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High output water cooled thermoelectric refrigerator

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Abstract

Thermoelectric cooling had been an alternative cooling method to vapor compression system. This is due to the lack of harmful refrigerant, packaging, as well as the low noise operation. Currently, there are application of a thermoelectric refrigerator. Most of the existing products are usually made in small size and lack the ability to quickly cool down the space or withstand external heat source such as having hot items being placed within the refrigerator. This research was an experiment regarding to the application of high output thermoelectric refrigerator. It involved a 720 watt water to air thermoelectric module placed through a 40 liter insulated cabin and temperature data are collected to determine the possibility of overcoming the demerits of thermoelectric refrigerators. The water flow rate had been regulated at 400, 500 and at the system's maximum limit of 600 liters per hour. The results were the system reached below the freezing temperature within 30 minutes under no load condition. Therefore the feasibility of high output thermoelectric cooler application is a compact and possible approach towards initiating a cooling scheme in closed area within a short time.

Keywords: High output, Thermoelectric, Cooling, Flow rate, Heat sink

1. Introduction

In 1823 Thomas Seebeck discovered that electric current that flows along a closed circuit with different material would have their junctions to maintain at different temperature. The thermoelectric cooling effect started in 1834 where Jean Charles Athanese Peltier had discovered a phenomenon of heating and cooling using an electrified junction of two different conductor [1]. Currently there are many cooling methods using heat transfer principle, thermoelectric cooling is one of the methods with the aid of the Peltier Effect. A thermoelectric plate receives electricity and would start to conduct heat. Recent applications had led to the possibility of making refrigerators with thermoelectric plate as a cooling source instead of a compressor that rely on refrigerants.

In 1995, Goktun S. had attempted in making a design of a thermoelectric refrigerator by analyzing the cooling capacity of the space [2]. In 2001, Chen L. had analyzed the performance of a thermoelectric refrigerator using theoretical approach [3]. In 2007 Sabah A. had created a solar powered thermoelectric cooler which he achieved in lowered temperature within a day [4]. In 2010, Jugsujinda S. had attempted to create an air to air thermoelectric refrigerator. The results were that the thermoelectric plate itself could reach low temperature while the interior temperature keeps decreasing slowly in a continuous manner [5].

It could be seen that there are still a question regarding to the cooling rate of thermoelectric refrigerator as it could not provide the cooling effect like a compressor driven system in the conventional freezer or refrigerator. In this research, a selection of high output thermoelectric plate are used and tested in an insulated box for 30 minutes to determine the cooling rate.

2. Materials and methods

2.1 Materials and related equations

Table 1 Initial Parameters

Item	Quantity – Specification
Thermoelectric Dimension TEC-12726 (2)	40mm x 40mm
Thermoelectric Dimension TEC-12710 (2)	50mm x 50mm
Thermoelectric Output TEC-12726 Combined	480 Watts
Thermoelectric Output TEC-12710 Combined	240 Watts
Hose Diameter	¾ Inches
Flow Rate Meter	Micronics Porta flow 300
Box Volume	40 Liters
Power Supply 220V	1,100 W / 96 A
Infrared Measurement Device Tolerance	+- 2 percent

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Table 1 shows the specification of the system which is determined using the equation. The theories behind the calculation of power supply specification are as following

Joule's Law

$$P = I V \quad (1)$$

Where "P" is the power in Watt, "I" is the current in Ampere, and "V" is the Voltage in Volts.
The details of the thermoelectric cooler module are as following

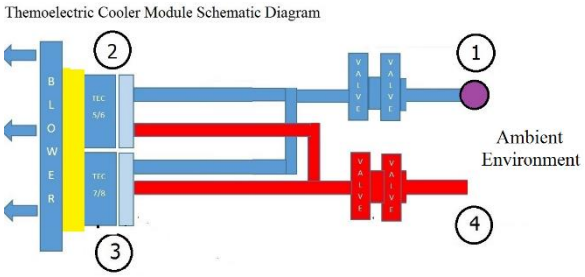

Figure 1 Thermoelectric module schematic diagram

Figure 1 explains the arrangement of the high output thermoelectric refrigerator in which each labeled points are explained as following.

At point 1, the flow meter regulates water flow into the system using rubber hose

At point 2, the heat sink is a medium of heat conduction between the thermoelectric plates shown at point 3 which the heated water will be rejected out at point 4 into the environment.

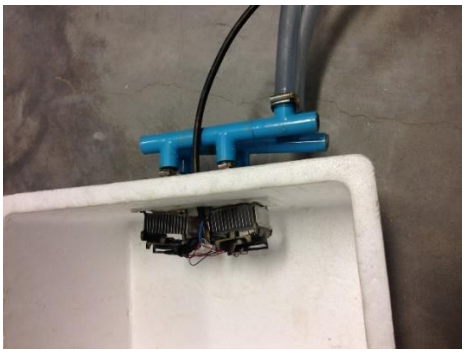

Figure 2 The thermoelectric module inserted through a foam box with top removed

Figure 3 The apparatus set with an infrared gun pointing inside to measure the ambient temperature

Figure 1, 2, and 3 shows the configuration of the system. The apparatus would use a flow meter to control a constant 400, 500, and 600 liter per hour of water flow rate that is used in the test. The system was operated for approximately 30 minutes and recorded at one minute interval.

3. Results and discussion

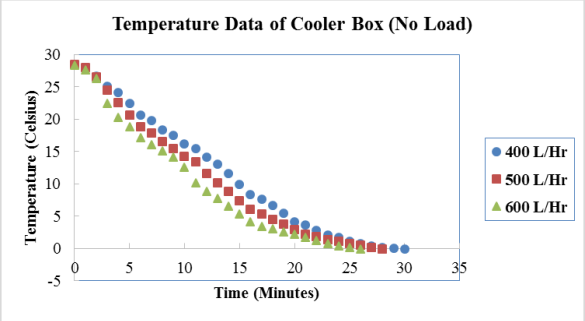

Figure 4 The temperature trend of a high output thermoelectric cooler

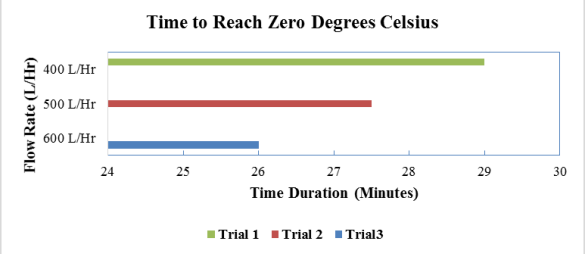

Figure 5 Comparison of time duration for reaching zero degrees Celsius

The results had displayed a cooling trend of the ambient temperature within the cooler box shown in Figure 4. The trend falls down in a rapid scheme during the beginning due water cooling and progressed constantly until it reaches below 5 degrees that the cooling scheme became less aggressive. Figure 5 showed different flow rates toward reaching freezing temperature. It is seen that when high amount of water flow is present, better heat transfer is provided.

The results proved that thermoelectric plate can be optimized into a cooling system such as freezer or refrigerator, only that it would consume a great amount of power in order to achieve this performance. If there is a system that the output could be adjusted, this method will act as a boost starter for the system, then a low output system can be applied to maintain the temperature. This is the solution towards operation noise as well as being environmentally friendly due to the lack of any refrigerant since the system use only tap water as the coolant. In the case that the system had been sealed, the flow rate of water is still possible to be controlled and using a radiator such as an automotive radiator with fan, the heat generated should be dissipated when compared to the water volume involved within the system.

4. Conclusions

The results showed that the temperature within the box reduced to approximately – 1 degrees Celsius in a timely manner. The temperature trend had decreased constantly

until it reaches the freezing point. This experiment only records the temperature measurement until the temperature drop trend will gradually decease as the temperature approaches to the limit of thermoelectric plate. This experiment is a practical application guideline towards a compact and effective cooling method.

5. Acknowledgements

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6. References

[1] Peltier JCA. Nouvelles expériences sur la caloricité des courants électrique. Annales de Chimie et de Physique 1834;56:371-386.
[2] Goktun S. Designs consideration of a thermoelectric refrigerator. Energy Conversion and Management 1995;36(12):1197-1200.
[3] Chen L, Gong J, Sheng L, Sun F, Wu C. Theoretical Analysis and Experimental Confirmation of the Performance of a Thermoelectric Refrigerator. Journal of Non-Equilibrium Thermodynamics 2001;26(1):85-92
[4] Abdul-Wahab SA, Elkamel A, Al-Damkhi AM, Al-Habsi IA, Al-Rubai'ey HS, Al-Battashi AK, et al. Design and experimental investigation of portable solar thermoelectric refrigerator. Renewable Energy 2009;34(1):30-34.
[5] Jugsujinda S, Vora-ud A, Seetawan T. Analyzing of Thermoelectric Refrigerator Performance. Procedia Engineering 2011;8:154-159.