Design of Home Power Plant Using Waste Heat Energy

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Abstract. Research on power generation using waste heat is a conversion process that utilizes thermoelectric generator elements, which can be generated from the heat produced by burning waste. This research aims to study and develop a system based on the capabilities of TEG components that can be designed to convert heat from fires into electricity. Based on the properties and advantages of the fuel components, the method used in this research is a system for converting heat energy into electrical energy where the heat from the fire will be used to recharging. The input to the system is the heat generated from burning organic waste. The input component in this simulation uses a converter, namely a Peltier, is functions to directly convert heat energy into electricity. The research results are an output that utilizes the LM317 IC as a regulator in the heat conversion system, converting voltage for the battery charger's output to ensure optimal function.

Keywords: Heat Electrical Energy, LM317 IC, Thermoelectric, Thermoelectric Generator (TEG)

1 Introduction

The use of electrical energy in Indonesia is increasing very rapidly in line with economic growth and population growth. Meanwhile, access to reliable and affordable electrical energy is a primary prerequisite for improving people's living standards. its availability is limited if used continuously and will run out over time. The increasing demand for electricity has resulted in an imbalance between demand and supply, so renewable sources of electrical energy will be needed (renewable energy). As a result, the reserves of electrical energy sources are increasingly depleted, especially those of fuel oil, which is a non-renewable fossil fuel. This requires Indonesia to find alternative fuels that are renewable (Sasmita et al., 2019). So the author designed a thermoelectric generator (TEG) simulation that is able to convert temperature differences directly into electrical quantities that can be used to charge batteries as electrical energy (Chaturvedi & Mamtani, 2020). Thermoelectric devices can be used to generate direct current (DC) electrical energy when there is a temperature difference. Thermoelectric modules are divided into two types, namely Thermoelectric as a cooler and as a generator (Liu et al., 2014).

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1.1 Thermoelectric

The material in the thermoelectric component is a material that can convert heat energy into electrical energy, or if given an electric voltage, there will be a temperature difference (Jin & Yang, 2018; Randriantsoa et al., 2024; Zoui et al., 2020). The impact or risk of small Thermoelectric devices does not produce toxic carbon dioxide gas or other pollution, such as heavy metal elements (Kim, 2018). Two concepts underlie how Peltier works. The Seebeck effect is the effect of two connected metal materials in an environment with two different temperatures, then an electric current or electromotive force will flow in the material (Nesarajah & Frey, 2016). While the thermoelectric effect is the opposite of the Seebeck effect, if two metals are glued together and then electricity is passed through, there is a temperature difference between the two sides of the metal (Ohnuma et al., 2017; Tang et al., 2020). The reversible heat of the electrode reaction, known as electrochemical peltier heat (EPH), is also a very important quantity in thermoelectrochemistry, often used for research on reversible thermodynamics and kinetics. The change in the total energy of an electron is opposite to the change in its electrostatic energy. If charged particles move freely in an electric field, energy is released. The opposite sign means that energy is absorbed at the hot junction of the thermocouple (Remeli et al., 2016). The hot junction is cooled, and the cold one is heated.

Peltier can generate electrical energy if there is a temperature difference on the side of the peltier body. The peltier effect is a thermoelectric phenomenon that utilizes the Seebeck effect. This peltier has two plates, one cold and one hot. Between the plates are several thermocouples, which are semiconductors made of Bismuth Telluride with 2 different types, one type N and one type P (Shi et al., 2020).

2 Methodology

In this study, through the design of an energy conversion tool from fire heat to electrical energy by regulating the voltage of the conversion results so that it can be used as a tool to convert fire heat from household waste into electric current (DC) with a maximum voltage of 9 V for battery chargers.

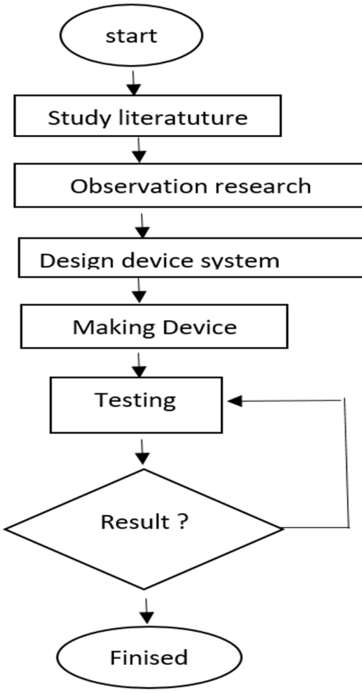

Figure 1. Research Flowchart

The research process starts from a literature study (searching for existing literature reviews that can be used as a basis for carrying out observations), making tools (starting from design, purchasing materials, and assembly), feasibility testing (initial testing of tools that can be used), field testing, and testing that aims to obtain real results.

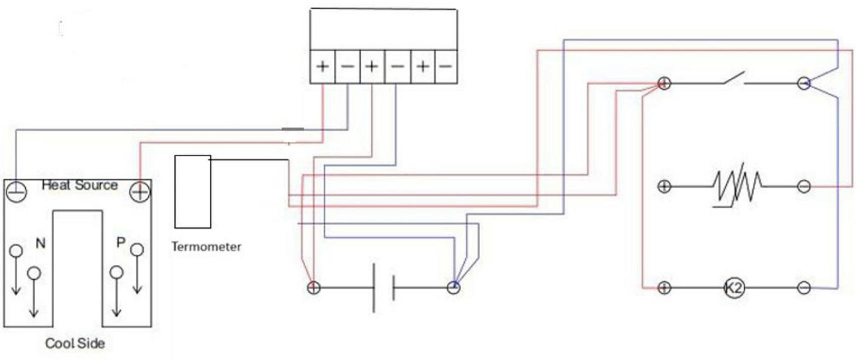

Figure 2. Block Diagram Design

The system input is the heat of the fire given to the peltier element. Peltier will convert heat into DC electricity. From several peltier element inputs, electricity is collected and regulated as part of a stabilization process. At the process stage, there is a change in heat energy that can produce electrical energy in the thermoelectric element. The voltage output after regulation is stored in the battery, and then it enters the inverter input, where the DC is converted to AC. The image above shows the design of the power circuit for the heat energy conversion system of fire into electrical energy.

Figure 3. Product Design

Designing the tool involves several steps of work carried out from the beginning to the end of the tool's testing, resulting in a series of tools that can function properly and according to the desired job description. determining the number of peltiers, selecting materials for the combustion furnace, and selecting fuel. After that, prepare the necessary tools and materials, such as a thermogun to measure temperature and a digital multimeter to measure voltage.

3 Result and Discussion

3.1 Result

The tests that will be carried out later include the output of the TEC1-12706 peltier with the LM317 IC as a regulator of the furnace temperature, fuel usage scale, and battery charging time.

Table 1. System with 1 Peltier

Burning condition	Time (Minute)	Generator plate temperature (°C)	Charger condition	Output TEG (V)
On	15	30	Off	0
On	20	35	On	0.30
On	25	45	On	0.40
On	30	45	On	0.53
On	35	50	On	0.65
On	40	50	On	0.67
On	45	55	On	0.80
On	50	60	On	0.86
On	55	65	On	0.92
On	60	70	On	1.1
On	65	75	On	1.4
On	70	85	On	1.6

From Table 1 above, it can be seen that the fire condition in the furnace is on for 15 minutes, and the temperature is 30°C. Then, when the peltier output is 0, increasing the temperature to 350 °C, the Peltier output increases to 0.35. The charger condition starts to charge the battery.

Table 2. System with 6 Peltier

Burning condition	Time (Minute)	Generator plate temperature (°C)	Charger condition	Output TEG (V)
On	15	30	Off	0
On	20	35	On	1.8
On	25	45	On	2.4
On	30	45	On	3.18
On	35	50	On	3.9
On	40	50	On	4.02
On	45	55	On	4.8
On	50	60	On	5.16
On	55	65	On	5.52
On	60	70	On	6.6
On	65	75	On	8.4
On	70	85	On	9.6

Table 2 shows that the test results of 6 peltiers connected in series indicate a continuous increase in voltage, which can be used to charge batteries optimally.

3.2 Discussion

Overall testing is done after all system components have been assembled. Peltier elements are connected in series and put together. In this test, a heat source is used from the combustion furnace. This process continues as long as the combustion flame remains lit or remains hot. After the flame goes out, a few moments later, the generator voltage begins to drop. In series, the device has functioned properly.

The use of fuel is very important because it affects the length of time the combustion takes to reach the desired temperature. For the fuel itself in this test, we used organic waste. I obtained it from the campus environment, such as tree trunks and dry leaves that I found there.

Table 3. Fuel and Time

Fuel Mass (g)	Time (Minute)
840	10
840	15
840	20
840	25
840	30
386	35
386	40
386	45
390	50
390	55
390	60
390	85

As shown in Table 3, the longer the combustion the less fuel is used, in testing the tool using 840 g in a period of 10 to 30 minutes then added another 386 g at 35 to 45 minutes to maintain the furnace temperature and the addition of fuel to the furnace at minute 50, namely 390 g to minute 85 exactly at the time and temperature that has been determined

Peltier-based waste power plant. The concept of a device utilizing peltier components as an electricity generator. Peltier can generate electricity because there is a difference in heat and cold absorbed by the peltier. The hot side absorbs the heat generated by combustion in the furnace, while the cold side is generated by water circulation. After that the output from the peltier goes to the solar charger controller after the solar charger controller goes to the battery/battery output from the SCC Connected to a digital volt meter to find out the voltage produced.

4 Conclusion

The utilization of heat in the combustion furnace with a peltier as an electricity generator has been carried out, and the results have been obtained according to what is desired. The power gain for 1 peltier is 3.9 V. The electrical energy gain from the 6-series peltier circuit is 9.5 V at a temperature of 850 °C. This circuit can already turn on the system to charge the 9 V battery. The combustion heat of the furnace can be produced by burning garbage, burning charcoal, or candle fire. Several areas can be improved, such as utilizing more peltiers to increase the energy produced. Additionally, incorporating a cooler into the furnace would prevent the peltier from being quickly damaged by heat.

The testing carried out on this tool system has yielded results in accordance with expectations, namely that it can be used as a battery charger, which can later be utilized for daily needs.

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