CONCEPTION OF TWO-WAY THERMOELECTRIC GENERATOR IN PASSENGER CAR CABIN MODEL

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Abstract: Temperature difference always plays a vital role in cars. Our project proposal is to develop a model to harness that temperature difference into electrical energy using "Seebeck Effect", by means of thermoelectric generators. These plate-like devices can convert the temperature difference into electrical energy (voltage or potential difference) which we can further use for other purposes.

I. INTRODUCTION

Here we are going to apply the principle in three different scenarios. Summer, winter, and in a parking car during the summer. We are going to use two-way thermoelectric generation in the project. First way of thermoelectric generation in the summer scenario and the second way of thermoelectric generation in the winter and in the parked car scenarios. Both the way of thermoelectric generations is using the 'See beck effect' but in ways to each other. We going to utilize this Seebeck effect by means of Peltier plate to convert the temperature difference into the potential difference. Peltier is a plate like device with two different sides on each side. The hot side need to expose to the hotter area and the cold side to the colder area which leads to the generation of the voltage from the terminals of the Peltier. The installation of these Peltier plate takes place in the region where the temperature difference between the surroundings and the car cabin takes place on a large extent i.e. car roof.

II. TEMPERATURE DIFFERENCE

As we discussed before temperature difference is utilized in three different scenarios. In summer the external temperature outside the car ranges from 30ºc to 45ºc and the temperature inside the car cabin lies between 15ºcand 25ºc where the temperature difference ranges from 50ºc and 30ºc. Similarly, in winter the external temperature outside the car ranges from 50ºc to 15ºc and the temperature inside the car cabin lies between 20ocand 30oc where the temperature difference ranges from 50ºc and 25ºc. In case of parked car also the external temperature outside the car ranges from 30oc to 45oc and the temperature inside the car cabin lies between 50ºcand 65ºc where the temperature difference ranges from 20oc and 35oc. Using this much temperature difference we are generating the voltage in the car cabin.

III. PROBLEM IDENTIFICATION

The conversion between two-way thermoelectric generation is the major problem of the project for the first way of thermoelectric generation the hot side of the Peltier should expose outside and the cold side of the Peltier to the inside cabin. In the same way in case of second way of thermoelectric generation the hot side should expose to the inside cabin and the cold side of the Peltier to the outside. So, it is literally impossible to turn the Peltier physically. The only way is to change the terminals of the Peltier. Even it is a bit tough task to identify the shift in the temperature difference from outside and inside cabin. To eradicate this, we have incorporated one microcontroller in the circuit where the shift between the summer, winter and scenario can be easily detectable and shuffle the terminals internally in the circuit.

IV. OBJECTIVE OF THE PROJECT

To generate the potential difference (voltage) from the temperature difference of the inside cabin and outside atmosphere and the harnessed voltage should be measured and stored in the battery to utilize for further purposes.

V. COMPONENTS OF THE PROJECT

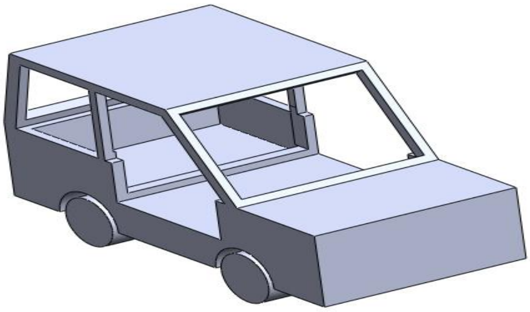
We are using 5 major components in our project. They are (1) Car cabin (2) TEG (3) Circuit board (4) Measuring aids (5) Storage systems.

Car Cabin

We have created a car cabin model using sheet metal and fiber glass to generate a real time cabin like experience and to accommodatethe circuit board and finally to incorporate the TEG on the top of the cabin. The below figure shows the model car cabin.

Figure 1 Car Cabin (Actual)

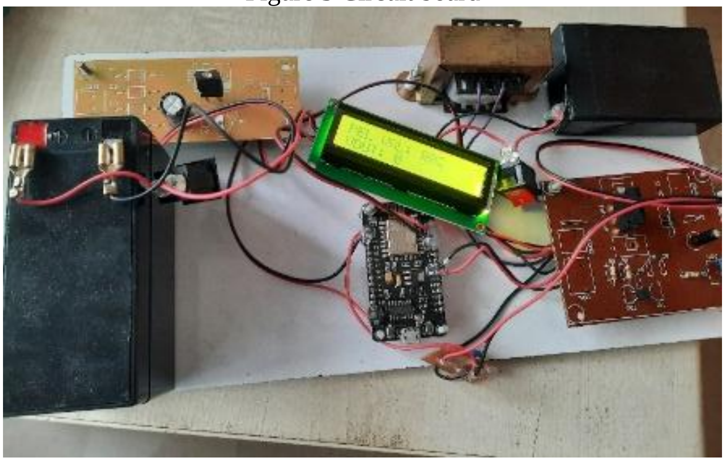
Figure 2 Car Cabin (CAD)



Circuit board

Circuit board is the mother of the project where all the components get integrated. Circuit board consists of the following sub components. They are (1) Switches (2) Step down transformers (3) Voltage Booster (4) Storage Battery (5) Integrated Circuit Board (6) Microcontroller unit (8) GSMWiFi module (7) Potentiometer display unit

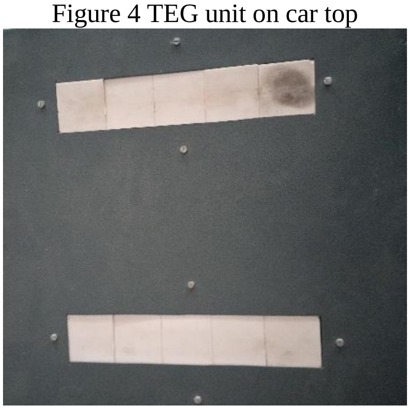
Figure 3 Circuit board



Thermoelectric Generator[TEG]

These are the crucial components for the whole project and responsible for the thermoelectric generation. We used 2 sets of the TEG where each set includes five individual TEG. All the TEG are connected in series and the final terminals are connected to the circuit board. TEG are mounted on the roof of the car cabin so that the hot side of them face the surroundings and the cold side facing the car cabin.

Figure 4 TEG unit on car top



Measuring Aids

Measuring gauges that we are using in this project are (1) Thermometer (2) Potentiometer (3) Mobile application.

Thermometer

Here we are using two digital thermometers for measuring the internal temperature of the cabin and the external temperature of the surroundings. Both of them shows the temperature in Celsius.

Figure 5 Digital Thermometer

Potentiometer

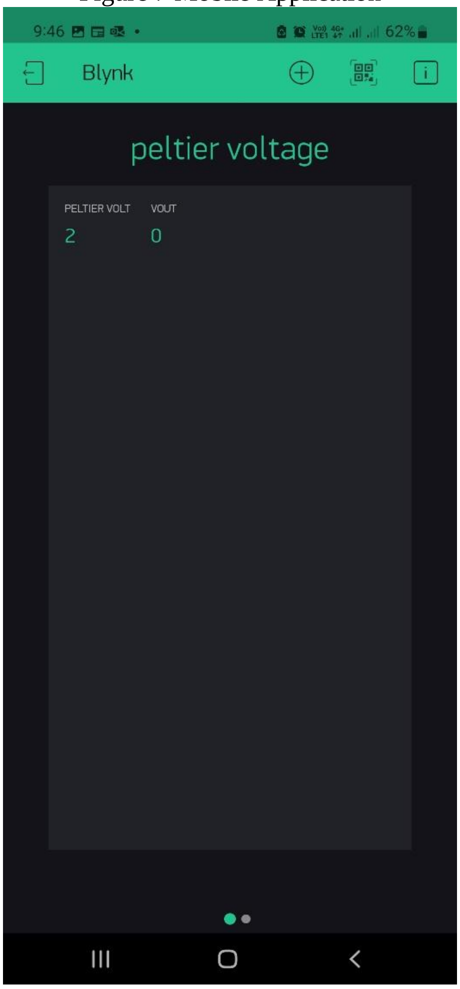
Here a digital potentiometer is internally connected with the circuit board. It displays two voltages (1) The voltage produced by the TEG unit, known as ‘Peltier voltage’ (2) The overall voltage produced by the unit, known as ‘Overall voltage’.

Figure 6 Digital Potentiometer

Mobile Application

A mobile application is developed to receive the Peltier and overall voltage details to the mobile of the user. A GSM based Wi Fi module is installed inside the integrated circuit for this operation.

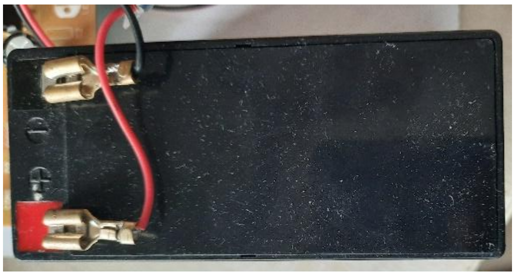
Figure 7 Mobile Application



Storage Systems

Here a 12v lead acid battery is used inside the circuit to receive the output voltage from the TEG unit and store it. The received output can be further used for other purposes of the vehicle.

Figure 8 Storage Battery



VI. Construction of Project

Introduction

Here is the brief construction of the project which clearly comprehends the functionality of the project. Construction of the projects includes several areas and we are going to discuss about each of them briefly in the further sections.

Model car cabin

A model car cabin is made in the scale of 10:1 to the original car cabin using the sheet metal material. The car cabin is not heat insulated but the heat exchange is managed to some extent by completely closed the car cabin.

The roof of the car cabin is incorporated with 2 sets of TEG where each set of it consists of 5 individual TEG plates of thickness 3 to 4 mm. All the TEG are connected in series with each other and finally connected to the circuit board.

A door is fixed in the back of the cabin to remove and place the circuit board inside the car cabin.

Circuit board

A circuit board is designed with all the essential components and kept inside the car cabin. It receives the output directly from the TEG unit as the terminals of the TEG unit are connected to the circuit board. It measures the output from the TEG unit and sends the value to the digital potentiometer and then sends the voltage to battery to charge it.

Measuring Gauges

Thermometers are mounted on the side of the car cabin to notice the temperatures easily. The measuring bulbs of the internal thermometer is placed inside the car cabin and the measuring bulb of the external thermometer is placed outside the car cabin exactly on the top of the TEG.

Digital potentiometer is also mounted on the side of the car cabin to notice the Peltier and overall output voltages easily. The voltage is actually measured inside the circuit board by receiving output from the TEG unit and the information is send to the potentiometer display and also to the GSM module to see the voltage by means of mobile application.

Construction at a glance

If we say shortly the TEG units are fixed on the roof of the car cabin and terminals are connected to the circuit board. The thermometers are mounted on the sides of the car cabin. The potentiometer is connected to the circuit board and mounted to the car cabin.

VII. Working of the Project

Introduction

As we discussed before the core objective of the project is to generate electricity from the temperature difference. So, the whole working of the project revolves around the objective of the project.

Car cabin

The sole purpose of the car cabin to replicate the conditions prevail in the real time application of the car cabin. Car cabin model incorporates all the components of the projects not only that the whole area of the application is the car cabin. Its shelters the TEG unit on the roof top and mounts thermometers and potentiometer on the body. Finally, it also accommodates the whole circuit board. It provides overall appearance to the project and mechanical support to all the other components.

Thermoelectric Generators

The whole principle of project is the functionality of the TEG. TEG receives the temperature difference and converts it into electric energy i.e. voltage. But the functionality of the TEG is of different types depending upon the seasonal scenario of the surroundings.

TEG function in summer

As we discussed in the introduction section in summer the external temperature is higher than the internal temperature of the car cabin. As the hot side of the TEG exposed to the outside atmosphere and the cold side to the car cabin, the potential difference is generated at the ends of the TEG. The voltage generated is directly proportional to the temperature difference between the hot and cold side. First way of thermo electrical generation is occurred here.

TEG function in winter

In winter the external temperature is lower than the internal temperature of the car cabin. As the cold side of the TEG exposed to the outside atmosphere and the hot side to the car cabin, the potential difference is generated at the ends of the TEG. The voltage generated is directly proportional to the temperature difference between the hot and cold side. Second way of thermo electricgeneration is occurred here.

TEG function in parked car during summer

In a parked car during summer the external temperature is lower than the internal temperature of the car cabin. As the cold side of the TEG exposed to the outside atmosphere and the hot side to the car cabin, the potential difference is generated at the ends of the TEG. The voltage generated is directly proportional to the temperature difference between the hot and cold side. Second way of thermo electrical generation is occurred here.

Scuffle between the two thermoelectric generators

It is highly impossible for a TEG to shuffle cold side into hot side and vice versa physically, but it is possible electrically by interchanging the terminals of the TEG when the temperature between inside and outside car cabin interchanged due to seasonal and situational variation. Again, it is difficult to detect the interchange of the temperature. Here, using the microcontroller, we can interchange the terminals of the TEG by detecting the temperature interchange using the same. So, the microcontroller plays a vital role in two-way thermoelectric generation.

Circuit board

Circuit board is the brain of the whole project. It receives the voltage input from the TEG unit and measures the voltage and sends the voltage value to the potentiometer display and then to the mobile application via Gsm-WiFi module. After measuring the voltage circuit board sends the voltage to the battery to charge.

Measuring gauges

Thermometers are mounted to the car cabin to display the internal and external temperatures of the cabin. Potentiometer receives the value from the circuit board and displays the same. Similarly,Gsm module sends the value to the mobile application.

Function at a glance

Let us discuss the whole function at a glance. When the TEG experiences the sufficient temperature difference it generates the potential difference and it is sent to the circuit board and send value of voltage to the potentiometer display and to the mobile application using Gsm module. Further the voltage is sent to the battery to charge and use for other purposes. Digital thermometers display the internal and external temperatures of the car cabin.

VIII. TESTING

Scenarios of testing

Testing is an essential procedure to check the ability and working efficiency of a project. Here the main objective of our project is to check the amount of voltage generated from the TEG unit by the thermoelectric generation. We need to measure the amount of voltage generated by the TEG unit with respect to the temperature difference created in between the external surroundings and inside the car cabin. So, we are going to test the project under three different cases. Because the functionality of the project differs from scenario to scenario. We are going perform tests under the following scenarios.

Scenario (1): In summer time where the external temperatures are relatively than the internal temperature of the cabin.

Scenario (2): In winter time where the external temperatures are relatively than the internal temperature of the cabin.

Scenario (3): In a parked car during summer, where the external temperatures are relatively than the internal temperature of the cabin.

Testing in scenario 1

Under this testing we are going to measure the output voltage and Peltier voltage generated by TEG unit from the display of the potentiometer obtaining under the summer temperature conditions. We are going to create artificial internal and external temperatures that prevails in summer generally. Then we take the readings of voltage with respect to these temperatures. So that we can check the real time efficiency of the project in this scenario.

Table 1 Temperatures of scenario 1

External temperature in (^{o}c)	Internal temperature (^{o}c)	Temperature difference (^{o}c)
30	15	15
35	15	20
40	20	20
45	20	25
45	15	30

Testing in scenario 2

Under this testing we are going to measure the output voltage and Peltier voltage generated by TEG unit from the display of the potentiometer obtaining under the winter temperature conditions. We are going to create artificial internal and external temperatures that prevails in winter generally. Then we take the readings of voltage with respect to these temperatures. So that we can check the real time efficiency of the project in this scenario.

Table 2 Temperatures of scenario 2

External temperature in (°c)	Internal temperature (°c)	Temperature difference (°c)
15	35	20
15	30	15
10	25	15
10	30	20
10	35	25

Testing in scenario 3

Under this testing we are going to measure the output voltage and Peltier voltage generated by TEG unit from the display of the potentiometer obtaining in a parked car under the summer temperature conditions. We are going to create artificial internal and external temperatures thatprevails in summer generally. Then we take the readings of voltage with respect to these temperatures. So that we can check the real time efficiency of the project in this scenario.

Table 3 Temperatures of scenario 3

External temperature in (°c)	Internal temperature (°c)	Temperature difference (°c)
30	50	20
35	55	20
35	60	25
40	60	20
40	65	25

Estimated Outcomes

These are the estimated outcomes that means theoretical results of the project. We can roughly estimate the result using the below graph and table. The below graph depicts the amount of voltage produced by the TEG module for the temperature difference.

Figure 9 Graph for theoretical values

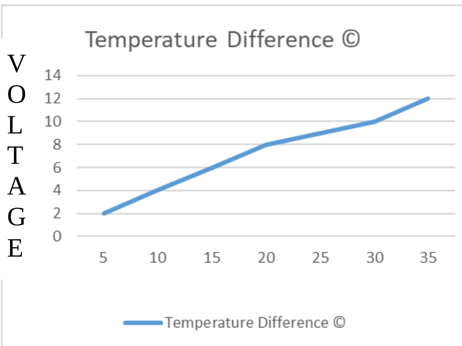


Table 4 Table of Theoretical values

S.No	Int Temp (ºc)	Ext Temp (ºc)	Temperature Difference (ºc)	Practical Voltage (V)
1.	30	15	15	3.5
2.	35	15	20	6.6
3.	40	20	20	6.7
4.	45	20	25	8
5.	45	15	30	10

IX. RESULT

Introduction

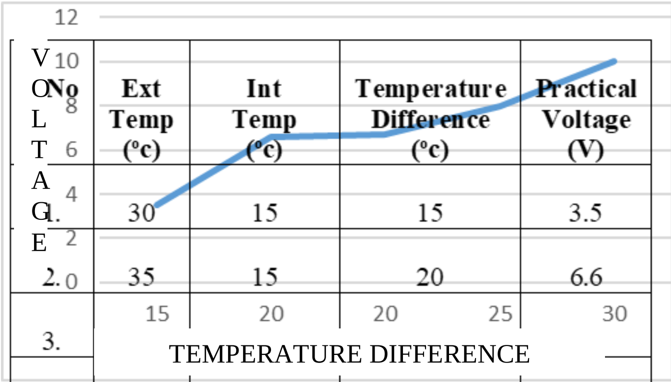
After conducting the tests as mentioned in testing, results are noted in the form of table and graph has been drawn to the temperature difference and voltage produced.

The practical outcomes of the tests are also compared with the theoretical outcomes.

Result for scenario 1

Figure 10 Graph for first scenario

Table 5 Table for first scenario



	Ext Temp (ºc)	Int Temp (ºc)	Temperature Difference (ºc)	Practical Voltage (V)
1.	30	15	15	3.5
2.	35	15	20	6.6
3.				
4.	45	20	25	8
5.	45	15	30	10

The results for the test conducted in the first scenario are mentioned below.

- For the maximum temperature difference of 30ºc we obtained 10v.
- For the minimum temperature difference of 15ºc we obtained 3.5v.
- For the average temperature difference of 22ºc we obtained 6.96v.

Result for scenario 2

Figure 11 Graph for second scenario

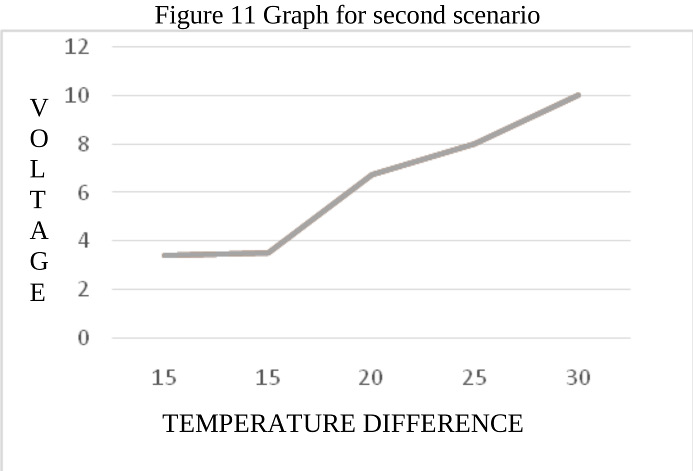


Table 6 Table for second scenario

S.No	Int Temp (ºc)	Ext Temp (ºc)	Temperature Difference (ºc)	Practical Voltage (V)
1.	35	5	30	10
2.	30	15	15	3.5
3.	25	10	15	3.4
4.	30	10	20	6.7
5.	35	10	25	8

The results for the test conducted in the second scenario are mentioned below.

- For the maximum temperature difference of 30ºc we obtained 10v.
- For the minimum temperature difference of 15ºc we obtained 3.5v.
- For the average temperature difference of 21ºc we obtained 6.32v.

Result for scenario 3

Figure 12 Graph for third scenario

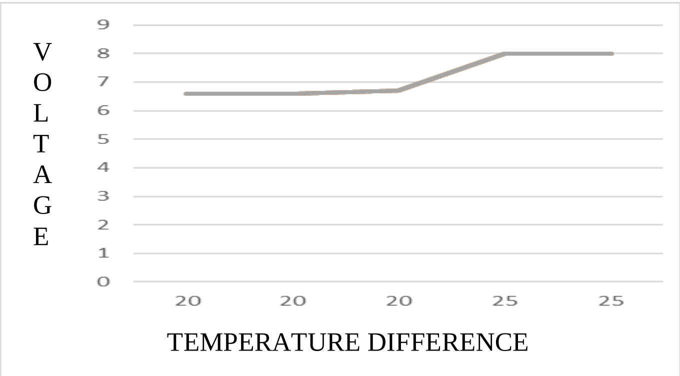


Table 7 Table for third scenario

S.No	Int Temp (ºc)	Ext Temp (ºc)	Temperature Difference (ºc)	Practical Voltage (V)
1.	50	30	20	6.6
2.	55	35	20	6.7
3.	60	35	25	8
4.	60	40	20	6.6
5.	65	40	25	8

The results for the test conducted in the first scenario are mentioned below.

- For the maximum temperature difference of 25ºc we obtained 8v.
- For the minimum temperature difference of 20ºc we obtained 6.6v.
- For the average temperature difference of 22ºc we obtained 7.18v.

X. CONCLUSION

In this project work we are concluding that it is possible to harness the temperature difference developed between the external surroundings and internal car cabin. By using the concept of thermoelectric generation, we can convert that temperature difference into electrical energy (voltage). With the help of fabricated car cabin model, we are able to generate voltage using the temperature difference, which can be taken to large extent under real time conditions.

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