PIV Experimental Study on the Influence of Double-Diffusion Effect on Indoor Pollutant Dispersion in Buildings

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Introduction

Good indoor air quality is not only crucial for people's health and comfort but also directly affects the quality of work and life. The vertical wall attached jet ventilation system combines the advantages of mixed ventilation and displacement ventilation, offering higher energy efficiency, lower energy consumption, and better air flow control capabilities. However, the efficient operation mode of this ventilation structure remains to be studied. Han teng and others have used the CFD method to study the characteristics of the indoor thermal environment when the vertical wall attached jet ventilation is used for heating, finding that the phenomenon of thermal stratification within the room is very pronounced, yielding a large amount of relevant data.

PIV experiment was used to obtain real-time experimental data on the internal air flow of the vertical wall attached jet ventilation system, revealing its flow field characteristics. Combined with CFD simulations, the air flow conditions under different operating conditions are obtained, providing more comprehensive and in-depth data support for the research.

Experiment

The text is based on an actual office prototype and constructs a PIV experimental platform for building indoor ventilation and heat exchange according to the principle of similarity. The dimensions of the ventilation test box are 50cm * 30cm * 25cm (length x width x height), using an up-supply and up-return air supply method, with the air outlet size being 12cm * 3cm. During the ventilation process, a blower is used to supply air to the experimental box, and a smoke generator is used to produce tracer particles. The blower and smoke generator are connected to a mixing box, thus maintaining a uniform concentration of tracer particles and further ensuring the effectiveness of the PIV test. The heating source uses a heating pad measuring 50cm * 30cm (length x width) placed at the bottom of the experimental box.

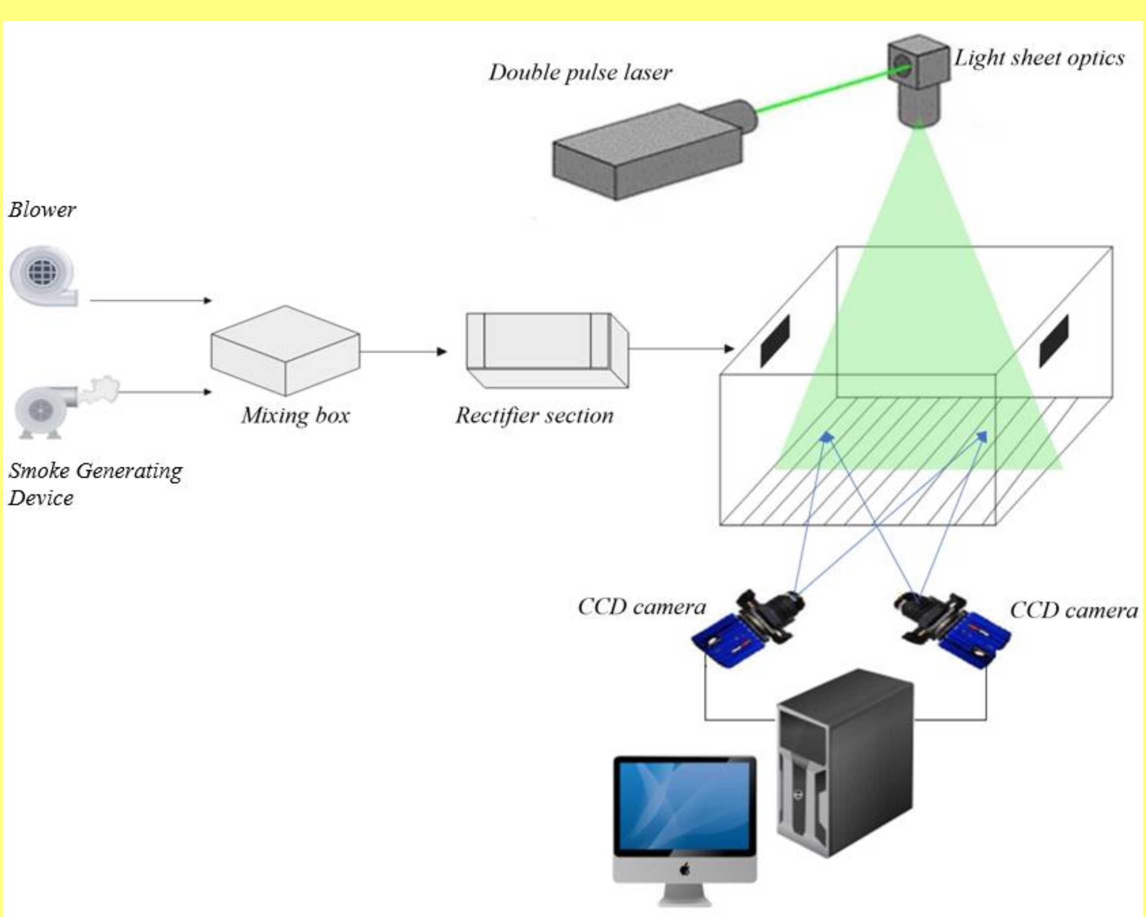

Fig.1. PIV experimental platform

Experimental setup

The ventilation and exchange performance of the vertical wall attached jet ventilation mode was investigated using PIV technology. Among the working conditions are: 1) An isothermal working state is one in which the temperature of the incident fluid (Incident temperature *te*=20 ° C) remains constant while the interior airflow organization form is subjected to varying air supply speeds. 2) Non-isothermal working state. The interior airflow organization under varying air supply speeds is examined when the temperature of the incident fluid deviates from the temperature within the test box (*te*=20 ° C, ,ambient temperature *ta*=30 ° C). And contrast the outcomes of the interior airflow arrangement between the two operating scenarios.

CFD simulation wase used to further analyzed the PIV conditions. This paper utilizes the finite volume method to discretize the control equations. The continuity equation and momentum equation use the built-in flow equation, while the concentration equation is custom-written using user-defined functions (UDF) and user-defined scalars (UDS). The discretization of the momentum and energy equations employs a second-order central difference, and the pressure-velocity coupling uses the simple algorithm for pressure coupling, with transient terms using an implicit format. The solution is computed by combining the initial and boundary conditions.

Results

The results of the PIV experiment, shown in Fig. 2, demonstrate that an isothermal air supply only causes vortices to form at the lower section of the fluid distribution, leaving the top part rather uniform. This reduces the likelihood that the airflow will cause discomfort to the human body.

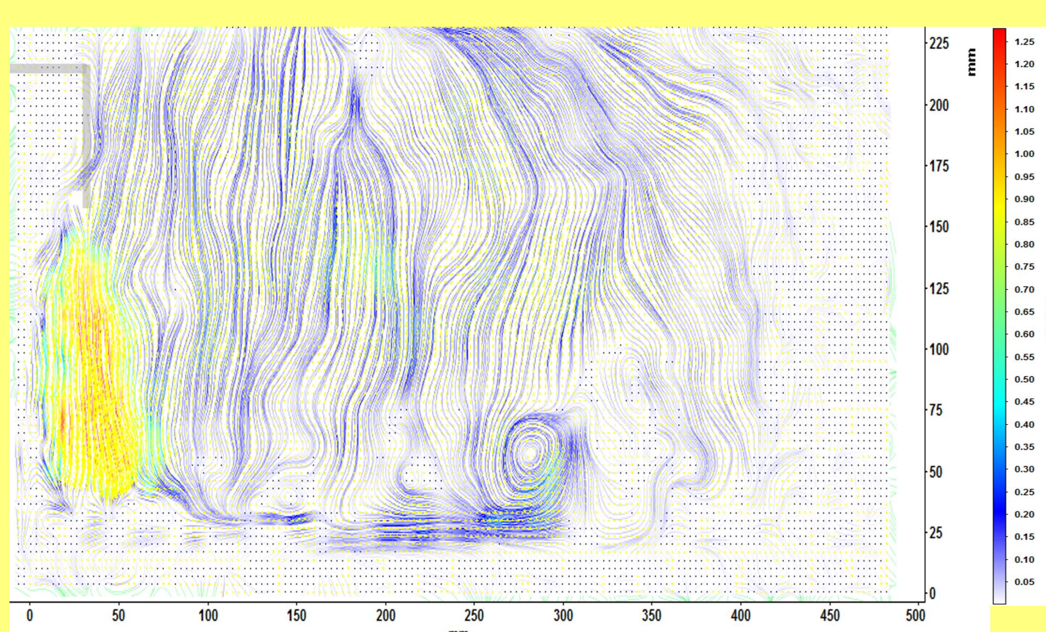

Fig.2. Airflow organization within the test box during isothermal air supply

The influence of buoyancy, on the other hand, rises with a non-isothermal air supply, as illustrated in Fig. 3. Heat-producing interior air that has been mixed with the jet causes a drop in buoyancy and density. Indoor vortices travel toward the upper portion of the space when the temperature inside rises due to the increased buoyancy. It is evident from the velocity vector diagram that buoyancy has a major impact on the velocity distribution.

The entire flow field is affected by buoyancy as temperature rises, which intensifies the mixing effect between the interior air and the jet

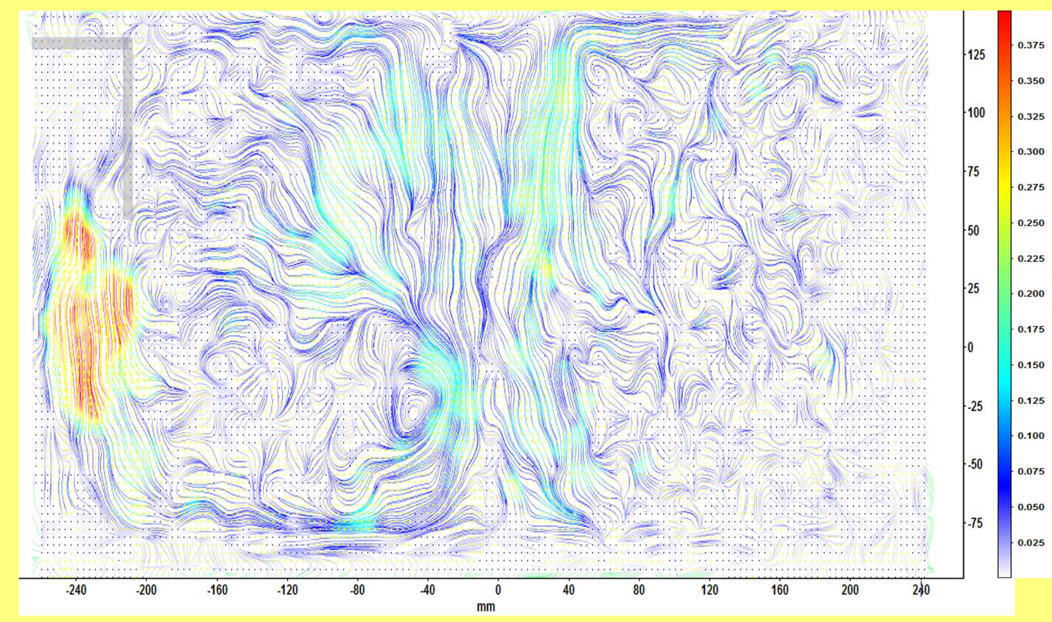

Fig.3. Airflow organization within the test box during non-isothermal air delivery

Subsequently, a numerical simulation of the isothermal air supply was performed, as shown in Fig.4, it can be observed that the trajectory of the jet is roughly the same as that of the PIV experiment.

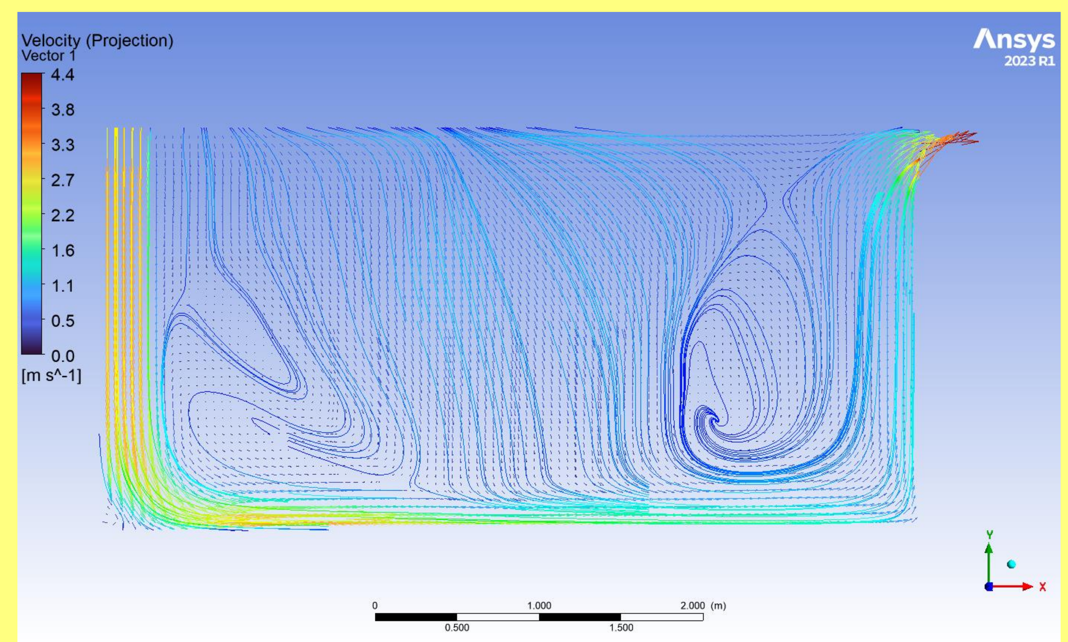

Fig.4. Velocity streamline of Isothermal air supply

Conclusions

The findings of this investigation led to the following deductions:

(1)The higher the initial velocity of the air supply outlet, the shorter the time it takes for the indoor flow field to become disordered, and the less significant the change in flow field. By raising the air supply outlet's initial velocity, ventilation performance can be improved and the horizontal attachment zone's lengthened.

(2)The air supply speed and air supply temperature are fixed, and the higher the indoor temperature, the more obvious the upward suction effect of the jet, and the more obvious the temperature non-uniformity.

References

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