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Study of Effect Comparison Thermoelectric Characteristics of TEC and TEG by Considering the Difference in Temperature and Variable Resistant

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Abstract— *The concept of a Peltier effect is a direct current that through the connection of two thermoelectric materials can produce a temperature difference at the end of the connection. The thermoelectric element functions as a means of converting electricity to thermal / heat which uses the concept of Peltier law, known as thermoelectric type TEC (thermoelectric cooler). The use of thermoelectric elements for electricity generation by changing thermal/heat into electricity is the concept of Seedback effect, which is applied to the TEG type thermoelectric element (Thermoelectric Generator). Both thermoelectric element types are capable of changing thermal/heat into electricity and vice versa. This study aims to analyze the thermoelectric capability of TEC and TEG types as thermal/heat converters into electricity.*

Experimental testing by heating and cooling on each side of the TEC and TEG type thermoelectric elements is carried out to obtain voltage and electric current values with variations in the load using resistors so that electric power can be calculated so that the characteristics (power) of the element are known. The term regulator is set at a difference of 70 ° C between elements.

This study resulted in the highest resistor loading value at 10 kΩ produced the highest power in the TEG type thermoelectric, with a difference of 0.00011 watts and proved TEG was more effective with the same working temperature against TEC, as a power plant (thermal-electricity). With the highest voltage and electric current, the TEG is 1.48 V and 0.00141 A

Keywords— *Characteristics, Thermoelectric, TEC, TEG.*

I. INTRODUCTION

Population growth in Indonesia is increasing rapidly every year. The greater the population growth, the greater the electricity demand in Indonesia. Nowadays the demand for electricity is not comparable to adequate electricity supply [1].

The use of fossil energy sources to generate electricity continuously will make fossil energy sources run out quickly. There needs to be an effort to utilize existing energy sources to improve energy efficiency.

One of the available energy sources is heat energy that is wasted from motorized vehicles. Fuel consumption in 100% fuel vehicles used is only about 30% used to drive vehicles, most of the energy is wasted in the form of heat that occurs in radiators and exhaust gases [2]. The use of thermoelectric generators requires heat energy as the main energy source [3]. Exhaust heat in a vehicle can be converted into electrical energy using a thermoelectric generator [4,5].

The thermoelectric generator module works based on the principle of the Seebeck effect which was first discovered in 1821 by Thomas Johann Seebeck [6]. The Seebeck effect is the effect that occurs when two different materials are connected to a closed circuit. Electric current flows in the circuit when two materials have different temperatures. Peltier effect is the opposite of the Seebeck effect. If two different materials are connected then an electric current is applied to the connection resulting in a different temperature.

This study is to determine the effect of temperature changes on TEG and TEC characteristics by testing the loading variation.

II. RESEARCH METHODS

1. *Thermoelectric Effect*

In the working principle of thermoelectric, there are 2 types of thermoelectric effects, namely the Seebeck effect and the Peltier effect. The Seebeck effect is caused by 2 different metal materials. The Peltier effect is caused by the current flowing in the circuit [5].

a. Seebeck effect

The Seebeck effect explains that there are two different ingredients which are then connected to the two ends. If there is a temperature difference between the two connections, there will be an electric current. When the connection is disconnected and then connected to a galvanometer there will be a voltage from both ends of the connection. The voltage value generated depends on the temperature difference and the Seebeck coefficient. The voltage value is stated in the equation:

$$V=S\times(Thot-Tcool) \quad (1)$$

Information :
V = Voltage, S = Seebeck coefficient, Thot = hot temperature
Tcool = cold temperature

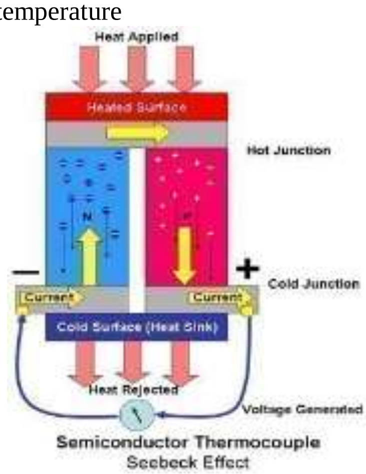

Fig. 1. Seebeck effect

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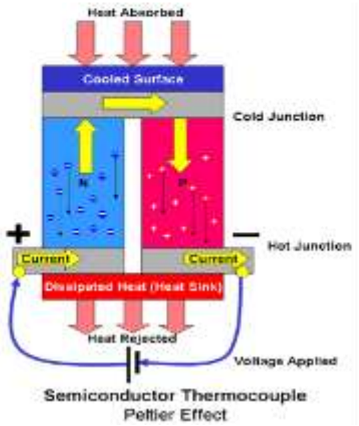
b. Peltier effect

Peltier effect is the opposite of the Seebeck effect. If two different materials are connected then an electric current is applied to the connection resulting in a temperature difference. Temperature differences at both ends of the connection cause there to be parts that absorb heat and there are parts that release heat.



Fig, 2. Peltier effect

2. *Thermoelectric Generator*

Thermoelectric Power Generating is a power plant invented by Thomas Johann Seebeck in 1821. This power plant is based on the Seebeck effect [6]. The use of thermoelectrics requires heat energy as the main energy source. The application of the use of thermoelectric generators is suitable for use in factories that have large heat discharges. Materials used in thermoelectric generators are Silicon Germanium, Lead Telluride and Bismuth Telluride Alloys.

Fig. 3. TEG module

3. *Thermoelectric TEC1-12705*

- The TEC1 12706 thermoelectric module used in this study is a thermoelectric module of the Thermoelectric Cooler type [1]. TEC1 thermoelectric module specifications 12705:
- Side size of 40 mm x 40 mm with a thickness of 3.8 mm
- The heat side temperature difference with the maximum cold side (Tmax) is 660C
- Maximum electric current flowing (Imax) of 6 Ampere
- The maximum allowable electrical voltage (Vmax) is 14.4 Volts
- Electrical Insulator ceramic material used is Aluminium (AI203)
- The maximum temperature in use is 1380 C

Fig. 4. TEC module

4. *Research Flow Chart*

The research method is carried out in stages. These stages include literature study, technical data collection, tool, and test scheme design process, thermoelectric measuring instrument assembly, data testing/retrieval characteristics of thermoelectric elements, data processing, discussion, and conclusions. This research method is explained as in Figure 5.

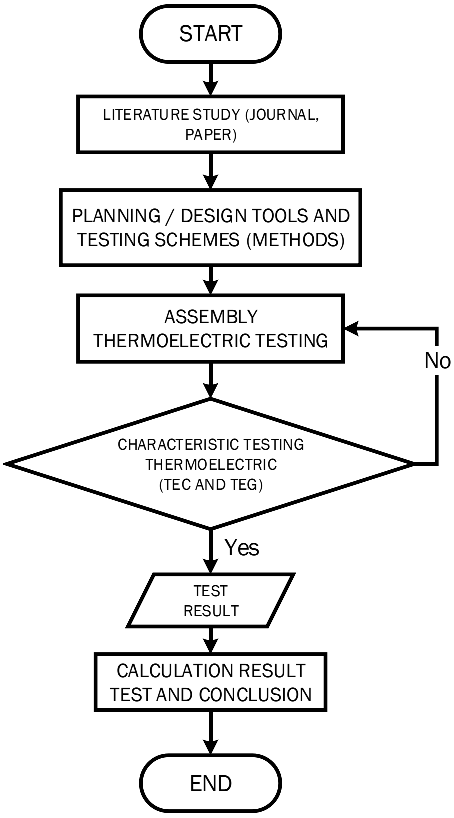


Fig. 5. Diagram alir penelitian

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III. SIMULATION AND DATA ANALYSIS

1. *Construction Design and Testing Scheme*

Heating and cooling treatments on each side were carried out to determine the research data of the thermoelectric element. The heating is carried out by heating the side of the thermoelectric element using a gas-fired heater. On the other hand, a cooling or heat dissipation process is carried out on the cold side (SD) of the element. Heat dissipation is carried out by adding/assisting cooling equipment, namely the computer processor fan, this is done so that the heat is wasted optimally.

Heating furnace/manufacturing test equipment is adjusted to the thermoelectric dimensions of the characteristics tested. The following is an illustration, shown in Figure 6. Thermoelectric characteristic (furnace) test equipment, the furnace is built with gypsum material which is relatively better for heat sealers, thus minimizing heat loss from the environment in the system (furnace to thermoelectric).

The cooler for the cold side (SD) uses a heat sink fan processor so that the heat dissipated optimally. On heaters for heat (SP) use an iron that is connected or exposed to fire from the gas stove, and glued to the thermoelectric element with the addition of heat conductive paste between the elements and iron, shown in figure 6.

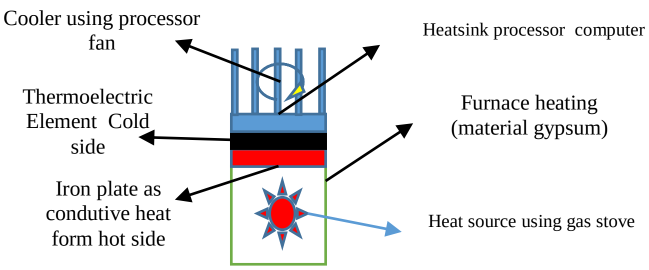

Fig. 6. Design of thermoelectric characteristics (furnace) test equipment

2. *Thermoelectric Measurement and Testing*

Tests to produce data are measured by a series of components as shown in figure 7, the electrical thermodynamic elements with a measuring instrument shown in Figure, and the data parameters from the test results are shown in Table 1, as follows:

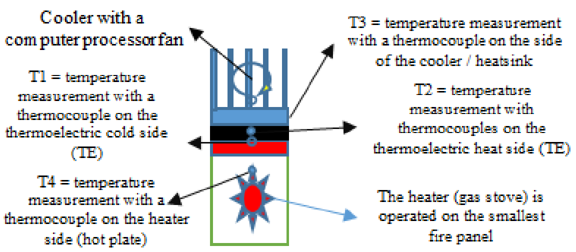

Fig. 7. Design of a thermoelectric characteristic test furnace

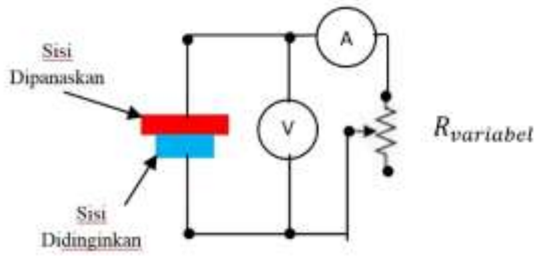

Fig. 8. Thermoelectric electrical testing circuit

In figure 9, sequential measuring devices and testers:
1. ohmmeter (resistor)
2. Ammeters (electric current)
3. voltmeter (voltage)
4. 4 channel thermocouple (T1, T2, T3 & T4)
5. Heating & cooling room / furnace
6. Resistor variable

Fig. 9. Assembly thermoelectric electrical testing circuit

3. *Data Processing*

Testing of TEC and TEG elements is done by changing the loading of 1000 ohm resistors to 10000 ohms with a range of 1000 ohms. And with using Ohm Laws with equation :

$$P = I^2 R$$

in the use of its equations, as follows:
P = power (W);
I = electric current (A);
R = resistant (Ω).

I. CONCLUSION

The results of the research on TEG and TEC thermoelectric characteristics with variations in resistor loading and setting the temperature difference between the two sides of the element at 70 ° C are generated:

1. The highest value of the electrical voltage on TEG = 1.48 V and TEC = 1.02 V;
2. The highest electric current value at TEG = 0.00141 A and TEC = 0.00094 A;
3. The highest value of electrical power at TEG = 0.00209 watts and TEC = 0.00092 watts;
4. The highest resistor loading value at 10k.ohm results in the highest power in the TEG type thermoelectric, with a difference of 0.00011 watts;

5. It can be analyzed which results in more effective TEG testing with the same working temperature against TEC, as a power plant (thermal-electricity).

TABLE 1. Characteristic data of TEC1-12705

FORM PERFORMANCE OF THERMOELECTRIC								
Date : 2018					**Location : Lab. Automotive Electricity**			
Type. Element : TEC 1-12705					**Element : TEC**			
Temp. Set point : T1~40, T2~110								
No.	**Resistor (Ω)**	**Voltage (V)**	**Electric Current (A)**	**Power (W)**	**Temp.**			
					(T1)	**(T2)**	**(T3)**	**(T4)**
1	1000	0,98	0,00094	0,00092	53,1	122,2	35	145,5
2	2000	1,01	0,00049	0,00049	54,5	124,5	35,2	143,6
3	3000	1,00	0,00033	0,00033	54,4	124	35,4	141,7
4	4000	1,01	0,00025	0,00025	54,7	124	35	141,2
5	5000	1,01	0,00020	0,00020	54,4	124,1	34,8	141,7
6	6000	1,02	0,00017	0,00017	55,2	125,1	35,2	141,4
7	7000	1,00	0,00014	0,00014	54,4	124,2	34,8	139,3
8	8000	1,01	0,00012	0,00012	54,7	124,3	35,2	139
9	9000	1,00	0,00011	0,00011	55,5	125,7	35,3	140,6
10	10000	1,00	0,00009	0,00009	55,1	124,4	35,3	139,1

TABLE 2. Characteristics of TEG SP1848

FORM PERFORMANCE OF THERMOELECTRIC								
Date : 2018				**Location : Lab. Automotive Electricity**				
Type. Element : SP1848				**Element : TEG**				
Temp. Set point : T1~40, T2~110								
No.	**Resistor (Ω)**	**Voltage (V)**	**Electric Current (A)**	**Power (W)**	**Temp.**			
					(T1)	**(T2)**	**(T3)**	**(T4)**
1	1000	1,48	0,00141	0,00209	39,5	110,1	37,2	125,7
2	2000	1,47	0,00073	0,00108	39,5	110,1	37,5	125,2
3	3000	1,48	0,00048	0,00071	39,8	110,3	37,4	125,4
4	4000	1,48	0,00036	0,00053	39,8	110	37,8	124,6
5	5000	1,47	0,00029	0,00043	39,8	110,1	38	125,6
6	6000	1,39	0,00023	0,00032	39,1	110,3	38	125,6
7	7000	1,42	0,00020	0,00028	42	110,2	39,7	124,2
8	8000	1,41	0,00017	0,00024	39,5	110,5	37,7	124
9	9000	1,39	0,00015	0,00021	39,4	110	37,2	121,4
10	10000	1,44	0,00014	0,00020	39,4	110,1	37,4	122,7

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