric resistivity (inverse of electric conductivity) and k is the total thermal conductivity. This figure-of-merit

may be made dimensionless by multiplying by $\overline{T}$ (average absolute temperature of hot and cold plates of the thermoelectric module, K),

$$Z\overline{T} = \alpha^2 \overline{T} / kR$$

And

$$\overline{T} = \frac{T_H + T_L}{2}.$$

The term α^2/R is referred to as the electrical power factor. In general, a thermoelectric power generator exhibits low efficiency due to the relatively small dimensionless figure-of-merit $(Z\overline{T} \leq 1)$ of currently available thermoelectric materials. The conversion efficiency of a thermoelectric power generator defined as the ratio of power delivered to the heat input at the hot junction of the thermoelectric device, is given by

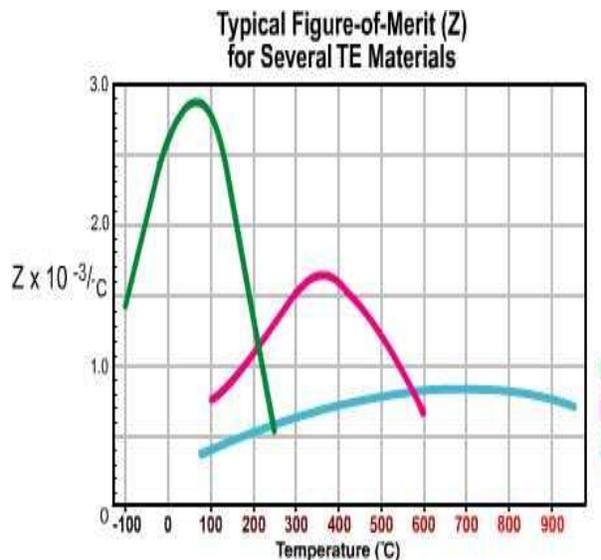$$\eta = \frac{\dot{W}_e}{\dot{Q}_H}$$

Figure 5: Performance of Thermoelectric Materials at Various Temperatures

HOT SOURCE

The Hot source is the waste gas present in IC engine. A copper plate is used to transmit the heat from the engine to the generator. Copper has the high thermal conductivity and high melting point.

TIME (mins)	EXHAUST TEMPERATURE(℃)
15	145
30	151
45	162
60	175

COLD SOURCE

The cold source is given by the air cooling system with the help of the fins. The fins are made up of aluminum. Aluminum is used because of its light weight and more cooling capacity. Based on the heat to be dissipated number of fins is calculated as 20.

Air cooling system is efficient than water cooling system and also water cooling system requires a separate tank and a circulation system.

The cold sources temperature is the room temperature and it is around 26-30℃.

Fig.6 Aluminum fin

HEAT TRANSFER

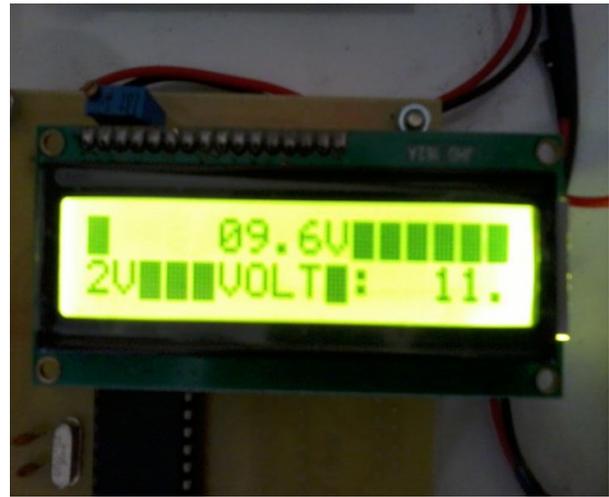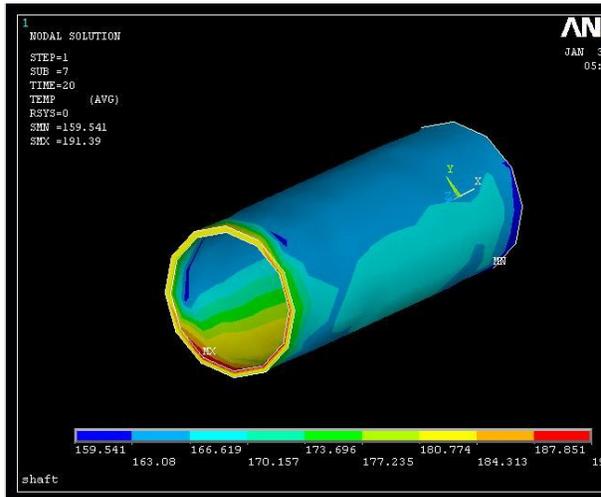The heat transfer in exhaust pipe is done using ansys.

Figure 7: Heat transfer in exhaust pipe.

The ansys result shows that the exhaust temperature is maximum at the left end i.e at the source. The temperature reduces as it moves further. Convection heat transfer takes place in the exhaust pipe. At first the flow is said to be turbulent and it changes to laminar.
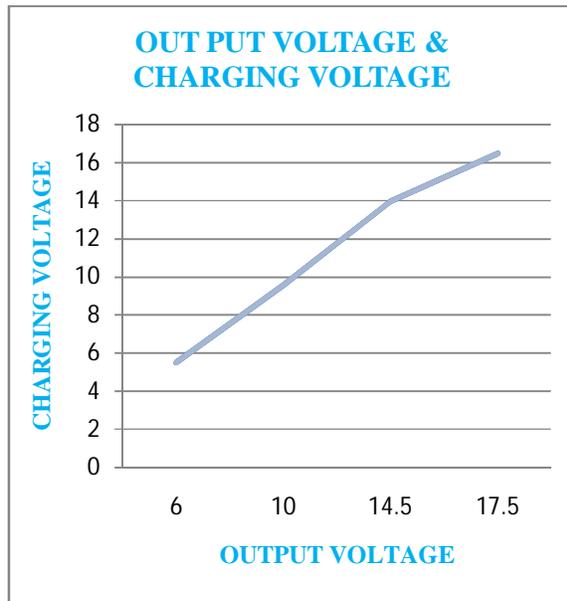
IV.   RESULT

EXPERIMENT OUTPUT

The experiment setup is made and following results were inhered.

TIME MINS	EXHAUST TEMPERATURE (℃)	OUTPUT VOLTAGE (V)	CHARGING VOLTAGE (V)
15	145	6.00	5.5
30	151	10.00	9.6
45	162	14.50	14.0
60	175	17.50	16.5

TEMPERATURE & VOLTAGE

OUT PUT VOLTAGE & CHARGING VOLTAGE
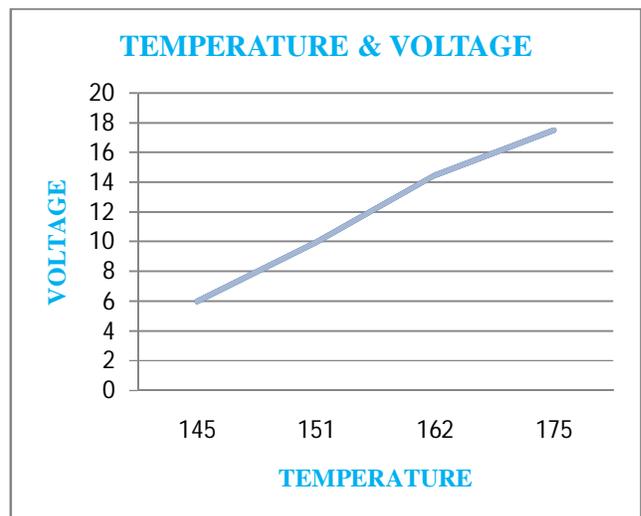
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V.   CONCLUSION

We conclude that TEG system of charging the battery could reduce the fuel consumption and also battery life used in automobiles could be increased. It is the best method for recovery of waste exhaust heat. The main advantage of TEG is that it produces power from the waste heat source.

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