Kanazawa Izumigaoka High School 02

Thermoelectric Generation During Disasters

IKEDA Shintaro ISODA Taiga OKAYA Reo HIRAOKA Tomoyasu MURATA Kousuke

Abstract

We considered using thermoelectric generation as a method of generating stable electricity at the time of disaster. Thermoelectric generation is a power generation method by the seebeck effect which is a phenomenon that voltage is generated when a temperature difference is added to different metals or semiconductors. In this study, the conditions for stabling the voltage.

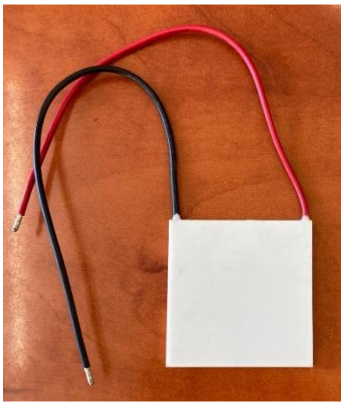
We assumed the use of thermoelectric power generation as a method to secure stable power in the event of a disaster. Thermoelectric power generation is a power generation method that uses the Seebeck effect, in which a voltage is generated when a temperature difference is provided between two different metals or semiconductors. In this research, we decided to investigate the conditions for stabilizing the voltage by examining the relationship between the temperature difference, the number of Peltier devices, and the voltage. As a result of the experiment,, it was found that the voltage value depends on the temperature from the equation expressing the Seebeck effect, and the element has a front and back side, and the larger the number of elements, the larger the voltage measured, and the longer the heating time, the larger the measured voltage. have understood.

1. Introduction

Now, electricity has become essential to our daily lives. We use it in various ways, such as charging smartphones, keeping food cool, generating light, etc.

However, maintaining access to electricity during disasters is currently an issue in the world. We need to be able to produce stable electricity by using only the resources we have around. Because of this need, we sought a way to generate electricity from just a difference of temperature, which always exists.

If we use electricity, it has to be stable. Something. Electricity voltage may remain stable by keeping the difference of temperature consistent or increasing the number of generators.Voltage may also be proportional to be the number of generators, but these questions are currently unanswered. To know if it is correct, we conducted three experiments.



Picture 1

2.Method

(i)experiment1

This experiment was conducted to investigate the relationship between temperature change and voltage change.We hypothesized that the temperature difference is proportional to the voltage.

We used one Peltier element, one hot plate, ice, two thermometers, one digital multimeter, one stopwatch, a copper container, and a lead wire.A Peltier element was sandwiched between ice water as the low temperature section and a hot plate as the high temperature section.

First, we set the temperature of the hot plate, set the Peltier device on top of the hot plate, placed a copper container filled with ice water on top of it, and connected the Peltier device, digital multimeter, and copper wire to create a circuit. Then, we measured and recorded the heating time, temperature of the ice water (low temperature section) and hot plate (high temperature section), and voltage .

(ii)experiment2

We conducted this experiment to investigate the relationship between the number of elements and voltage change.We hypothesized that as the number of elements increases, individual voltage fluctuations cancel each other out, resulting in smaller overall voltage fluctuations.

First,we filled the thermostat with water and set the water temperature to 70 ℃ ,and after the water temperature in the thermostat stabilizes at 70℃, place aluminum foil and a copper plate on top of the water in the thermostat, and place Peltier elements (1 to 4) on top of it.

Then, we started measurement at the same time as cooling the Peltier element directly with ice placed in a copper container,and measured the temperature and voltage of the ice water (low temperature section) and water in the thermostat (high temperature section) every 15 seconds for 10 minutes.

(iii).experiment3

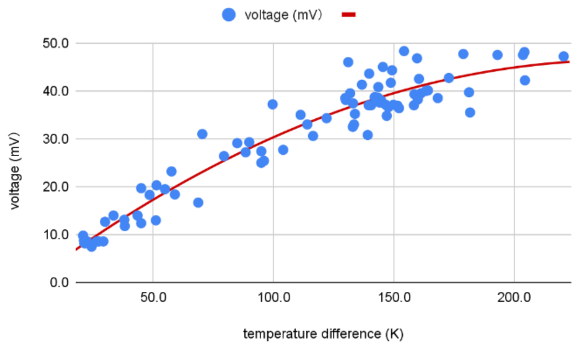
We used 4 Peltier devices, 1 thermostat, ice, 1 thermometer, 1 digital multimeter, 1 stopwatch, a copper container, a conductive wire, and a copper plate.

We filled the thermostat with water and set the water temperature to 70℃. After the water temperature in the thermostat stabilized at 70℃, we placed aluminum foil and a copper plate on top of the water in the thermostat, and placed 1 to 4 Peltier devices on top of it. We started measuring at the same time as we started cooling the Peltier device with ice placed in a copper container. We measured the temperature and voltage of ice water (low temperature section) and water in the thermostat (hot section) every 15 seconds for 10 minutes.

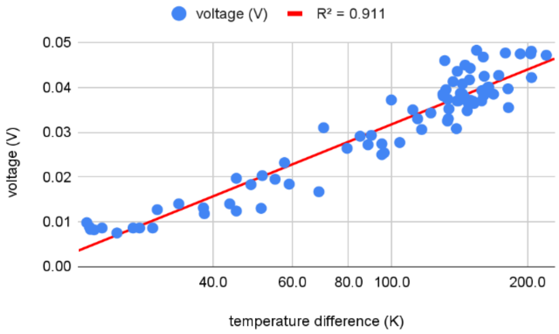
3.Result

(i)experiment1

The graph1 has a linear axis of temperature difference on the horizontal axis and a linear axis of voltage on the vertical axis.The graph2 has the logarithmic axis of temperature difference on the horizontal axis and the linear axis of voltage on the vertical axis.



graph1

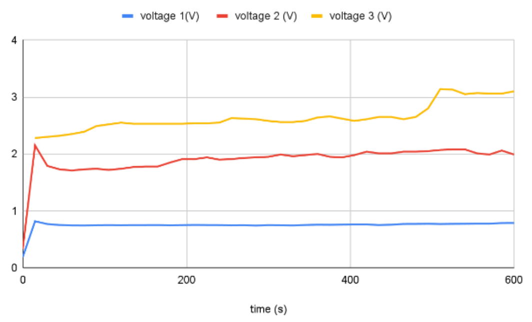


graph2

(ii)experiment2

This graph3 shows the change of voltage between each number of generators.

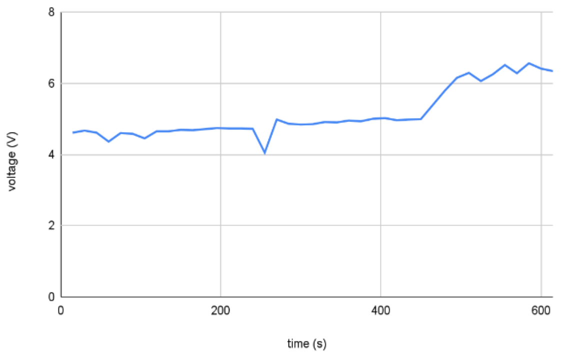
We can see that the more number of generators, the more the value of voltage we can measure.



graph3

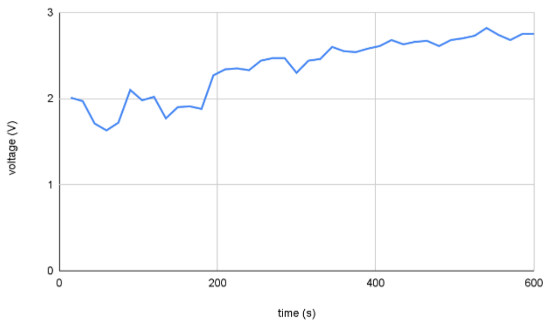
(iii).experiment3

This graph 4 shows the relationship between voltage and time right after starting heating generators.
We recorded approximately 2 to 3 V.



graph4

This graph 5 shows the relationship between voltage and time 30 minutes after starting heating generators.
We recorded approximately 4 to 6V.



graph5

4.Discussion

(i)experiment1

From the experimental results, we found that the voltage change as the temperature difference changes is curvilinear, and the voltage is not directly proportional to the temperature difference. This is consistent with the theoretical formula of the Seebeck effect.
First we explain about Seebeck coefficient α.It is

・Voltage per temperature difference.
・There is temperature dependence.
・Represented by the following formula

We thought the following happened in the experiment. As the temperature at each end changed, the Seebeck coefficient changed in a complicated manner, and the voltage generated by the same temperature difference varied.

Also, using the least squares method (*Note 1), we were able to approximate the straight line $V=0.040 \log_{10}\Delta T -0.049$ ..

(ii)experiment2

・The more elements there are, the more severe the voltage fluctuations will be.

This is thought to be because the larger the number of elements, the more a small voltage change caused by a small temperature change is amplified.

(iii).experiment3

We recorded a larger voltage 30 minutes after starting heating generators than right after starting heating generators.
When we heat generators for a long time, heat circulates inside them thoroughly. As a result, generators have larger electrical resistance, and because electrical resistance is proportional to voltage, we record larger voltage.

5.Conclusion

The stability of voltage can be improved by considering
① temperature change
②the number of Peltier elements
③the length of time we heat generators

In our experiments, we could not create an electric current, a flow of electricity, and we need an electric current for thermoelectric generation in the real situation of natural disaster. Therefore, we are going to consider the way to connect each generator in order to cause both electric current and voltage.

6.Reference

1) Shin Nishiyama and Takeo Hattori,"*The wonder of materials*"
http://www.bekkoame.ne.jp/~shin/zai/zaifusi.htm 15th Febrary 2023
2) Semiconductor Engineering of Nagoya University
http://www.echo.nuee.nagoya-u.ac.jp/~amano/H29/SEMI/LN-13.pdf 15th Febrary 2023
3) Lec control Inc. "Is the generation by "the Seebeck effect" possible? Trial manufacture and inspection of the electrical generator."
https://www.lec21.com/report-seebeck-effect/ 25th May 2022
4) Akihiro Inoe "physics of condensed matter 1 lecture note"
https://home.hiroshima-u.ac.jp/ino/lecture/SSP1note11_ino2017.pdf 1st March 2023
[Translated from Japanese.]