Modern Fabrication Technology for Free Thermo-Electric Power Generation from Automobile Waste Heat

R.Thilakar[1], Dr.S.Narayanan[2]
[1]*PG Student, SNS College of Engineering*
[2]*Assistant Professor, SNS College of Engineering*

***Abstract*: This system presents the investigation of power generation using the combination of heat sources and thermo-electric generators. A majority of thermal energy in the automobile is dissipated as waste heat to the environment. This waste heat can be utilized further for power generation. The related problems of global warming and dwindling fossil fuel supplies has led to improving the efficiency of any industrial process being a priority. One method to improve the efficiency is to develop methods to utilize waste heat that is usually wasted. Two promising technologies that were found to be useful for this purpose were thermoelectric generators and heat sources. Therefore, this project involved making a bench type, proof of concept model of power production by thermoelectric generators using heat from the engine and simulated heat radiation. The experiment of the proposed system was obtained with a counter flow air duct heat exchanger. The results obtained show an increase in the ratio of mass flow rate in upper duct to lower duct has a positive effect on the overall system performance. A higher mass flow rate ratio results in a higher amount of heat transfer and higher power output. The proposed system can be used for waste heat recovery from the automobile technologies where thermal energy is used in their daily process.**

Index Terms: Thermo-electric generator, automobile technology

INTRODUCTION

Heat transfer is a discipline of thermal engineering that concerns the generation, use, conversion, and exchange of thermal energy (heat) between physical systems. Heat transfer is classified into various mechanisms, such as thermal conduction, thermal convection, thermal radiation, and transfer of energy by phase changes. Engineers also consider the transfer of mass of differing chemical species, either cold or hot, to achieve heat transfer. While these mechanisms have distinct characteristics, they often occur simultaneously in the same system.

Heat conduction, also called diffusion, is the direct microscopic exchange of kinetic energy of particles through the boundary between two systems. When an object is at a different temperature from another body or its surroundings, heat flows so that the body and the surroundings reach the same temperature, at which point they are in thermal equilibrium. Such spontaneous heat transfer always occurs from a region of high temperature to another region of lower temperature, as described by the second law of thermodynamics. Heat convection occurs when bulk flow of a fluid (gas or liquid) carries heat along with the flow of matter in the fluid. The flow of fluid may be forced by external processes, or sometimes (in gravitational fields) by buoyancy forces caused when thermal energy expands the fluid (for example in a fire plume), thus influencing its own transfer. The latter process is often called "natural convection". All convective processes also move heat partly by diffusion, as well. Another form of convection is forced convection. In this case the fluid is forced to flow by use of a pump, fan or other mechanical means.

Thermal radiation occurs through a vacuum or of energy by means of photons in electromagnetic waves governed by the same laws.

1.1 Overview

Heat is defined in physics as the transfer of thermal energy across a well-defined boundary around a thermodynamic system. The thermodynamic free energy is the amount of work that a thermodynamic system can perform. Enthalpy is a thermodynamic potential, designated by the letter "H" that is the sum of the internal energy of the system (U) plus the product of pressure (P) and volume (V). Joule is a unit to quantify energy, work, or the amount of heat. Heat transfer is a process function (or path function), as opposed to functions of state; therefore, the amount of heat transferred in a thermodynamic process that changes the state of a system depends on how that process occurs, not only the net difference between the initial and final states of the process. Thermodynamic and mechanical heat transfer is calculated with the heat transfer coefficient, the proportionality between the heat flux and the thermodynamic driving force for the flow of heat. Heat flux is a quantitative, vectorial representation of heat-flow through a surface.

In engineering contexts, the term *heat* is taken as synonymous to thermal energy. This usage has its origin in the historical interpretation of heat as a fluid (*Caloric*) that can be transferred by various causes, and that is also common in the language of laymen and everyday life. The transport equations for thermal energy (Fourier's law), mechanical momentum (Newton's law for fluids), and mass transfer (Fick's laws of diffusion) are similar, and analogies among these three transport processes have been developed to facilitate prediction of conversion from any one to the others. Thermal engineering concerns the generation, use, conversion, and exchange of heat transfer. As such, heat transfer is involved in almost every sector of the economy. Heat transfer is classified into various mechanisms, such as thermal conduction, thermal convection, thermal radiation, and transfer of energy by phase changes.

1.2 Concepts of the System

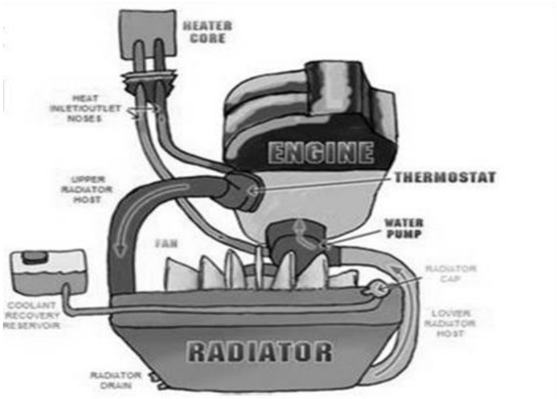

Fig: 1.1 Heat sources of the automobile

Engine and silencer from all the vehicles produces the heat at the time of running. This heat radiates to environment and increases the global heat day by day. So that temperature of the earth increases rapidly every year due to increasing the vehicles, electrical and electronic goods. All mentioned goods are producing the heat when it is in ON. Our system is mainly focused towards harvesting the waste heat from vehicles and it converts the electricity power. This harvesting power can be utilized for different applications.

Benefits:

- Free micro power generation system
- Avoid global radiation due to heat from automobile

1.3 Existing system

Waste heat recovery puts excess heat to work, providing warmth for buildings or steam or process heating for chemical processing. That conserves valuable energy by extracting thermal energy from a waste stream and putting it to work. Waste heat recovery has been proven through decades of application. Aavid Thermacore's passive two-phase heat pipe technology enables the process to enter the 21st century. Heat pipe technology, with its low thermal gradient two-phase mode of heat transfer, enables more efficient energy recovery by minimizing the ΔT required between two process streams. That enables higher levels of energy recovery, or permits the use of a smaller, lower-cost heat exchanger solution. Waste heat recovery has been applied to a wide range of residential, commercial and industrial applications, and heat pipe heat exchanger solutions have been applied to improve performance in all these areas:

- Make-up air heat exchangers (residential)
- Dehumidification heat exchangers (commercial)
- High-temperature waste gas heat exchangers (power and chemical process industries)

1.4 Proposed method:

In this system Thermal Energy is harvesting from various electrical, electronic and mechanical running devices. This energy level is in the range of micro. This energy converted into electrical energy which can be used for low power devices. Thermoelectricity (TE) is the conversion of heat into electricity (Seebeck effect), or of electricity into heat (Peltier effect). The use of the Seebeck effect could allow heat to be saved which would be otherwise lost. Although the conversion efficiency is very low, it has been enjoying renewed favour for several years, and novel research and development leads have been investigated, such as new materials and the structuring of matter at the nanoscale. This combination has led to active investigations worldwide, but without achieving the decisive breakthrough, which will give TE a prominent place among energy harvesting technologies.

2 SYSTEM FUNCTION

2.1 Functional Block diagram of the System:

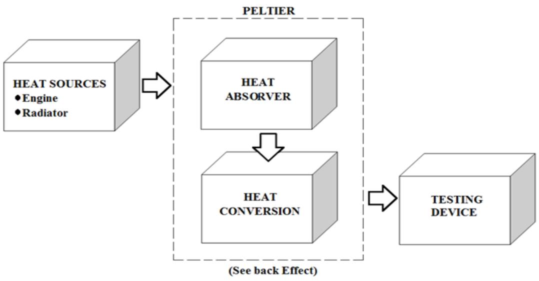

Fig: 2.1 functional block diagram of the system

2.2 Blocks description

In this block consists of Heat sources, PELTIER module and output energy testing device (Motor / Light indicator / charger). The heat sources such as engine; radiator and silencer tube produces the heat when it is in running. The PELTIER module consists of heat harvesting substances as well as heat convertor (converts electricity). The output testing device may be a DC motors or LED light indicators or Mobile phone charger.

2.3 METHODOLOGY

Thermoelectricity (TE) is the conversion of heat into electricity (Seebeck effect), or of electricity into heat or refrigeration (Peltier effect). The use of the Seebeck effect could allow heat to be saved which would be otherwise lost. Although the conversion efficiency is very low, it has been enjoying renewed favour for several years, and novel research and development leads have been investigated, such as new materials and the structuring of matter at the nanoscale. This combination has led to active investigations worldwide, but without achieving the decisive breakthrough, which will give TE a prominent place among energy harvesting technologies. The most promising applications of TE, in the context of energy saving, concern thermal engine heat recovery (particularly in transport applications), and human body heat scavenging to power portable devices. TE for energy harvesting has several barriers to overcome: low conversion efficiency; toxicity; and low availability of chemical elements constituting part of the most interesting thermoelectric materials. In this context, the main challenges for nanotechnology are to demonstrate high efficiency improvement, and to display low cost implementation in thermoelectric materials.

n in thermoelectric materials.

2.4 Mechanisms

The fundamental modes of heat transfer are:

<u>Advection</u>

Advection is the transport mechanism of a fluid from one location to another, and is dependent on motion and momentum of that fluid.

<u>Conduction</u> or <u>diffusion</u>

The transfer of energy between objects that are in physical contact. Thermal conductivity is the property of a material to conduct heat and evaluated primarily in terms of Fourier's Law for heat conduction.

<u>Convection</u>

The transfer of energy between an object and its environment, due to fluid motion. The average temperature is a reference for evaluating properties related to convective heat transfer.

<u>Radiation</u>

The transfer of energy by the emission of electromagnetic radiation.

n in thermoelectric materials.

3 HARDWARE REQUIREMENTS AND SPECIFICATION

3.1 PELTIER

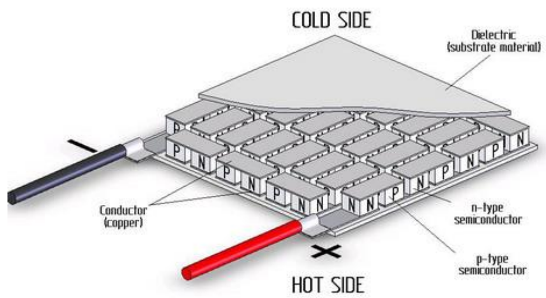

Fig: 3.1 construction diagram of PELTIER

The first thermoelectric phenomenon was discovered by French physicist and meteorologist Jean Peltier (1785-1845). The basic idea behind the Peltier effect is that whenever DC passes through the circuit of heterogeneous conductors, heat is either released or absorbed at the conductors' junctions, which depends on the current polarity. The amount of heat is proportional to the current that passes through conductors.

As a result of works performed by Russian academician A.F. Ioffe and his colleagues the semiconducting alloys were synthesized allowing to apply this effect in practice and to begin the full-scale production of thermoelectric refrigerating devices for wide use in various fields of human activities. The basic TEC unit is a thermocouple, which consists of a p-type and n-type semiconductor elements, or pellets. Copper commutation tabs are used to interconnect pellets that are traditionally made of Bismuth Telluride-based alloy.

Thus, a typical TEM consists of thermocouples connected electrically in series and sandwiched between two Alumina ceramic plates. The number of thermocouples may vary greatly - from several elements to hundred of units. This allows to construct a TEM of a desirable cooling capacity ranging from fractions of Watts to hundreds of Watts.

When DC moves across TEM, it causes temperature differential between TEM sides. As a result, one TEM face, which is called cold, will be cooled while its opposite face, which is called hot, simultaneously is heated. If the heat generated on the TEM hot side is effectively dissipated into heat sinks and further into the surrounding environment, then the temperature on the TEM cold side will be much lower than that of the ambient by dozens of degrees. The TEM's cooling capacity is proportional to the current passing through it. TEM's cold side will consequently be heated and its hot side will be cooled once the TEM's polarity has been reversed.

Thermoelectric effect:

The thermoelectric effect is the direct conversion of temperature differences to electric voltage and vice versa. A thermoelectric device creates voltage when there is a different temperature on each side. Conversely, when a voltage is applied to it, it creates a temperature difference. At the atomic scale, an applied temperature gradient causes charge carriers in the material to diffuse from the hot side to the cold side. This effect can be used to generate electricity, measure temperature or change the temperature of objects. Because the direction of heating and cooling is determined by the polarity of the applied voltage, thermoelectric devices can be used as temperature controllers.

The term "thermoelectric effect" encompasses three separately identified effects: the Seebeck effect, Peltier effect, and Thomson effect. Textbooks may refer to it as the Peltier–Seebeck effect. This separation derives from the independent discoveries of French physicist Jean Charles Athanase Peltier and Baltic German physicist Thomas Johann Seebeck. Joule heating, the heat that is generated whenever a current is passed through a resistive material, is related though it is not generally termed a thermoelectric effect. The Peltier–Seebeck and Thomson effects are thermodynamically reversible, [1] whereas Joule heating is not.

Seebeck effect:

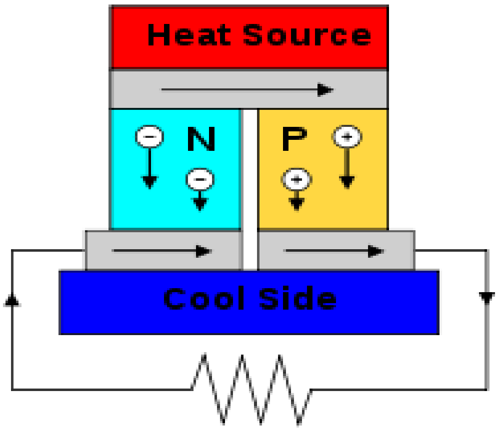

Fig: 3.2 see back effect

The Seebeck effect is the conversion of temperature differences directly into electricity and is named after the Baltic German physicist Thomas Johann Seebeck. Seebeck, in 1821, discovered that a compass needle would be deflected by a closed loop formed by two different metals joined in two places, with a temperature difference between the junctions. This was because the metals responded to the temperature difference in different ways, creating a current loop and a magnetic field. Seebeck did not recognize there was an electric current involved, so he called the phenomenon the thermomagnetic effect. Danish physicist Hans Christian Ørsted rectified the mistake and coined the term "thermoelectricity".

The Seebeck effect is a classic example of an electromotive force (emf) and leads to measurable currents or voltages in the same way as any other emf. Electromotive forces modify Ohm's law by generating currents even in the absence of voltage differences (or vice versa); the local current density is given by

$$\mathbf{J} = \sigma(-\boldsymbol{\nabla} V + \mathbf{E}_{\mathbf{emf}})$$

where $V$is the local voltage and $\sigma$is the local conductivity. In general, the Seebeck effect is described locally by the creation of an electromotive field

$$\mathbf{E}_{\mathbf{emf}} = -S\boldsymbol{\nabla} T$$

Where $S$is the Seebeck coefficient (also known as thermopower), a property of the local material, and $\boldsymbol{\nabla} T$is the gradient in temperature T.

The Seebeck coefficients generally vary as function of temperature and depend strongly on the composition of the conductor. For ordinary materials at room temperature, the Seebeck coefficient may range in value from −100 μV/K to +1,000 μV/K (see Seebeck coefficient article for more information). If the system reaches a steady state where $\mathbf{J} = 0$, then the voltage gradient is given simply by the emf: $-\nabla V = S\nabla T$. This simple relationship, which does not depend on conductivity, is used in the thermocouple to measure a temperature difference; an absolute temperature may be found by performing the voltage measurement at a known reference temperature. A metal of unknown composition can be classified by its thermoelectric effect if a metallic probe of known composition is kept at a constant temperature and held in contact with the unknown sample that is locally heated to the probe temperature. It is used commercially to identify metal alloys. Thermocouples in series form a thermopile. Thermoelectric generators are used for creating power from heat differentials.

Peltier effect:

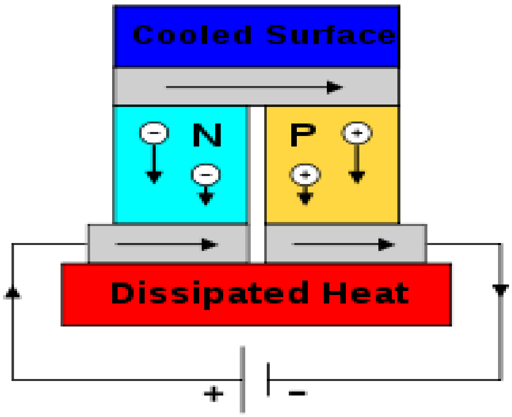

Fig: 3.3 PELTIER Effects

The Peltier effect is the presence of heating or cooling at an electrified junction of two different conductors and is named for French physicist Jean Charles Athanase Peltier, who discovered it in 1834. When a current is made to flow through a junction between two conductors A and B, heat may be generated (or removed) at the junction. The Peltier heat generated at the junction per unit time, $\dot{Q}$, is equal to

$$\dot{Q} = (\Pi_A - \Pi_B) I$$

where $\Pi_A(\Pi_B)$ is the Peltier coefficient of conductor A (B), and I is the electric current (from A to B). Note that the total heat generated at the junction is not determined by the Peltier effect alone, as it may also be influenced by Joule heating and thermal gradient effects (see below). The Peltier coefficients represent how much heat is carried per unit charge. Since charge current must be continuous across a junction, the associated heat flow will develop a discontinuity if Π_A and Π_B are different. The Peltier effect can be considered as the back-action counterpart to the Seebeck effect (analogous to the back-emf in magnetic induction): if a simple thermoelectric circuit is closed then the Seebeck effect will drive a current, which in turn (via the Peltier effect) will always transfer heat from the hot to the cold junction. The close relationship between Peltier and Seebeck effects can be seen in the direct connection between their coefficients: $\Pi = TS$ A typical Peltier heat pump device involves multiple junctions in series, through which a current is driven. Some of the junctions lose heat due to the Peltier effect, while others gain heat. Thermoelectric heat pumps exploit this phenomenon, as do thermoelectric cooling devices found in refrigerators.

Applications:

- Thermoelectric generators
- Peltier effect
- Temperature measurement
- Thermal Cyclers for Polymerase Chain Reaction

Environmental specification

S. No.	Parameters	Values
1.	Outside Temperature (Do) (°C)	43
2.	Inside Temperature (Di) (°C)	3
3.	Internal Fan Motor Wattage (W)	1
4.	Gasket Thickness (m)	0.01
5.	Gasket Height (m)	0.025
6.	Outside Material Thickness (m)	0.00028
7.	Inside Material Thickness (m)	0.00036
8.	M/C Area Top Temperature (°C)	48
9.	Inside Heat Transfer Coefficient $\left(\frac{w}{m^2K}\right)$	10
10.	Outside Heat Transfer Coefficient $\left(\frac{w}{m^2K}\right)$	10
11.	Outside Material Thermal Conductivity HIPS $\left(\frac{w}{mK}\right)$	0.188
12.	Inside Material Thermal Conductivity HIPS $\left(\frac{w}{mK}\right)$	0.188
13.	Gasket Thermal Conductivity $\left(\frac{w}{mK}\right)$	0.07
14.	Heat Extender Material $\left(\frac{w}{mK}\right)$	373
15.	Top Foam Thickness (m)	0.025
16.	Foam Thermal Conductivity $\left(\frac{w}{mK}\right)$	0.01944

To design thermoelectric components we need to calculate heat load on refrigerator due to active, passive and air changing load, the total heat load is calculated for following specification mentioned in table and Environmental condition mentioned in Table I.

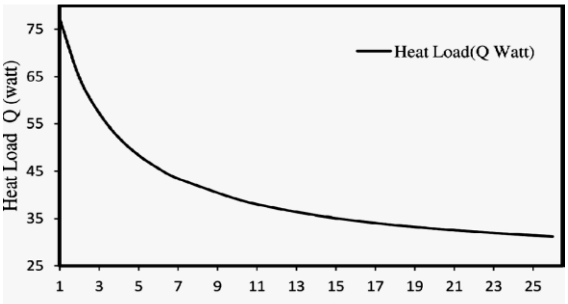

Fig. Heat Load vs. Foam Thickness

4.CONCLUSION

The report has been successfully completed for describing about the system design, parameters, and formulas. This system focused towards harvesting the thermal energy from the automobile system and converts into electricity micro power. The most promising applications of TE, in the context of energy saving, concern thermal engine heat recovery (particularly in transport applications), and human body heat scavenging to power portable devices. TE for energy harvesting has several barriers to overcome: low conversion efficiency; toxicity; and low availability of chemical elements constituting part of the most interesting thermoelectric materials. In this context, the main challenges for nanotechnology are to demonstrate high efficiency improvement, and to display low-cost implementation in thermoelectric materials.

REFERENCE

[1] Aavid Thermaocore
[2] Matthew Bond and Jae-Do Park, Senior Member, IEEE
[3] Yogesh K. Ramadass and Anantha P. Chandrakasan, Fellow, IEEE
[4] Kazuaki Yazawaa) Department of Electrical Engineering, Baskin School of Engineering, University of California Santa Cruz
[5] Dejan Rozgi´c, Student Member, IEEE, and Dejan Markovi´c, Member, IEEE
[6] Yen Kheng Tan and Sanjib Kumar Panda, National University of Singapore
[7] Paul David Mitcheson Analysis and Optimization of Energy-Harvesting Micro-Generator Systems
[8] Hyung-Jo Jung; Seung-Woo Lee; Dong-Doo Jang; ivil & Environ. Eng. Dept., KAIST, Daejeon, South Korea
[9] James M. Gilbert∗ Farooq Balouchi Department of Engineering, University of Hull, Hull HU6 7RX, UK