International Journal of Electrical, Energy and Power System Engineering (IJEEPSE)
e-ISSN: 2654-4644
Vol. 6, No. 1, pp. 126-132, February 2023
http://www.ijeepse.id

Optimization Position Variable Refrigerant Flow In Building Using CFD Method

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Abstract— Variable refrigerant flow type is a multi-split type air conditioner for multi-story buildings. The aim of this study getting obtains optimization placement of the condensing unit to inlet air temperature in a multi-story building using the CFD method. The simulation was conducted from the 11th to the 30th floor. There are three variations of condensing unit position on each floor (Variation 1), on every two floors (Variation 2), and on the roof (variation 3). The result of the first variation is 35.32 °C, with the difference between the highest and lowest is 3.9 °C. The average temperature of the 2nd variation is 34.44 °C, with the difference between the highest and lowest being 0.92 °C. The average temperature of the 3rd variation is 36.65 °C, with the difference between the highest and lowest being 8.03 °C. Among the three variations, the 2nd variation of the condensing unit input air temperature is lower. Then the difference between the highest and lowest temperatures is not too far apart, indicating a more even distribution of air. The 1st, 2nd, and 3rd variations condensing unit position do not exceed Panasonic VRF air conditioner operational temperature limit, which is 52 °C.

Keywords— variable refrigerant flow, CFD, condensing unit, air temperature, multi-story building.

I. Introduction

As the population of Jakarta increases from 2010 to 2020 it reaches 954.3 thousand people [1] with a density of 15,900 people per km2 [2] which has an impact on the needs of residential, offices, hospitals, and other commercial buildings. This is marked by the construction growth in Jakarta from 2018 to 2019, which is around 17.52 % [2]. The construction of multi-story buildings is very suitable for areas that have limited land, such as Jakarta.

The air temperature in Jakarta can be reached 34,2 °C [3], which is related to the need for air conditioning so that building users in Jakarta experience thermal comfort. One type of air conditioner suitable for multi-story buildings is the variable refrigerant flow (VRF) type. Using VRF-type air conditioners obtained energy savings and potential cost savings, reliability, and flexibility in operation [4]. Kwon (2013) researched evaluating the multi-function VRF-type air conditioner. When the ambient temperature increases, it caused the condensing temperature of the condensing unit to be higher, so that the COP_{actual} value decreases [5] [6]. Faldian (2017) got results that increasing the distance between the barrier grille and the condensing unit effect increases pressure and temperature. It involved an increase in electricity consumption-, and a decrease in cooling capacity [7]. Jin (2015) got the result that an increase in EER caused an increasing distance from the wall [8]. This can sometimes interfere with the operation of the air conditioner when the outside air temperature exceeds the safe operating temperature limit in the specifications of the air conditioner. The placement change of the condensing unit from 5 cm to 20 cm resulted in a faster cooling rate of 40 minutes, 12 % lower condensation pressure, 18% lower compression work, 9 % increased refrigeration effect, and 30% increased COP [9]. Yin Zhang (2017) researched a 30-story building using VRF-type air conditioning. The condensing unit inlet air average temperature was reduced by 22 % because the condensing unit was placed at intervals of two floors compared to each floor [10].

In this study, there were 3 variations in the placement of the condensing unit from the 11th to the 30th floor. Several variations were made, 1st variation condensing unit (CU) was placed on each floor, the 2nd variation CU was placed at intervals of two floors, and the 3rd variation CU was placed on the roof by the computational fluid dynamics (CFD) method. The aim of this study getting obtains optimization placement of the VRF air conditioning unit.

II. Methodology

A. Research Method

Fig. 1 describes the steps of this study.

B. Preliminary Data on Building Conditions

This study uses the design of an apartment building in the Jakarta area. The total number of floors is 30 floors. Floors 11 to 30 are used as residences, so the air conditioning of these floors is simulated using Ansys FLUENT. Meanwhile, floors 1 to 10 were not simulated because of parking areas and public facilities. Each floor consists of VRF-type air conditioning systems. The air temperature in Jakarta is 34,2 °C [3]. The distance between the condensing units was 700 mm [11].

Table I is the cooling load of System 1. System 1 consists of 14 evaporating units connected by refrigerant pipes to the condensing unit. The total cooling load of System 1 is 76.6

kW. So that the required condensing unit is the same as the cooling load, which is 76.6 kW. The unit code of the condensing unit is CU-1130/S1. CU indicates a condensing unit that is placed outdoors to remove hot air from the condenser. 11~30 is an 11 to 30-floor number. S1 represents the system to -1, or 76.6 kW. Then, in the Panasonic VRF-type air conditioning catalog, a condensing unit with a capacity of close to 76.6 kW was selected, namely a condensing unit with the model name U-12ME2H7 combined with U-16ME2H7. The combined capacity of the U-12ME2H7 and U-16ME2H7 is 78.5 kW.

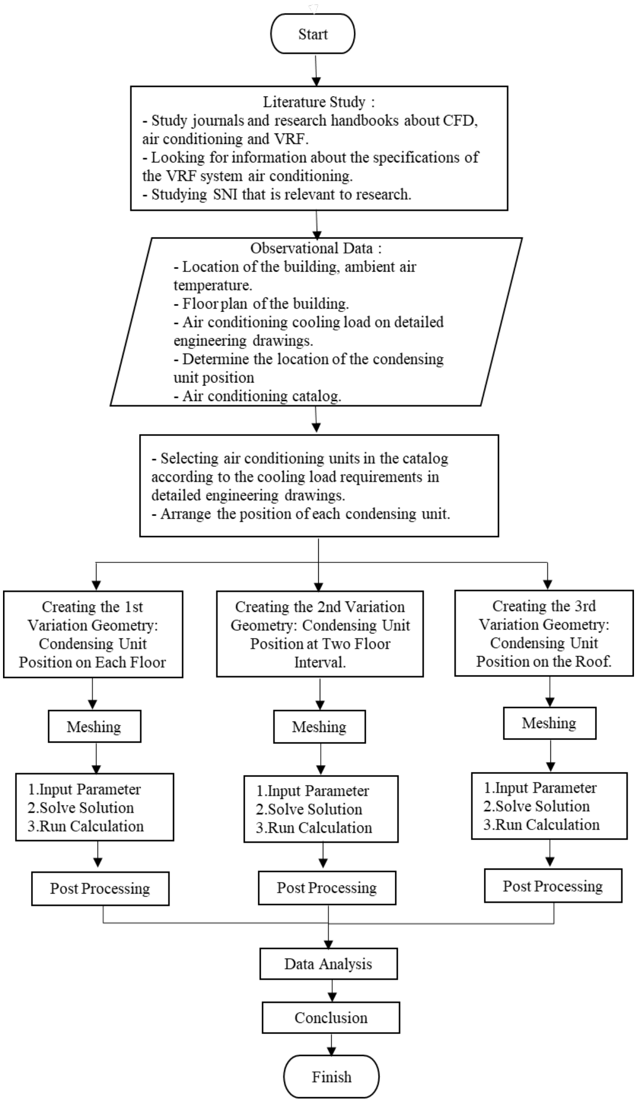

Fig 1. Flowchart of Research

TABLE I. COOLING LOADING EACH FLOOR – SYSTEM 1 [12]

Unit Code	Type	Room	Cooling Load (kW)	Qty	Total Cooling Load (kW)
FCU/1BR-LV	Duct	Living Room	4.5	6	27
FCU/1BR-BR	Duct	Bedroom	3.6	6	21.6
FCU/LL	Duct	Lift Lobby	5.6	1	5.6
FCU/COR.1~2	Duct	Corridor	22.4	1	22.4
CU-11~30/S1	**CU VRF – System 1**			**1**	**76.6**

Table II is the cooling load on System 2. System 2 consists of 13 evaporating units, which are connected via refrigerant pipes to the condensing unit. The total cooling load for system 2 is 54.9 kW. so that the required condensing unit is the same as the cooling load, which is equal to 54.9 kW. The unit code of the condensing unit is CU-1130/S2. CU indicates a condensing unit that is placed outdoors to remove hot air from the condenser. 1130 is 11 to 30-floor number. S2 is the second system, which is 54.9 kW. Then, in the Panasonic VRF type air conditioning catalog, a condensing unit with a capacity of close to 76.6 kW was selected, namely a condensing unit with the model name U-20ME2H7. The capacity of the U-20ME2H7 is 56 kW.

TABEL II. COOLING LOADING PER FLOOR – SYSTEM 2 [12]

Unit Code	Type	Room	Cooling Load (kW)	Qty	Total Cooling Load (kW)
FCU/2BR-MBR	Duct	Master Bedroom	5.6	1	5.6
FCU/2BR-LV.1&2	Duct	Living Room	3.6	2	7.2
FCU/2BR-BR	Duct	Bedroom	2.8	1	2.8
FCU/1BR-LV	Duct	Living Room	4.5	2	9
FCU/1BR-BR	Duct	Bedroom	3.6	2	7.2
FCU/STD	Duct	Bedroom	5.6	2	11.2
FCU/2BR-MBR	Duct	Master Bedroom	3.5	1	3.5
FCU/2BR-LV	Duct	Living Room	5.6	1	5.6
FCU/2BR-BR	Duct	Bedroom	2.8	1	2.8
CU-11~30/S2	**CU VRF - System 2**			**1**	**54.9**

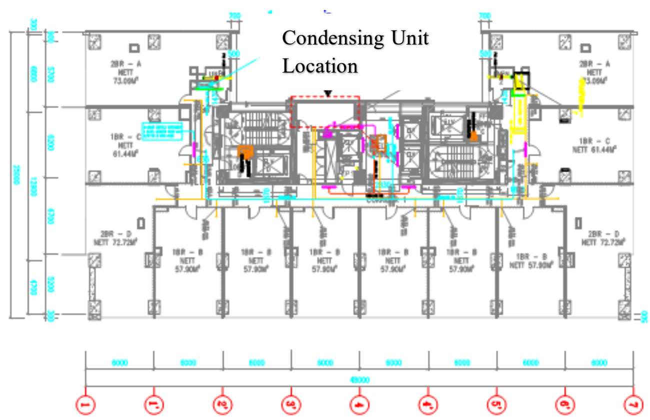

Fig. 2. Typical Layout of Floors 11 to 30[12]

In this study, there are three variations :

- In 1st variation, condensing units were placed on each floor of the building as shown in fig. 2. The typical layout was floored from 11 to 30. so that each floor will have 3 condensing units, namely U-20ME2H7, U-16ME2H7, and U-12ME2H7. The total number of condensing units was 60.
- In 2nd variation, condensing units were placed at intervals of every 2 floors of the building as shown in fig.2, which had a typical layout of floors 11 to 30. So, for every two floors, there will be six condensing units:

Received: Feb 17, 2023 | Revised: Feb 26, 2023 | Accepted: Feb 28, 2023

U-20ME2H7, U-16ME2H7, and U-12ME2H7. The total number of condensing units was 60.

- In 3rd variation, the condensing units were placed on the roof as shown in fig 3., the typical layout of the roof floor. The total number of condensing units is 60 was placed on the roof.

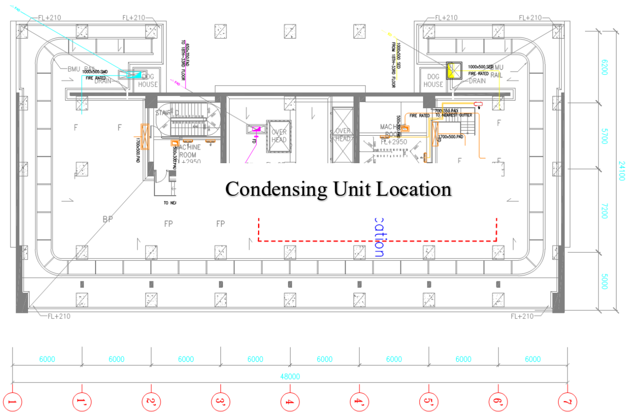

Fig. 3. Typical Roof Floor Layout[12]

Table III is Panasonic VRF type air conditioners specification [13]:

TABLE III. COOLING LOAD PER FLOOR – SYSTEM 2

CU Panasonic	Air Flow (m^3/h)	Air Flow (m^3/s)	Mass Flow kg/s	Qe (kW)	COP
U-12ME2H7	13920	3.867	4.736	33.5	4.73
U-16ME2H7	13920	3.867	4.736	45	4.13
U-20ME2H7	24300	6.750	8.268	56	3.76

C. Calculation of Parameters Required in the Simulation

In fig. 4, Qe is the heat energy absorbed by the evaporator from the conditioned room. Qc is the heat energy that is discharged into the environment. This can happen because of the work that is put into the vapor compression system.

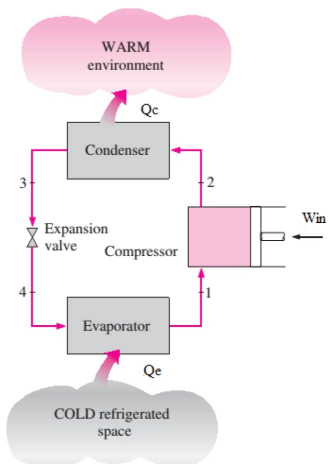

Fig. 4. Schematic of Vapor Compression Air Conditioning System Schematic [14].

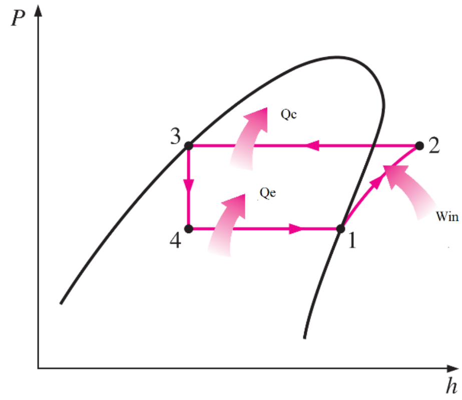

Fig. 5. Diagram p-h of Vapor Compression Air Conditioning System p-h diagram [14].

From fig. 5 obtained the following correlation [14]:

$$Qc = Qe + Win \tag{1}$$

$$Win = Qc - Qe \tag{2}$$

$$COP = \frac{Qe}{Win} \tag{3}$$

By substituting equation (2) into equation (3), we obtain equation (4).

$$COP = \frac{Qe}{(Qc-Qe)} \tag{4}$$

Which:

Qe = Cooling Load (Watt)

Qc = The amount of heat released in the condenser (Watt)

Win = Compression Work (Watt)

COP = Coefficient of performance

Then, to calculate the temperature of the air leaving the condenser using equation (5) [15]:

$$Qc = (\dot{m}) \times Cp \times \Delta T \tag{5}$$

$$\Delta T = To - Tin \tag{6}$$

Which :

Qc = The amount of heat released by the condenser (Watt atau J/s)

$\dot{m}$ = Mass flow rate (kg/s)

Cp = Specific heat capacity of air 1006.43 (J/kg.K)

ΔT = To-Ti temperature difference

To = Temperature of the air leaving the condenser

Ti = Temperature of the air entering the condenser

Velocity can be calculated using equation (7)[15]:

$$\dot{v} = A\ x\ v \tag{7}$$

D. Geometry

Fig. 6(a) shows a variation in the placement of one condensing unit on each floor. Figure 5(b). The second variation is the placement of condensing units at intervals of two floors. Figure 6. The third variation of the placement of the condensing unit on the rooftop.

Received: Feb 17, 2023 | Revised: Feb 26, 2023 | Accepted: Feb 28, 2023

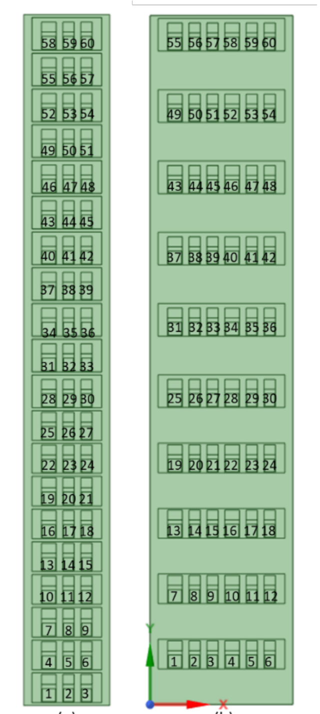

Figure 6. Condensing unit geometry (a) Variation 1: per floor (b) Variation 2: 2-floor intervals

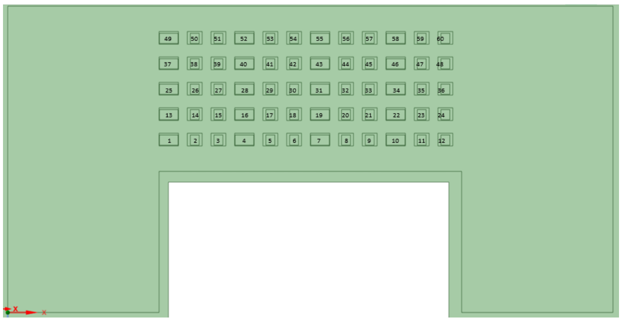

Figure 7. Condensing Unit Geometry Variation 3 in the roof floor

Condensing units with numbers 1, 4, 7, 10, 13, 16, 19, 22, 25, 28, 31, 34, 37, 40, 43, 46, 49, 52, 55, and 58 use the Panasonic VRF condensing unit model U-20ME2H7, with a cooling capacity of 20 hp. Condensing units with numbers 2, 5, 8, 11, 14, 17, 20, 23, 26, 29, 32, 35, 38, 41, 44, 47, 50, 53, 56, and 59 use the Panasonic VRF condensing unit model U-16ME2H7, with a cooling capacity of 16 hp. Condensing units with numbers 3, 6, 9, 12, 15, 18, 21, 24, 27, 30, 33, 36, 39, 42, 45, 48, 51, 54, 57, and 60 use the Panasonic VRF condensing unit model U-12ME2H7, with a cooling capacity of 12 hp.

III. Result And Discussion

A. Parameters Required in CFD Simulation

Parameters that have been calculated are needed when setting up boundary conditions. These parameters are calculated in tables IV, V, and VI.

TABLE IV. BOUNDARY CONDITION SET UP – OUTLET CONDENSING UNIT PLACEMENT, VARIATION 1 ON EACH FLOOR AND VARIATION 2 ON EVERY TWO FLOOR

Floor	Model	Boundary	Type	Parameter	
				V (m/s)	T (°C)
Floor 11 to 30 Typical	U-20ME2H7	Outlet CU1.1	Velocity	3.28	42.72
	U-16ME2H7	Outlet CU1.2	Velocity	4.38	45.92
	U-12ME2H7	Outlet CU1.3	Velocity	4.38	42.71

TABLE V. BOUNDARY CONDITION SET UP – OUTLET CONDENSING UNIT PLACEMENT VARIATION 3, IN THE ROOF FLOOR

Floor	Model	Boundary	Type	Parameter	
				V (m/s)	T (°C)
Floor 11 to 30 Typical	U-20ME2H7	Outlet CU1.1	Velocity	5.68	42.72
	U-16ME2H7	Outlet CU1.2	Velocity	6.79	45.92
	U-12ME2H7	Outlet CU1.3	Velocity	6.79	42.71

TABLE VI. BOUNDARY CONDITION SET UP – OUTLET CONDENSING UNIT POSITION VARIATION 3, IN THE ROOF FLOOR

Floor	Model	Boundary	Type	Parameter
				Mass Flow Rate (kg/s)
Floor 11 to 30 Typical	U-20ME2H7	Inlet CU1.1	Mass Flow Rate	8.268
	U-16ME2H7	Inlet CU1.2	Mass Flow Rate	4.736
	U-12ME2H7	Inlet CU1.3	Mass Flow Rate	4.736

B. Air Temperature Distribution in 1st Variation

In fig. 8, the color contour of the outlet air temperature of the condensing unit U-20ME2H7 is yellow around 42.3 °C. Because almost the hot air from the condensing unit is released into the free air, the inlet air temperature condensing unit has a dark blue color. In Figure 8, the average air temperature entering the condensing unit is 34.74 °C. The lowest air temperature entering the condensing unit is 34.24 °C, while the highest air temperature entering the condensing unit is 35.11 °C.

In fig. 9, the contour of the air temperature coming out of the condensing unit is around 45 °C; this is consistent with the analytical temperature coming out of the condensing unit U-16ME2H7, which is higher than the other condensing units. Because only some of the hot air from the condensing unit is released into the free air, some of the air enters the condensing unit above and below it. The average air temperature entering the condensing unit is 36.83 °C. The lowest air temperature entering the condensing unit is 34.28 °C, while the highest air temperature entering the condensing unit is 38.11 °C.

In fig. 9, the contour of the air temperature coming out of the condensing unit U-12ME2H7 is yellow around 42.3 °C. Because almost all of the hot air from the condensing unit is released into the free air, the air entering the condensing unit has a dark blue temperature. In Figure 8, the average air temperature entering the condensing unit is 34.4 °C. The lowest air temperature entering the condensing unit is 34.22 °C, while the highest air temperature entering the condensing unit is 34.56 °C.

Received: Feb 17, 2023 | Revised: Feb 26, 2023 | Accepted: Feb 28, 2023

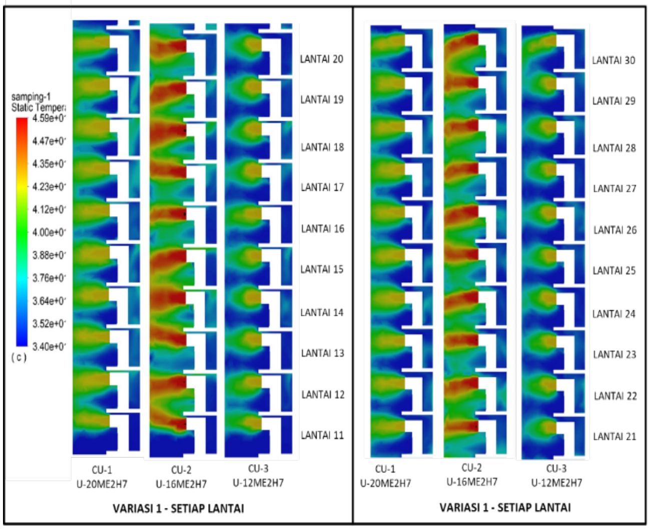

Fig. 8. Air Temperature Distribution in Variation 1 (Condensing Unit Placement on each floor).

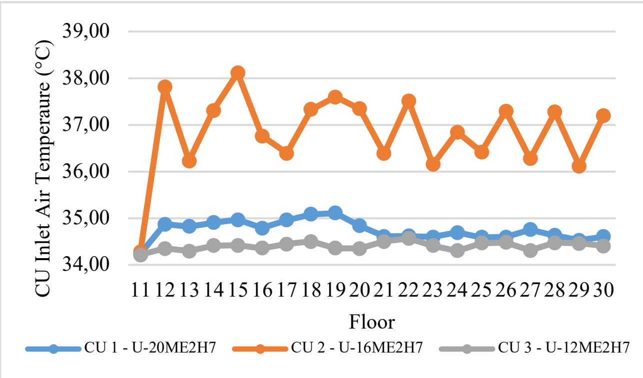

Fig. 9. Inlet AirTemperature Curve, Condensing Unit Variation 1, Placement on Each Floor

C. *Air Temperature Distribution 2nd Variation*

In fig. 10, the three condensing units are on the left for odd floors, starting from floors 11 to 19. The air released by the condensing units is not sucked in by the condensing units on the upper floors or the lower floors because the vertical distance between the condensing units is quite far, up to 3.3 meters. However, as seen in Figure 10, there are fluctuations in the temperature of the air entering the condensing unit. This is because six condensing units are placed horizontally.

Fig 11. the condensing unit U-20ME2H7 for even floors is higher than for odd floors. This is because the floor condensing unit is located in the middle. The average air temperature entering the condensing unit is 34.42 °C. The lowest air temperature entering the condensing unit is 34.28 °C, while the highest air temperature entering the condensing unit is 34.76 °C.

The average temperature of the air entering the condensing unit U-16ME2H7 is 34.39 °C. The lowest air temperature entering the condensing unit is 34.28 °C, while the highest air temperature entering the condensing unit is 34.66 °C. The condensing unit U-12ME2H7 for odd floors is higher than for even floors. This is because the condensing units with odd floors are located in the middle. The average air temperature entering the condensing unit is 34.5 °C. The lowest air temperature entering the condensing unit is 34.23 °C, while the highest air temperature entering the condensing unit is 35.15 °C.

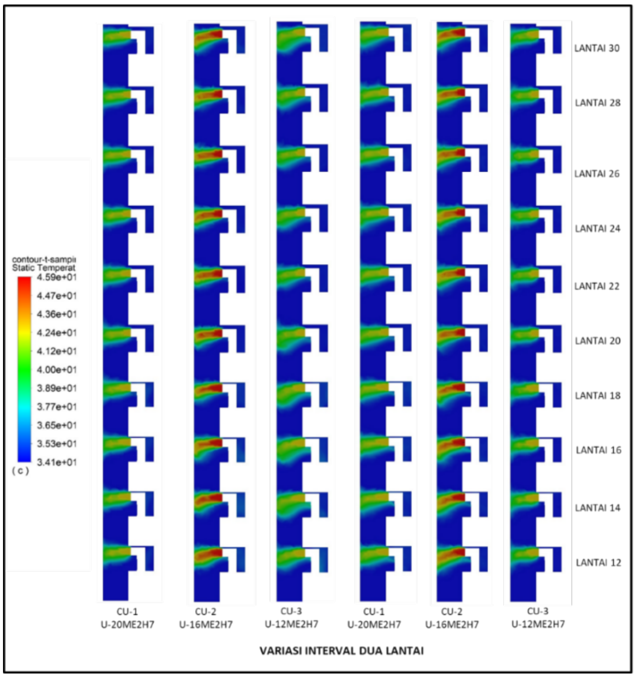

Fig. 10. Air Temperature Distribution in Variation 2 (Condensing Unit Placement on Interval Two floor)

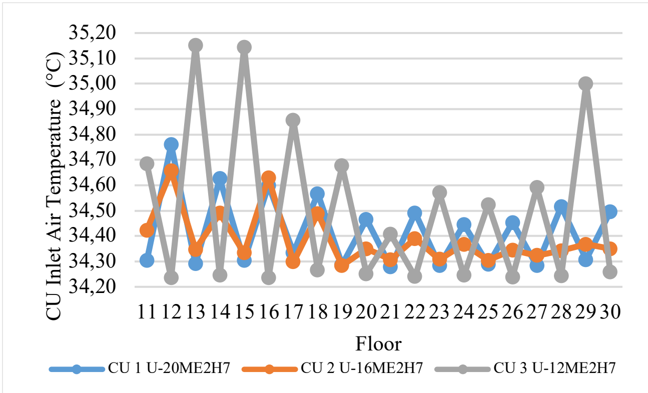

Fig. 11. Inlet Air Temperature Curve, Condensing Unit Variation 2, Placement on Interval Two Floor.

D. *Air Temperature Distribution 3rd Variation*

In the placement of the third variation of the condensing unit, it is placed on the roof floor. Column 1 is located on the far left, and column 12 is located on the far right. In fig. 12, Heat collects in the middle column. It can be seen from columns 2–11 that the air temperature is dominated by yellow, green, and red.

Fig. 13 shows the temperature curve of the air entering the condensing unit for each floor. The air temperature began to rise from the 14th to the 20th floors, then fell from the 21st to the 26th floors. Except for the 18th floor, 22 condensing units numbered 3 and 2 experienced a decrease in temperature due to their location on the outer side, where they were close to the surrounding air and not exposed to heat from other air condensing unit exhaust. Also, except for the 19th floor, 23 condensing unit number 1 experienced a temperature decrease because its location was on the outer side, close to the surrounding air, and not exposed to heat from other condensing unit air coming out.

Received: Feb 17, 2023 | Revised: Feb 26, 2023 | Accepted: Feb 28, 2023

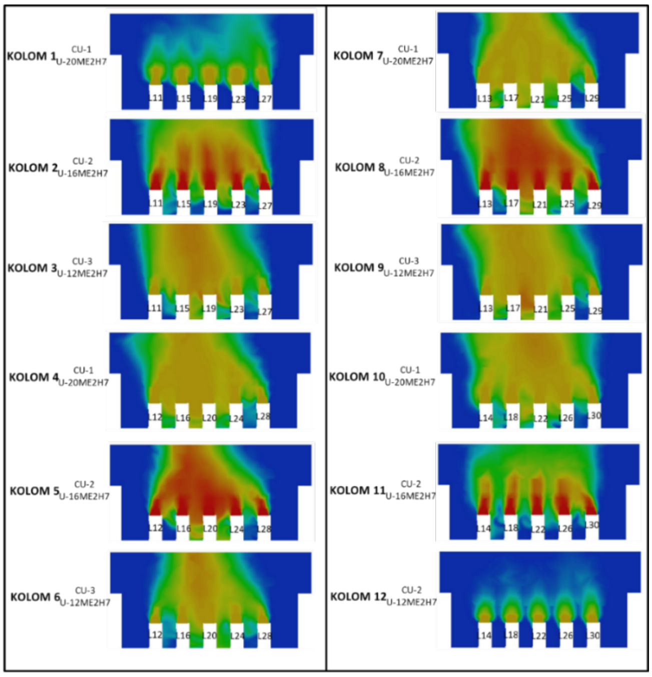

Fig. 12. Air Temperature Distribution in Variation 3, Condensing Unit Placement on the Rooftop.

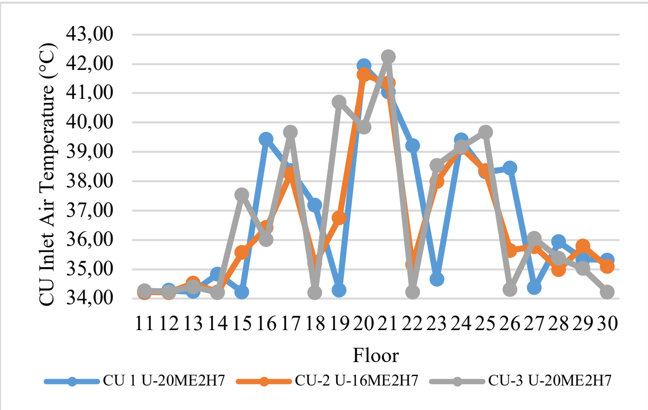

Fig. 13. Inlet Air Temperature Curve, Condensing Unit Variation 3, Placement on the Rooftop.

The average air temperature entering the U-20ME2H7 condensing unit is 36.75 °C. The lowest air temperature entering the condensing unit is 34.2 °C, while the highest air temperature entering the condensing unit is 41.94 °C. The average air temperature entering the U-16ME2H7 condensing unit is 36.51 °C. The lowest air temperature entering the condensing unit is 34.21 °C, while the highest air temperature entering the condensing unit is 41.63 °C. The average air temperature entering the U-12ME2H7 condensing unit is 36.69 °C. The lowest air temperature entering the condensing unit is 34.2 °C, while the highest air temperature entering the condensing unit is 42.23 °C.

E. Discussion Analysis

The first variation is the placement of the condensing unit on each floor. In this study, the temperature only changed slightly. Meanwhile, in Yin Zhang's research, the air temperature increases as the floors rise. This study did not use grilles on the facade of the building so that the hot air that comes out of the condensing unit can be released freely into the outside air. And as a result, the hot air coming out of the condensing unit is not sucked into the input side of the condensing unit. It can be seen in Fig. 14 that the temperature of variation 1 in this study is relatively low. Meanwhile, in Yin Zhang's research, grilles were installed on the facade of the building so that the hot air coming out of the condensing unit was held back by the grilles. which resulted in the return air being sucked in by the condensing unit, which can be seen in fig. 14. The temperature of variation 1 of Yin Zhang's research was relatively high. Then the air coming out of the condensing unit is sucked in by another condensing unit that is on a higher floor.

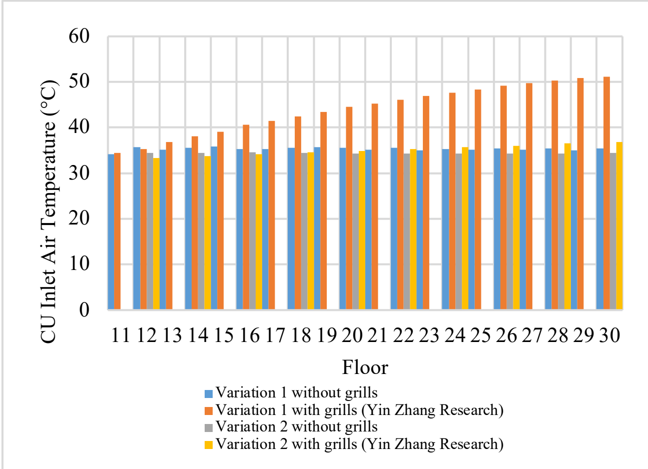

Fig. 14. Inlet Air Temperature Curve for Condensing Unit Variations 1st and 2nd in this study and other studies.

The second variation is the placement of the condensing units at intervals of two floors. Both in this study and in Yin Zhang's study, the temperature at the outlet of the condensing unit from the 11th to the 30th floor changed only slightly. This is due to the distance between the condensing unit on the lower floor and the one above, which is 3.3 meters wide. So the possibility of air being sucked in by the condensing unit on the upper floors is low.

IV. Conclusion

The average temperature of the 1st variation is 35.32 °C, with the highest and lowest differences being 3.9 °C. The average temperature of the 2nd variation is 34.44 °C, with the highest and lowest differences being 0.92 °C. The average temperature of the third variation is 36.65 °C, with the highest and lowest differences being 8.03 °C. The 2nd variation is more optimal than 1st variation, and 3rd variation. Because the inlet air temperature of the condensing unit is the lowest. Then the difference between the highest and lowest temperatures is not too far apart, indicating even air distribution. The inlet air temperature of condensing units in all variations does not exceed the operating temperature limit of the Panasonic VRF conditioner, which is 52 °C.

Acknowledgment

We gratefully acknowledge and appreciate Laboratorium Teknik Mesin, FTI, and Universitas Trisakti, for their outstanding contribution to this research.

References

[1] BPS, "Hasil Sensus Penduduk 2020 - DKI Jakarta," Sensus Pendud. 2020, vol. 6, no. 5, pp. 1–18, 2020.

[2] 2020 Badan Pusat Statistik, Konstruksi Dalam Angka. 2020.

[3] Badan Standar Nasional Indonesia, "SNI No. 03-6572-2001 Konservasi Energi Sistem Tata Udara pada Bangunan Gedung," 2020.

Received: Feb 17, 2023 | Revised: Feb 26, 2023 | Accepted: Feb 28, 2023

[4] T. N. Aynur, Y. Hwang, and R. Radermacher, “Simulation comparison of VAV and VRF air conditioning systems in an existing building for the cooling season,” Energy Build., vol. 41, no. 11, pp. 1143–1150, 2009.

[5] L. Kwon, “Experimental Evaluation of a Multifunctional Variable Refrigerant Flow System in an Educational Office Building,” University of Maryland, College Park, 2013.

[6] M. Bruelisauer, F. Meggers, E. Saber, C. Li, and H. Leibundgut, “Stuck in a stack - Temperature measurements of the microclimate around split type condensing units in a high rise building in Singapore,” Energy Build., vol. 71, pp. 28–37, Mar. 2014.

[7] Faldian, “Kajian pengaruh jarak penghalang pada sisi masukan udara kondenser terhadap konsumsi energi dan kapasitas pendinginan mesin tata udara,” in Prosiding Seminar Nasional XII "Rekayasa Teknologi Industri dan Informasi 2017 Sekolah Tinggi Teknologi Nasiona Yogyakarta, 2018.

[8] W. Jin, Y. Zheng, Y. Zhang, and Y. Jiang, “Experimental Study of Factors Affecting the Performance of a Semi-enclosed Outdoor Air-conditioning Unit,” in Procedia Engineering vol. 121, pp. 1713–1720, 2015.

[9] Triaji Pangripto Pramudantoro, “Uji Performansi Mesin A / C Split 1 PK Akibat Pengaruh Variasi Jarak Instalasi Outdoor-Unit Terhadap Dinding,” Energi ISSN 2089-2527, vol. 10, no. November, pp. 36–39, 2020.

[10] Y. Zhang, Z. Wei, E. Long, X. Zhang, and S. Guo, “Outdoor air thermal plume simulation of layer-based VRF air conditioners in high-rise buildings,” in Energy Procedia, vol. 142, pp. 3787–3792, 2017.

[11] R. Duan, X. Wang, Y. Song, and J. Liu, “Influence of Air-conditioning Outdoor Unit Arrangement Strategy on Energy Consumption,” in Procedia Engineering, 2016.

[12] T. L. Indonesia, “MVAC SYSTEM DRAWING LIST,” 2021.

[13] Panasonic, “FSV VRF SYSTEMS,” 2021.

[14] M. A. B. Yunus A. Cengel, Thermodynamics: An Engineering Approach, 5th ed. McGraw-Hill Science/Engineering/Math, 2015.

[15] S. K. Wang, Handbook of air conditioning and refrigeration, 2nd ed., vol. 32, no. 02. 2011.

BIOGRAPHIES OF AUTHORS

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Received: Feb 17, 2023 | Revised: Feb 26, 2023 | Accepted: Feb 28, 2023