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Smart Thermoelectric Earth-Air Generator Safety System

Raşit Ahıska, and Özge Bakar
Department of Physics, Faculty of Science, Gazi University, Turkey

Abstract: In this study, the soil-air generator of the thermoelectric safety system working with soil heat was investigated. For this, a special electronic safety device was made and the output parameters of the device were investigated. In order to investigate the operation of the thermoelectric "earth-air" generator safety system in real nature conditions, temperatures at the soil depth and soil surface equal to the length of the generator in four different regions of Ankara in four seasons were measured and modeled. Afterwards, physical parameters such as power P(W), voltage U(V) and current I(A) produced by the generator according to ΔT were examined by using all this scientific information with a special test setup. According to the results obtained, it has been determined that the Intelligent thermoelectric earth-air generator safety system (ATES) has the feature of notifying the security units in case of area violation by generating its own electricity with the help of the heat in the soil without the need for any electrical cable. In addition, the environmentally friendly ATES system is an innovative product and it has been seen that it will be used in various fields, especially in military applications.

Keywords: Thermoelectricity, generator, earth-air, security system, ATES.

1. Introduction

Nowadays, the need for alternative energy sources is constantly rising, and it gained prominence to evaluate these sources in terms of energy efficiency. The usage of existing electronic safety devices postponed since there are no available autonomous clean energy sources that have at least ten years of life span, and are affordable in terms of ecological aspects. And this issue can't be solved by using cell batteries, batteries, and other similar chemical power sources. The solutions used for this area are not eco-friendly and are expensive. The Advantage of the Smart Thermoelectricity Safety System with Soil-Air Generator (ATES) that works with a renewable heat source is the performance, and the operating life of the device doesn't show an alteration based on the power. This development enables the production of the power of the source using low power and is eco-friendly and autonomous. The biggest advantage of the ATES that is going to be produced is that it can generate electricity by using the heat from the environment as soil-air, even though there is a very small temperature difference. In addition, since ATES has a smart electronic system, it can function for 20-25 years, and it is an innovative product [1].

2. Experimental Method/Theoretical Method

In this study, the parameters of a soil-air thermoelectric generator obtained from TES Ltd Company, are analyzed and searched. Especially, the parameters such as the power P(W) that the generator produces based on ΔT, the voltage U(V), and the flow I(A). By calculating the temperatures in the depth and on the surface of the soil that has the same depth length as the generator's length around Ankara's four regions during four seasons, a model that fits these parameters, was created. Based on the obtained temperature differences, generator lab tests are made. At the same time, the electronics of ATES are analyzed. According to the out parameters, custom circuits are designed and created. After assembling ATES completely, it was tested by giving electronic

Corresponding author: Özge Bakar, Student, research field: thermoelectric. E-mail: ozge9019@gmail.com.

loads. Thus, according to the data, the optimal region will be chosen and the site tests of ATES will be performed in that region. Based on the obtained real results, the areas of usage of ATES are detected.

2.1 The Structure of a TEG

The foundation of the thermoelectric generator (TEG), is based on the "Seebeck" effect. Seebeck, one of the thermoelectric energy processes, is to convert the production's heat flow to electric power directly and to be working longer without requiring maintenance [2, 3].

The use of TEM as TEG is shown in Fig. 1.

A thermoelectric module's (TEM) foundation, includes thermoelements consisting of type n– and p– semiconductors, series in terms of electricity, and parallel in terms of themic. Termoelements are packed between two ceramic plates, as series in terms of electricity, and parallel in terms of themic. This package whose basic structure is shown in Figure 1 is called TEM. Ceramics used in the package of TEM became the standard procedure in the industry [5]. By providing the best balance between mechanical stress, electrical resistance, and thermal conductivity [4-6].

The advantages of obtaining electric power off of Thermoelectric Modules (TEM) are;

- The absence of the moving parts,
- Their simplicity in their structure,
- They don't require maintenance,
- They are long-lasting (more than 100,000 hours),

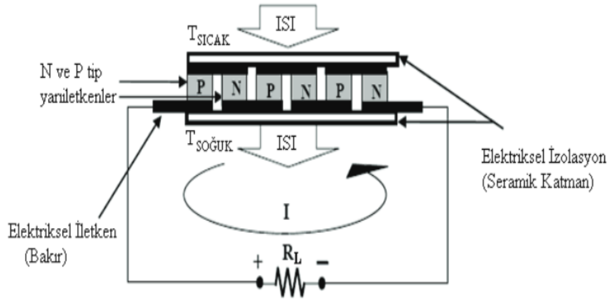

Fig. 1 The use of thermoelectric module as thermoelectric generator).

- They allow temperature control (±0.1°C),
- They obtain electrical energy directly,
- They work quietly,
- They are reliable,
- They work stable,

Besides these advantages, the biggest disadvantage is their low yield (5-10%) [4].

2.2 Usage Areas of TEGs

In the usage of renewable Energy sources, thermoelectric generators (TEJ) have a significant role. TEGs can be used in rural areas and space studies through advantages such as weight and reliability. For example, Voyagers' thermoelectric generators which are made of silicon-germanium energize that space vehicle, since 1980 [7, 8]. The usage areas of TEGs are quite wide and a few examples are shown in the Figs. 2-4.

2.3 Thermoelectric Safety System

Intelligent Thermoelectric Soil-Air Generator Safety System (ATES) equipment, which will be hidden under the ground around the borders and housing estates. Without requiring an electricity cable, it generates its electricity with the heat from the soil and alarms the security forces in case of incursion and other issues happen. Thus, it is not affected by unsolicited status' such as power cuts and keeps functioning.

Fig. 2 TEGs provide energy sources for wristwatches by utilizing the temperature difference between body temperature and environment temperature.

Fig. 3 Supplying the electrical energy requirement of a soldier with TEGs, therefore reducing the weight he carries.

Fig. 4 The image of the first Smart Thermoelectric Waste-Heat Plant.

2.4 Example Practice

The aim of this study is to analyze a soil-air thermoelectric generator, create electronic circuits and research its features. By collecting data from the area, the studies in the laboratory are simulated. During the four seasons, differences in soil temperatures were measured at 25 cm, and 50 cm depths in and on the surface of the soil in six different places of Ankara.

The maximum amount of difference in terms of temperature based on the data obtained in four seasons was noted. Another example of this data is shown in Figs. 7 and 8.

Fig. 5 This image of the thermometer taken from 25 cm soil depth on 29.05.2021.

Fig. 6 This image of the thermometer was taken from 50 cm soil depth on 29.05.2021.

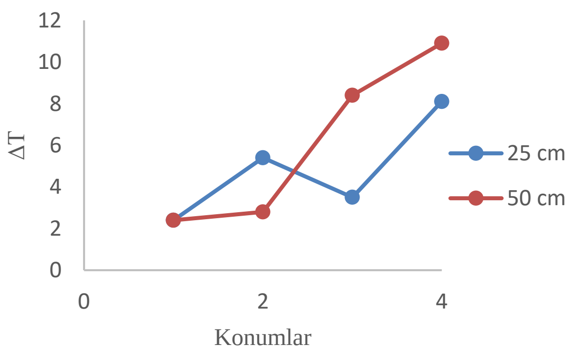

Fig. 7 Maximum temperature differences are based on the locations of the data obtained in winter.

In Fig. 7, Number 1 location is Bağlum, number 2 location is Keçiören, number 3 location is Kızılcahamam, number 4 location is Beşevler, and number 5 location is Yenimahalle. Based on the locations, the highest ΔT value is shown at 25 cm and

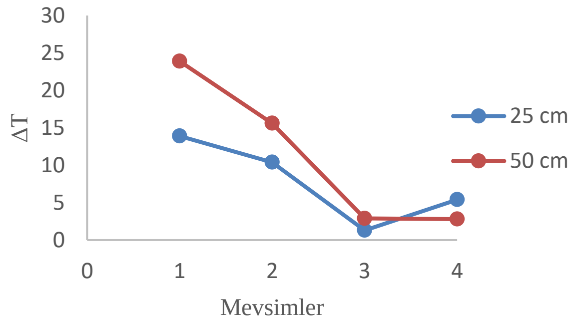

Fig. 8 Based on the location.

50 cm soil depths. The highest temperature difference was calculated in Yenimahalle, and it was 11°C.

The highest ΔT value was noted at 25 cm and 50 cm soil depths according to the seasons in the Bağlum location. Number 1 represents Spring, number 2 represents Summer, number 3 represents Autumn and number 4 represents Winter. In Spring, the highest temperature was reached.

Experiment

This study aims to create and research the circuits of The Smart Thermoelectricity Safety System with Soil-Air Generator (ATES). The order of the work is: basic scientific research and designing, creation, and application of the security system. By collecting data from the area, the studies in the laboratory are simulated. During the four seasons, differences in soil temperatures were noted at 25 cm, and 50 cm depths in and on the surface of the soil in five different places of Ankara.

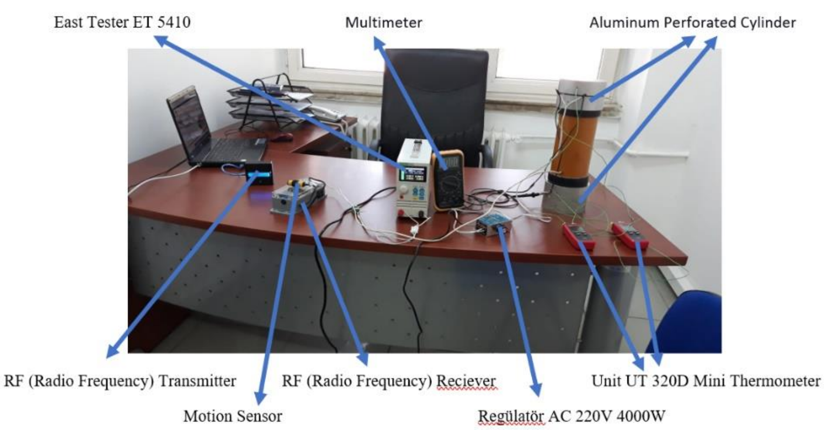

Fig. 9 TEJ test setup.

3. Results and Discussions

The temperature difference — power relationship at different resistors is shown in Table 1, and the temperature difference — voltage relation at different resistors is shown in Table 2.

Table 1 ΔT temperature difference and power relationship at different resistors.

R = 1 Ohm		R = 2 Ohm		R = 2.5 Ohm		R = 3 Ohm	
ΔT, °C	P, W	ΔT, °C	P, W	ΔT, °C	P, W	ΔT, °C	P, W
12.9	0.08	12.9	0.16	13.4	0.19	13.5	0.21
12.1	0.11	13	0.17	12.6	0.19	14.3	0.24
12.3	0.11	13.9	0.19	14	0.21	15.1	0.25
12.7	0.11	15.2	0.21	13.7	0.21	15.7	0.27
14.5	0.13	14.5	0.2	14.5	0.22	16.1	0.28

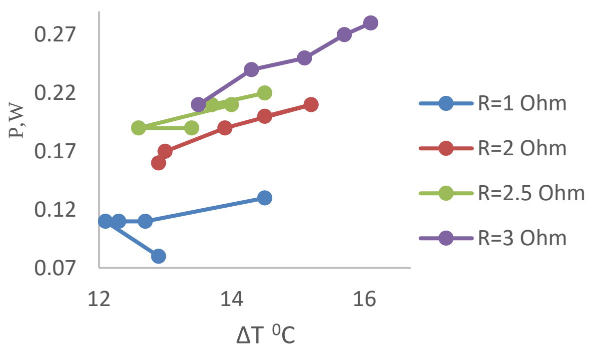

Fig. 10 Temperature difference-power relationship in the system.

Table 2 ΔT Temperature differences and Voltage relations in different resistances.

R = 1 Ohm		R = 2 Ohm		R = 2.5 Ohm	
ΔT °C	U, V	ΔT °C	U, V	ΔT °C	U, V
12.2	0.08	12.9	0.16	12.6	0.19
12.3	0.11	13	0.17	14	0.21
12.7	0.11	13.9	0.19	13.7	0.21
12.7	0.1	15.2	0.21	14.5	0.22
14.5	0.13	14.5	0.2	15.3	0.23

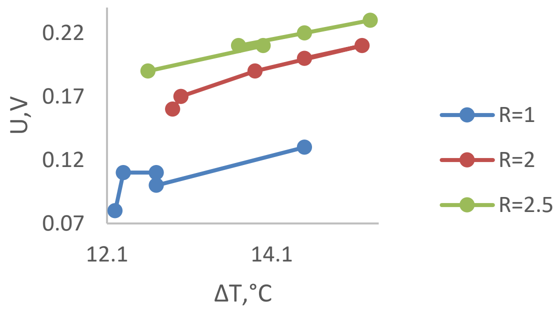

Fig. 11 Temperature differences-voltage relation in the system.

4. Conclusions

In this study, The Smart Thermoelectricity Safety System with Soil-Air Generator. That is powered by a renewable Energy source, the soil temperature is designed, produced, and analyzed. The temperature of the soil in the same depth length as the generator's length and the temperature of its surface around Ankara's four regions during four seasons was calculated and modeling was made based on these data. Also, for the four seasons, four different regions of Ankara were analyzed in terms of soil-air temperature differences, thoroughly. According to these results, the highest temperature difference was calculated in Bağlum, as ΔT = 23.9°C, during Spring. With the obtained information, the real results of the temperature differences were modeled. To achieve this goal, a special test setup was created, the thermoelectric features of the "soil-air" generator were analyzed in the laboratory environment and the working conditions of the electronic security system were determined. Based on the obtained results, the fact that thermoelectric safety system's production and usage is opportune.

Acknowledgments

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