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REALIZATION OF THERMOELECTRIC GENERATOR USING A PELTIER CHIP

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ABSTRACT

This paper provides a thorough description of the experimental set up and the procedure that was conformed to in order to test the hypothesis of generating electricity from the temperature difference of an automotive vehicle using a peltier chip. The experimental readings were compared to the theoretical calculations and subsequently, based on the empirical relationship between the output voltage and the temperature difference, various techniques both mechanical as well as electrical to optimize the output power such that it can be used effectively have been discussed.

KEYWORDS: Peltier effect, thermoelectric circuits, Peltier chip, automotive energy generation

INTRODUCTION

Alternators are one the most used electrical generators in the world especially when it comes to generating electricity in a mobile environment without any electrical connections to the outside environment particularly in the case of automobiles. They have various advantages over the other primitive methods of generating electricity namely the dc dynamos when it comes to efficiency and durability. Moreover, with various modifications in the construction of an alternator it is possible to use the alternator at much higher speeds.

The main disadvantage of using alternators is that we need to use high-power semiconductor switching devices in order to convert AC to DC. This leads to very bulky rectification modules which in turn are difficult to cool. This can be overcome by using small thermoelectric generators that have a distinct advantage of having no moving parts [1]. Apart from that, these generators being compact and scalable can be easily designed to operate with small temperature differences and small heat sources. But with such design relaxations comes the problem of low efficiency. Also, since these thermoelectric generators can only be developed and designed using nanotechnology, the scope of operation is limited.

These drawbacks can be surmounted by using an array of peltier chips electrically connected in such a way that we get maximum power from the same. These peltier chips or their curved variation can be attached to the exhaust system at those points where we can get maximum temperature difference. Since the voltage output that takes place is directly proportional to the temperature difference of the system, sufficient power output can be obtained by putting the chip at places of maximum temperature difference i.e. the automotive exhaust system.

In the work reported here, this chip that uses the peltier effect in order to create a temperature difference from electrical energy was used. One side of this peltier chip was put in contact to the exhaust gas output with the help of a very well insulated heat-exchanger. The other side of the peltier chip was put in contact with a heat fin keeping it at the room temperature. The temperature difference generates electricity which can in turn be measured. This electricity could be passed on to a rectifier and LC filter circuit in order to get satisfactory voltage and current values so as to be used either to constantly recharge the battery or in other electricity consuming amenities.

METHODOLOGY

This section provides a thorough description of the experimental set up and the procedure that was conformed to in order to test the initial hypothesis of generating electricity from the temperature difference of a peltier chip. Later, the experimental readings were compared to the theoretical calculations.

Experimental Method:

A peltier chip finds its uses mainly in the air-conditioning industry creating temperature differences when a voltage difference is applied between its two terminals. This peltier chip uses the concept of a thermocouple to produce this temperature difference. In the methodology employed here, a 1.3 hp petrol engine (60cc, 2 stroke, 3000 rpm) was taken in order to generate and emulate a life sized engine on which this modulation is designed to take place. This engine was run at no-load and the hot side of the peltier chip was put next to a heated metal sheet and the cold side next to a heat fin, whose sole objective was to create a temperature gradient for the successful operation of the experimental set-up. The hot air from the exhaust pipes was made to flow through a section of bent copper wires that heated the metal plate. In order to reduce the heat losses, an insulated rubber covering was provided to this heat exchanger system. A standard multimeter was used to measure the current and the voltage outputs of the set-up.

Theoretical:

In order to calculate the theoretical efficiency of the set-up, equations 1-5 have been used [2]:

$$\eta = \frac{P_P}{Q_H} \cong \frac{P_P}{Q_C + P_P} \quad (1)$$

where

P_P is the power generated by the Peltier chip.

Q_H is the heat input to the module.

Q_C is the heat output of the module.

$$Q_H = \left[K_P(T_H - T_C) + (S_P.T_H.I) - (\tfrac{1}{2}.I^2.R_P)\right] \quad (2)$$

K_P is the thermal conductance

S_P is the Seebeck coefficient

R_P is the total resistance

I is the current flowing in the circuit

Similarly,

$$Q_C = \left[K_P(T_H - T_C) + (S_P.T_C.I) - (\tfrac{1}{2}.I^2.R_P)\right] \quad (3)$$

$$P_P = Q_H - Q_C = V_P.I \quad (4)$$

Where

V_P is the voltage produced by the peltier chip

$$V_P = S_P.(T_H - T_C) - IR_P \quad (5)$$

In order to calculate the efficiency of the system both theoretical and experimental, equation 1 has been used. The differences in the theoretical and the experimental findings have been characterized in the table 1.

TABLE I. *Comparision of methodology*

	Experimental	Theoretical
Internal Resistance (Rp)	1.7 ohm	1.7 ohm
Max. Current (I)	184 mA	184 mA
Inlet Temperature (Th)	393 K	393 K
Outlet Temperature (Tc)	353 K	353 K
Max. Peltier voltage (Vp)	1.84 V	1.94 V
Electrical Power (Pp)	338.56 mW	376.36 mW
Efficiency	7.69%	8.23%

RESULTS AND DISCUSSION

In this section, a discussion with regards to the real world application aspects of the experimental set-up has been included. We see that the efficiency limit prescribed by the experimental set-up is within the limits put forward by the theoretical methodology. The slight difference in the two can be attributed to imperfect measurement of the two temperatures as well as the improper measurement of the internal peltier chip resistance.

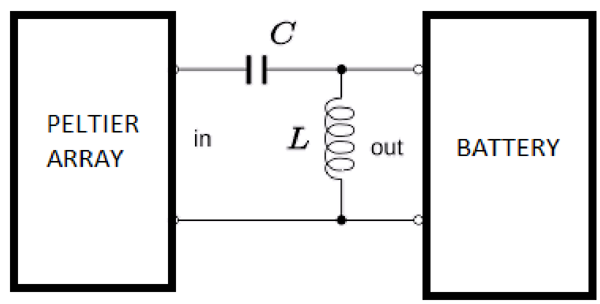

Fig 1: Filter Circuit

An observation that can be made is that the voltage waveform is a pulsating dc. In order to use this dc power to recharge the battery we need to convert it into pure dc voltage. Figure 1 includes the filter circuitry that can be used to do this conversion [3]. The waveform of the output voltage and the corrected dc voltage has been included in the figure 1. This corrected dc voltage can be directly used to recharge the battery. Also it is imperative to understand that in order to recharge the battery; we need to have more number of peltier chips connected in an array. Connecting the peltier chips in parallel will increase the current available at the output likewise connecting the peltier chips in series will increase the voltage level available in order to provide us with the power required to charge the battery.

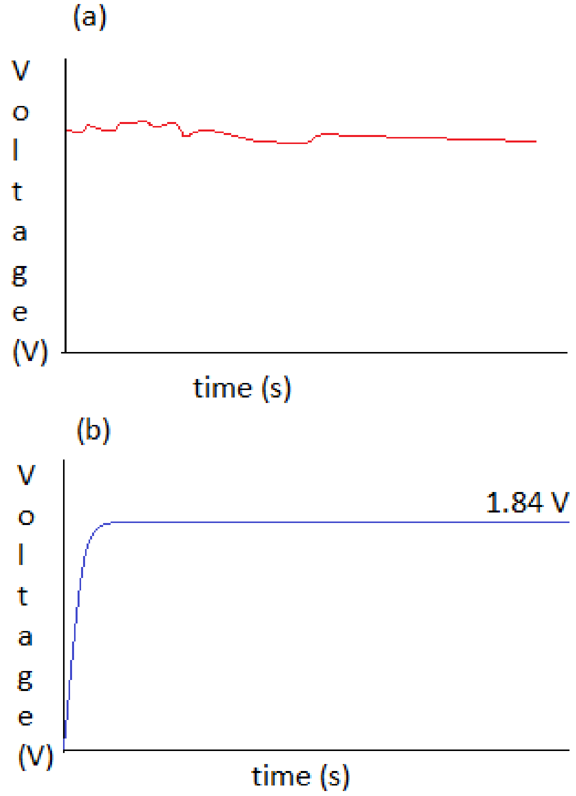

Fig. 2:(a) Peltier chip output waveform, (b) corrected output

CONCLUSION

It can be concluded that this method of thermoelectric generation can be widely used in order to make sure that the residual energy at the exhaust end can be effectively used. If the efficiency of this technique of electricity generation can be increased then it would spell a huge change in the automotive industry. The increase in the efficiency can be undertaken by providing a much larger temperature gradient.

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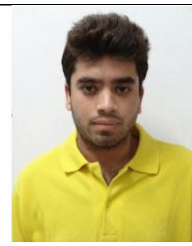	**Anmol Shah** A 4th year student at Institute of Technology, Nirma University. Majoring in electrical engineering, areas of research include design optimization of rotating machines and HVDC. Email: 12bee009@nirmauni.ac.in
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