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Thermoelectric power generation using waste heat energy

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Abstract
In recent years, an increasing environmental issues of emissions, in particular global warming and the limitations of energy resources. The possibilities of thermoelectric systems contribution to "green" technologies, specifically for waste heat recovery. As waste heat recovering techniques, such as thermoelectric generator (TEG) is developed. Thermoelectric generator direct converts waste-heat energy into electrical power where it is unnecessary to consider the cost of the thermal energy input. The application of this technology can also improve the overall efficiency the of energy conversion systems in automobile by using waste heat energy.

Keywords
Waste heat recovery, thermoelectric generator, seeback effect, thermoelectric material

1. INTRODUCTION

1.1 Principle

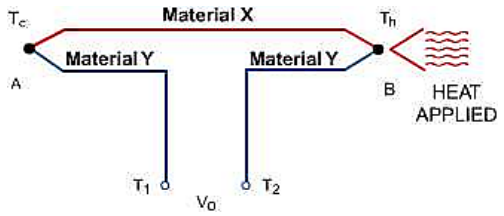

Fig 1.1 Seeback Effect

In thermoelectric power generation electric energy produce by waste heat energy. The heat energy is available from different heat resource like exhaust heat energy from gas in I C engine, heat energy from steel manufacturing, thermal power plant, refinery etc. The electrical power is produce by principle of "seeback effect" discovered by Thomas Seebeck in 1821. It states that "When a temperature difference is established between the hot and cold junctions of two dissimilar materials (metals or semiconductors) a voltage is generated and generated voltage is directly proportional to the temperature".

In convention system heat energy is converted in to mechanical energy and then converted into electric energy by help of electric generator but this system the heat energy is direct converted in to electric energy by help of thermoelectric power generator.

1.2 Construction

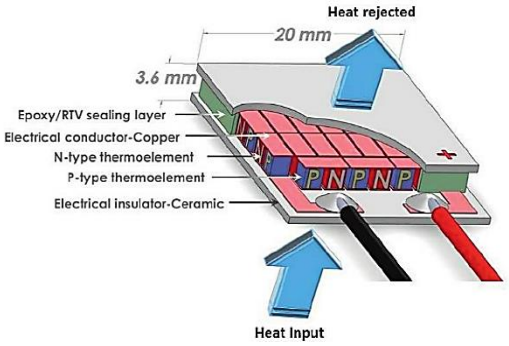

Fig 1.2 Thermoelectric power generator

In thermoelectric power generator consist of P – N junction (thermo element) as shown in above figure. The P-N semiconductor is sandwich in between the hot plate and cold plate and connect by the help of conducting strip in electrically series to more voltage is generated. The load (LED light) is connect to the P-N junction. This assembly is attach to the heat source like a silencer of heavy vehicles (bus, truck), reactor of refinery, furnace of steel manufacturing plant, condense in steam power plant.

1.3 Working

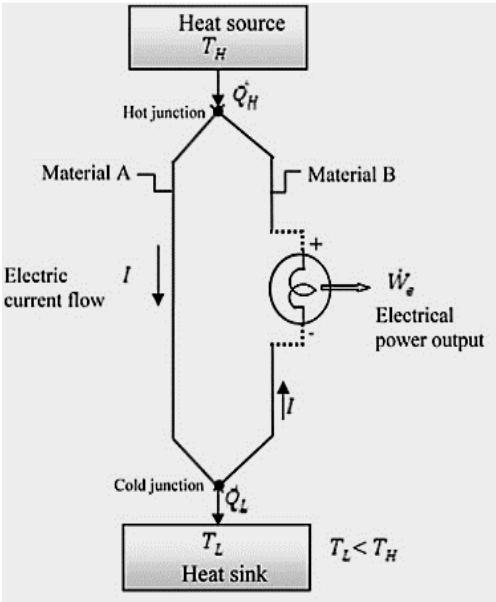

Fig 1.3 Working of TEPGS

T_h is high temperature and T_L is low temperature and heat is transferred from a high-temperature heat source to a low-temperature sink. 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. This voltage store in a battery and start the LED light by inverter.

1.4 Method of arrangement of TEG

A. Thermal
B. Electrical

A. Thermal

Fig 1.4 TEG in Thermal Parallel

The TEM is connect in parallel so maximum heat energy is utilized.

B. Electrical

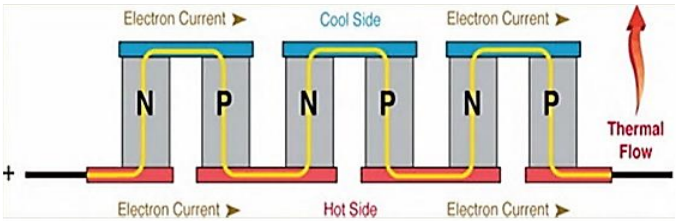

Fig 1.6 TEM in electrically series

The TEM is connect in series in so output power is high.

1.5 Types of thermoelectric generator

A. Plate type

B. Ring type

A. Plate type

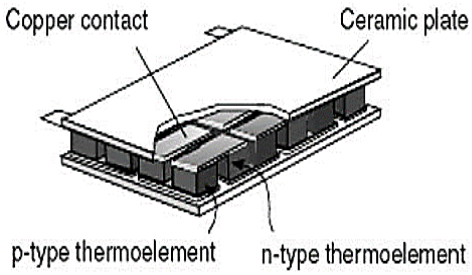

Fig 1.7 Plate type TEG

This type of TEM use for flat surface.

B. Ring type

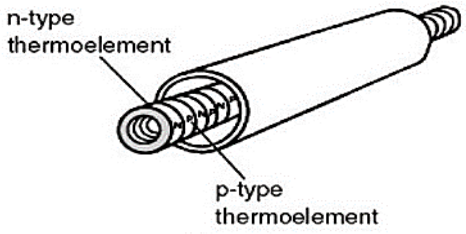

Fig 1.8 Ring type TEG

This type of TEM used in cylindrical shape like silencer in automobile, condenser, hot pipe of steam or other fluid.

1.6 Performance of thermoelectric generator

The potential of a material for thermoelectric applications is determined in large part to a measure of the material's dimensionless figure of merit (ZT), where, α is the Seebeck coefficient, σ the electrical conductivity, ρ the electrical resistivity, and κ the total thermal conductivity.

$$ZT = \frac{\alpha^2 \sigma T}{k} = \frac{\alpha^2 T}{k\rho}$$

2. MAIN WORK

2.1 Design of thermoelectric power generation system

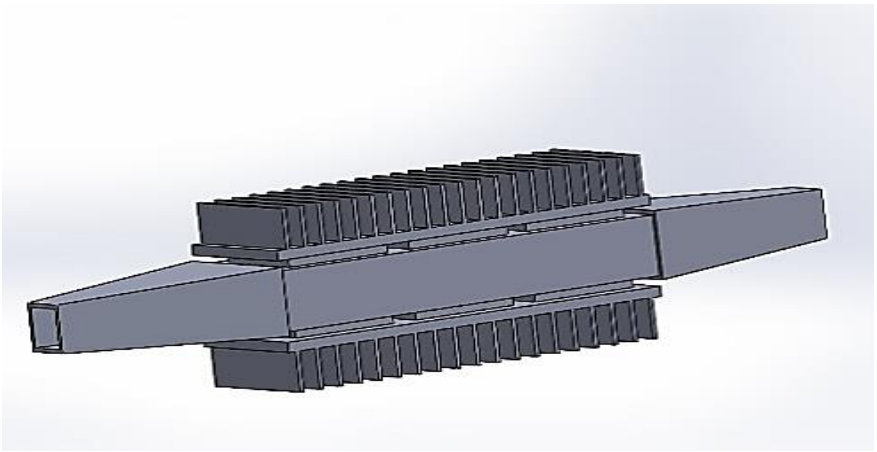

Fig 2.1 Assembly of thermoelectric power generation system

2.2 Component of thermoelectric power generation

A. Thermoelectric generator
B. Hot chamber
C. Fins
D. Draft
E. Battery
F. Switches
G. Wires
H. LED bulb

A. Thermoelectric generator

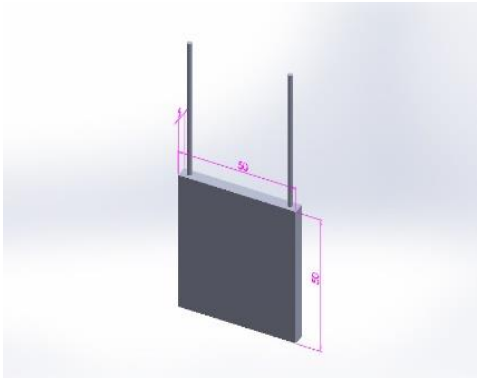

Fig 2.2 Thermoelectric generator

The thermoelectric module is consist of P (positive) - N (negative) semiconductor. The arrangement of thermoelectric module is parallel in thermally and series in electrically.

N-type

An N-type semiconductor material has an excess of electrons. In this way, free electrons are available within the lattices and their overall movement in one direction under the influence of a potential difference results in an electric current flow. This in an N-type semiconductor, the charge carriers are electrons.

P-type

In a P-type semiconductor material there is a shortage of electrons, i.e. there are 'holes' in the crystal lattice. Electrons may move from one empty position to another and in this case it can be considered that the holes are moving.

B. Hot chamber

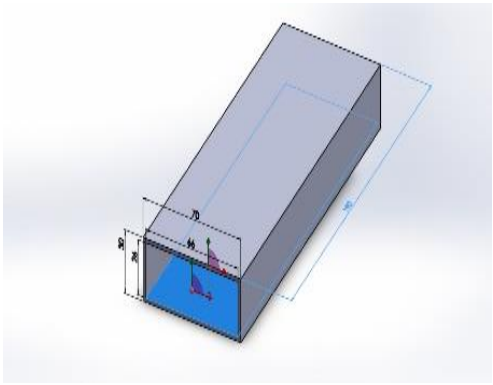

Fig 2.3 Hot chamber

It is an insulator of electric energy but conductor of thermal energy. The material is use for plate is alumina.

C. Fins

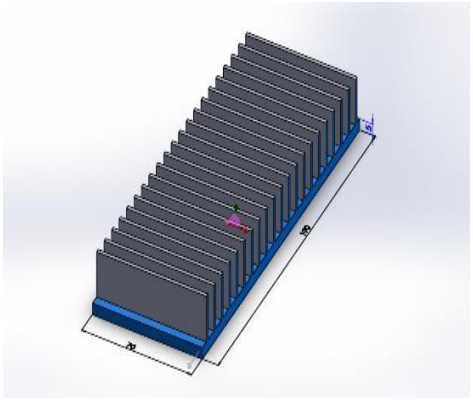

Fig 2.4 fins

It is use for maximum heat transfer at the cold side fins is used. It is made from aluminium.

D. Draft

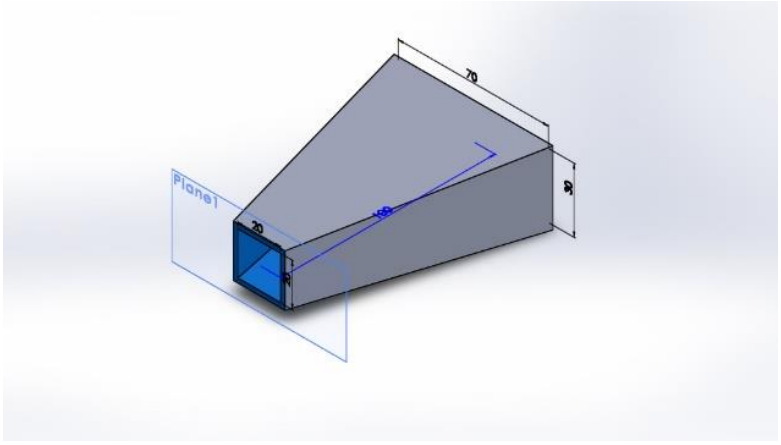

Fig 2.5 Draft

The main function of draft is increase the pressure of exhaust gas.

E. Battery

It is a chemical device to store the electric power.

F. Switches

It is use to on/off the electrical power connection

G. Wires

It is use to make connection between the load (LED light) and sources (battery).

H. LED light

It is converted electric power into light energy.

2.3 Circuit of thermoelectric power generation system

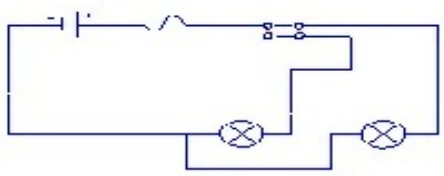

Fig 2.6 Circuit of thermoelectric power generation system

In thermoelectric power generator DC power is produce and that DC power is use to charge the battery. This battery is use to start the LED light. Fuse and 4-way switch is used to start LED light for high beam and low beam.

3. RESULT

Table.1. Result table of Automobile exhaust thermo-electric generator design & performance analysis

Engine speed (rpm)	Temp drop (^{o}c)	Voltage (V)	Current (A)	P_{in} (V)	P_{out} (V)	η (%)
2250	7	5.54	0.55	116.56	3.04	2.61
2850	8	6.03	0.62	164.22	3.73	2.21
3200	9	7.35	1.1	206.13	8.08	3.32
3606	10	9.01	1.33	253.81	11.9	4.72
3970	11	10.5	1.45	300.25	15.1	5.07

4. CONCLUSION

The efficiency of thermoelectric power generation system depend upon temperature difference, material, speed of engine, working hours of engine. As speed increases the efficiency of thermoelectric generator increases.

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