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Comparative Reliability Of Types Of Thermoelectric Generators Based On Three Circuit Variations

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Keywords

Comparative Analysis, Thermoelectric Generator, Three Circuit Variations

Abstract. In this final project, the characteristics of the thermoelectric generator Type SP1848 27145 SA have been tested using three variations of the circuit, where in the test the three types of circuit use the same cooling and heating sources, the heat source uses the hot fire of a spirit stove and in the cold part uses a tank filled with running water without heatsing. The highest voltage output results were recorded in testing using a series circuit. The voltage recorded in the series circuit test was 19.91 volts, only taking 47.17 seconds.□T 44°C but when testing with a load the highest result was recorded in a test using a parallel series circuit, a result of 9.74 watts was recorded at□T 44°C and the highest current obtained in the parallel series circuit test recorded a final result of 0.76 amperes.

1. INTRODUCTION

The development of renewable and environmentally friendly alternative energy needs to be carried out in order to meet energy needs and sustain life, therefore a tool is needed that can capture temperature differences into electrical energy for generating thermoelectric generators. The need for electrical energy cannot be separated from the needs of living things in carrying out daily activities. This has the impact that along with very rapid growth in the field of technology, energy needs will also increase, however, not all energy sources currently used can be renewed so that as time goes by, these fossil fuel sources will run out. For example, non-renewable energy is conventional energy. Conventional Energy is energy that is available in limited quantities. One example of conventional energy that is most widely used is fossil energy. (Muhammad Ady Pradana, 2020).

Now the availability of energy in Indonesia is decreasing. This is caused by a reduction in energy sources, due to an imbalance between demand and the amount of energy available. In today's technological developments, various alternative and new renewable energies have been launched to reduce the impact of global warming. However, the availability of new renewable energy sources in Indonesia is still not fully utilized maximum. This research was carried out based on the use of new renewable energy sources, especially geothermal energy to produce electrical energy, namely using a thermoelectric generator (TEG) as an alternative energy source. Thermoelectric generators can convert temperature differences into electrical quantities directly, but TEG still has several shortcomings, namely having a low efficiency value of 10%. Things that reduce efficiency are that the heat convected in the TEG is not absorbed completely and the cooling system is not perfect so that the TEG cannot work optimally. This is what underlies this research, namely designing a heat insulation system to maximize the work of the TEG module. Apart from that, the resulting electrical power is utilized to charge batteries as an alternative energy producer. (Shanti Candra Puspita et al, 2017).

Thermoelectric generators have long been used to produce electrical energy, where when a temperature difference occurs between two different semiconductor materials, this thermoelectric module will flow current to produce a voltage. In general, the use and working principles of thermoelectric generator modules are almost the same as solar panels considering that the capacity of electrical power that can be produced is not too large, limited to recharging batteries, but the advantage of thermoelectric generators is that they can be used at any time considering that the availability of heating sources is unlimited, therefore this research carried out to find out more about the potential of the SP1848 27145 SA type thermo electric generator when connected in series, parallel and parallel series, which later from the three testing processes will be It is known how much voltage, current and electrical power can be generated in each circuit test

Based on the problem formulation described above, the researcher provides problem boundaries so that the problem does not spread and remains focused on the problem being studied. The problem boundaries used as a reference in working on this final assignment are:

1. The thermoelectric generators used are 10 SP1848 27145 SA series
2. This research focuses on voltage, power and electric current
   able to generate a thermoelectric generator.
3. Testing for each circuit was carried out for 3 minutes until it reached a voltage of 12 volts or a maximum temperature of 80°C.
4. The types of circuits used are series, parallel, and parallel series.
5. Variations in research using loads and without loads.

Literature Review

Related research

In this final research assignment, a literature study will be carried out to search for references that are relevant to the case or problem to be solved. The sources used include books, articles and related journals. Research related to Thermoelectric Generators has been carried out by several universities and research institutions in Indonesia and abroad.

According to (Sumarjo, 2017) with the research title "Utilization of heat sources in stoves using 10 thermoelectric generators connected in series for lighting applications". Thermoelectric Generator is an alternative energy that uses a temperature difference system to produce electrical energy. In this thermoelectric generator system, a stove is used as a medium for utilizing the required heat. The thermoelectric system that we are studying uses 10 TEG-SP1848-27145 SA thermoelectrics arranged in series with a variety of combustion media in the form of firewood, LPG gas and spitrus. The use of different combustion media affects the voltage output provided by the thermoelectric. The temperature difference between the cold side and the hot side of the thermoelectric generator (ΔT) when it is stable is 35°C using wood fuel, 39°C using LPG gas fuel and 20°C using methylated spirits fuel. Optimum voltage provided uses LPG gas fuel with (ΔT) 39°C with an output of 1.62 Volts (Sumarjo, J., et al, 2017).

According to (Adriyani Rusli, 2019), with the research title "Conversion of Heat Energy into Electrical Energy Using a Thermoelectric Generator". In this final project, a conversion of Heat Energy into Electrical Energy was carried out using a Thermoelectric Generator. The goal to be achieved is to find out how a thermoelectic generator converts heat energy into electrical energy. The methods used include literature study, collection of tools and materials, design, and data collection. From the design results, it can be concluded that the fire heat absorbed by the Heansink is then channeled to the Thermoelectric Generator from 01:00 to 01:10, with an average voltage of 1.46 V to 6.15 V, a current of 0.04 A to 0.15 A. , and power from 0.0584 W to 0.9225 W. From the results of experimental observations carried out, the difference between the input and output currents is quite different from the input voltage, namely 2.32 V, while the output is 12.15 V, 13.55 V, 14.76 V, 15.43 V, 16.23 V, 17.55 V, 18.87 V, 19.43 V, 20.32 V, 21.54 V, 22.84 V, 23.66 V, 24.54 V, 25.32 V up to 26.67 V. After we get a voltage of 26.67 V we can adjust the voltage that will turn on each each burden (Rusli, A., et al, 2019).

History of Thermoelectric Generators

Thermoelectricity is a means of convection of energy from temperature gradient differences to potential energy. The thermoelectric phenomenon was first discovered in 1821 by the German scientist, Thomas Johan Seeback. It connects copper and iron in a circuit. Between the two metals, a compass needle is placed. When the metal side is heated, the compass needle moves. This happens because the electric current that occurs in the metal creates a magnetic field. This magnetic field moves the compass needle. This phenomenon became known as the Seebeck effect. In 1834, Jean Charles Peltier, a French national, Seebeck's discovery provided inspiration to see the opposite of this phenomenon. He applied electricity to two pieces of metal glued together in a circuit. When an electric current is applied, heat is absorbed at the connection between the two metals and heat is released at the other connection. This heat release and absorption reverse each other once the current direction is reversed. This discovery occurred in 1934 and became known as the Peltier effect.

The Seebeck and Peltier effects later became the basis for the development of thermoelectric technology. (Muhammad Wiranda, 2021).

Figure 1. Thermoelectric Generator Module

Thermoelectric is a device that can directly convert heat energy into electrical energy. In principle, this technology is a technology that utilizes a thermoelectric semiconductor material that can convert thermal energy into electrical energy. Thermoelectricity itself generally uses materials that are semiconductors or in other words use solid-state technology. The structure of thermoelectrics is a thermoelectric structure which consists of an arrangement of P-type elements, namely material that lacks electrons, and also consists of an arrangement of N-type elements, namely material that has excess electrons. Heat enters on one side and is removed from the other side. This heat transfer produces a voltage across the thermoelectric junction and the magnitude of the resulting electrical voltage is proportional to the temperature gradient. It can be concluded that if a metal rod is heated and cooled at 2 metal poles, the electrons on the hot side of the metal will kmoves actively and has a higher flow velocity compared to the cold side of the metal.

With a higher speed, electrons from the hot side will diffuse to the cold side and cause an electric field to arise in the metal or material. A thermoelectric element consisting of P-type and N-type semiconductors. Next, the heat in the channel enters a thermoelectric module (TEG) whose material has been determined. The hot air flow from the condenser will affect the temperature of the conductor material by convection. After that, the thermoelectric generator receives heat by conduction from the designed conductor. Before that, the cold side of the thermoelectric has a heatsink installed to keep the temperature cool. Then the electrical voltage output on the thermoelectric is measured with a multimeter (D Aditya, 2019).

Thermoelectric Generator

Thermoelectric Generator is an electricity generation technology that uses thermal energy or heat. This tool uses a component called "Peltier". In general, Peltier is a ceramic that can produce hot and cold energy if a voltage is applied to it. The way this generator works is if there is a temperature difference of more than 30 °C between the two sides of the peltier, the peltier will produce electricity (Adriyani Rusli, 2019).

Thermoelectric components work by converting heat energy into electricity directly (thermoelectric generator), or with the reverse function, namely generating cold from electricity (thermoelectric cooler). To obtain electricity, thermoelectric components simply need to be placed in a circuit that connects the heat and cold sources. The prototype designed to produce a certain amount of electricity according to the type and amount of material used. The work of thermoelectric coolers is not much different. If a thermoelectric component is electrified, the heat around it will be absorbed. Thus, to cool the air, there is no need to use a cooling compressor like conventional cooling machines. For electricity generation purposes, generally the materials used are semiconductor materials. Semiconductors are materials that are able to conduct electric current but are not perfect. The semiconductors used are n-type and p-type. The semiconductor material used is an extrinsic semiconductor material. The problem for thermoelectrics is to obtain materials that are able to work at high temperatures (Muhammad Ady Pradana, 2020).

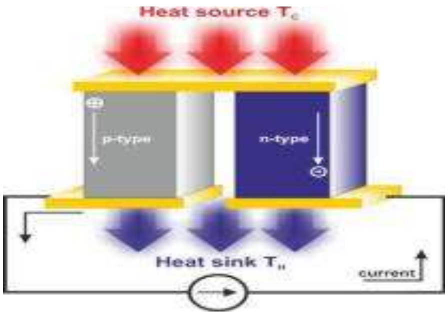

Figure 2. Semiconductor Arrangement in Thermoelectrics

The temperature difference in the two components Bismuth and Telluride causes the transfer of electrons from the negative pole to the positive pole, the greater the difference temperature, the faster the electrons move, so the resulting current will be greater (Sandy Anggriawan Sasmita, et al, 2019).

How a Thermoelectric Generator Works

Thermoelectric technology works by converting heat energy into electrical energy directly (thermoelectric generator), or vice versa, from electricity producing cold (thermoelectric cooler). To produce electricity, thermoelectric materials are simply placed in a circuit that connects hot and cold sources. From this circuit, a certain amount of electricity will be generated according to the type of material used. The work of thermoelectric coolers is not much different. If a thermoelectric material is electrified, the surrounding heat will be absorbed. Thus, to cool the air, a cooling compressor is not needed as is the case in conventional cooling machines (Muhammad Ady Pradana, 2020)

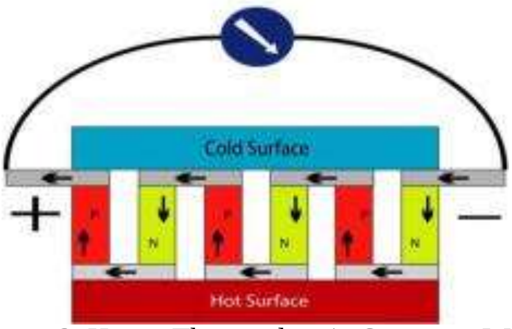

Figure 3. How a Thermoelectric Generator Works

The TEG structure can be seen in Figure 1. This shows the TEG structure which consists of an arrangement of N-type elements (electron-deficient material) and P-type (electron-excess material). Heat enters on one side of the TEG and heat is removed through the other side. The heat transfer process produces a voltage that passes through the TEG structure connections and the magnitude of the resulting voltage is proportional to the temperature difference (Sandy Anggriawan Sasmita, 2019).

2. METHODS

The research method is a scientific way to obtain data with this aim and use. The research method used is the design method. Design is a stage of activity to define or describe the analysis results of a system into technical language in order to get a clear and detailed picture of a component being implemented (Sugiyono, 2017).

The research method used in this research is the experimental method, with this method the author continues to develop various research that has been carried out, both achieving results and those that have not been successful, so that from the development carried out, results can be obtained in accordance with the objectives to be achieved and of course it can still be achieved. carried out for improvement in subsequent experiments.

The process of working on research tools is divided into three stages, the initial stage is determining the materials, then determining the tools needed to help with the process of making the

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tools and the final stage is the assembly and testing process. Testing of thermoelectric generators is carried out in three stages, namely using series, parallel and parallel series circuits.

3. RESULTS AND ANALYSIS

Testing the characteristics of the thermoelectric generator is divided into two stages, the initial stage is carried out without load testing, while the second stage of testing is carried out by adding a 5-12 Volt DC lamp load. The data on the results of tests carried out on the tools or systems created are as follows:

No-Load Testing

The results of the circuit testing produced research data as follows:

Table 1. Test Data for Series Circuit Thermoelectric Generators

NO	Th	Tc	□Q	Voltage	Minute
1	32°C	24°C	8°C	5.8	0.13
2	28°C	22°C	16°C	8.87	0.16
3	46°C	22°C	24°C	10.58	0.46
4	57°C	22°C	35°C	12.04	0.52
5	63°C	19°C	44°C	19,19	0.78

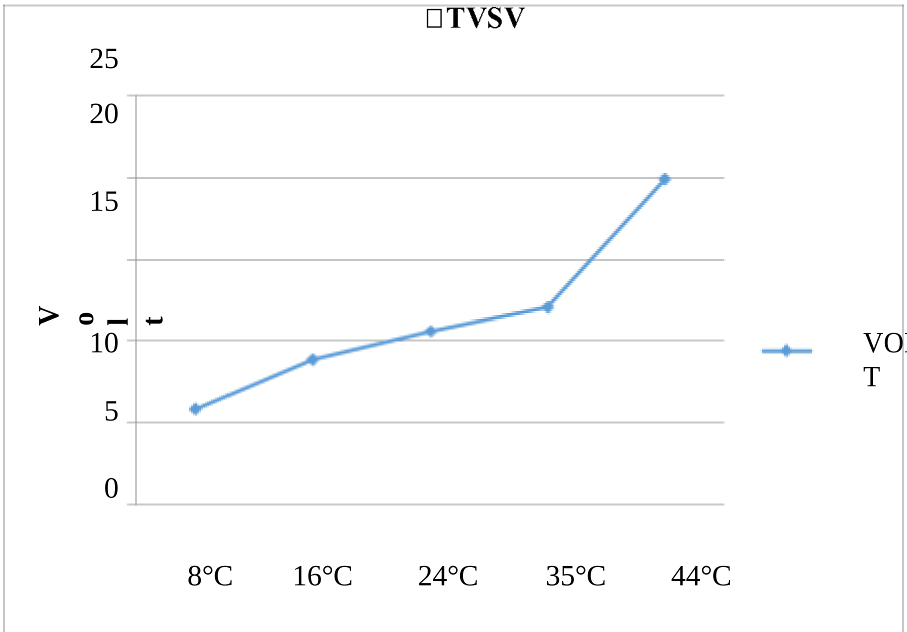

Figure 4 Graph□T and Series Circuit Voltage

Parallel Circuit Thermoelectric Generator Test Results

Table 2. Parallel Circuit Thermoelectric Generator Test Data

NO	Th	Tc	□Q	Voltage	Minute
1	60°C	25°C	35°C	1.53	1.00
2	66°C	25°C	41°C	1.82	1.30
3	68°C	25°C	43°C	2.57	2.00
4	70°C	25°C	45°C	3.11	2.30
5	72°C	25°C	47°C	3.45	2.53

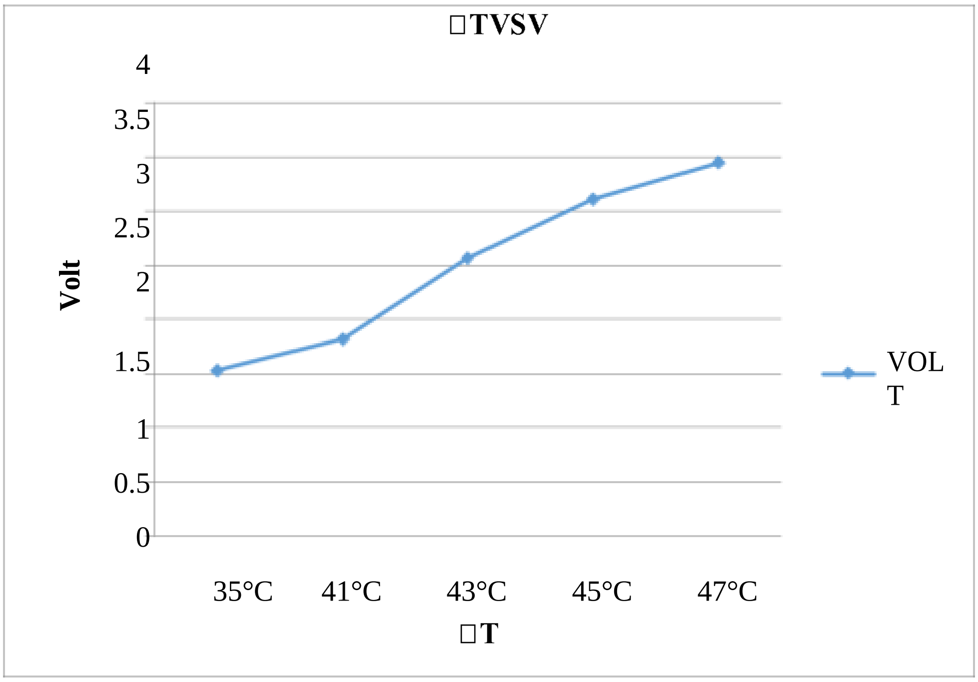

Figure 5. Graph□T and Voltage in Parallel Circuits

Test Results for Series Parallel Circuit Thermoelectric Generators

Table 3. Series Circuit Thermoelectric Generator Test Data Parallel

NO	Th	Tc	□Q	Voltage	Minute
1	53°C	26°C	27°C	8.75	1.00
2	62°C	26°C	36°C	10.65	1.30
3	66°C	26°C	40°C	11.73	2.00
4	68°C	26°C	42°C	11.96	2.30
5	70°C	26°C	44°C	12.82	3.00

Analysis: The results of testing data for thermoelectric generators in series without using a load can be seen in table 4.1. During initial testing precisely at 0.13 minutes with Th 32°C, Tc 24°C, and□T 8°C The output voltage that can be produced by a small thermoelectric generator is quite large at 5.8 volts, this value continues to increase and peaks at 0.78 minutes. with Th 63°C, Tc 19°C and□T 44°C the output voltage that can be produced has reached 19.19 volts.

Testing using a parallel circuit, the voltage increase is relatively slow, as can be seen in table 4.2, even after testing for 3 minutes, the voltage that can be generated by the circuit parallel is only 3.4 volts with Th 72°C, Tc 25°C and□T 47°C, it can occurs due to the nature of the type of parallel circuit itself where the positive and negative output of each thermoelectric generator are connected into one, in other words 10 thermoelectric generators are equivalent to 1 generator.

Testing using a mixed series-parallel circuit does not increase the voltage too quickly, but the voltage generated is quite stable, as can be seen in table 4.3. During the 1.00 minute test the voltage was produced recorded 8.75 volts with□T 36°C then rose to 10.65 volts at minute 1.30 and continued to rise to 11.73 volts at minute 2.00, 11.96 minutes to 2.30 and the highest voltage was 12.82 volts at minute three with Th 70°C, Tc 26° C And□T 44°C.

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4. CONCLUSION

Based on the results of testing and data processing carried out in comparative analysis research on SP1848 27145 SA type thermoelectric generators using three circuit variations, the following conclusions can be drawn: In the no-load test using a series circuit the voltage increase occurred quite quickly, for the thermoelectric generator it reached 12volt voltage in less than 1 minute, more precisely in 31.7 seconds with□T 35°C the highest voltage was achieved at 19.91 volts with a record time of 47.17 seconds and with□T 44°C. This can happen because each series series thermoelectric generator which is arranged sequentially will produce a greater output voltage, in accordance with the formula that applies to series circuits, namely Rs = R1 + R2 + R3. Meanwhile, during the test with the highest current and power load, the test using a parallel series circuit resulted in the highest power result being 9.74 watts and a current of 0.76 Ampere. From the results of experiments and testing of three types of circuits without load, the highest value was obtained in the series circuit test, while the test with the highest current and power load was obtained in the parallel series circuit test. It can be concluded that the highest voltage is obtained at series circuits and the current produced from parallel series circuits is much better than other circuits. The bigger the difference□T to the voltage then the value of V/°C will be. The largest average value of power factor is using a parallel series circuit variation of 0.18watt/°C. The largest average value of current factor is when using a parallel series circuit variation of 0.016ampere/°C.

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