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# Realization of Electric Voltage from Exhaust

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***Abstract-*** With the increase in population the energy consumption has also increased. Human race is in search of new technology for different energy sources to meet the present demand. Thermoelectric generation is one such emerging technology. This technology uses the waste heat carried away in flue gas or smoke passing through chimney, automobiles, exhaust etc. which is let into the environment to extract electric power. The conversion from heat to electric potential is done with the help of a device called Thermopile. This work primarily concentrates on two objective. Firstly to determine the electric potential at the junction of two different materials. secondly to utilize the developed potential (to operate the load or can be stored in battery).This is an attempt to acknowledge a new technology, a renewable and cost effective one, This will be an alternative source to meet the present demand of energy consumption. This paper describes a method to extract electrical energy from exhaust of a chimney. This can be further extended to other system exhausts also.

***Index Terms-*** Flue gas, Thermoelectric generation, Thermopile, Seebeck effect.

## I. Introduction

Thermoelectric revolves around modern day thermocouples and their application in power generation. The phenomenon involving an inter conversion of heat and electrical energy is termed as thermoelectric effect. The concept of thermoelectric effect was brought forward by a German scientist Thomas JohamSeebeck in 1821. According to this, a voltage is produced at the junction of two different materials. If a closed path is provided a current will flow in the circuit. This is the direct conversion of temperature difference to electric voltage and vice-versa. Below figure shows the illustration of seebeck effect.

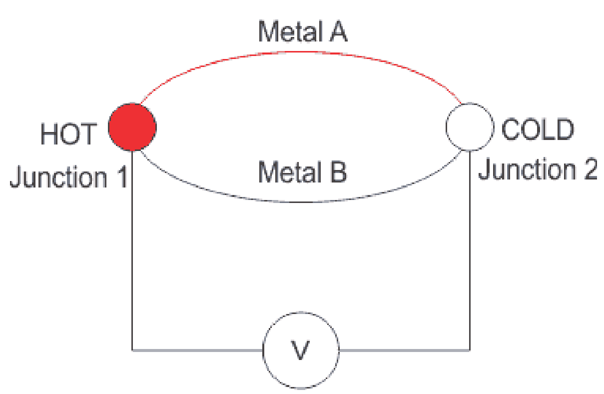


**Fig1: Illustration of Seebeck effect**

The electromotive force, or emf(V), that appears in an open circuit is the emf developed by the thermocouple to block the flow of electric current. If the circuit is opened an emf $E_{ab}$ is generated, which is called the Seebeck voltage. This emf $E_{ab}$(V) is directly proportional to the differential temperature $\Delta T$(K) between the two junctions.

$$E_{AB}=S_{AB} * \Delta T \qquad (1)$$

Where,
$E_{AB}$=Seebeck voltage
$S_{AB}$=Seebeck coefficient
$\Delta T$= differential temperature

There exists a temperature difference everywhere. At an atomic scale, an applied temperature gradient causes charged carriers in the material to diffuse from hot side to cold side, similar to a gas that expands when heated hence inducing a thermal current. Likewise significant temperature difference is obtained on the surface of the household chimney or industrial chimney, and vehicle exhaust from which considerate amount of voltage can be obtained. The voltage so obtained can be used drive low load operating dc devices such as charging mobile, batteries, lightning in vehicle, indicator, and also be connected along with solar panels to add up the voltage.

## II. THERMOPILE

A thermopile is a device which uses the temperature gradient present between the hot surface of the thermopile and the environment to convert waste heat into electricity. Thermopile is usually a two different semiconductor material or alloy or metal connected electrically in series. As the junction gets heated the valence electrons in the warmer part of the thermopile start moving towards the colder part of thermopile. These electrons are sole responsible for the production of electricity.

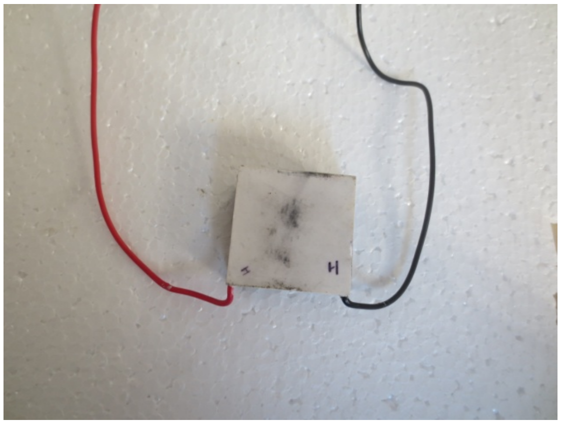

**Fig2: A typical thermopile**

## III. METHODOLOGY

Building of model chimney

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Placing of thermopile on the chimney

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Placing the model on the heat source

↓

Extraction of electric potential

↓

Utilization of developed potential

**Fig3: Assembly model**

In the proposed system the model chimney is a metal chimney. It is rectangular in shape. The thermopiles are placed at the suitable height not exceeding its rated temperature, four thermopiles on each surface on series connection. The model chimney is placed on the heat source. When the flue gas or smoke passes out through the chimney to the environment it carries heat with it. This heats up the chimney. When thermopiles are placed over the chimney the hot surface of the thermopile gets heated. The temperature gradient between the hot and cold side of the thermopile will produce an electric potential according to the principle of Seebeck effect, which can be utilized to operate the load.

## IV. TESTS CONDUCTED

Tests were conducted to extract the useful potential from the exhaust heat. The test was conducted at a room temperature of $28^{O}$ C. They were carried on the following:

1. On model chimney
2. On diesel generator chimney

1 On model chimney

1.1. Series Connection

The thermopiles are placed over the surface of the chimney at different heights depending upon the suitable temperature as determined before. One thermopile block is placed over each surface. All thermopiles are connected in series. This is done by connecting the positive terminal of one thermopile over one surface with the negative terminal of the other thermopile over other surface. This is continued till the connection reaches to the last thermopile. The load is connected to the thermopile. LED is used as a load. The total output voltage is given by the sum of individual output voltage as,

$V_{out} = P_1 + P_2 + P_3 + P_4$ (2)

Where, $P_1$, $P_2$, $P_3$, $P_4$ are voltage of each thermopile

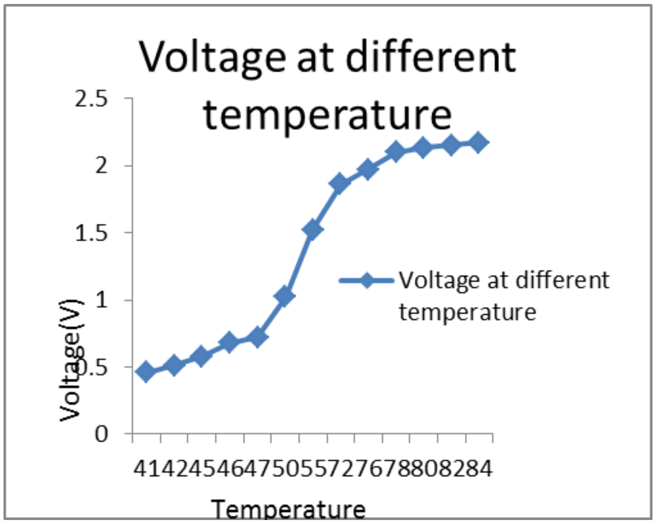


**Fig4: Temperature ($^0$C) vs. Voltage graph for series connection**

1.2. Parallel Connection

The placement of the thermopile over the chimney is same as that of the series connection test. In this the four thermopile blocks are divided into two strips. Each strip contains two thermopile block. Two thermopile blocks are connected in parallel and the two strips are connected in the series. The load is connected across two strips containing the thermopile blocks. The output voltage is given by,

$V_{out} = P_1 \text{or } P_2 + P_3 \text{or } P_3$(3)

Where,

$P_1$, P2, P3, $P_4$ are voltage across each block.

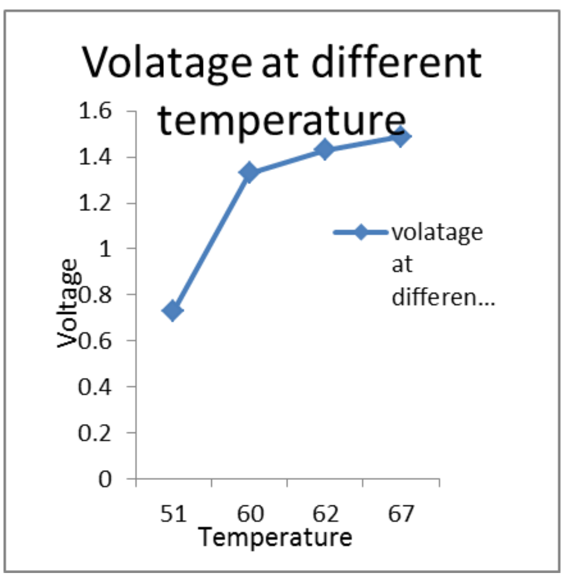


**Fig5: Temperature vs Voltage graph for parallel connection**

2. On diesel generator chimney

A similar test was conducted with six thermopile in series placed at a suitable height on diesel generator chimney as shown in the fig6. The voltage so produced is used to charge a mobile. The test result is tabulated below.

| Required output for charger | Obtained output from test setup |
|---|---|
| 3.7 volts | 4.8 volts |

**Fig6: Implementation on DG chimney**

## V. RESULTS

The test was implemented on a modeled chimney and diesel generator chimney. The results in each case is as tabulated in table7.

| Implementation on | Max. temperature gradient($^{O}$C) | Max.voltage obtained(V) |
|---|---|---|
| Modeled chimney | | |
| • Series connection | 48 | 2.3 |
| • Parallel connection | 45 | 1.58 |
| Diesel generator chimney | 50 | 4.8 |

## VI. CONCLUSION AND FUTURE SCOPE

When an experiment is done on model chimney and diesel generator chimney, we are successful in getting a considerable amount of voltage. The voltage so produced was utilized to

- Charge a mobile battery of 3.7 volts
- Glow an LED of 3.8 volts and
- To run a small dc motor which operates at(3V-9V)volts

The voltage so obtained is from the waste heat. This is just an attempt to introduce a new technology, a renewable and cost effective, which is still unnoticed in the field of electricity. The produced output voltage is of smaller magnitude as a limited number of thermopiles were used. Greater range of voltage can be obtained by increasing the number of thermopile. This dc voltage can be converted to 230V ac using a converter and can be utilized for various applications.

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