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 conditioning equipment 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 an 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 chamber 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 airflow 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 rainfall 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
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](image)

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].

| 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].

| 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          |
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](image)

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](image)

![Fig. 5. The calculation results of 3 m/s air velocity value](image)

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](image)

![Fig. 7. Air conditioner flow pattern with velocity data input of 3 m/s](image)

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].
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.

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 2.5 m/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.

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