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The Effect of Air Conditioning Load on Air Conditioning System Performance at the Computer Laboratory of UNM Mechanical Engineering Vocation

Nur Fadillah[1], Djuanda[1], Badaruddin Anwar[1], Muhsin Z.[1], Ady Rukma[1]
[1]Mechanical Engineering Vocation, Makassar State University, Makassar, South Sulawesi, Indonesia
E-mail: djuanda@unm.ac.id

Abstract—*This research is a descriptive study to determine the effect of variations in room temperature on the cooling time required for air conditioning machines at the Computer Laboratory of UNM Mechanical Engineering Vocation. Data collection was carried out in two conditions: without a load and with the room being loaded. As a result, the lower the temperature that must be achieved, the longer the cooling time required where overall the minimum temperature that can be achieved is 24°C with the required cooling time of 1,326.35 seconds or 22.11 minutes for the computer on and 1,139.35 seconds or 18.99 minutes for the computer not turning on.*

Keywords— *Room temperature, cooling time, air conditioning, cooling load.*

I. INTRODUCTION

Room temperature is one of the supporting factors for comfort in activities and at rest. Since long time ago, there have been many air conditioning techniques that have been applied by humans to obtain a comfortable room temperature. Until at the beginning of the 20th century, the air conditioning machine was invented, this until now was known by this name Air Conditioner (AC).

Air Conditioner is a machine that functions to regulate and maintain the temperature and humidity of the room so that the room remains cool and comfortable. However, the large use of air conditioners is now not uncommon to find complaints about the performance of the air conditioner itself, one of which is at the Computer Laboratory of Mechanical Engineering Vocation.

With learning activities that involve several people and the use of electronic devices such as computers in it, a cool and comfortable room temperature is needed where to reach the room temperature itself a lower temperature is needed than the initial temperature of the room with the help of air conditioning. Unfortunately, the condition of the room that is cool and comfortable often takes a long time to achieve so that it is enough to affect learning activities that take place in terms of comfort.

Furthermore, apart from the general public's knowledge regarding the effect of indoor cooling load on air conditioning performance, simpler indicators are needed so that it is easier to understand the influencing factors other than the cooling load factor itself, one of which is the degree of room temperature that must be achieved by the air conditioning. Rozaq (2019) concluded that the compressor works when the room temperature has not been reached according to what is set at Air Conditioner and stop when the room temperature is reached as desired.

Based on this, this study aims to find out how the influence of variations in room temperature on the cooling time needed for air conditioning machines at the Computer Laboratory of UNM Mechanical Engineering vocation.

Based on SNI 03-6572-2001 quoted from Sarinda (2017) stipulates that the standard temperature level that is comfortable for Indonesians consists of three parts, namely:

a. Comfortable cool, between effective temperatures of 20.5°C – 22.8°C.
b. Optimum comfort, between effective temperatures of 22.8°C – 25.8°C
c. Comfortable warm, between effective temperatures of 25.8°C – 27.1°C

The results of his study indicate that the ambient temperature in the room changes by time. In general it appears that the room temperature at 06.00 until 17.00 had a significant temperature difference. The average temperature measurement shows that the highest average is in room 35C 201 (28.445°C), while the lowest is in 35E 105 (27.8°C). The average temperature of the four rooms scored above optimal comfort scale, which is 28.1°C, or higher. The lowest average temperature is obtained at 06.00 WIB with 26°C and the highest average is at 13.00 that reached 29.525°C.

Yang (2010) developed an artificial neural network model for predicting optimal precooling times for office buildings. This is a general technique for mapping nonlinear relationships between inputs and outputs without knowing the details of these relationships in building control. system. As a result of performance evaluation using the optimized ANN model, the coefficient of determination (R2) showed a value of 0.99 or higher. It was shown that his optimized ANN can accurately determine the pre-cooling time.

Recent developments in building information modelling (BIM) have introduced enhanced modelling capabilities. Pezeshki et.al (2020) had introduced a new method using

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BIM2BEM to estimate heating and cooling time after starting up an HVAC system. BIM creation is done with the information of a case study model in Autodesk REVIT software. The BIM is then converted to a Finite Element Model (FEM) in COMSOL Metaphysics software and a Building Energy Model (BEM) obtained in winter and summer, preserving anomalies and anomalies, such as the difference in verticality and variable thickness. Then, the cooling and heating time of the whole room after turning on the cooling and heating devices is calculated and compared with the actual results.

Analysis of indoor thermal comfort of different air-conditioning systems had been promoted by Zhao et.al. (2021). It was found that the indoor staff area with personalized air conditioning by radiant cooling had the lowest air supply temperature, PMV and PPD, and air supply rate as required. The thermal comfort effect of the human body is significantly better than that of the other two types of air conditioners, which provides a standard for the design, promotion and application of new air supply air coolers, and personalized cooling air conditioners in real projects.

Mastur et al. (2016) conducted a study on the effects of load variation, cooling time and ambient temperature on cooler performance. The study used split air conditioners with a capacity of PK, as well as to achieve the highest refrigerant mass flow rate, cooling efficiency, compressor capacity and efficiency factor of the variants lamp load. The independent variables in this study are 100 watts, 200 watts, 300 watts, 400 watts, 500 watts. While the relevant variable is the constant rotation of the compressor, refrigerant type 22, the walls of the test installation room are made of plywood. The temperature drop in the space of the test setup becomes slower, as the cooling load increases, as the larger load on the lamp releases more heat into the air. Peak refrigerant mass flow at 500 watt bulb load was 0.060556 kg/s, for 8 minutes. The highest cooling efficiency for a 100 watt lamp load is 202.702 kJ/kg for 20 minutes. Peak compressor power on a 500-watt lamp load was 0.701 kW for 8 minutes. The highest efficiency factor on a 300-watt lamp load is 18.27979 kW for 4 minutes.

Cooling is the process of changing the temperature of an object or room from a high temperature to a low temperature. In addition to changing temperature, cooling also results in a change in phase/state. Based on the understanding of time and cooling, it can be concluded that cooling time is a measure of the length of interval/distance required from an initial temperature condition to a final temperature condition which is lower than the previous temperature.

II. Research Method

This research is a descriptive study by identifying the cooling load factors in the room before taking data on the effect of variations in room temperature on the required cooling time.

The procedure in this study is briefly divided into three stages, namely identifying cooling load factors, preparing research equipment, and conducting research. The equipment used in this study includes split air conditioning, thermocouples, data acquisition devices, laptops, and computers. As for the implementation stage of this research, it was carried out in two conditions, namely the condition of the computer not turning on and the condition of the computer turning on where each condition was researched three times based on the following stages:

1. 1st Condition
   - Installing thermocouples at three points in the room
   - Connect and activate the data acquisition device with the laptop
   - Setting the AC to a temperature of 17°C without turning on the computer in the Computer Laboratory room
   - Calculate and record the time needed for the air conditioner to reach a temperature of 26°C to 23°C
2. 2nd Condition
   - Turn on all computers in the Computer Laboratory room so that the cooling load increases
   - Connect and activate the data acquisition device with the laptop
   - Set the air conditioner to 17°C
   - Calculate and record the time needed for the air conditioner to reach a temperature of 26°C to 23°C

The room used is a computer laboratory of Mechanical Engineering Vocation. The air conditioning system uses 2 split ACs with a capacity of 9000 Btu/h. There are 7 desktop computers in the room. The test room layout is shown in Figure 1.

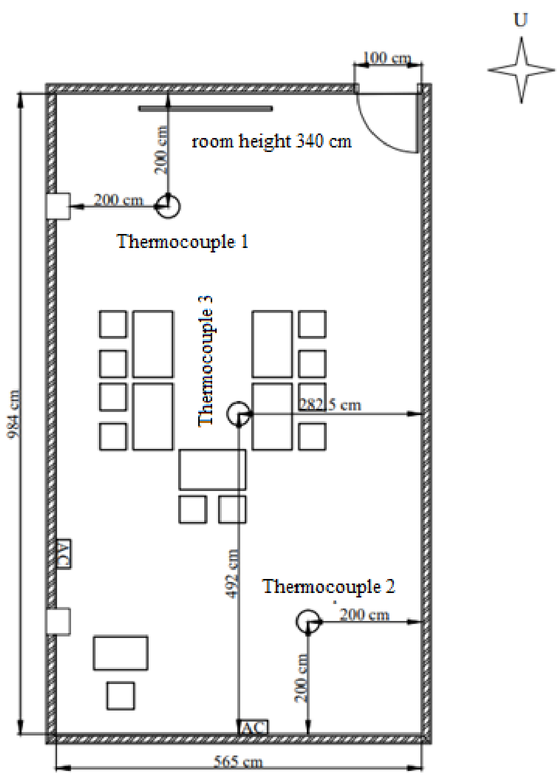

Fig. 1. Test room layout

Measurement of room temperature using a type K thermocouple with the acquisition data used is NI Daq 9074. The programming language used isLabVIEW.

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III. Result And Discussion

Based on the data collection that has been done, several cooling time measurement results are obtained as follows:

1. The Cooling Time Required by the Air Conditioning Machine for Variations in Room Temperature with the Computer Not Turning On

In collecting this data, three measurement results were obtained from each thermocouple. The first measurement is on thermocouple 1 which is located farthest. The results of measuring the cooling time needed by the air conditioning by thermocouple 1 can be seen in the following table:

TABLE 1. Cooling time for variations in room temperature the condition of the computer does not turn on by thermocouple 1

Temperature targets (°C)	Cooling time (s)			Average
	I	II	III	
26	219.24	493.92	480.76	397.97
25	1,099.28	1,232.84	951.16	1,094.43
24	2,496.76	1,857.80	1,345.96	1,900.17
23	4,137.56	-	-	4,137.56

The results of measuring the cooling time required for air conditioning by thermocouple 2 can be seen in the following table:

TABLE 2. Cooling time for variations in room temperature the condition of the computer does not turn on by thermocouple 2

Temperature targets (°C)	Cooling time (s)			Average
	I	II	III	
26	96.32	71.12	96.04	87.83
25	187.32	147.28	430.36	254.99
24	609	335.72	557.76	500.83
23	1,116.36	889.28	1,554.56	1,186.73

The results of measuring the cooling time needed by the air conditioning machine by thermocouple 3 can be seen in the following table:

TABLE 3. Cooling time for variations in room temperature the condition of the computer does not turn on by thermocouple 3

Temperature targets (°C)	Cooling time (s)			Average
	I	II	III	
26	132.44	155.68	152.32	146.81
25	284.48	363.72	428.12	358.77
24	846.44	1,182.72	1,022	1,017.05
23	1,538.60	1,888.04	2,179.52	1,868.72

From the measurement results obtained for each thermocouple, the effect of variations in room temperature on the cooling time required for the air conditioning machine when the computer is not turned on can be described as follows:

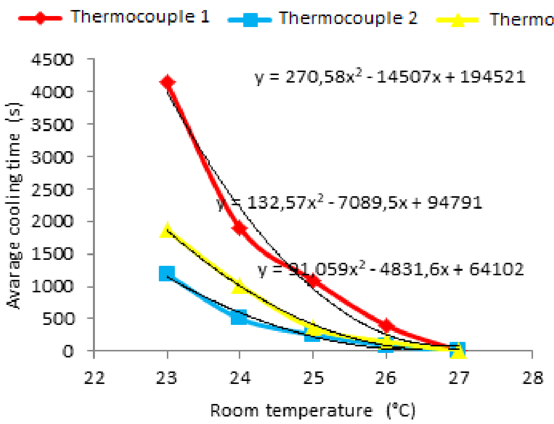

Fig. 2. Graph of cooling time required for air conditioning to variations in room temperature with the computer off

Based on the graph, it can be understood that the thermocouple that takes the longest time to reach a certain room temperature is thermocouple 1 where the minimum temperature that can be achieved is 23°C with the required cooling time is 4,137.56 seconds or 68.96 minutes. While the thermocouple that takes the fastest time to reach a certain room temperature is thermocouple 2 followed by thermocouple 3 where both of them are able to reach a temperature of 23°C with respective times of 1,186.73 seconds or 19.79 minutes and 1,868.72 seconds or 31.45 minutes.

This is caused by the difference in the location of the three thermocouples where thermocouple 1 is located farthest from the two air conditioners. Thermocouple 2 is located closest to the air conditioner, while thermocouple 3 is located in the middle of the room.

2. Cooling time required for air conditioning for variations in room temperature with the computer on

In data collection with the computer on, three measurement results were obtained from each thermocouple. The first measurement is by thermocouple 1 which is located farthest from the two air conditioning machines. The results of measuring the cooling time needed by the air conditioning machine by thermocouple 1 can be seen in the following table:

TABLE 4. Cooling time for variations in room temperature with the computer on (Thermocouple 1)

Temperature targets (°C)	Cooling time (s)			Average
	I	II	III	
26	705.04	723.52	367.36	598.64
25	1,448.72	1,074.36	886.20	1,136.43
24	-	2,274.16	1,409.80	1,841.98
23	-	-	-	-

The results of measuring the cooling time needed by the air conditioning by thermocouple 2 can be seen in the following table:

TABLE 5. Cooling time for variations in room temperature with the computer on (Thermocouple 2)

Temperature targets (°C)	Cooling time (s)			Average
	I	II	III	
26	93.80	127.40	80.64	100.61
25	421.12	188.16	148.96	252.75
24	1,730.68	402.08	306.32	813.03
23	2,221.80	1,247.68	1,06792	1,512.47

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The last one is thermocouple 3 which is located in the middle of the room. The results of measuring the cooling time required for air conditioning by thermocouple 3 can be seen in the following table:

TABLE 6. Cooling time for variations in room temperature with the computer on (Thermocouple 3)

Temperature targets (°C)	Cooling time (s)			Average
	I	II	III	
26	302.68	232.12	126.28	220.36
25	954.24	613.20	362.88	643.44
24	2,122.96	1,050	799.12	1,324.03
23	-	2,314.76	1,792.56	2,053.66

From the results obtained for each thermocouple, the effect of variations in room temperature on the cooling time required for the air conditioning when the computer is on can be described as follows:

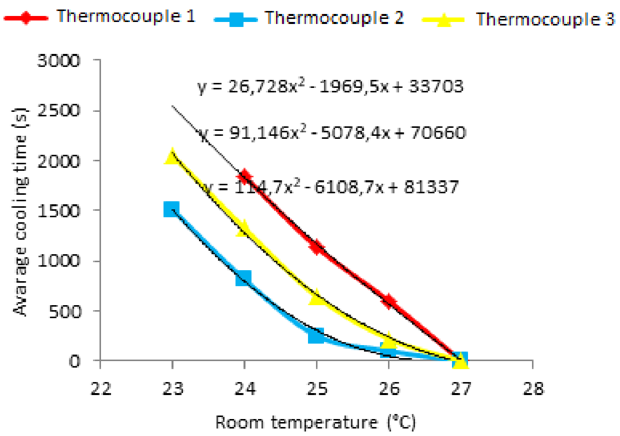

Fig. 3. Graph of cooling time required for air conditioning to variations in room temperature with the computer on

Based on the graph, it can be understood that the thermocouple that takes the longest time to reach a certain room temperature is thermocouple 1 where the minimum temperature that can be achieved is 24°C with the required cooling time is 1,841.98 seconds or 30.70 minutes. While the thermocouple that takes the fastest time to reach a certain room temperature is thermocouple 2 followed by thermocouple 3 where both of them are able to reach a temperature of 23°C with a time of 1,512.47 seconds or 25.21 minutes and 2,053.66 seconds or 34.23 minutes respectively.

The difference in the required cooling time and the minimum temperature that can be achieved by the three thermocouples is caused by the capacity of the air conditioner installed in the room is only 2 HP while the area of the conditioned room is 55,596 m^2 with an increased cooling load from the previous condition. This is what causes the distribution of conditioned air to be uneven so that thermocouple 1 is unable to reach a temperature of 23°C while thermocouples 2 and 3 are able to reach a temperature of 23°C with different cooling times required by both.

3. Comparison of cooling time required for an air conditioning to variations in room temperature by the two Conditions

Based on the measurement of the cooling time needed by the three thermocouples for each condition, the average cooling time for the room as a whole can be obtained. First, the average overall cooling time for the room when the computer is not turned on can be seen in the following table:

TABLE 7. Average cooling time overall room computer turn off

Temperature targets (°C)	Average cooling time of thermocouple (s)			Average
	1	2	3	
26	397.97	87.83	146.81	210.87
25	1,094.43	254.99	358.77	569.40
24	1,900.17	500.83	1.017.05	1,139.35

Whereas the average cooling time for the room as a whole when the computer is on can be seen in the following table:

TABLE 8. Average cooling time overall room computer turn on

Temperature targets (°C)	Average cooling time of thermocouple (s)			Average
	1	2	3	
26	598.64	100.61	220.36	306.54
25	1,136.43	252.75	643.44	677.54
24	1,841.98	813.03	1,324.03	1,326.35

Based on these two tables, it can be seen that the two conditions have differences in the cooling time required for air conditioning to variations in room temperature which are quite significant. These differences can be seen in the following comparison chart:

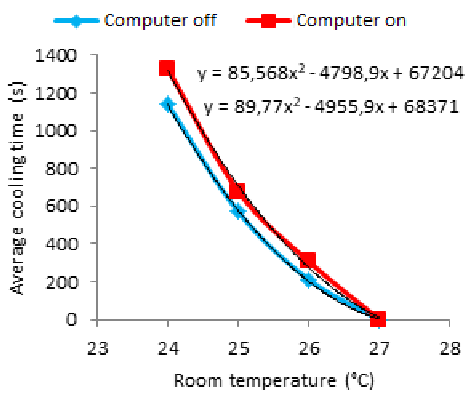

Fig. 4. Graph of comparison of cooling time required by air conditioning for both conditions

From this graph it can be understood that air conditioning which works when the computer is on is generally capable of reaching a minimum temperature of 24°C with an average cooling time of 1,326.35 seconds or 22.11 minutes. In contrast to the air conditioning machine that works when the computer is not turned on which is able to reach a minimum temperature of 24°C with an average cooling time of 1,139.35 seconds or 18.99 minutes.

This is caused by the capacity of the air conditioner installed in the room is only 2 HP while the conditioned area of the room is 55,596 m^2 with a cooling load that increases from 17,544.2782 Btu/h when the computer is not on to 18,544.9082 Btu/h when the computer is on. This is in accordance with the results of research conducted by Mastur

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et.al (2016) which resulted in several conclusions, one of which stated that the temperature drop in the test installation room was slower due to the increased cooling load. This is because a greater cooling load will release greater heat into the room.

In addition, based on the graph, it can also be understood that in addition to air conditioning which works when the computer is on as a whole, it requires a longer cooling time than when working when the computer is not turned on, also the lower the temperature that is set, the longer the cooling time needed to reach that temperature. This supports the research conducted by Rozaq (2019) which states that the compressor works when the room temperature has not been reached according to what is set in air conditioning and stops when the room temperature has been reached as desired.

IV. Conclusion

Based on the results and discussion in the previous chapter, it can be concluded that at the Computer Laboratory of UNM Mechanical Engineering Vocation the lower the temperature that must be achieved by the air conditioning machine, the longer the cooling time needed to reach that temperature where overall the minimum temperature that can be achieved at both conditions are 24°C with the required cooling time respectively 1,326.35 seconds or 22.11 minutes for the computer on and 1,139.35 seconds or 18.99 minutes for the computer not on.

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