International Journal of Electrical, Energy and Power System Engineering (IJEEPSE)
e-ISSN: 2654-4644
Vol. 3, No. 3, pp. 89-93, October 2020
ijeepse.ejournal.unri.ac.id

Effect of Evaporator Outflow Rate on Air Distribution in the Computer Laboratory using CFD

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***Abstract*—The ideal room temperature will create comfort in the learning and teaching process. With increasing outdoor air temperature due to climate change, an air conditioner is needed to reach the ideal room temperature. An air conditioner is an air conditioner that is needed to regulate the temperature and humidity of the air in a room. The purpose of this study is to determine the airflow pattern produced by air conditioning equipment and to determine the distribution of air temperature in the computer laboratory room. Computational Fluid Dynamic (CFD) is a simulation method used by using the ANSYS application. Based on research conducted in a computer laboratory room which has a length of 12 m, a width of 12 m, a chamfer of 3.93 m and a height of 3 m, the airflow pattern produced by the air conditioner is relatively the same between the variable air velocity 2.5 m / s and 3 m / s. Where the air will move straight in accordance with the outlet shape of the air conditioner and then experience a decrease in speed over a certain distance and a change in the direction of air flow occurs due to exposure to room properties and eventually spreads throughout the room. The average temperature in the computer laboratory room for the variable air velocity 2.5 m/s is 24°C. Meanwhile, the variable air velocity 3 m/s 23 ° C.**

Keywords— air flow pattern, air conditioner, CFD, room temperature, temperature distribution

I. INTRODUCTION

Students spend most of their time in the classroom during the learning process. Therefore, it is important to ensure the air distributed in the classroom is at the ideal room temperature [1][2]. Unfortunately, not all classrooms have the ability to create comfortable temperatures. This tends to impact on reduced productivity for students and lecturers.

Therefore, to solve this problem, a study was conducted to display a simulation of airflow produced by an air conditioner with conditions and variables obtained from known data through field observations as well as questions and answers.

According to the Oxford dictionary, the climate is defined as "an area with certain conditions including humidity, temperature, light, wind, etc." In addition, the Merriam-Webster dictionary defined climate as the average weather condition in a place or area comprising of wind speed, temperature, and rainfall, which is calculated over the years. The Big Indonesian Dictionary defined it as the state of air comprising of humidity, temperature, sunshine, clouds, and rain that occurs in a place or area and calculated for a long period. [2].

In every activity carried out by humans, especially at work, thermal comfort is needed to optimize productivity, and this is similar to the learning and teaching processes. Based on a reference to the Decree of the Minister of Health No. 261 / MENKES / SK / II / 1998, the ideal room temperature is between 18°C - 26°C [3][4].

According to D.A. Trisnaadmidjaja, the room is a physical form of a region in geographic and geometric dimensions that acts as a place for humans to carry out their life activities [4]. The wall is one of the elements used to cover or separate one room from another.

Air conditioning systems are used in many countries to provide thermal comfort and ideal indoor temperature acceptable to everyone [5][6][7]. An air conditioner is a device used in air conditioning systems to achieve thermal

Received: Sept 30, 2020 | Revised: Oct 10, 2020 | Accepted: Oct 13, 2020

comfort and the ideal indoor temperature acceptable to everyone. The working principle is to transfer the heat energy contained in a room. This is in accordance with the law of energy conservation, where it can neither be created nor removed rather it can be transformed.

Computational Fluid Dynamic (CFD) is a numerical analysis method, which uses a computer device to obtain information (predictions) related to fluid flow patterns in certain conditions of time and space. This is not only peculiar to the airflow pattern, rather it is also used to analyze temperature distribution. By using the CFD method, the prediction of fluid flow in various systems (designs) is carried out more easily, effectively, and efficiently, compared to when the design was directly applied to the experimental method. The results of fluid flow prediction using CFD are also more complete than the experimental method which runs into problems of cost, availability, precision, the accuracy of measuring instruments, and correct measurement methods [8].

II. Research Methods

A. Research Methods

This study uses CFD analytics with the ANSYS *software*. The simulation method is used to obtain the modeling pattern of the airflow produced by the air conditioner in the room. In this analytical process, the input data used is made similar to the actual conditions, such as the location of the building, geometry of space, properties in the room, and the number of teachers and students in the computer laboratory.

B. Data Collection

The Data were collected through direct observation in the field and by conducting *interviews* to obtain the specific data required, such as the room's geometry, material properties of the walls and floors, number of computers, type of lighting, and the layout of the air conditioner [8].

C. Building Orientation

The room used in this study, as shown in Fig. 1 and 2, is located in one of the tax center buildings in West Jakarta. This room is a computer laboratory with length, width, height, and chamfer sizes of 12m, 12m, 3m, and 3.93m, respectively.

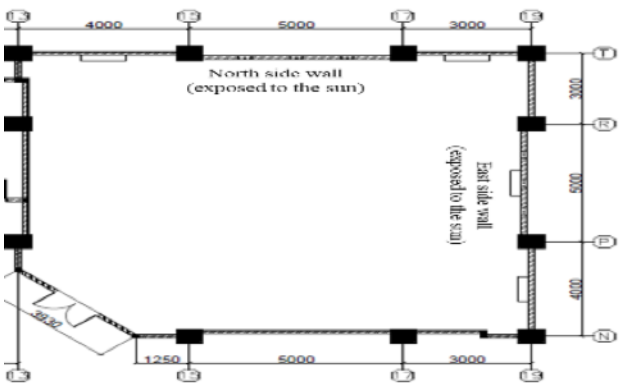

Fig. 1. Plan of the computer laboratory room

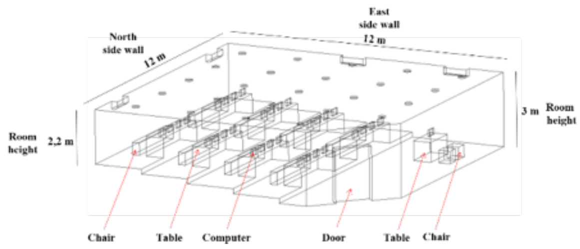

Fig. 2. Three-dimensional image of the computer laboratory room

D. Property and Room Load Data

The cooling load needed in the computer laboratory room is influenced by the amount of heat received. While the amount of heat generated indoors comes from all the properties in the room. Indoor properties that generate heat are shown in Table I [9][10][11][12].

TABLE I. INDOOR COOLING LOAD DATA

Description	Quantity (Pcs)	Load (Watt)	Total load (Watt)
Downlight plc lamp	24	18	432
Computer	35	250	8750
Projector	1	250	250
People	35	-	-

E. Thermal Conditions

This laboratory is located on the ground floor of the building, with the north and east sides exposed to direct sunlight. The highest outside temperature of 30°C to 34°C was collected from 10:30 AM to 04:00 PM. Meanwhile, the west and south sides were not exposed to direct sunlight, therefore they were in line with the building's temperature.

F. Simulation Parameters

The parameters used as data input in the simulation are references from journals or similar studies with several different values according to the calculation results based on actual field data. Details of the parameters in this simulation are shown in Table II [11].

TABLE II. SIMULATION PARAMETERS

Item	Settings
Type	Pressure-Based
Time	Steady
Gravity	On
Energy	On
Viscous	Standard k-e, Standard Wall Fn
Turbulent Kinetic Energy	Second Order Upwind
Turbulent Dissipation Rate	Second Order Upwind
Initialization	Standard
Number Of Iteration	2000
Velocity	2,5 m/s ; 3 m/s
Temperature Outlet	294 K
Heat Source	Heat Flux
Wall Partition	Convection

Received: Sept 30, 2020 | Revised: Oct 10, 2020 | Accepted: Oct 13, 2020

G. Temperature Data Collection

Indoor temperature data collection was carried out at 24 locations, as shown in Fig. 3. The descriptions B and K are used to denote row and column. The temperature data collection in the simulation can be carried out on the features in CFD.

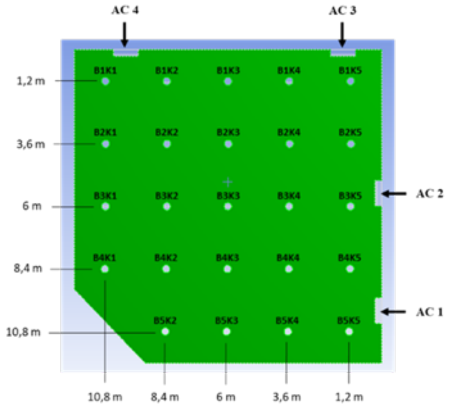

Fig. 3. Location of temperature data collection points

III. Results And Discussion

A. Simulation Calculation Results

Fig. 4 and 5, show the calculation results of the data input on the geometry of the computer laboratory. The convergent calculation result was achieved in iteration 1717 and 1019 for air velocity data inputs of 2.5 m/s and 3 m/s.

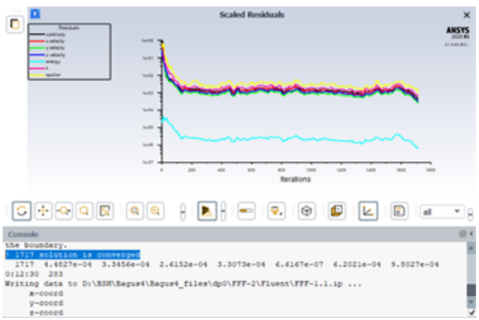

Fig. 4. The calculation results of 2.5 m/s air velocity value

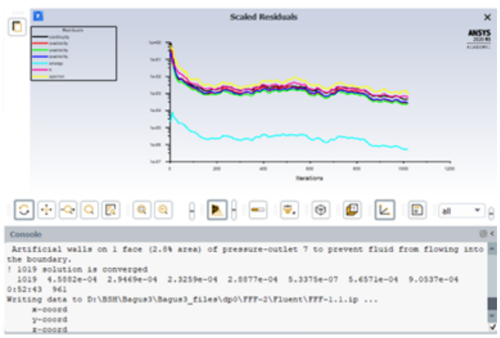

Fig. 5. The calculation results of 3 m/s air velocity value

B. Air Flow Pattern

The simulation results indicate that the airflow pattern and velocity produced by the air conditioner at a value of 2.5 m/s and 3 m/s were insignificant. Both have an airflow pattern that moves straight in accordance with the outlet shape of the air conditioner. It furthermore, decreases in speed over a certain distance and changes in the direction of airflow due to exposure to room properties such as tables, chairs, computers and walls. The airflow pattern produced by the air conditioner in the computer laboratory room are shown in Fig. 6 and 7. These figures show that the airflow pattern produced by the four air conditioners can spread to all corners of the computer laboratory room.

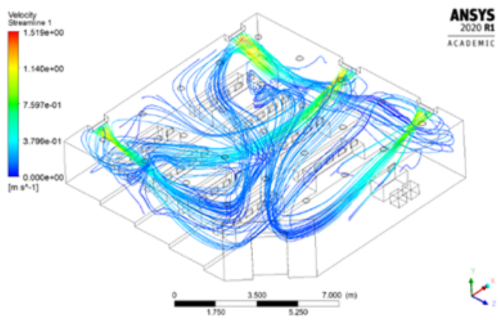

Fig. 6. Air conditioner flow pattern with data input of 2.5 m/s

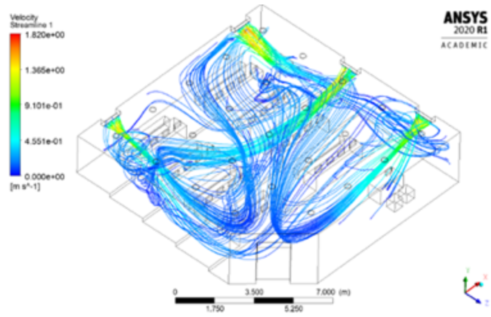

Fig. 7. Air conditioner flow pattern with velocity data input of 3 m/s

C. The Effect of Air Flow Velocity on Air Conditioner Device towards Computer Laboratory Room Temperature

The simulation results show the temperature distribution in the computer laboratory room on the Z-X and X-Y axis in Fig. 8 and 9, respectively. These two figures show that the temperature distribution produced by the air conditioner is fair throughout the room. The high temperature from the simulation results lies in the computer at 313,265 K, which is equivalent to 41°C. This is because computers are indoor properties that generate the greatest heat. This is also due to the fact that the computer device is not directly exposed to the airflow from the air conditioner in certain areas [13].

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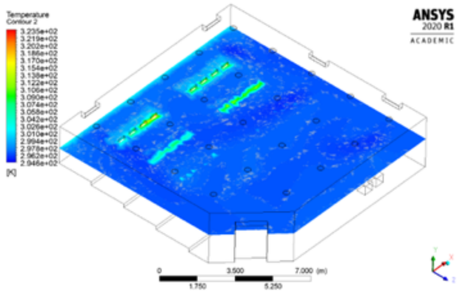

Fig. 8. Temperature distribution on the Z-X axis

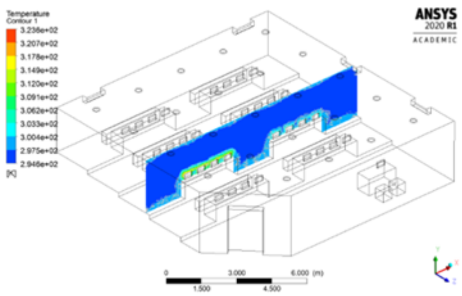

Fig. 9. Temperature distribution on the X-Y axis

D. *Comparison of Temperature Distribution towards the Effect of Air Flow Velocity from Air Conditioning Device*

In the two simulations carried out with different airflow velocity parameters, namely 2.5 m/s and 3 m/s, measurements were made at 24 points, and were evenly distributed in the room. Furthermore, the two data were compared to determine the ideal air velocity capable of reaching a comfortable temperature in the computer laboratory room. The measurement results and the comparison between the two simulations are shown in Table III. Fig. 10 is a graph of the temperature comparison between two velocity variables, with the aims to ease visual reading [14][15].

The comparison results obtained between the two different velocity variables illustrates that the points in row two, column two (B2K2), do not reach a comfortable temperature in the room. The air velocity variable of 2.5 m / s at point B2K2 reaches a temperature of 301,117 K or the equivalent of 28 ° C. Meanwhile, the velocity variable of 3 m / s at that same point reaches a temperature of 300.637 K or equivalent to 27 ° C.

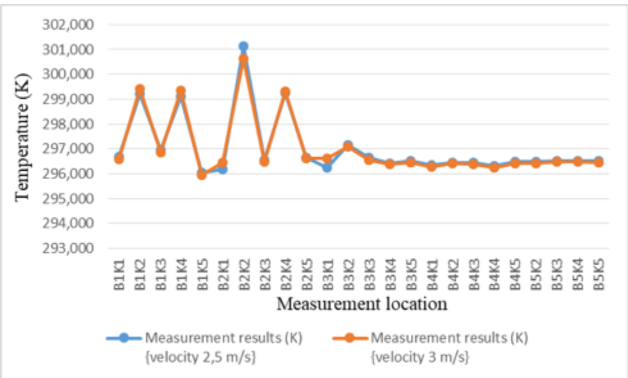

Fig. 10. Graph of temperature comparison between two different velocity variables

TABLE III. COMPARISON OF TEMPERATURE BETWEEN TWO DIFFERENT VELOCITY VARIABLES

No.	Measurement location	Measurement results (K) {velocity 2,5 m/s}	Measurement results (K) {velocity 3 m/s}
1	B1K1	296,695	296,583
2	B1K2	299,231	299,430
3	B1K3	296,952	296,869
4	B1K4	299,104	299,333
5	B1K5	296,051	295,949
6	B2K1	296,199	296,467
7	B2K2	301,117	300,637
8	B2K3	296,556	296,483
9	B2K4	299,232	299,329
10	B2K5	296,668	296,612
11	B3K1	296,261	296,612
12	B3K2	297,173	297,091
13	B3K3	296,664	296,565
14	B3K4	296,417	296,377
15	B3K5	296,535	296,468
16	B4K1	296,364	296,288
17	B4K2	296,458	296,411
18	B4K3	296,444	296,376
19	B4K4	296,324	296,251
20	B4K5	296,495	296,417
21	B5K2	296,499	296,421
22	B5K3	296,538	296,478
23	B5K4	296,508	296,473
24	B5K5	296,534	296,467

IV. CONCLUSION

Based on the simulation results in this research, it can be concluded that:

a) The airflow patterns produced by the air conditioner at velocities of 2.5 m / s and 3 m / s are the same. At these velocities, the air moves straight in accordance with the outlet shape of the air conditioner and then experience a decrease in velocity over a certain distance as well as a change in the direction of airflow due to exposure to room properties such as tables, chairs, computers and walls, before spreading throughout the room.

b) The temperature distribution in the computer laboratory, at a velocity of 2.5m / s and 3 m / s, is fairly even and has reached a comfortable temperature in the room. This is evident from the 24 temperature measurement points. However, one of the points does not reach a comfortable temperature in the room, namely B2K2.

c) The average temperature in the computer laboratory room for the variable of air velocity at 2.5 m/s and 3 m/s are 297.042 K or 24 ° C, and 296,926 K or 23 ° C, respectively.

ACKNOWLEDGMENT

The authors would like thank to the Simbelmawa Kemdikbud (PKM-M programme) and Universitas Trisakti for supporting funding of this research.

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