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Finite Element Method Using Ansys Thermoelectric To Convert the Thermal Energy into Electrical Energy in Industries

Ramesh Kumar R[1], Suren M.E[2], Suse Raja Prabaharan M.E[2]
[1]Department of Mechanical Engineering, Cape Institute of Technology, Anna University of Chennai, Tamil Nadu, India
[2]Assistant Professor, Department of Mechanical Engineering, Cape Institute of Technology, Anna University of Chennai, Tamil Nadu, India

ABSTRACT

Current scenario concerns include increasing world power consumptions and raising greenhouse heat emission posing serious considerations. Thermoelectric energy conversion incorporates direct energy conversion from heat sources to electric energy conservation. It incorporates direct energy conversion from heat sources to electric energy conservation and the underlying physical into rapid effect has been well recovered in this past century. The thermoelectric effect is that the use of temperature differences to electric voltage creation and vice versa. A considerable number of primary fuels could be stored if some of the waste heat generated from Ovens, Kilns, Boilers, Furnaces, IC engines etc. are recovered through waste heat generating system. In a diesel engine, substantial energy (10 to 30%) is lost through the engine exhaust gas as waste heat. It means a large fraction of the fuel energy remains untapped and gain of energy from waste heat is appreciable. This waste heat can be used for generating the thermoelectric power by using thermoelectric materials. Recently, the "nanoparticle-in nanocomposite" is formulated to enhance thermoelectric characteristics which augment the interface scattering of photons for reducing the lattice as well as bipolar thermal conductivities. The high-energy ball-milling is an effective methodology to produce thermoelectric nanocomposites in large scale. Thedesirable characteristics of the thermoelectric materials are high Seebeck coefficient, high conductivity and low thermal conductivity. In this work the thermoelectric generator is designed and numerically analyzed using Ansys 2021R2 software by using the copper alloy and p and n type semiconductors. The heat is utilized from the automobile exhaust. The current generation, current density and the flow direction of the current will be determined numerically using ANSYS software.

I. INTRODUCTION

In recent decades, human activities such as deforestation and construction have its significant impact on the atmosphere and the energy absorbed by the distribution market is increasing each year, because of the growth in the industrial disciplines. Although highly environmental user friendly, efficient and cleaner battery such as artificial recovered systems are used to alter the number of ways to provide latent heat, the consumption and reliance on electricity generated from coal have still increased to synchronize with the vehicle expansion year by year. It is allowed to pass through the environment without being reused for its usefulness or economic values. The value of the heat generated is to be considered rather than its amount. The mechanism to recover the unused heat depends on the temperature of the waste heat gases. Large quantities of hot flue gases are generated from diesel engine, boilers, kilns, ovens and furnaces. This chapter briefly describes various methods to extract and utilize the waste heat from automobile spares. While some waste heat losses from industrial processes are inevitable, facilities can reduce these losses by improving equipment efficiency or installing waste heat recovery technologies year .

The "Law Concerning the Rational Use-Of Energy" (Energy Conservation Law), as amended in 2008 where the obligated business and Indian representatives participated and published reports about the energy consumption of the Automobile sectors. The Indian authorities promised a 7.1% reduction in greenhouse gasses from 2017 in keeping with the "Prathama green yochana system" succeeding in Gujarat. Preparations are made in order to reach the aforementioned reduction target in the legal arena, through such efforts as an amendment to the Energy Conservation Law. This legislation demands action, such as the entry of energy consumption reports on the part of individual industries, with the duties executed on company operators and franchise operators participated in convenience shopand dining businesses on a scale that surpasses a certain level, to manage energy consumption.

The typical energy balance flow chart of the diesel Engine is given in Figure 1.1 in which considerable portion of the heat is lost (about 36 %) as Exhaust

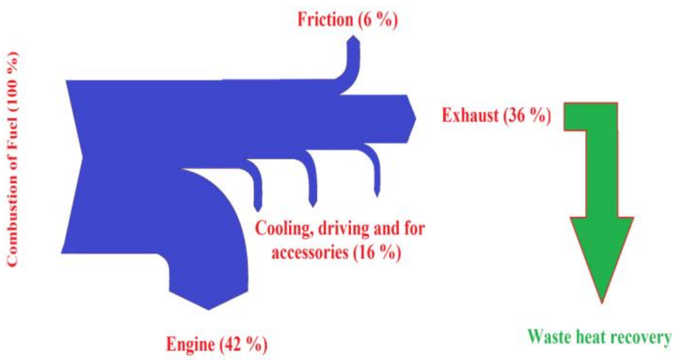


Figure 1 Typical heat balance of diesel engine systems

Recovering a part of this waste heat would result in saving of considerable amount of the primary fuel. Although the energy lost in waste gases cannot be fully recovered, a considerable amount of the heat could be recovered. The loss can also be minimized if the measure outlined in this chapter is adopted.

The uses of waste heat include generating electricity, preheating combustion air, preheating furnace loads, absorption cooling and space heating. The direct and indirect benefits of the waste heat recovery are given below,

a) Reduction in pollution
b) No moving parts
c) Reduction in Equipment size
d) Less maintenance requirements

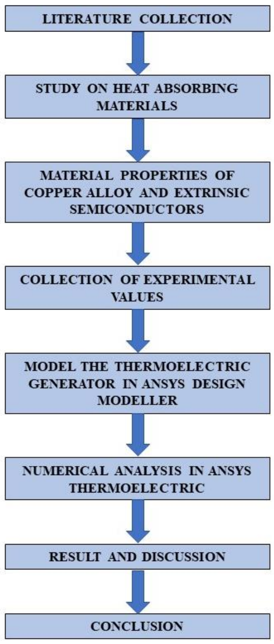
e) Reduction in auxiliary energy consumption
f) Reduced harmful emissions
g) Silent Operation
h) Durable
i) No chemical reactions
j) No corrosion and wear

It is also necessary to evaluate the selected waste heat recovery system on the basis of financial analysis such as investment, depreciation, payback period, the rate of return etc.

Table 1 Maximum temperature range sources

Type of Device	**Temperature (°C)**
Nickel refining furnace	1370-1650
Aluminium refining furnace	650-760
Zinc refining furnace	760-1100
Copper refining furnace	760-815
Steel heating furnaces	925-1050
Copper reverberatory furnace	900-1100
Open heart furnace	650-700
Cement kiln (Dry process)	620-730
Glass melting furnace	1000-1550
Hydrogen plants	650-1000
Solid waste incinerators	650-1000
Fume incinerators	650-1450

II. MATERIALS AND METHODS



2.1 Thermoelectric Generators

Generally, it consists of many N-type and P-type semiconductors which are connected thermally in parallel and electrically in series (Figure 2). A voltage is generated when one side of the TEG is cooled and the other side is heated.

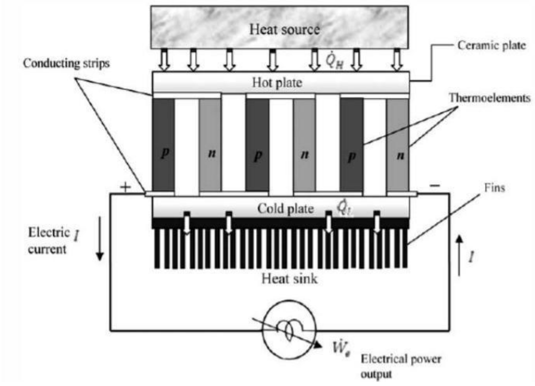


Fig 2 Typical Single-Stage Thermoelectric Power Generator

It generates electrical energy from any temperature difference and their efficiency depends on the temperature difference. Generally, the efficiency of TEG system is less than 3%. Another factor which can be used to compare the efficiencies of different TEGs which are operating at same temperatures is their electric figure of merit (ZT).

2.2 Thermoelectricity

The electric energy is generated due to the temperature difference between the junctions and its proportionality constant is known as the Seebeck coefficient or thermoelectric power or thermoelectricity. The first commercial Thermo Electric generator has been launched in 1925 in the name "Thermattaix" and it is shown in Figure 3

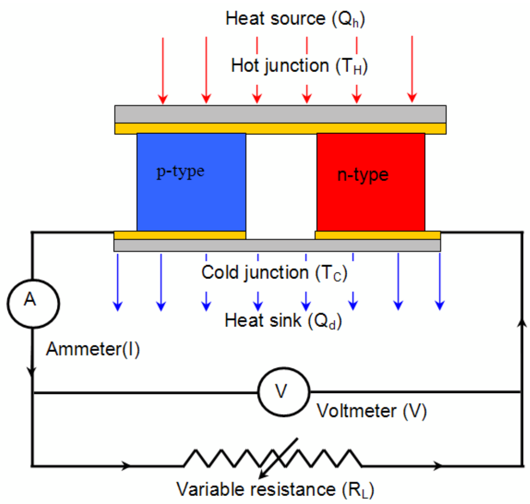


Fig 3 Thermoelectric Generator

The thermoelectric generator comprises p-type semi-conductors combined metal plate. If the junctions of b and a are maintained at different temperatures T1 and T2 at which T1> T2, an open-circuit electromotive force (emf) is induced in the circuit. The figure of merit is proportional to the efficacy of the device. Values of ZT=1 are deemed great, and worth of ZT is about 3-4 which would be considered for further applications.

III. RESULT AND DISCUSSION

3.1 Design of thermoelectric generator

The thermoelectric generator is designed using Ansys 2021R2 design modeler. The orthographic and the isometric view of the designed TER is shown in the below figure.

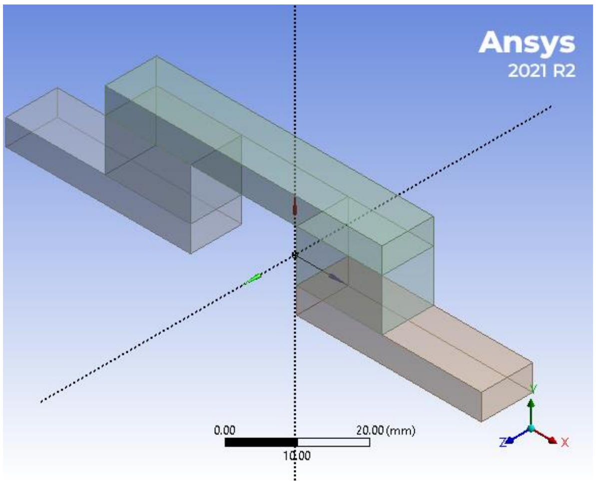


Fig 3 Orthographic view of the TEG designed

3.2 Materials used

Table 2 Materials and suitable part name

Sl. No	Name of the part	Material used
1	P-Base	Copper alloy
2	P-Leg	P-Type semiconductor
3	Top face	Copper alloy
4	N-base	Copper alloy
5	N-Leg	N-Type semiconductor

3.3 P-type semiconductor

A p-type semiconductor is an extrinsic type of semiconductor. When a trivalent impurity (like Boron, Aluminum etc.) is added to an intrinsic or pure semiconductor (silicon or germanium), it is said to be a p-type semiconductor. Trivalent impurities such as boron (B), gallium (Ga), indium (In), aluminum (Al) etc. are called acceptor impurity. Ordinary semiconductors are made of materials that do not conduct (or carry) an electric current very well but are not highly resistant to doing so. They fall half way between conductors and insulators. An electric current occurs when electrons move through a material. In order to move, there must be an electron 'hole' in the material for the electron to move into. A p-type semiconductor has more holes than electrons. This allows the current to flow along the material from hole to hole but only in one direction.

Semiconductors are most often made from silicon. Silicon is an element with four electrons in its outer shell. To make a p-type semiconductor extra materials like boron or aluminum are added to the silicon. These materials have only three electrons in their outer shell. When the extra material replaces some of the silicon it leaves a 'hole' where the fourth electron would have been if the semiconductor was pure silicon.

3.4 N-type semiconductor

An N-type semiconductor is a impurity mixed semiconductor material used in electronics.
The pentavalent impure atoms like phosphorus, arsenic, antimony, bismuth or some other chemical element are used to produce n-type semiconductors. These impure atoms are called donor impurities because they give free electrons to a semiconductor. The doping increases the number of charge carriers in the material for conduction. A n-type semiconductor is a lot more conductive than the pure silicon or germanium.
Semiconductor materials like silicon and germanium have four electrons in their outer shell. The outer shell of electrons is called the valence shell. The four electrons are used by the semiconductor atom in forming bonds with its neighboring atoms. This leaves a low number of electrons available for conduction.

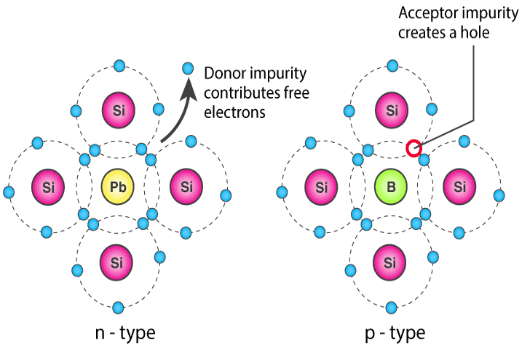


Fig 4 Extrinsic semiconductors

3.5 Result

- The problem created to find the current generated and heat absorbed by a thermo electric generator.
- The boundary conditions as per the literature is 452^{0}C as hot side temperature and 22^{0}C as cold side temperature.
- The material selected for this analysis is copper alloy and p-type and n-type semiconductors.
- The hard mesh is used to mesh the designed object, the size of the element is 0.0015m.

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