Experimental evaluation of thermoelectric generator based on oven application for energy harvesting

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ABSTRACT – In this research paper, energy harvesting using heat waste from oven to generate electricity via thermoelectric generator (TEG) module. The experimental setup was investigated in open circuit from room temperature rise to 105°C in 60 min using kitchen oven with custom-made aluminum heatsink. The maximum voltage output was generated about 0.92V in single TEG module where gradient of TEG 0.075V/°C. The harvested output voltage can be used in simple LED lighting system and power bank during waste heat released from oven applications.

1. INTRODUCTION

Nowadays, the smart devices applied in internet of things (IoT) for our daily life such as bio-sensors, touch sensors, etc. needs battery to power the system. Therefore, energy harvesting system from the environment is the solution to replace battery used for the smart devices. In energy harvesting context is defined as conversion of electrical energy from waste energy such as vibration, temperature, magnet, solar and radio frequency [1-2]. Most of the electrical energy harvested in form of alternative current, A.C and direct current, D.C. For an example piezoelectric and magnet energy produced A.C and solar system and thermoelectric produced D.C. output.

Thermoelectric generator module (TEG) is popular and famous for energy harvesting application due to the size and simple setup using differential temperature from heat waste such as oven and natural heats from environment. The TEG module produced D.C output where the system does not need conversion from A.C to D.C as cost saving without rectifier system.

The TEG applied seebeck effect and it was introduced by Thomas Seebeck (1821) where an electrical current will be produced when a differential temperature at the junction of two different metals. The output voltage of the seebeck as shown:-

$$V = S\ x\ dT \qquad (1)$$

where,
V = voltage output
S = Seebeck coefficient in volts/°K
dT = the temperature difference across TEG, Th-Tc
Th, Thermal hot surface of TEG
Tc, Thermal cold surface of TEG

This research paper covered an experimental setup and characterization using single TEG module. The TEG module was attached on the body of kitchen oven as a heat waste and voltage output was analyzed in the graph for the optimum gradient temperature.

2. METHODOLOGY

Figure 1 shown the experiment setup where one unit of TEG (Multicomp: MCPE1-12707AC-S) was attached on top body of the oven with using controller box act as on and off switch with timer function [3]. The experiment was carried out using oven by controlling room temperature to rise up 105 °C in 60 min.

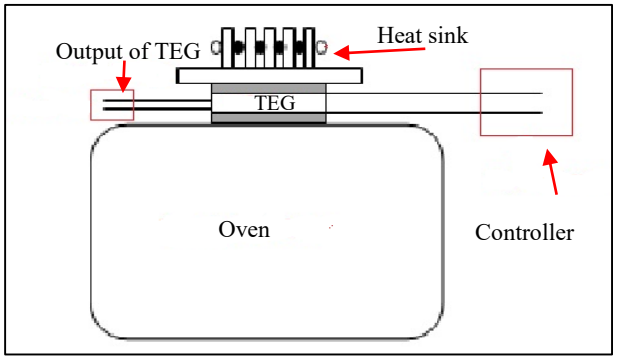

Figure 1 Diagram of experimental setup.

Figure 2 Custom-made heatsink.

In order to improve the difference temperature for the TEG to generate electricity, a custom-made aluminium heatsink was fabricated and attached with TEG module in the experiment setup as shown in Figure 2.

3. RESULTS AND DISCUSSION

The data of difference temperature, temperature and voltage were measured using high speed data logger measurement device (Hioki: LR8400-20). Figure 3 shows the maximum temperature rise from room temperature using kitchen oven in 60 mins before the TEG module attach on the oven body. The differential temperature versus voltage output as shown in Figure 4 where the voltage output of the TEG module about 0.075 V/°C using single TEG module. Figure 5 shown the maximum output voltage harvested from the TEG module in 60 mins where using custom-made heatsink is about 0.92V in open circuit using single TEG module and the voltage output is higher than other researchers who did their experimental in waste heat in LCD and oven applications [4].

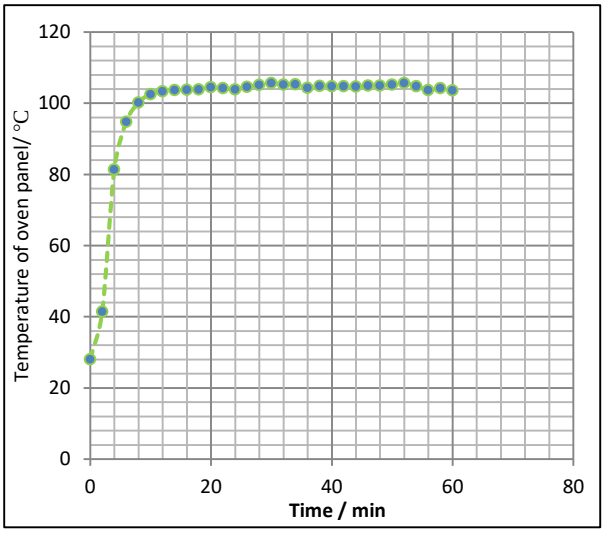

Figure 3 Temperature of oven panel.

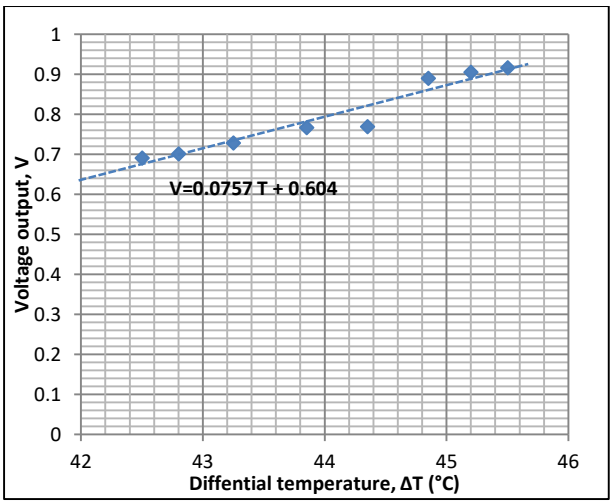

Figure 4 Differential temperature vs voltage output.

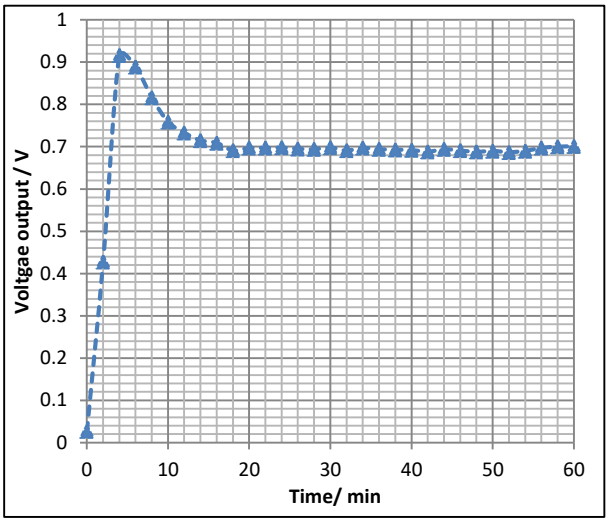

Figure 5 Voltage output versus time.

4. CONCLUSION

In this paper, the thermoelectric generator based on oven application was successful developed. The maximum voltage output was able to be harvested in open circuit about 0.92V using single TEG module where the gradient of TEG module was 0.075V/°C. Future work will be carried out in closed circuit with resistance load, DC-DC boost converter and output applications

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