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Electricity Generated From Exhaust Gases

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Abstract: *In present scenario, some countries (India, Japan, South Korea, China) generate 74% electricity from coal. Radio activity pollution, heating, global warming etc. causes in environment because burning of fossil fuel, oil, gas etc. Also in industry, most of the expenses are due to energy (both electrical and thermal) labour and materials. Therefore ensuring environment free with including several advantages, a new technology need to be introduce. A thermoelectric module (TEG) can convert waste heat (exhaust gases from vehicle, thermal power plant and gases generated in village while burning of wood, petrol, diesel) directly in DC voltage (electricity) using see beck effect. A thermoelectric module (TEG) is a solid state device. It cannot produce any waste during electricity production. Hence thermoelectric systems contribute to 'Green Technologies' or 'Renewable Source' specifically for waste heat recovery from industry exhausting flue gases. Thermoelectric module is position-independent and flexible present along operating life time. This technique can have associated most outcome. The selection can have appliance which convert waste heat energy directly into electric power improve overall efficiencies of conversion system. It can be used in urban and rural areas. This technique will help in cost reduction of electricity. Waste heat required for this conversion is also less. By using this energy is used to operate AC as well as DC appliances. The target is to tackel problem facing the traditional single-stage system and to advance TEG application.*

Keywords: Waste heat, thermoelectric module, seebeck effect, thermoelectric generator, thermoelectric material, direct energy conversion, renewable source, electricity

I. Introduction

1.1 Field of Invention

This invention relates to the waste heat generated from fossil fuel and other gases. All research directions said that, waste heat recovery (WHR) is most important due to the widespread existence and high accessibility of suitable resources. According to India Bureau of Energy Efficiency, the waste heat recovery is beneficial for reduction in electricity and it's cost, reduction in radio activity pollution and equipment sizes and also reduction in energy consumption. Also there are a number of devices to fulfil waste heat recovery (WHR) condition, thermoelectric generator (TEG) is one of them. It has been utilized in most applications. A thermoelectric power generator is a solid state device in which waste heat energy converted into electrical energy which works on seebeck effect.

1.2 Background of Invention

In recent years, some countries (India, Japan, South Korea, China) generate 74% electricity from coal. Radio activity pollution, heating, global warming etc. Causes environmental issues. Therefore, a environment free with including several advantages a thermoelectric system introduce as a 'Renewable Source' specifically for waste heat recovery from industry exhausting flue gases. A thermoelectric generator (TEG) can convert waste heat (refrigerator outer surface heat, laptop heat, iron box heat, solar radiation heat, human body heat, exhaust gases from vehicle, thermal power plant, gases generated in village while burning of wood, petrol, diesel) directly in DC voltage using seebeck effect. Vast amount of quantities such as waste heat are released into earth's environment much of it at temperature which are too low to recover using conventional electrical power generators.

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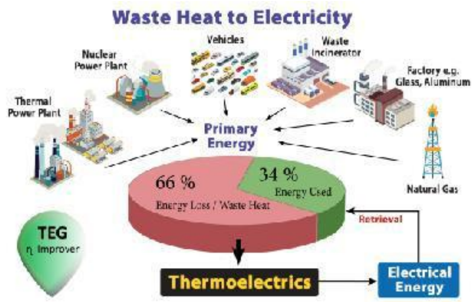

1.3 Necessity of TEG

Solar energy, wind energy, hydro energy, tidal energy etc are the renewable sources of energy. These energies are used to generate electricity in different form and method. But there are some disadvantages that these methods were faced such as if there is no sun light there will be no generation of electricity. Also wind and hydro energy having their own drawback that it produce less power and insufficient for wider usage.

The rural and urban pollution in India was last reported at 69.90 and 30.1 (% of total pollution) respectively in 2010, according to a Indian Census published in 2011. The growth rate of pollution in rural and urban areas was 12.18% and 31.80%. To reduce this pollution and generate electricity in the form green technology thermoelectric generator (TEG) need to be introduce.

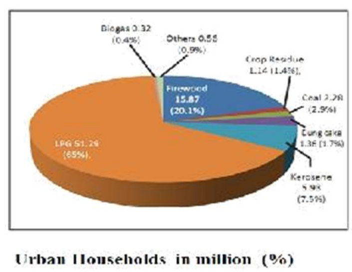

Figure: Urban household in million (%)

Thermoelectric generator (TEG) has no moving parts during operations because of this it doesn't produce noise and harmful agents. It is used to generate electricity in a safe manner i.e. it doesn't produce waste in environment. It need inputs like waste heat emitted from refrigerator outer surface heat, laptop heat, iron box heat, solar radiation heat, human body heat, exhaust gases from vehicle, thermal power plant, gases generated in village while burning of wood, petrol, diesel etc to produce output as a green energy in the environment. It also helps to reduce the cost, pollution, equipment size and energy consumption.

1.3 Concept Seebeck Effect

The Seebeck effect states that the temperature difference between two dissimilar electrical conductors or semiconductors produces a DC voltage difference between the two substances. When heat is applied to one of the two conductors or semiconductors, heated electrons flow toward the cooler conductor or semiconductor. If the pair is connected through on electrical circuit, direct current flows through the circuit.

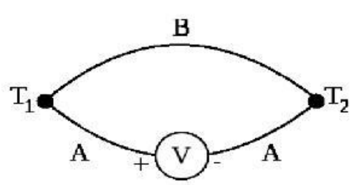

Figure: Seeback effect

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1.4 Peltier Effect

The discovery of the Seebeck inspires Jean Charles Peltier to see the opposite of the phenomenon. He is an electric discharge on two pieces of metal that are glued in a circuit. When electric current is applied, heat absorption occurs at the junction of the two metals and the release of heat on the other connection. Release and heat absorption are mutually turned so the current direction is reversed. The discovery occurred in 1934 which was then known as the Peltier effect, as shown in figure.

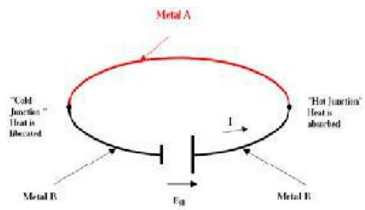

Figure: Peltier effect

1.5 Thermoelectric Effect

The thermoelectric effect states that the direct conversion of temperature differences to electric voltage and vice versa. A thermoelectric device creates a DC voltage when there is a different temperature on each side.

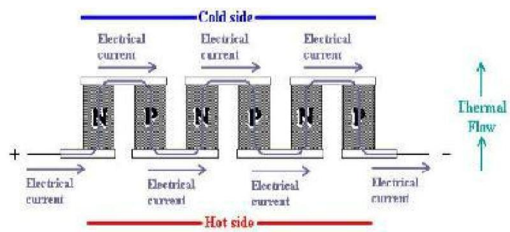

Figure: Thermoelectric effect

II. Thermoelectric Generator

2.1 Construction

Thermoelectric generator is a device that converts thermal energy directly into electrical energy. Thermoelectric generators are the device that are solid-state heat components constructed of flow essential junctions which are p-type and n-type. The p-type junction has an increased concentration of positive charge and the n-type junction has an increased concentrated of negative charged elements.

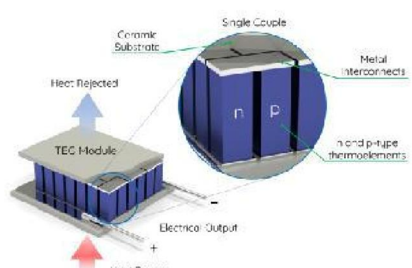

Figure: Simplified illustration of TEGs

2.2 Selection of material for TEG

Metals are play very important role in TEG's, despite metals merit of high ratio of electrical to thermal conductivity, there are total 26 main semiconductors present in modern world.

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These materials largely affect the performance of thermoelectric generator (TEG). Hence, it is important to select the proper selection of material to design a better thermoelectric generator (TEG). Also there is a need to compare or examine various materials for better performance. Thermoelectric generator (TEG) has segmented structures. Within a segmented structure, each material should be used in their best temperature range (BTR).

Group	Material	BTR (K)
Hot Side Material (700 K-1000 K)	CoSb3PbTe SiGe	600650-850-1100 >1000
Cold Side Material (300K-400K)	Bi2Te3	<350

Table: N-type material groups by best temperature range

Group	Material	BTR (K)
Hot Side Material (700 K-1000 K)	CeFe4Zn4SiGeb12b3 TAGS	900>850>600-1300
Cold Side Material (300K-400K)	Bi2Te3	<450

Table: P-type material groups by best temperature range

III. Working

Thermoelectric generator (TEG) consists of one hot side and other cold side. The hot side with higher temperature, will drive electrons in the n-type leg toward the cold side with lower temperature, which cross the and pass into the p-type leg, thus through the circuit as sown in Fig.4.1. Holes in the p- type leg will then follow in the direction of the current. The current can then be used to power a load.

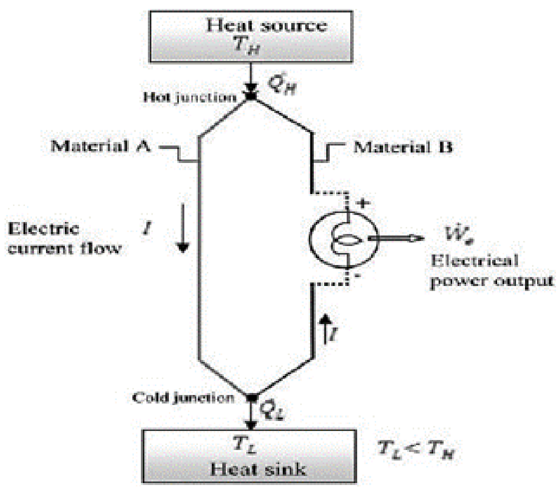

Figure: Principle of thermoelectric generator

In 1821, J. T. Seebeck (1770-1831) discovered that dissimilar metals are connected at two different locations (junctions) it will develop a micro-voltage. If the two junctions are different temperatures. In case of a Peltier cooler module the Seebeck voltage can be determined by 1

VS =α (Th −Tc)... (1)

where Th-Tc is the temp difference between heat applied and cold side of TEG.

TEG Components

1. Thermoelectric internal elements
2. Thermoelectric covering
3. Thermal withstanding 4. Copper wire

If temperature difference is kept constant, then the diffusion of charge carriers will form a constant heat current. If the rate of diffusion carriers are equal, there would be no net change in charge within the TE leg. If the temperature difference increases the voltage is also increases.

Figure: Thermoelectric generator with fin heat sink

IV. PROBLEM DEFINITION

Some developing countries and most populated industrialized countries (India, China, South Korea) generate 74% electricity from coal. And also shortage of fossil fuel and coal. Oil and gas are imported from other countries. In some villages harmful exhaust gas is released through burning of wood while cooking. It is harmful for human being which is cooked at that time. So that radio activity pollution, heating, global warming also may occur due to fossil fuel. It has average of 3 to 10 hours of daily power-cuts because the increase in demand of consumer utilization electricity exceeds so that the production of electrical energy is lesser then the consumer demand. And also the generating the power from non-renewable sources may affect to harmful environment and pollute the nature. New generation are depending upon the rechargeable batteries or diesel/petrol engine etc. when there is no power and at the time of load shedding. The use of generator is common in industrial and other sector. This is ultimately increases the shortage of power and more cost. Also the people are not utilizing the power properly they were unnecessarily wasting the power and they are not able to designing the power consumption properly. Hence basically a low power consumption in that also wasting means in the future we live without light. Now a days consumer demand is more then the power production that is the major difficulty to overcome.

4.1 Objective

The aim of this project is to develop much cleaner noise less cost effective different way of power generation method for charging the battery as well as to utilization proper only the requirement of usage, which helps to reduces the global warming as well as reduce the power shortages, heating, load shedding and also we can transfer the portable generating unit. In this project there is conversion of waste heat into electricity by using thermoelectric generator. Waste may refrigerator heat, vehicle radiator heat, laptop heat, even body heat can waste heat to thermal powwer plant's waste heat, gases generated in village while cookiing, petrol, diesel can be used as a input source to generate electricity and it can be rotate a fan continuously if the uniform supply is provided and also stored in a rechargeable lead acid battery for further usage. And also waste energy human body locomotion also produce electricity body weight locomotion of the energy in to electrical energy by using electromagnetic induction principle. Thereforre, it is a new form of 'Green Technology'.

1. Charge the mobile battery where ever waste heat is realised.
2. Maintain the heat transfer from hot side to cold side because of uniform rotation of fan.
3. Charge the 12v battery for further usage to converting by using inverter to 220v.

V. SCOPE OF THE STUDY

The scopes of project study are;

1. By using thermoelectric generator connecting in series/parallel we can generate the maximum level power.
2. Even body heat, refrigerator outer surface heat, thermal power plant's waste heat, gases generated in village while cooking, petrol, diesel also generate the heat that can be utilizing by using TEG to generate.
3. By installed in the vehicle above the radiator means the vehicle battery will charge self.

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VI. Literature Survey

In today's world electricity gennerated by many ways from burning of wood, petrol, coal, dieesel etc. But it has 3 to 10 hours daily power-cuts because of excessive demand from consumers. This electricity is not so sufficient. So the electricity production is less as per consumer demand. Also global warming, radio acctivity pollution, heating etc increases now a day because of burning of these fuels. Global warming average measured temperature of Earth's near surface air and oceans increases since the mid-20th century. Also it's projected continuation. It's temperature increased 0.74 ± 0.18 °C (1.33 ± 0.32 °F).

Thomas Jon Seebeck (1934) invented seebeck effect. At the heart of the thermoelectric generator effect there are two metals which are conducting materials and form a temperature difference results in the form of DC voltage. That's why TEG is used.

VII. Block Diagram

This section gives the brief description of each component used in designing "Green Technology' from waste heat to generate electricity by using thermoelectric power generation (TEPG) TEC12706 device.

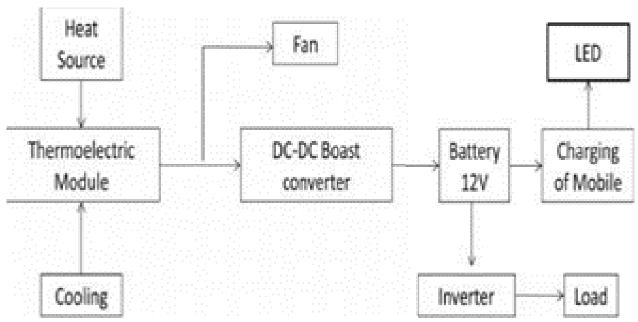


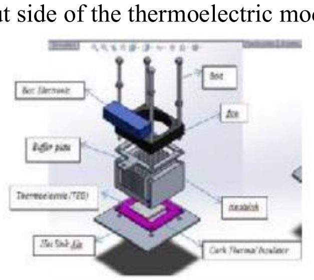
Figure: Block Diagram

7.1 Heat Source

When waste heat (refrigerator outer surface heat, laptop heat, iron box heat, solar radiation heat, huuman body heat, exhaust gases from vehicle, thermal power plant's waste heat, gases generated in village while burning off wood, petrol, diesel) is given to a one surface of thermoelectric module it generates DC voltage. Therefore waste heat is act as an input source.

7.2 Thermoelectric moddule (TEG)

When heat is applied to one side of module there will be a continuous electron or holes will flow continuously because of heated temperature. Heated electron flow toward the cooler conductor because heat transform is uniform and DC voltage is developed at the output side of the thermoelectric module.



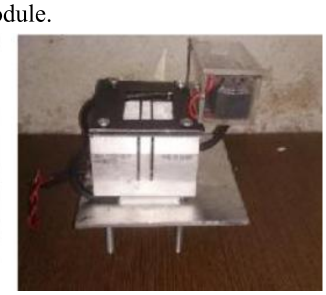


Figure: (a) Design of TEG device **Figure:** (b) Thermal electric generator (small module)

A fan is used to indicate that whether the waste heat is converted into electricity or not.

7.3 DC-DC boost Converter

The DC-DC boost converter is used to “step-up” an input voltage which is given by thermoelectric module is 1.5 volt to output voltage for charrging a 12v DC battery.

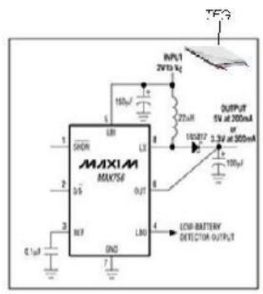
7.4 Mobile Battery

After the regulated voltage is passed to the battery terminal to charge the mobile so that the required specification is 3.8 v li-ion batteries 5.70wh is required. Finally the mobile battery will charge under desired voltage condition. Inverter The function of inverter is to ‘invert’’ the direct current (DC) input into alternating current (AC) output. It coverts 12v Dc into 230v AC.

7.5 Load (Lammp)

Lamp is an AC load which is operateed on alternating current. It indicates that we can use AC appliannces using waste heat. Lamp consume total 40 W of power. LED is used to indicate that mobile battery is charging or not. If LED will glow continuously then the mobiile battery charging is in process and if it is not glowing means there is
9.

Circuit diagram and working by Using TEG



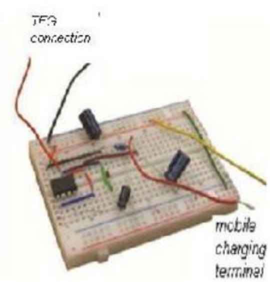


Figure: Circuit diagram **Figure:** 1;5 Volt From 1.5 Volt Circuit Schematic

The MAX756/MAX757 are CMOS step-up DC-DC switching regulators for low input voltage or battery-powered systems. The MAX756 accepts a positive input voltage down to 0.7V and converts it to a higher output voltage of 3.3V or 5V. The MAX757 is an adjustable version that accepts an input voltage down to 0.7V and generates a higher adjustable output voltage in the range from 2.7V to 5.5V. The full-load ~ Max756 combine a switch-mode regulator with an N-channel MOSFET, precision voltage reference, and power-fail detector in a single monolithic device. The MOSFET is a “sense-FET” type for best efficiency, and has a very low gate threshold voltage to ensure start-up under low-battery voltage conditions (1.1V type).

The circuit can be easily wired on a very small rectangular PCB. All connections should be kept as short as possible. If available try to add a better quality 8 pin DIP socket for IC1. The power inductor’s (L1) DC resistance significantly affects efficiency. For highest efficiency, limit L1’s DC resistance to 0.03 Ohm or less. A thru-hole type standard power inductor can be used. Simultaneously, the ESR of all capacitors (bypass and filter) affect circuit efficiency. Best performance is obtained by using special low-ESR capacitors.

Complete steup to charge the mobile battery by using thermoelectric generator. complete setup to charge the mobile battery is shown in fig, When c a n d e l heat is applied to the hot side the TEG get absorb the heat. It alsoo get waste heat from any body (ex- refrigerator heat, laptop heat, heat from the vehicle, solar heat, and even human body is also a waste heat source for TEG). Under this when heat absorbs one side it rejected at the other side (cold side) heat transfer take place from hot surface to cold surface. So that the electron will flow and fan start to rotate. Then a DC-DC boost convert is useed to step up a DC voltage from 1.5 volt to 12v to chager DC battery which is shown in a black colour. The required power for the mobile battery is 3.8 volt it is at the output terminal at the circuit is as shown in the fig a.

As it is heat transfer take place from heat applied side to cold side. These thermoelectric generators of two terminals are to connected i.e. positive terminal is connected to fan side and the other terminal is connected to DC-DC boost converter.

Circuit elements consist of LED (3.5v),Mobile battery (3.8v), lamp (40W). When heat is applied to the hot side under certain temperature (30 to 300 degree C) electrical power from heat flow across a hot to cold side temperature gradient more thermoelectric generator need to be connected in cascade to make the maximum voltage.

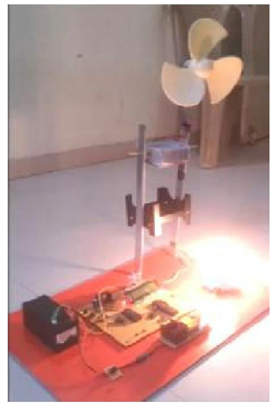


Figure: (a) Normal condition of circuit **Figure:** (b) Operating condition of circuit

Thermoelectric device fan rotates to flow of electron to the thermo electric generator so that continuously electron will flow through fan when applied heat to the TEG. DC-DC boost converter is used to to "step-up" an input voltage which is given by thermoelectric module is 1.5 volt to output voltage for charging a 12v DCC battery. Zener diode helps to eliminate the excess voltage flow to the battery because battery required to charge. LED (light emitting diode) is shows the battery is charging or not and it ill glow when the output voltage is above 3.5 volt.

Test analysis by waste heat from boiler tube The exhaust of flue gasses sounds very interesting. We believe the efficiency of such a system would be in the range of 10.6% for QW of Si/SiGe. This takes 5 into account 10 C temperature loss on both the hot and cold end of the thermoelectric for heat transfer We tested five different modules with different semi-conduct materials in order to find the TEG with the maximum output at a specific temperature difference. Fig. 1 shows the schematic of the module tests. The TEG module was clamped tightly in between two containers, one was the hot side with a high temperature and another was the cold side with a low temperature.

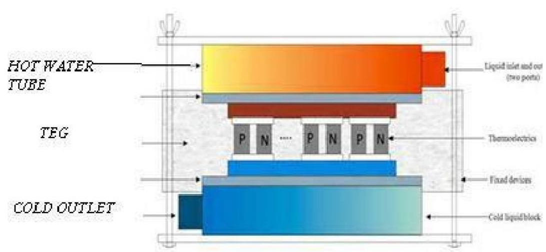
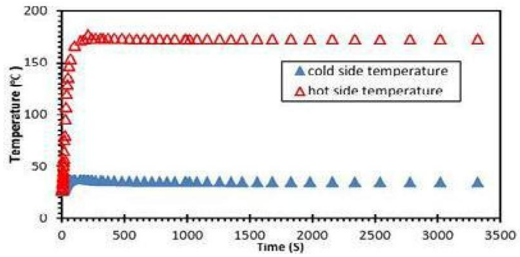


Figure: shows the schematic of the module tests.

We kept the temperature on the hot side at about 200°C by using a digital thermostat oil bath and used the tap water as the cooling liquid on the cold side with a temperature of about 20°C. The temperatures of both hot and cold sides were measured and the results are shown in graph. The temperature was measured using two micro-thermocouples with very thin tips.

The temperature on the hot side of the modules was stabilized at about 180°C and that on the cold side at about 40°C. The increase in the temperature on the cold side from 20 to 40°C was because of the heat conduction from the hot side through the TEG modules. The temperature difference was stabilized at around 140°C. The results illustrate that the test system for thermoelectric power generation was stable



Test analysis from human body heat (both male and female)

This experiment focuses on extracting heat energy from four parts of the human body, which are forehead, wrist, palm, and calf. The energy-harvesting rate for different actions is one of the significant factors when harvesting heat. Therefore, this experiment also investigates the effects of three human actions, including resting, walking and running when performing the test for each body part. During the experiment, each action was carried out for at least 10 minutes in an indoor setting. A healthy male participant weighs 70 kg with 170 cm tall (body mass index of 24.22 kg/m²), and a female participant weighs 60 kg with 164 cm tall (body mass index of 22.31 kg/m²) have to test participants. The measurement for each different body part was repeated three times to obtain an average reading. Two type-K thermocouples were connected in series and securely attached to the top and bottom of the TEG. These attachments were made to exactly record the skin temperature and room temperature by using a dual channel type-K thermocouple thermometer. The temperature difference between the body temperature (hot side) and room temperature (cold side) was calculated. Figure 1 shows the illustration of the TEG placement at one of human body parts. Whereas, Figure 2 shows the experimental assembly of the TEG and other devices.

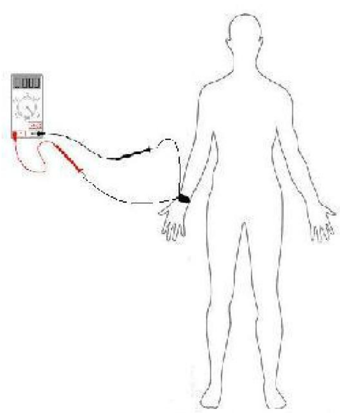


Figure: Illustration of energy harvesting at the human wrist.

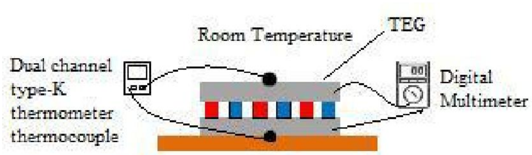


Figure: Experimental assembly of the TEG attached to the human skin.

VIII. Experimental Procedure

A small hole was made at the wristband and headband to place the TEG so that it is exposed to the room temperature. Next, the both participants securely put on the wristband or headband and carefully adjusted the compression of the band as they found comfortable at their body or skin. The experiment was carried out between 10 am to 2 pm to get a consistent temperature during the day. Temperatures for both sides (skin and room) were recorded before and after each action to observe the temperature difference when the action was carried out. The recorded data was also used to determine the

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temperature difference between both hot (skin) and cold sides of the body.

Each action was carried out for 10 minutes while the data for the TEG's voltage and resistance was recorded using a digital multimeter. When resting, both male and female participants simply sat on a chair. Whereas for walking and running, they performed the action on a treadmill with speeds of 3.3 km/hr and 7.3 km/hr for walking and running. There was a rest time of 10 minutes after the both participants completing the action to reduce and stabilize the skin temperature and the heart rate. The device assembly at both (male and female) participants' body parts (wrist) is shown in Figure 3. For each temperature difference and action, there will be a different amount of output power generated by the TEG system from both male and female participates. Hence, once the voltage, V, and the resistance, R, are measured, the output power, P can be calculate using Eq. (1):

$$P = \frac{V^2}{R} \quad (1)$$

(a) (b) (c) (d)

Figure: Device assembly a) at wrist; (b) forehead; (c) calf and (d) palm

Results Comparison between Male and Fe male Participants

The average hot side temperatures of male and female participants are nearly similar for all actions (over 34 °C), except for the female's resting temperature. The resting temperature stays around 30 °C regardless of body parts as shown in Figure. When comparing male and female results, it is shown that most male's average temperatures are higher than female. This is reasonably true since various studies have found that male's hand temperatures tend to be higher than female's hand temperature due to the underlying physiological variations such as weight, height and proportions of a body that may influence the capability of male and female to maintain heat

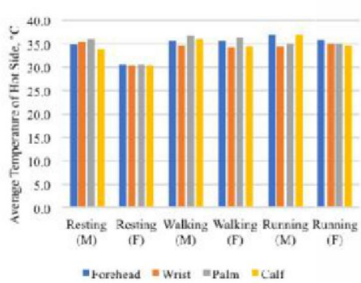

Figure: Comparison of the average hot side (skin) temperature between male and female participant at different body locations for various activities.

Figure shows the differences in power generated from both male and female participants at each body part for resting, walking and running. Powers created when resting for the female participant are too small regardless of body parts, which are about 0.01 mW. It can also be seen that the power generated at the wrist or calf for fe male's walking action has the lowest value, which is below than 0.05 mW. In contrast, the power generated for the male participant shows the highest reading in every action, which is generally over 1.5 mW. Nonetheless, for running, the lowest power generated is at palm, approximately 0.8 mW. Body parts that can generate the maximum power for each action are identified and tabulated in Table 1 and Table 2 for male and female participants, respectively.

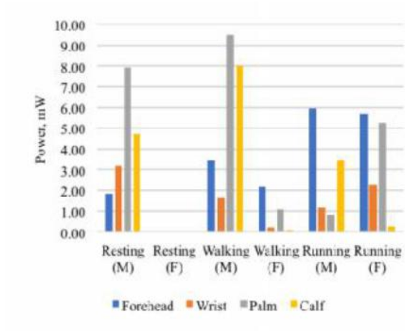

Figure: Comparison of power generated between male and female participant at different body locations for various activities.

Body Parts	Activity	Power, mW
Palm	Resting	7.93
Palm	Walking	9.50
Forehead	Running	4.49

Table 1: Maximum power generated with the related body part for each activity performed by the male participant

Body Parts	Activity	Power, mW
Wrist	Resting	0.04
Forehead	Walking	2.18
Forehead	Running	5.69

Table 2: Maximum power generated with the related body part for each activity performed by the female participant.

Test analysis from Burner

Fundamentally, there are total four components in the system. (i) A heat source (ii) A cold side (iii)) Heat sink (iv) Electrical load. This system performs better w ork with TEG by using a conversion principle. Heating source gives heat and cold side remains cold that's why a temperature difference is created in the form of DC voltage. This is given to the electrical load. This system also includes a voltage regulation circuit or a fan for the heat sink.

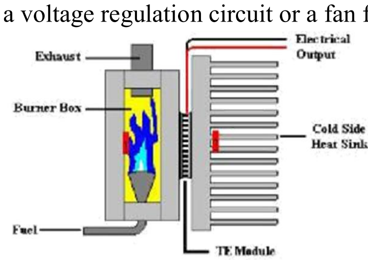

Figure: one example of such a system

IX. Result Analysis

Basically waste heat is used to charge the 12V DC battery. The syste is tested to meet the objectives and hence the result obtained. For the analysis a thermoelectric generator (TEG) is putted on a hot chamber plate(bodyheat or iron box). I am using here to get fast output and the aluminium heat sink square shaped is placed on the top side (40x40x40) daimension. Heat sink of the other side of the thermoelectric generator (cold side). The hot plate (ron box) is sated at different temperature rating from 30°C to 220°C . So that to know the voltage and current by using mutimeter that was produced by this TEG. By using thermometer to determine the applied temperature exactly on hot side of the TEG and cold side side. Equation is given by

Temperature (%T) = Temperature Hot (Th) – Temperature Cold (TC)

where Th-Tc is the temp difference between heat applied and cold side of TEG.

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X. CONCLUSION

Now a day, electricity is a generated by many ways using solar, hydro, thermal and nuclear energy. Solar, wind and hydro power plant are renewable sources of power plant. Thermal and nuclear are limiting sources which causes radio activity pollution, global warming, heating etc. These are harmful for environment. In case of solar energy, there is no light then solar energy will not generate power also wind and hydro energy having their own disadvantages that they produce less power. Burning of coal, gas, oil are the conventional input to generate electricity. Hence new 'Renewable Source' has to be introduced. The TEG technology gives pollution free energy to world. Also it doesn't have any moving parts i.e. it is solid-state device. Therefore, it doesn't generate waste substances in environment. It doesn't have major drawback like other electricity generated methods. By using this energy we charge 12v battery. Then we can use further AC as well as DC appliances from it.

XI. ADVANTAGES

1. Clean, pollution free, Noise less.
2. Cost is less.
3. This is a Non-conventional system.
4. No fuel is require.
5. Easy maintenance.
6. Promising technology for solving power crisis to an affordable extent.
7. Simple in construction.
8. Required less space.
9. It can be use at any time when it necessary.
10. Less number of parts required.
11. We can charge any electronic devices.
12. Electricity can used for many purposes.

XII. DISADVANTAGES

1. Improper variation of temperature gradient difference may damage the TEG.
2. Complex design.

XIII. APPLICATIONS

1. Thermoelectric Generators are basically used in where the power production is less.
2. In automobile vehicle produce heat that can be used for generating electricity by using TEG.
3. Recharge the battery where ever waste heat is obtained.

XIV. SCOPE OF THE FUTURE WORK

1. By using proper thermoelectric material help to increase the output voltage.
2. By addition of the more TEG in SERIES is to increase the voltage.

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