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Performance Study of Thermo-Electric Generator by Heat Exhaust with Two Wheels Motorcycle

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Abstract— **This work was the studying of recharge the electric of two wheels exhausts gas by the thermo-electric system. The evaluation was 35°C and 42°C of environment temperature with load/unload at 1400 rpm used two speeds for 2 to 30 minutes. The result showed that at the 60 km/hour speed generated voltage average 21.86 volts, 0.55 Amp, it can be charged to 12 VDC battery by-charger controllers for the preventive reverse to the thermos-electric plate. As the idle speed of both environment temperatures have lowest, and not enough to charge the battery. The error of thermos-electric power generator must to a constant temperature and heat transfer system is low performed.**

Keywords— Two-wheel motorcycle, Exhaust Gas Recirculation, Thermo-electric, Heat exchanger, DC generator

I. INTRODUCTION

The estimation of total energy input in internal combustion engines was about 20 to 50% and loosed by the exhaust waste heat. As more of the researcher has been recovered from heat of exhaust to achieved electrical requirements of a car and the thermoelectric technology (TET) was used the electrical generator with heat surface [1, 2]. The heat of exhaust gases was high temperature compared to the heat of coolant and lubricant oil. As high temperatures shows the possibility of conventional energy by thermoelectric generator (TEG) to attach to the exhaust heat energy. It's converted a heat engine into electric energy and the principle of the Seebeck effect generated electric power [3, 4, 5]. Thermoelectric (TE) energy converted is fabricated by coupling two conjugate p-type and n-type doped semiconductors like in solid-state devices can transform heat given off sources into electric power and considered as an alternative and the familiar technology of environment of obtaining and recovering heat which is directly converted [2,4,5,6]. The working was the temperature differences at the junction to make an electrical current. For the circuit configuration, the knowledge that the series connecting got encourage to not only immediately voltage but also current, and the parallel connectors gave a solely of power [4]. The improvement of semiconductor materials can be the best combination of performance such feedback coefficient, electrical resistivity, and thermal conductivity, and the other benefit are the ability to used electron to conduct current [7]. On the cold side and a hot side of the thermoelectric modules, the heat is absorbed by electrons as it gives a high energy level in the n-type element of semiconductor at the hot side. The electrons are moved into the system by the energy of the power supply. The high energy level element (n-type) is banished by the heat sink as electron movement to a lower level element (p-type) [8]. The main design of thermoelectric modules is bismuth telluride material base for cooling or integrate cooling and heating used while electric power is built by a temperature difference of thermoelectric module. The reverse behavior used the temperature differential of the surface of the module and generated electric power caused [9]. Thermoelectric devices are evident advantages and environments family feature. The weak benefit, it has low efficiency [10, 11]. The other distinct advantages of this technology were involving no moving parts or bulk fluids, low maintenance, lightweight, no vibration, no optics, and sonic signal, and flexibility on heat source [12]. Also, its easy availability, low cost, and low operating temperature range with considerable efficiency make the use of bismuth telluride an effective module. This work was studying the thermos-electric power generator (TEG) apply to the exhaust heat of a motorcycle at 125cc with 95% gasohol fuel, and 12VDC battery charging.

II. EXPERIMENTAL

A. Experimental Setup

As the single thermos-electric create low voltage and to achieve high voltage, the connection electrical technique was selected in mixing as series and parallel form to a module. The one end of the hot side was heated and the temperature gradient is maintained concerning the other end of the cold side [13]. As thermos-electric specification, was power generator TEG Peltier type model SP1848-27145, dimension is 4.0 (w) x 4.0 (L) x 3.4 (T) mm, material is ceramic / bismuth telluride, working environment: -60 - 125°C, Temperature electromotive force (a): >190x uV/°C, conductivity: 850-1250 Ω-1cm-1, Thermal conductivity (K): 15 - 16x10-3 W/°C cm. The thermos-electric was working by the different temperature of both sides, heat side attached into the exhaust pipe and cooling plate is mounted on a cold side. The cooling plate circulated and transferred heat into the system by water and cool down by radiator. Figure 1 (a) shows the arrangement of “n” and “p” type material in a TEG module and (b) installing with an exhaust pipe.

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(a) (b)

Figure 1 (a) Thermo-electric of "N" and "P" type and (b)preparing the installation of thermo-electric into the exhaust pipe of motorcycle

All most thermoelectric generators comprise several individual modules that may be electrically connected in either series, parallel, or series/parallel arrangement. This generator has an NT (Total number of modules) with NS (Number of modules connected in series) and NP (Number of modules connected in parallel). The total number of modules in the system is:

$$NT = Ns * Np \quad (1)$$

B. Design of Themo-Electric Generator

The thermo-electric cell is low generated voltage and low output power [6]. The design of the connective is served need the battery of two wheels motorcycle. Base on the additional current of electric is series connecting and parallel is voltage increased. Both of them are mixing as design and modify it.

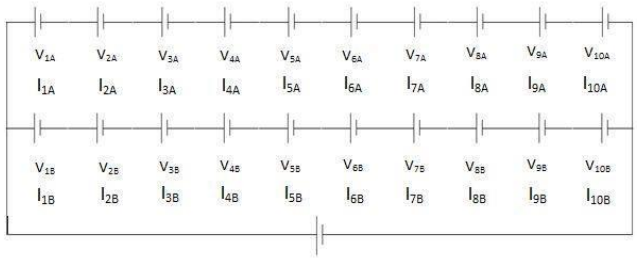

Figure 2 Diagram of current and voltage increasing for thermo-electric generators

$$V_{TA} = V_{1A}+V_{2A}+V_{3A}+V_{4A}+V_{5A}+V_{6A}+V_{7A}+V_{8A}+V_{9A}+V_{10A} \quad (2)$$

$$V_{TB} = V_{1B}+V_{2B}+V_{3B}+V_{4B}+V_{5B}+V_{6B}+V_{7B}+V_{8B}+V_{9B}+V_{10B} \quad (3)$$

$$V_{Total} = V_{TA}+V_{TB} \quad (4)$$

When V_{TA} is the total voltage of group A, V_{1A}, V_{2A}, V_{3A}, …, V_{10A} is the voltage of each thermoelectric device in group A. V_{TB} is the total voltage of group B, V_{1B}, V_{2B}, V_{3B}, …, V_{10B} is the voltage of each thermoelectric device in group B. V_{Total} is total of voltage.

$$I_{TA} = I_{1A}=I_{2A}=I_{3A}=I_{4A}=I_{5A}=I_{6A}=I_{7A}=I_{8A}=I_{9A}=I_{10A} \quad (5)$$

$$I_{TA} = I_{1A}=I_{2A}=I_{3A}=I_{4A}=I_{5A}=I_{6A}=I_{7A}=I_{8A}=I_{9A}=I_{10A} \quad (6)$$

$$I_{Total} = I_{TA}+I_{TB} \quad (7)$$

When I_{TA} is the total voltage of group A.I_{1A}, I_{2A}, I_{3A},…, I_{10A} are the voltage of each thermoelectric device in group A. I_{TB} is the total voltage of group B.I_{1B}, I_{2B}, I_{3B}, …, I_{10B} is the voltage of each thermoelectric device in group B. I_{Total} is total of voltage.

$$P = I * V \quad (8)$$

When P is power (Watt), I is current (Amp), V is voltage (V)

C. Tester Instrument

Figure 3 (a) the measurement tool for the voltage and current output by multi-meter, which Kyoritsu digital millimeters model 1009, DC measure is 400mV- 600V (input Impedance 10MΩ) ± 0.6%rdg±4Dgt, and input/output of the cooling system is measured by digital temperature controller model TTM-J4. The calculation of cooling is a difference between the input (cold water) and output (hot water).

(a) (b)

Figure 3 (a) multi-meter for voltage and ampere measurement and (b) digital temperature controller for input/output for cooling system

III. RESULTS AND DISCUSSION

A. Study of Perfomance for Mixing Conneted with A Thermo-Electric Generator

The voltage and current are the output type of the main device of the performance system, and also the heat source in the exhaust of two wheels motorcycle. The experimental thermoelectric generator is testing each mixed connecting for basting performance by an average of two-wheel motorcycle, at 40 km/hour, the difference of both sides is 55 degrees centigrade of hot side and cooling side, the thermoelectric generated 1.34 voltage and 0.16 ampere by each. This battery is 12 VDC capacities and item 3 is connecting selected. Table 1 thermoelectric performance of generator connecting.

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Table 1 Performance of the thermoelectric generator by the connecting method.

Item	description	Resistant	Voltage (V)	Ampere (A)	Power (W)
1	20 pieces with series	46.0	26.8	0.16	4.288
2	20 pieces with parallel	0.115	1.34	3.2	4.288
3	10 pcs./set with series and 2 sets with a parallel	11.5	13.4	0.32	4.288
4	10 pcs/set with parallel and 2 sets with series	0.46	2.68	1.6	4.288
5	5 pcs./set with series and 4 sets with a parallel	2.875	6.7	0.64	4.288
6	5 pcs./set with parallel and 4 sets with series	1.84	5.36	0.80	4.288
7	4 pcs./set with series and 5 sets with a parallel	1.84	5.36	0.80	4.288
8	4 pcs./set with parallel and 5 sets with series	2.875	6.70	0.64	4.288
9	2 pcs./set with series and 10 sets with a parallel	0.46	2.68	1.60	4.288
10	2 pcs./set with parallel and 10 sets with series	11.50	13.4	0.32	4.288

B. *Temperature of Themo-Electric in Idel Speed with No Loaded*

As the environment temperature is 35°C with no loaded at idle speed observed the start engine has 2°C difference temperature until 10 minutes increased to 10°C difference. At 20 minute testing time, the difference temperature is 16°C and 18°C in 30 minutes. While, 42°C of environment temperature shows the different temperature is 2°C, at start engine until 10 minutes, the difference temperature increased to 11°C then continuous to 16°C at 20 minutes and 24°C at 30 minutes, shown in Figure 4. The comparison at 35°C and 42°C of environment, at 42°C has higher than 35°C but they are the lowest difference temperature.

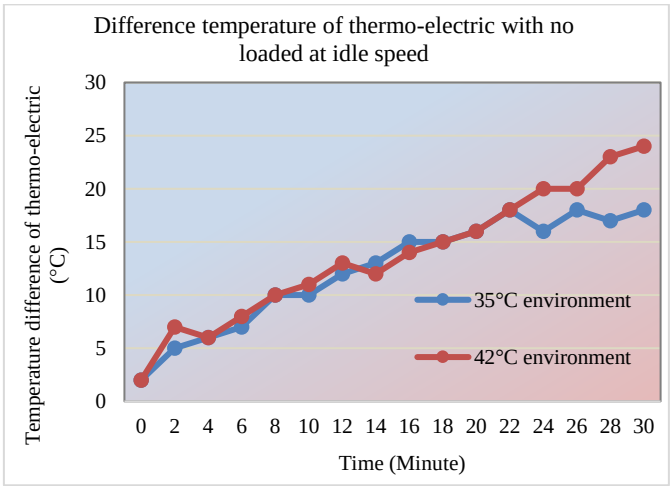

Figure 4 the difference of temperature for thermo-electric at idle speed with no loaded

C. *Voltage Generating of Thermo-Electric in Idle Speed with No Loaded*

Base on the idle speed test, the thermoelectric generator must to higher difference temperature so; the idle speed has the lowest difference temperature. They are generating the lowest voltage about 3.3 voltages at 30 minutes with a 0.07-ampere current show in Figure 5. It cannot be charging to battery 12 VDC both of them.

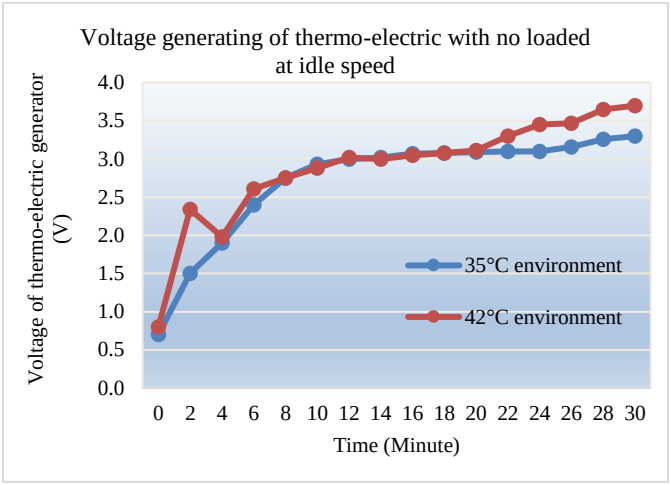

Figure 5 Generating voltage of thermo-electric at idle speed with no loaded

D. *Temperature of Thermo-Electric at a Differenct Speed with Loaded*

Figure 6 shows the difference of temperature of thermo-electric of both speeds within 150 kg loaded at 42°C environments, at 40km/hour speed, the difference of temperature is 5°C at start point until at 10 minutes increased to 41°C, 57°C at 20 minutes, and 56°C at 30 minutes. While, at 60 km/hour speed, 6°C at start point the difference temperature increased to 72°C at 10 minutes, 87°C at 20 minutes, and 89°C at 30 minutes. The comparison to difference temperature, 60 km/hour speed is better than 40 km/hour speed and the 40 km/hour speed is better than idle speed.

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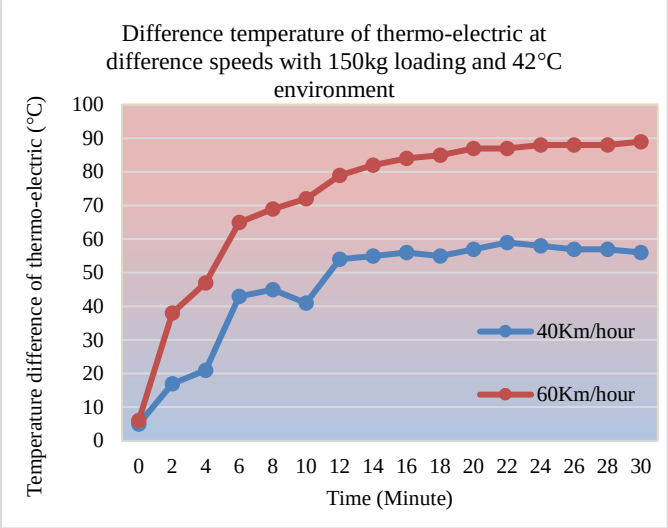

Figure 6 Difference temperature of thermo-electric of 40 km/hour and 60km/hour within 159 kg loading at 42°C environment

E. Voltae Generating of Thermo-Electric at a Differnct Speed with Loaded

As the knowledge of the thermoelectric power generator, they must difference temperature on working. The 40 km/hour speed shows higher than 12 voltages at 10 minutes; it's enough to charge the battery 12 VDC. But at 60 km/hour used only 4 minutes, it can be charging the battery.

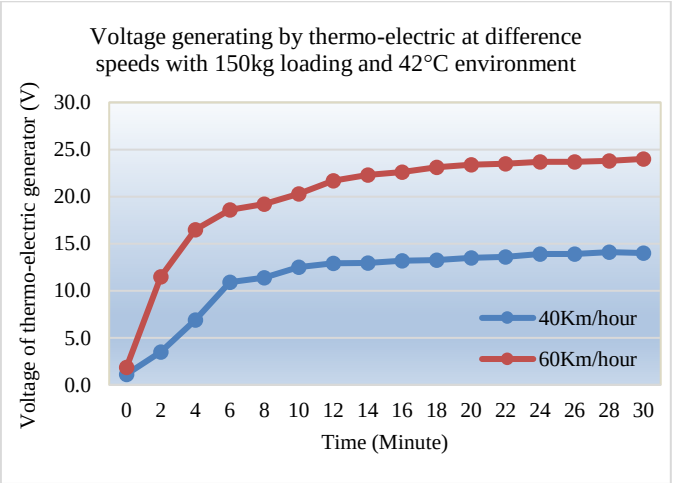

Figure 7 Voltage generating by thermo-electric difference speeds with 15 kg/loading and 42°C environment

IV. CONCLUSION

The studying of thermoelectric power generator performance with the exhaust heat of a two-wheels motorcycle used 20 pieces of the thermoelectric plate. The 60 km/hour speed generated voltage average 21.86 volts, 0.55 Amp, it can be charged to 12 VDC battery by-charger controller for the preventive reverse to the thermos-electric plate. The difference temperature for idle speed of both environments has the lowest, and not enough to charge the battery. The error of thermos-electric power generator must to a constant temperature and heat transfer system is low performed.

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