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Role of Thermo-Electric Generator in Recovery of Waste Heat of Automobile

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Abstract: **Today world is facing lots of problem regarding energy crisis and thermal energy management. As we know that Environmental pollution has been more emphasized heavily recently and in Internal combustion engine, The engine exhaust has a tremendous amount of energy and out of Total heat supplied to the engine in the form of fuel approximately 30-40% converted into useful work and the remaining one is expelled in the form exhaust gases and this exhaust gases can be recovered by using waste heat recovery system. Thermo electric principle can be used for recovering waste heat and convert into useful work by using See back effect by creating potential difference. The study shows the possible methods to recover waste heat energy from engine exhaust of an Automobile and techniques to maximize energy efficiency. Viewing from socio-economic perspective, as the level of energy consumption is directly proportional to the economic development and total number of population in the country, the growing rate of population in the world today indicates the energy demand is likely to increase [1].**

Keywords:* *Energy, Waste heat recovery, Thermo-electric generator, Automobile, Emissions.

I. INTRODUCTION

Today we are facing the problem of shortage of fossil fuels as well as the problem of pollution. Out of all the available sources, the internal combustion engines are the major consumer of fossil fuel. In pollution. Out of all the available sources, the internal combustion engines are the major consumer of fossil fuel. In pollution. Out of all the available sources, the internal combustion engines coolant in the form of heat .By utilizing a portion of the lost thermal energy to change the battery instead of using an alternator the overall fuel economy can be increased by 10%.Depending on the engine load the exhaust temperatures after the catalytic converter reach about 300-500ºcentigrade .Thermoelectric generators are small with no moving parts and they are relatively efficient at these temperatures so they are ideal for such applications . Thermoelectric parts and they are relatively efficient at these temperatures so they are ideal for such applications. Thermoelectric gradients [2, 3].

The latest developments and technologies on waste heat recovery of exhaust gas from internal combustion engines the latest developments and technologies on waste heat recovery of exhaust gas from internal combustion engines and new developments on turbocharger technology [4].

According to national energy conservation law and regulations for energy, consumption investigation and energy audit management. [5]

Recovery activities in general order include:

- Identification of all energy systems
- Evaluation of conditions of the systems
- Analysis of impact of improvement to those systems

Need of waste heat recovery

There is need of waste heat recovery because we are facing the problem of energy crisis in terms of conventional sources of energy.

By using waste heat we can save not only conventional sources of energy but also we can enhance the efficiency of these sources of energy.

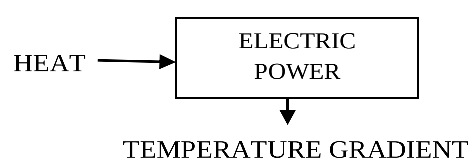
By using waste heat we can go along with sustainable development in an easy way as it is the demand of today's world.

It is better to have something rather than having nothing and in the case of heat recovery we are saving some amount of energy which we can use not only for our self but also for upcoming generation.

In general we can say that by saving waste heat we are not only securing our self but also upcoming generation from facing the problem of energy crisis which is the current issue of today's world and it also play an important role in making India a developed country as energy plays an important role in other dimensions which are related to our economic zones.

II. METHODS OF WASTE HEAT RECOVERY

Waste heat recovery can be carried by different ways. Depending upon the medium to generate electric power.



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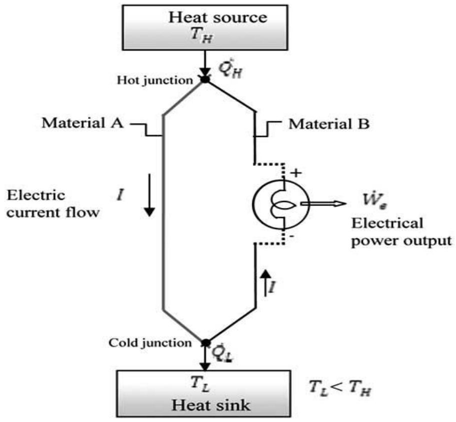

Fig . Basic concept of a thermoelectric power generator based on sees back effect.

Theory and operation of thermoelectric based system is based on the phenomenon called See back effect. When a temperature difference is established between the hot and cold junctions of two dissimilar materials (metals or semiconductors) a voltage is generated, i.e., See back voltage. Based on this See back effect, thermoelectric devices act as electric power generators.

Thermoelectric power generation have a capability to recover some exhaust heat from I.C. Engine. A schematic diagram showing how the exhaust heat converted into electric power applied to an internal combustion engine using thermoelectric power generator.

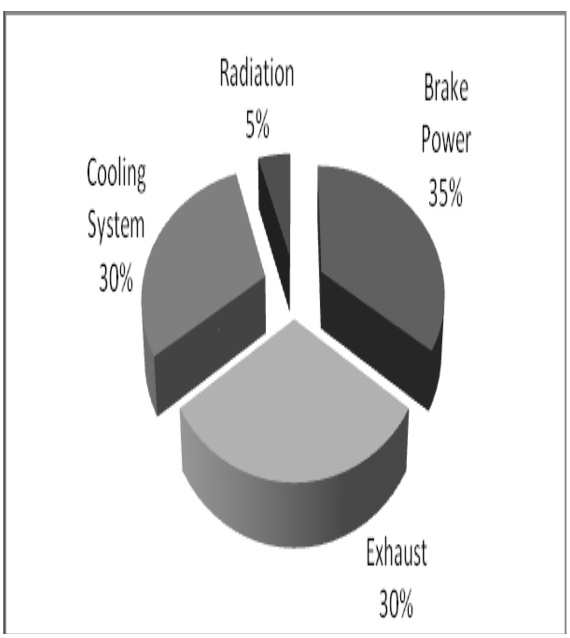

Fig . Total fuel energy content in I.C Engine

III. POSSIBILITY OF WASTE HEAT RECOVERY

Sr. No.	Engine type	Power output kW	Waste heat
1	Small air cooled diesel engine	35	30-40% of Energy Waste loss From I.C. Engine
2	Small agriculture tractors and construction machines	150	
3	Water air cooled engine	35-150	
4	Earth moving machineries	520-720	
5	Marine applications	150-220	
6	Trucks and road engines	220	

Table . Various engines and their output

In general, diesel engines have an efficiency of about 35% and thus the rest of the input energy is wasted. Despite recent improvements of diesel engine efficiency, a considerable amount of energy is still expelled to the ambient with the exhaust gas. In a water-cooled engine about 35 kW and 30-40% of the input energy is wasted in the coolant and exhaust gases respectively. The amount of such loss, recoverable at least partly, greatly depends on the engine load. Mr. Johnson found that for a typical 3.0 l engine with a maximum output power of 115 kW, the total waste heat dissipated can vary from 20 kW to as much as 400 kW across the range of usual engine operation. It is suggested that for a typical and representative driving cycle, the average heating power available from waste heat is about 23 kW, compared to 0.8–3.9 kW of cooling capacity provided by typical passenger car VCR systems [6]. Since, the wasted energy represents about two-thirds of the input energy.

Sr. No.	Engine	Temperature in °C
1	Single Cylinder Four Stroke Diesel Engine	456
2	Four Cylinder Four Stroke Diesel Engine (Tata Indica)	448
3	Six Cylinder Four Stroke Diesel Engine (TATA Truck)	336
4	Four Cylinder Four Stroke Diesel Engine (Mahindra arjun 605 DI)	310
5	Genset (Kirloskar) at power 198hp	383
6	Genset (Cummims) at power 200hp	396

Table- This temperature can be taken from various surveys.

Availability of Waste Heat from I.C. Engine:

The quantity of waste heat contained in a exhaust gas is a function of both the temperature and the mass flow rate of the exhaust gas:

$$\dot{Q} = \dot{m} \times C_p \times \Delta T$$

Where, Q is the heat loss (kJ/min); is the exhaust gas mass flow rate (kg/min); is the specific heat of exhaust gas (kJ/kg°K); and is temperature gradient in °K. In order to enable heat transfer and recovery, it is necessary that the waste heat source temperature is higher than the heat sink temperature. Moreover, the magnitude of the temperature difference between the heat source and sink is an important determinant of waste heat's utility or "quality". The source and sink temperature difference influences the rate at which heat is transferred per unit surface area of recovery system, and the maximum theoretical efficiency of converting thermal from the heat source to another form of energy (i.e., mechanical or electrical). Finally, the temperature range has important function for the selection of waste heat recovery system designs [7, 8].

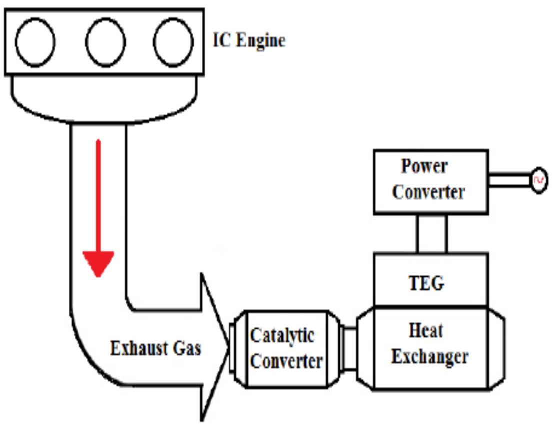

Fig. Methodology of arrangement of TEG

Thermoelectric devices may potentially produce twice the efficiency as compared to other technologies in the current market [9].

By using this methodology we can convert waste exhaust gases into electric power. In this the exhaust gases in the pipe provide the heat source to the thermoelectric generator, whereas the sink provided by circulation of cooling water.

Thermoelectric material-

They are divided into three groupings based on temperature ranges:-

- Alloy based on Bismuth in combination with Antinomy, Tellurium and selenium (Low temperature material used up to 450K).
- Based on alloy of Lead (Intermediate temperature materials used up to 850K).
- Fabricated from silicon-germanium alloy (High temperature materials up to 1300K).

Fig. A Thermoelectric Module.

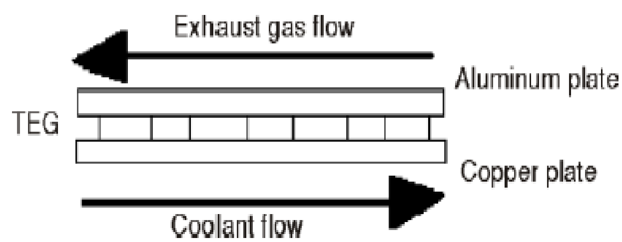

Fig. Diagram of TEM sandwiched between hot plate and cold plate.

Properties		Hastelloy	Steel	Stainless steel	Copper	Duralumin
Type		-	AISI 1010	AISI 302	99.9 Cu + Ag	-
Melt point [K]		1533	1670	1670	1293	923
Density [kgm^{-3}]		8300	7830	8055	8950	2770
k [$Wm^{-1}K^{-1}$]	T = 294 K	9.1	-	-	-	-
	T = 300 K	·	64	15	386	174
	T = 473 K	14.1	-	-	-	-
	T = 500 K	-	54	19	-	188
k_p [$Jkg^{-1}K^{-1}$]	T = 294 K	486	-	-	-	-
	T = 300 K	-	434	480	385	875

Table- Shows the thermal properties of the alloys.
So it's shows to use aluminium to make plates.

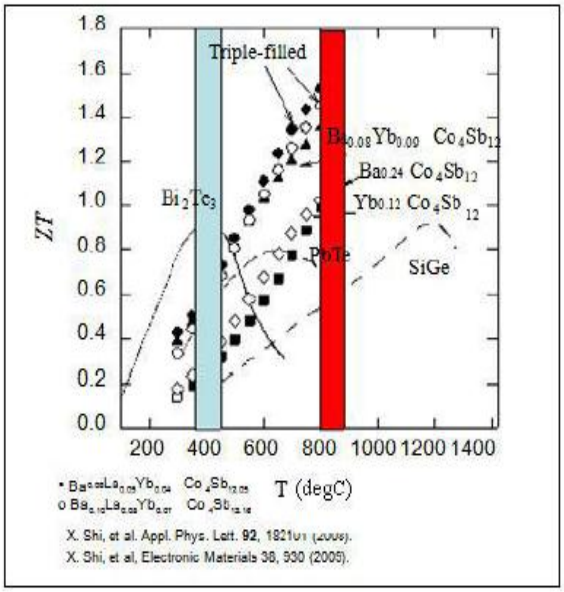

Fig. Shows temperature ranges for thermoelectric material [10].

A single thermoelectric couple is constructed from two 'pellets 'of semiconductor material usually made from Bismuth Telluride (Bi2Te3). One of these pellets is doped with acceptor impurity to create a P-type pellet; the other is doped with donor impurity to produce an N-type pellet. The two pellets are physically linked together on one side, usually with a small of copper, and mounted between two ceramic outer plates that provide electrical isolation and structural integrity. For thermoelectric power generation, if a temperature difference is maintained between two sides of the thermoelectric couple, thermal energy will move through the device with this heat and an electrical voltage, called the See beck voltage, will be created. If a resistive load is connected across the thermoelectric couple's output terminals, electrical current will flow in the load and a voltage will be generated at the load. Practical thermoelectric modules are constructed with several of these thermoelectric couples connected electrically

In series and thermally in parallel. Standard thermoelectric modules typically contain a minimum of three couples, rising to one hundred and twenty seven couples for larger devices. A schematic diagram of a single thermoelectric couple connected

For thermoelectric power generation and a side view

Of a thermoelectric module.

As we know that temperature of pipe surfaces of exhaust gases is very high near about 300-500ºC. So a heat exchanger is made which conducts heat from exhaust pipe to thermoelectric modules.

IV. RESULT AND DISCUSSION

As we know that thermoelectric material low efficient material therefore the major drawback of thermoelectric power generator is their relatively low conversion efficiency but thermoelectric power generators have many advantages like they require less maintenance; they are simple, compact and safe; they are environmentally friendly; they are flexible power sources; they have very small size.

Through thermoelectric generators the amount of power which we get is from the waste heat. In other words we can say that we are saving some heat from getting waste and it is better to have something rather than having nothing. There are several ways to increase the amount of power-

- If we increase the no. of modules we would able to produce more power depending upon hot side temperature.
- Thermoelectric power generator gives maximum power of near about .85 to .90 watt as the hot side temperature was low near about 80ºC but if we increase hot side temperature to near about 180ºC we can get 1.7 watt of power.

So this project emphasizes on the importance of thermoelectric generators in the present scenario as a power saving and maintaining ecological balance tool. Technology would be able to improve the efficiency of the thermoelectric generators and we should work for improving the temperature of the hot side so that we would get more power. This technology will be beneficial for India as we are facing the problem of shortage of fossil fuels and problem of global warming.

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