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Design of Portable Air Conditioner Cooling Combination System Using Thermo Electric Cooler and Water Cooler Based on Arduino Uno

Wiwik Wiharti [a,1,*], Akbar Abadi [a,2], Yona Mayura [a,3], Falia Indriana [a], Nguyen Thi Bich Ngoc [b]

[a] Electrical Engineering Study Programme, Department of Electrical Engineering, Politeknik Negeri Padang, Indonesia
[b] Faculty of Electrical and Electronics Engineering (FEEE), Ho Chi Minh City University of Transport, Ho Chi Minh City, Viet Nam
[1] wiwikwiharti@pnp.ac.id; [2]akbar@pnp.ac.id; [3]yona@pnp.ac.id
* corresponding author

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ABSTRACT

A room can be categorised as comfortable or not depending on the temperature and humidity of the air in the room. In order for the room temperature to be maintained, an Air Conditioner (AC) is needed. In the AC there is refrigerant as the most important component that functions to provide cool and cold effects in the room. However, refrigerant leakage in AC is one of the causes of greenhouse emissions that have an impact on climate change. In order to reduce the emissions caused by AC usage, many researchers are utilising Peltier as a device designed to replace the AC cooling system. In order for TEC to work optimally when cooling the air in the room, it is necessary to design a combination system of Portable Air Conditioner (AC) cooling using TEC and Arduino Uno-based water cooler. The working principle of designing a portable Air Conditioner cooling combination system using TEC and water cooler requires a temperature set point value in the water cooler system, where the Arduino is given a set point temperature range on the heatsink. The temperature on the heatsink affects the pump speed. if the higher the temperature on the heatsink read by the DS18B20 temperature sensor, the pump will work quickly to cool the heatsink side. The temperature on the heatsink, pump speed, and the height of the water cooler in the tub are displayed on the LCD. Before assembling and arranging the components that will be used in the portable Air Conditioner cooling combination system using TEC and water cooler, the design flow of the working principle and tool design of the portable Air Conditioner cooling combination system is needed. After the components are assembled and arranged, the test results are obtained with the conclusion that the TEC with the water cooler method is better at cooling a room measuring 1x1 metre than the water cooler method.

1. Introduction

A room can be categorised as comfortable or not depending on the temperature and humidity of the air in the room. The air temperature in a room is categorised as comfortable with the temperature and humidity of the room being occupied maintained at a temperature range between 20°C-22°C (68°F-72°F) and humidity between 40%-60%. [1]. In order for the room temperature to be maintained, an Air Conditioner (AC) is needed. In the AC there is a refrigerant as the most important component that serves to provide a cool and cold effect on the room. Refrigerant is a gaseous chemical substance used as a heat transfer medium where heat is absorbed from the room to be cooled from the evaporator and discharged into the environment through the condenser. [1]. However, air

conditioners are considered expensive and their cooling systems are proven to be ineffective in humidifying conditions. [2].

As air conditioning use increases, these humidity impacts will become five times greater by 2050 in the absence of additional technology or policy interventions to slow or reverse the growth in emissions. [3]. Refrigerant leakage in air conditioners is one of the causes of greenhouse emissions that impact climate change. In addition, there are several causes of air conditioning to be the main donor of emissions, namely: (1) operational energy use or "cooling energy" (emissions associated with the electricity that powers the air conditioner), (2) embodied emissions (emissions released during production), and (3) refrigerant leakage (direct emissions released during operation and end-of-life). [3]. In order for the emissions. caused by the use of air conditioners to be reduced, many researchers are utilising peltier as a device designed to replace the AC cooling system. Where the peltier device known as Thermo Electric Cooling (TEC) is one of the technologies that has a promising cooling effect in line with the conventional cooling cycle. [4]. Besides having a cooling side, peltier also has a hot side that can be utilised for various life problems. The hot side of the peltier is usually called the heat sink, while the cold side of the peltier is called the cold sink. The heat sink side of the peltier can be used as a combustion of used oil from motor vehicles and industry, where the heat generated by combustion can be used to heat the chicken coop and can also be used to generate electricity to power the blower [5].

While the cold sink side can be used to cool the air in the room [2], [4], [6]-[10]. In order for TEC to work optimally when cooling the air in the room, this paper discusses the design of a Portable Air Conditioner (AC) cooling combination system using TEC and Arduino Uno-based water cooler.

2. Research Methodology

In the research of designing a combination system of Portable Air Conditioner (AC) cooling using TEC and Arduino Uno-based water cooler utilising 9 peltier pieces to cool the room. By conducting tests, it can be seen the absorption of a thermoelectric room cooling system that utilises the peltier effect as a substitute for refrigerant. In order for the peltier element to work optimally, it is necessary to extract heat from the heat sink side of the peltier by pumping heat in the water cooler which is directly conducted through the heatsink and discharged into the air by the AC fan. By providing variations in water mass, it will be known the maximum peltier element in reducing temperature. In the temperature setting, the Arduino uno microcontroller is used.

The working principle of designing a portable Air Conditioner cooling combination system using TEC and Arduino uno-based water cooler is divided into two parts to see the effectiveness in cooling the room, namely:

1. Working principle using thermoelectric

Thermoelectric cooling based on the peltier effect is when DC current is applied to a peltier element consisting of 1 pair of P-type and N-type semiconductors, it will cause one of the peltier elements to absorb heat (cold) and one side to release heat (hot).

In heat dissipation, heatsinks and fans are given to have effective performance, as well as the coldsink side.

2. Working principle of Arduino uno-based water cooler

The cooling system using Arduino uno aims as a control to accelerate heatsink cooling. Which in the heatsink is given a copper pipe to channel the water cooler so that the copper pipe can absorb heat and drain it faster than just using a fan.

In Figure 1. the following is a flow chart of the working principle of designing a portable Air Conditioner cooling combination system using TEC and water cooler.

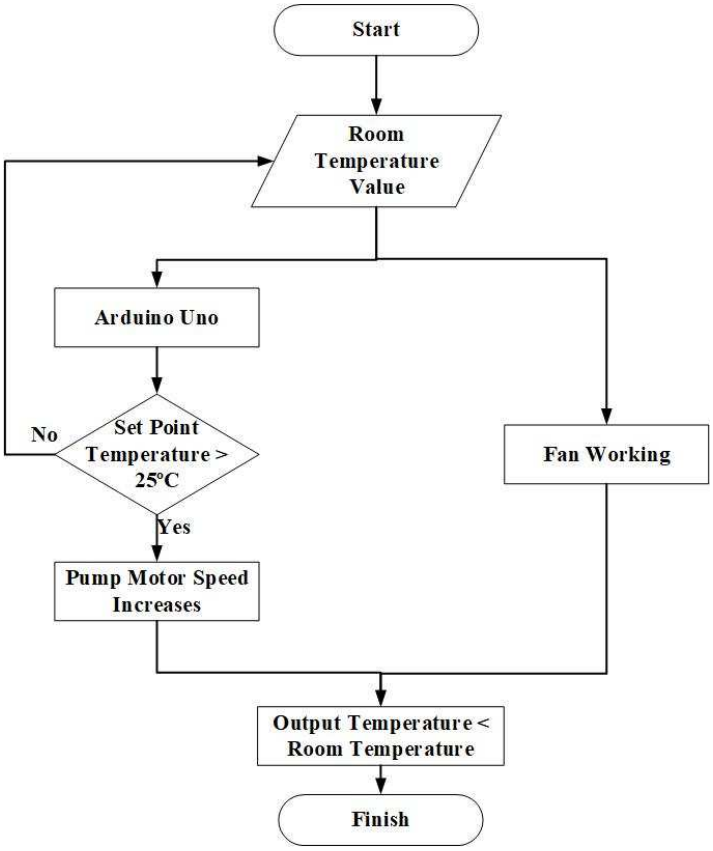

Figure 1. Flow Chart of the Working Principle of the Design of Portable Air Conditioner Cooling Combination System Using TEC and Water Cooler

Describe the preparation methods and characterization techniques used. Explain briefly, but still accurately such as size, volume, replication and workmanship techniques. The new method must be explained in detail so that other researchers can reproduce the experiment. While established methods can be explained by picking out references.

In Figure 1. above, it can be explained that the working principle of designing a portable Air Conditioner cooling combination system using TEC and water cooler requires a temperature set point value on the water cooler system, where the Arduino is given a set point temperature range on the heatsink. The temperature on the heatsink affects the pump speed. if the higher the temperature on the heatsink read by the DS18B20 temperature sensor, the pump will work quickly to cool the heatsink side. The temperature on the heatsink, pump speed, and water cooler in the tub are displayed on the LCD to make it easier for users to know about the pump speed, the height of the water cooler which uses a water level that functions as a determinant of the height of the water cooler and also knows the temperature on the heatsink side.

3. Results and Discussion

Before assembling and arranging the components that will be used in the portable Air Conditioner cooling combination system using TEC and water cooler, the design flow of the working principle of the design of the portable Air Conditioner cooling combination system using TEC and water cooler is needed as in Figure 2. below.

In Figure 2. below, it can be explained that when the PLN source with a voltage of 220 V enters the DC 12 V power supply. Here a 12 V 30 A DC power supply and a 12 V 60 A DC power supply are used. After being given a 12 V DC source, the DC fan located before the peltier element heatsink, as well as the DC fan located after the coldsink will turn on.

When the peltier element gets supply from the source, the peltier element on the heatsink side will immediately heat up, therefore a DC fan is placed before the heatsink to cool the heatsink and the faster the heatsink side melts the heat, the faster the coldsink side cools down which is indicated by the dewy coldsink. After that, the cold generated by the coldsink side will be blown away by the DC fan located after the coldsink to the room. To speed up the coldsink side, the heatsink side is sprayed with water cooler in the fins of the heatsink with the help of a water pump and Arduino UNO Atmega 328p to adjust the speed of the water pump according to the temperature on the heatsink.

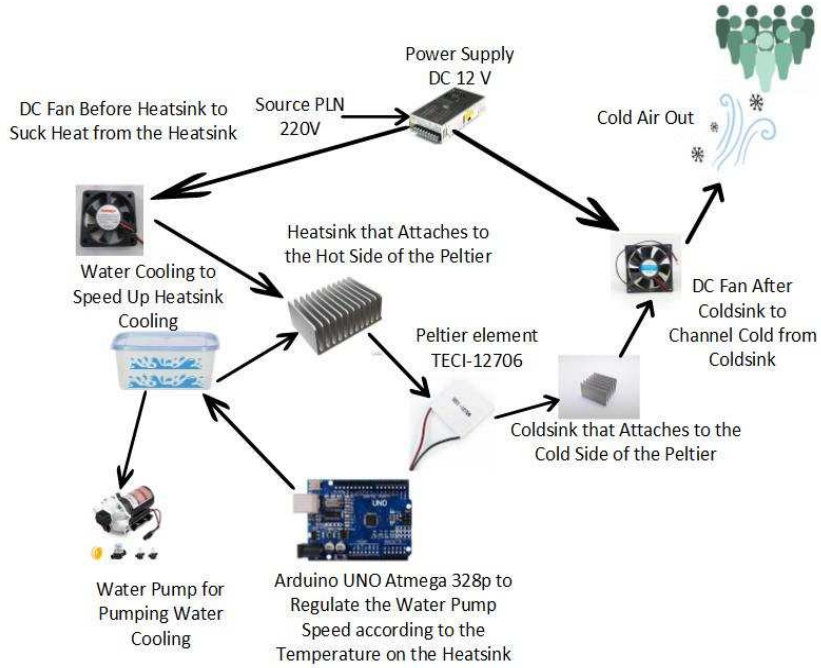

Figure 2. Design Flow of the Working Princple of the Design of Portable Air Conditioner Cooling Combination System Using TEC and Water Cooler

After getting the design flow of the working principle of designing a portable Air Conditioner cooling combination system using TEC and water cooler, it is necessary to design the design of a portable Air Conditioner cooling combination system using TEC and water cooler before assembling and arranging the components that will be used in the portable Air Conditioner cooling combination system using TEC and water cooler. The tool design of the portable Air Conditioner cooling combination sFigure 3. Tool Design of Portable Air Conditioner Cooling Combination System Using TEC and Water Coolerystem using TEC and water cooler can be seen in the following Figure 3.

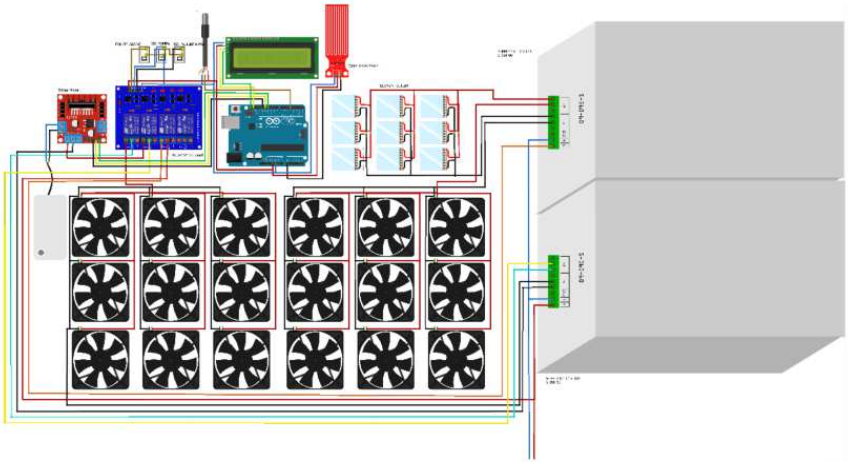

Figure 3. Tool Design of Portable Air Conditioner Cooling Combination System Using TEC and Water Cooler

Figure 4. Display of Portable Air Conditioner Cooling Combination System Tool Using TEC and Water Cooler

After getting a suitable tool design from a portable Air Conditioner cooling combination system using TEC and water cooler, the components used in the portable Air Conditioner cooling combination system using TEC and water cooler are assembled and arranged to be as in Figure 4. below. After the device is designed and assembled, testing is carried out by comparing the temperature produced by TEC using a water cooler system and an air cooler in a room measuring 1x1 metre. Testing was carried out in 3 times, namely in the morning, afternoon, and evening. The test results in the morning can be seen in Table 1.

Table 1. Comparison of Room Temperature and Peltier in the Morning

Initial Room Temp (℃)	No.	Water Cooler (℃)	Room Temp with Water Cooler (℃)	Air Cooler (℃)	Room Temp with Air Cooler (℃)	Time (a.m.)
	1	13,5		14,6		08.00
	2	18,7		19,6		08.10
	3	15,9		15,6		08.20
	4	17,2		17,2		08.30
27,2	5	15,5	**22,4**	15,7	**23,2**	08.40
	6	18,7		19,5		08.50
	7	17,8		18,2		09.00
	8	16,8		20		09.10
	9	17,6		18,9		09.20

In Table 1, it can be seen the comparison of room temperature before and after using a portable Air Conditioner, where the temperature produced by TEC using a water cooler system and an air cooler in a room measuring 1x1 metre at a room temperature of 27.2 oC in the morning can be described by the graph in Figure 5. below.

In the graph in Figure 5. below, it can be seen the comparison between TEC using the water cooler and air cooler method in a 1x1 metre room at a room temperature of 27.2 oC in the morning. Where the lowest temperature at TEC with the water cooler and air cooler method occurred at 08.00 a.m. with a temperature generated by TEC of 13.5 oC and 14.6 oC and the highest temperature at TEC with the water cooler method at 08.10 a.m. and 08.50 a.m. with a temperature of 18.7 oC and the highest temperature at TEC with the air cooler method occurred at 09.10 a.m. with a temp`erature

of 20 oC. So, the average between the temperatures generated by TEC using the water cooler method at 08.10 a.m. with a temperature of 20 oC. So that the average between the temperatures produced by TEC with water cooler and air cooler methods is 16.9 oC and 17.7 oC. Where the temperature produced by TEC with the water cooler method is cooler than the air cooler method in the morning.

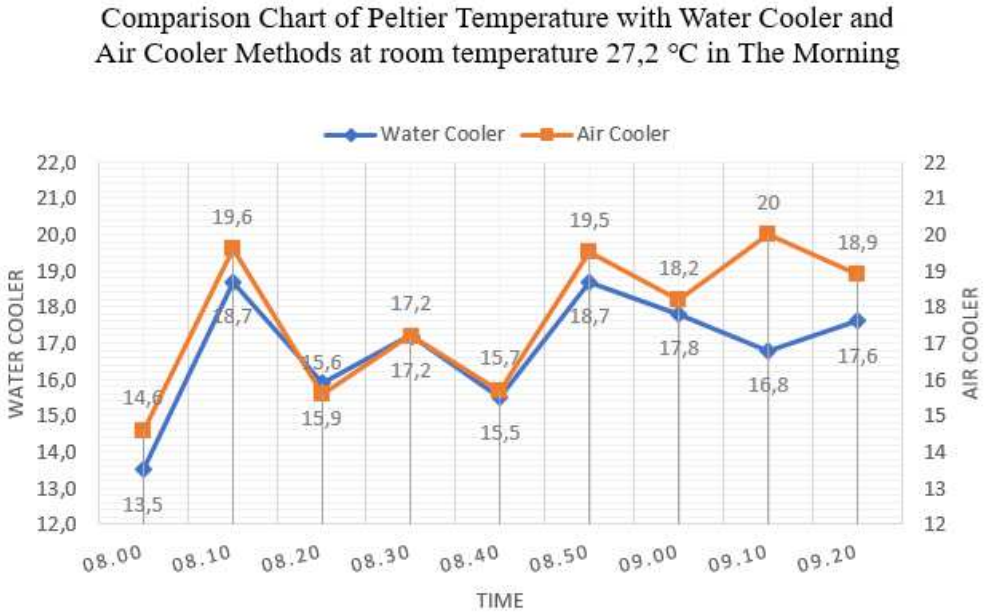

Figure 5. Comparison Chart of Peltier Temperature with Water Cooler and Air Cooler Methods at Room Temperature 27,2 ºC in the Morning

While for the test results during the day can be seen in Table 2, below:

Table 2. Comparison of Room Temperature and Peltier in the Noon

Initial Room Temp (°C)	No.	Water Cooler (°C)	Room Temp with Water Cooler (°C)	Air Cooler (°C)	Room Temp with Air Cooler (°C)	Time (p.m.)
	1	14,3		14,8		12.00
	2	20,6		20,4		12.10
	3	17,1		17,3		12.20
	4	17,5		17,8		12.30
29,6	5	14,7	**23,2**	16,1	**24,5**	12.40
	6	19,2		19,8		12.50
	7	19,5		20		01.00
	8	18,9		20,7		01.10
	9	18,4		19,6		01.20

From the data obtained from Table 2 above, it can be seen the comparison of room temperature before and after using a portable Air Conditioner, where the temperature generated by TEC using a water cooler and air cooler system in a room measuring 1x1 metre at a room temperature of 29.6 oC at noon can be described by a graph in Figure 6. below.

In the graph in Figure 6. below, it can be seen that the lowest temperature at the TEC with the water cooler and air cooler method occurred at 12.00 p.m. with a temperature generated by the TEC of 14.3oC and 14.8oC and the highest temperature at the TEC with the water cooler method at 12.10 p.m. with a temperature of 20.6 oC and the highest temperature at the TEC with the air cooler method occurred at 01.10 p.m. with a temperature of 20.7oC. So that the average between the temperatures

generated by the TEC with the water cooler and air cooler method is 17.8oC and 18.5oC. So that the average between the temperatures produced by TEC with water cooler and air cooler methods is 17.8oC and 18.5oC. Where the temperature produced by TEC with the water cooler method is cooler than the air cooler method during the day.

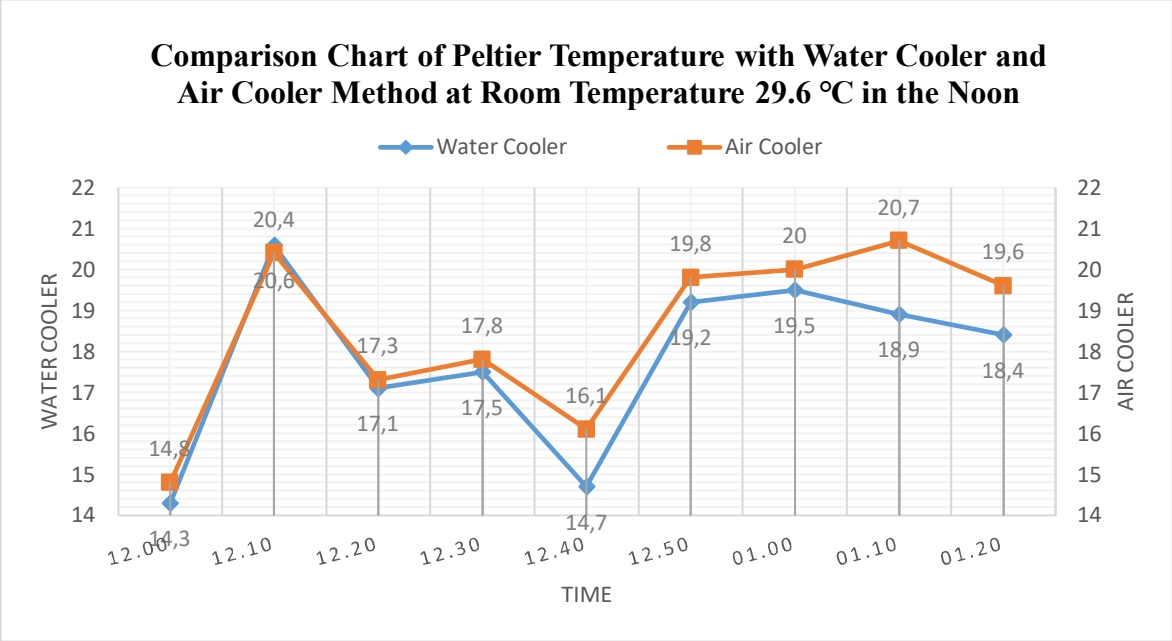

Figure 6. Comparison Chart of Peltier Temperature with Water Cooler and Air Cooler Method at Room Temperature 29.6 °C in the Noon

While for the test results in the afternoon can be seen in Table 3, below:

Table 3. Comparison of Room Temperature and Peltier in the Afternoon

Initial Room Temp (°C)	No.	Water Cooler (°C)	Room Temp with Water Cooler (°C)	Air Cooler (°C)	Room Temp with Air Cooler (°C)	Time (p.m.)
28,4	1	14	22,7	14,8	23,9	04.30
	2	19,3		20		04.40
	3	16,5		16,1		04.50
	4	17,4		17,6		05.00
	5	15,8		15,9		05.10
	6	18,7		19,6		05.20
	7	18,5		19,5		05.30
	8	17,9		20,3		05.40
	9	18,4		19,4		05.50

From the data in Table 3 above, we can draw a graph of the temperature produced by TEC with a water cooler system and an air cooler in the afternoon, as shown in Figure 7 below.

In the graph in Figure 7. below, it can be seen the comparison between TEC using the water cooler and air cooler method in a 1x1 metre room at a room temperature of 28.4oC in the afternoon. Where the lowest temperature at TEC with the water cooler and air cooler method occurred at 04:30 p.m. with the temperature generated by TEC of 14oC and 14.8oC and the highest temperature at TEC with the water cooler and air cooler method occurred at 04:40 p.m. with temperatures of 19.3oC and 20oC. So that the average between the temperatures produced by TEC with water cooler and air cooler

methods is 17.39oC and 18.13oC. Where the temperature produced by TEC with the water cooler method is cooler than the air cooler method in the afternoon.

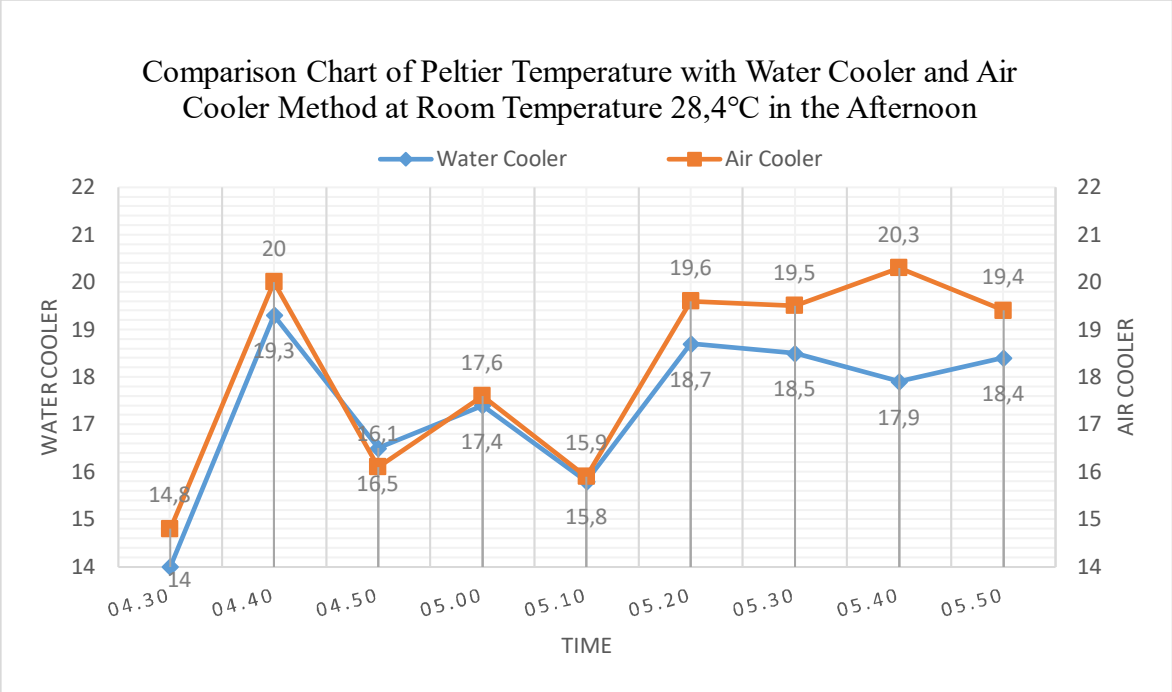

Figure 7. Comparison Chart of Peltier Temperature with Water Cooler and Air Cooler Method at Room Temperature 28,4°C in the Afternoon

From the results of the comparison between TEC using the water cooler and air cooler methods in the morning, afternoon, and evening, the TEC results obtained with the water cooler method are cooler than the air cooler method. But for the results of the comparison of the initial room temperature and the room temperature produced by TEC with the water cooler and air cooler method in the morning, afternoon, and evening can be seen in Figure 8:

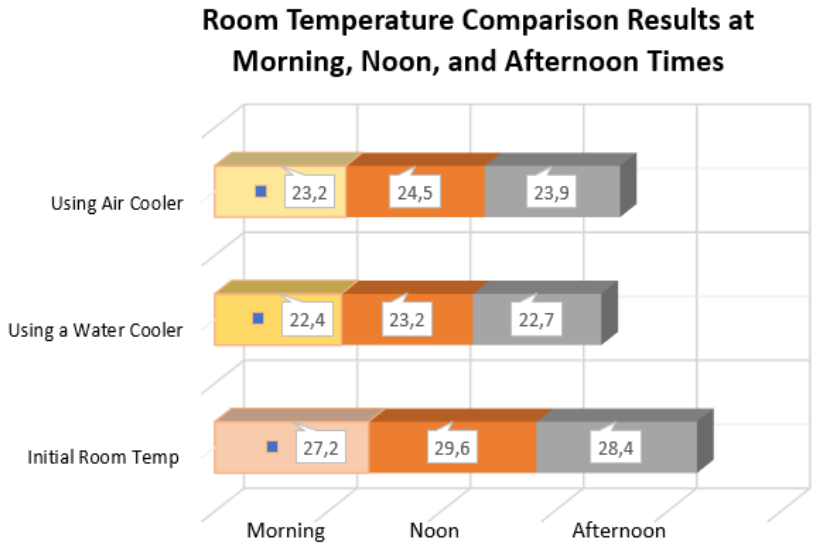

Figure 8. Comparison Chart of Initial Room Temperature and Room Temperature Generated by TEC with Water Cooler and Air Cooler Methods at Morning, Noon, and Afternoon

From the graph above, it can be seen that in the morning with an initial room temperature of 27.2oC can be reduced by TEC using the water cooler method by 4.8oC so that the room temperature obtained is 22.4oC, while TEC using the air cooler method can reduce the room temperature by 4oC

so that the room temperature obtained is 23.2oC. Thus, the room temperature in the morning produced by TEC with the water cooler method can be reduced by 0.8oC greater than the air cooler method. Thus, the room temperature in the morning produced by the TEC with the water cooler method can be reduced by 0.8oC greater than the air cooler method, so the TEC with the water cooler method is cooler than the air cooler method.

At noon with an initial room temperature of 29.6oC can be reduced by TEC using the water cooler method by 6.4oC so that the room temperature obtained is 23.2oC, while TEC using the air cooler method can reduce the room temperature by 5.1oC so that the room temperature obtained is 24.5oC. Thus, the room temperature during the day produced by the TEC with the water cooler method can be reduced by 1.3oC greater than the air cooler method, so the TEC with the water cooler method is cooler than the air cooler method.

While in the afternoon with an initial room temperature of 28.4oC can be reduced by TEC using the water cooler method by 5.7oC so that the room temperature obtained is 22.7oC, while TEC using the air cooler method can reduce the room temperature by 4.5oC so that the room temperature obtained is 23.9oC. Thus, the room temperature in the afternoon produced by the TEC with the water cooler method can be reduced by 1.2oC greater than the air cooler method, so the TEC with the water cooler method is cooler than the air cooler method.

The average between the initial room temperature and the temperature produced by TEC with water cooler and air cooler methods in the morning, afternoon, and evening is 28.4oC in the initial room temperature, 22.8oC in the temperature produced by TEC with water cooler method, and 23.9oC in the temperature produced by TEC with air cooler method. So, it can be concluded that the TEC with the water cooler method is better at cooling a room measuring 1x1 metre than the air cooler method.

4. Conclusion

From the experiments conducted with various scenarios, it can be concluded that the TEC with the water cooler method is better at cooling a room measuring 1x1 metre than the air cooler method.

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