Influence of different air supply parameters on indoor thermal comfort of upper air supply room

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Abstract: The temperature field, velocity field and PMV evaluation indexes under different air supply parameters are calculated by using Airpack software to divide grids and carry out numerical simulation. The cloud maps of evaluation indexes for different air supply parameters are compared and analyzed. The result determines the optimal air supply parameters.

1. Introduction
The temperature field, velocity field and PMV evaluation indexes under different air supply parameters are calculated by using Airpack software to divide grids and carry out numerical simulation. The cloud maps of evaluation indexes for different air supply parameters are compared and analyzed. Determine the optimal air supply parameters.

2. Mathematical equations
The three conservation laws of physics determine the laws that the fluid movement should follow, they are energy conservation law, momentum conservation law and mass conservation law respectively, and these conservation laws are expressed through the governing equation[1].

Energy conservation equation
\[ \frac{\partial}{\partial t}(\rho e) + \nabla(\rho v \cdot e) = \nabla(k \cdot \nabla T) + q + \varepsilon \]

Momentum conservation equation
\[ \frac{\partial (\rho u)}{\partial t} + \frac{\partial (\rho \mu u)}{\partial x} + \frac{\partial (\rho \theta u)}{\partial y} + \frac{\partial (\rho \omega)}{\partial z} = - \frac{\partial \rho}{\partial x} + \frac{\partial}{\partial x}(\lambda \text{div} u) + \frac{\partial}{\partial y} \left[ \mu \left( \frac{\partial u}{\partial x} + \frac{\partial u}{\partial y} \right) \right] + \frac{\partial}{\partial z} \left[ \mu \left( \frac{\partial u}{\partial x} + \frac{\partial u}{\partial z} \right) \right] + \rho F_x \]

Mass conservation equation
\[ \frac{\partial \rho}{\partial t} + \nabla(\rho v) = 0 \]

3. Physical model
The geometric model of the office room established in this paper is 5m in length, 4m in width and 3m in height, and the size of the air inlet is 0.2m×0.3m. On the basis of ignoring other Heat sources, the room contains two computers and two people, which are used as Heat sources. In the numerical
simulation calculation, various work activities of people are ignored. In short, people are regarded as energy sources similar to hollow bricks, and the Heat flux of each person is 50W/m². The computer will be represented as a hollow brick in front of the person in the room with a Heat flux of 100W/m² for each computer. The geometric model of the upper air supply room is shown in Figure 1:

![Figure 1: Geometric model](image)

Through access to information, when the temperature of air supply outlet between 18 to 25 °C, the speed of air supply outlet between 2.5 to 3.8 m/s, when researchers workspace has good comfort, so as a standard interval selected from five different operating mode, analysis and comparison on the difference of the interior flow field under different working conditions it is concluded that the optimal air supply parameters, in the analog simulation in the following five kinds of operating mode, as shown in table 1:

| Working condition | Air supply temperature T(K) | Air supply speed V (m/s) |
|-------------------|----------------------------|--------------------------|
| A1                | 298                        | 2.5                      |
| A2                | 298                        | 3                        |
| A3                | 298                        | 3.5                      |
| A4                | 297                        | 3.5                      |
| A5                | 296                        | 3.3                      |

4. Temperature field, velocity field simulation research

The boundary conditions are set as follows: the ambient pressure is set as the return air pressure of the air outlet by default, the wall, wall surface and floor are set as the adiabatic surface, and the Heat flux of each person is 50W/m², The Heat flux of each computer is 100W/m². And then input the heat flux data into the software.

For A1 working condition, the air supply parameter T1V = 25°C1 = 2.5m/s, air supply parameter t under A2 conditions2V = 25°C2 = 3m/s and A3 working condition air supply parameter T3 V =
25°C3=3.5m/s. The temperature field of Y section one meter above the ground when the human body is sitting still is shown in Figure 3, Figure 4 and Figure 5.

According to Fig. 3 of A1 working condition, it can be concluded that the up-supply air mode is adopted. When people sit quietly, the temperature around the body is between 31-39°C because of the high heat of people and computers. Compared with the distribution of air supply parameters in A1 working condition, the temperature distribution of room A2 has some changes. Compared with the distribution of air supply parameters in A1 working condition, the range between 27-28°C has expanded, and the overall temperature field is more consistent. The temperature in most areas of the room under three working conditions is between 29°C. The temperature around the body of A1 is between 28.6-30.25°C, the temperature around the body of A2 is between 28.9-30.25°C, and the temperature around the body of A1 is between 27.75-29.5°C. The temperature around the body of A3 working condition is closer to the "golden temperature"
5. PMV simulation analysis of upper air supply room

The PMV around the human body is around 2.5, and the human body feels very warm. A2 conditions around the human body and computer PMV value relative to the working condition of 1, most range around 1.45 in the rooms, the room most scope belong to slightly warm, A3 most room under the condition of the middle area is 1.14-1.4 range, good comfort, and A4 conditions around the computer PMV value around 2.6, PMV index is around 2 around the person, people will feel the warm, A5 conditions found room most of the range in 1-0.29, within the scope of the computer and the human body around the PMV index is in 0.24-1.3 range, All belong to the most comfortable range of human thermal comfort. Therefore, working condition 5 is the optimal working condition, that is, when the air supply temperature is 23°C and the air supply speed is 3.3m/s, the thermal comfort of human body reaches the best.

6. Conclusion:
1. Conditions in the process of simulation, the working condition of 2 and 3, three conditions of the supply air temperature is the same, just changed the supply air velocity, the working condition of three kinds of numerical simulation, the analysis of three kinds of working condition of the temperature field, velocity field, can see clearly from the air supply outlet position close to the supply air velocity is large, the human body and temperature is higher, around the computer could not reach the requirements of the human body comfortable.

2. The PMV is characterization of the human body thermal evaluation index, PMV comparison
analysis of the five conditions, analysis of the flow field distribution, for the first four PMV value, through observation of PMV value figure can be concluded that PMV value not within the scope of the human body thermal comfort, the optimal, but most of the working condition of 5 through analysis we can draw the room range in -1-0.29 range, is the most comfortable scope of thermal comfort of human body. Around the human body and computer, the PMV value is within the range of -0.24 -- 1.3, which also belongs to the most comfortable range of human thermal comfort. Therefore, working condition 5 is the most suitable working condition for human life and labor.

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