

Study on the Construction of Fans to Achieve City Air Duct

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Abstract. Since 2013, there have been varying degrees of haze in China and air quality plummeted, which limits the pace of China's economic development. The construction of urban air duct is a way to improve the urban climate environment through urban construction planning. Based on the theory of urban air duct construction, this paper proposes that we can simulate the urban environment by FLUENT to find out the construction route of urban air duct, and install the fan in the obstruction point to realize the smoothness of the city wind. And through simulation, it is verified that the installation of the fan can effectively improve the flow field at different altitudes, which opens up the obstacle and realizes the construction of the urban air duct.

Introduction

Since the reform and opening up, with the large-scale development and construction of the city and the rapid increase in building density, natural landforms have been changed, which make underlying surface rough. So that China's urban wind generally show a decreasing trend [1]. Therefore, the opening of urban air ducts to promote urban air circulation, reduce air pollution and make more comfortable living environment is particularly important [2]. Based on the theory of urban ventilation corridor and the existing urban planning and construction, we plan to install fans on high building. In that way, the city pollutant will be disturbed and the haze formation will be cut off.

Construction and Simulation of Urban Air duct Model

The construction of mathematical model.

Urban air ducts are generally constructed according to the following rules:

City air duct should follow the prevailing wind direction of the city.

Build the buffer zone and strengthen the ventilation effect. The buffer area is usually through the square, the park and so on.

Width standard. City air duct must reach a certain width in order to have a good ventilation effect.

On the basis of this theory, the theoretical duct is obtained by simulation. Here we simulate a building through FLUENT.

In city air circulation and thermal conductivity are complex, mainly relate to the environment, buildings, materials and green vegetation. At the same time, taking the air circulation and various heat transfer effects, as well as the associated continuity equation, momentum equation, energy equation and the standard k-ε describing turbulence into account, the following equation can be constructed.

$$\frac{\partial \rho}{\partial t} + \frac{\partial(\rho u_i)}{\partial x_i} = 0 \quad (1)$$

$$\frac{\partial(\rho u_i)}{\partial t} + \frac{\partial(\rho u_i u_j)}{\partial x_j} = \rho g_i - \frac{\partial \rho}{\partial x_j} + \frac{\partial \tau_{ij}}{\partial x_j} \quad (2)$$

$$\frac{\partial(\rho c_p T)}{\partial t} + \frac{\partial(\rho c_p u_j T)}{\partial x_j} = \frac{\partial}{\partial x_j} \left(\lambda \frac{\partial T}{\partial x_j} \right) + \tau_{ij} \frac{\partial u_i}{\partial x_j} + \beta T \left(\frac{\partial \rho}{\partial t} + u_j \frac{\partial \rho}{\partial x_j} \right) \quad (3)$$

$$\frac{\partial}{\partial t} (\rho k) + \frac{\partial}{\partial x_j} (\rho k u_j) = \frac{\partial \rho}{\partial x_j} \left[\left(\mu + \frac{\mu_i}{\sigma_k} \right) \frac{\partial k}{\partial x_j} \right] + G_k + G_b - \rho \varepsilon \quad (4)$$

$$\frac{\partial}{\partial t} (\rho \varepsilon) + \frac{\partial}{\partial x_j} (\rho \varepsilon u_j) = \frac{\partial \rho}{\partial x_i} \left[\left(\mu + \frac{\mu_i}{\sigma_\varepsilon} \right) \frac{\partial \varepsilon}{\partial x_j} \right] + \rho C_1 S \varepsilon - \rho C_2 \frac{\varepsilon^2}{k + \sqrt{\nu \varepsilon}} + C_{1\varepsilon} \frac{\varepsilon}{k} C_{3\varepsilon} G_b + S_\varepsilon \quad (5)$$

ρ, c_p, λ, μ and β are the density of the fluid, the specific heat capacity, the thermal conductivity, the dynamic viscosity and the bulk expansion coefficient; u_i and u_j are the velocity vectors in the direction i and j ; x_i and x_j are i and j Coordinate is; p is the pressure; τ_{ij} is the viscous force, k and ε are the turbulent kinetic energy and the turbulence; t is the time; T is the temperature; g_i is the gravitational acceleration in the i direction. C_i is a model constant based on fluid turbulence viscosity, and G is a term dependent on buoyancy.

Determination of boundary conditions.

The ambient wind speed can be analyzed as an entrance boundary. Assuming the location of the building is in the prevailing wind of northeast direction. Figure 1 shows the current situation of the three-dimensional model. In the figure, X, Y, represent east and north direction. Taking effects of ambient wind and natural convection into account the dual, both sides of the vertical surface are defined as the exit boundary and the top surface is also defined as the exit. All the surfaces and the wall are non-slip boundary.

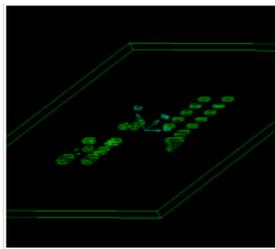


Fig.1 The three -dimension view of the area

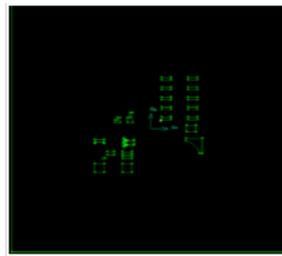


Fig.2 The two -dimension view of the area

Simulation results.

We use a building as an example to simulate a basic flow field distribution, construct a basic flow field three-dimensional model as follows: Set the boundary conditions in FLUENT according to the above conditions and we calculate the flow field distribution:

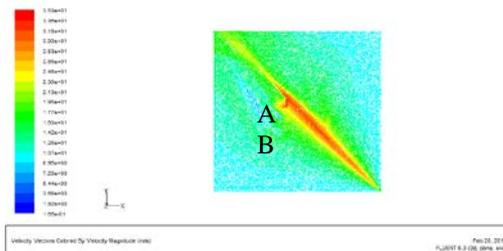


Fig. 3 The flow field distribution

It can be seen that A and B buildings are the main obstacle.

We install fans on A and B, that is adding the speed of the entrance on the A and B. Taking the roof as the reference surface, we select 25m, 15m, 5m, and -5m, -15m, -25m height to observation flow Field distribution, the simulation results are as follows:

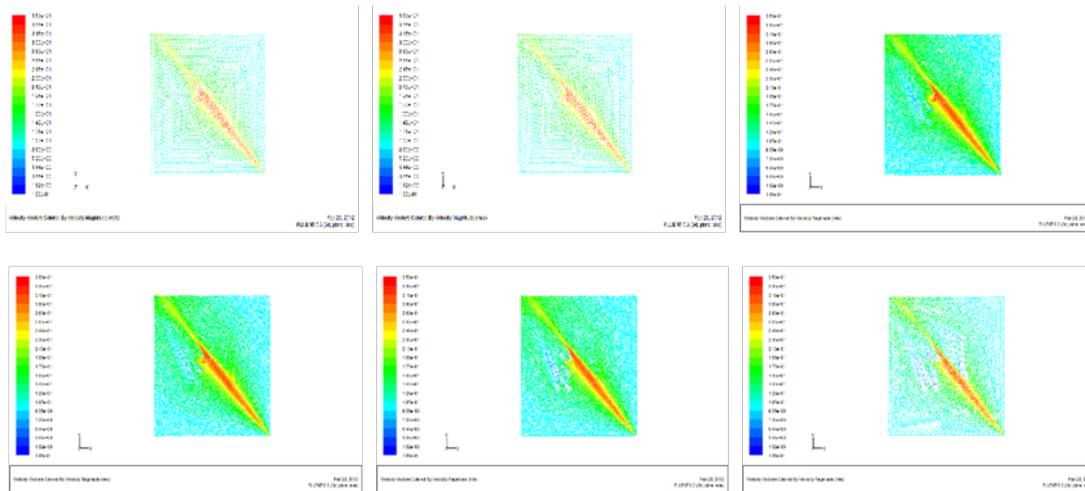


Fig. 4 The flow field distribution

And then simulate the distribution of flow field of A and B section at different wind speeds. The results are as follows:

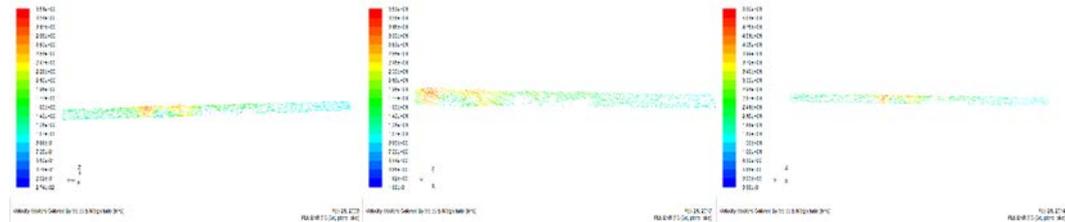


Fig. 5 The flow field distribution

Summary and analysis.

A. From the simulation results, we can see that the ground has a speed field when we install fans on A and B. If the flow rate of the fan outlet is 5m/s, the different altitude's wind speed can reach above 3m/s near the building and the average wind speed in the area can reach more than 2m/s.

B. It can be seen from the simulation results that the larger the wind speed, the more uniform the flow field in the area, so that the pollutants are more likely to be evacuated. And the installation of the fan strengthen the vertical direction the air flow, which can damage the formation of inversion layer and evacuate pollutants.

C. After the installation of the fan, the city wind along the direction of the corridor to extend, that is, the installation of the fan can form a smooth ventilation corridor. It is conducive to the introduction of popular wind, and strengthen the ventilation effect. If we can use more fans, then the entire building group will be better ventilated. It is significant for improvement the haze weather and the city heat island effect.

Conclusion

In this paper, we theoretically confirmed the correctness of the urban air duct by analyzing the cause of haze. And with the simulation of FLUENT, the paper puts forward the planning method of urban air duct and verifies the feasibility of the construction of the wind turbine. Get the following conclusions:

- 1) The main reason for the formation of haze weather is the stability of the atmospheric structure of the city and no air convection.
- 2) Urban air duct can lead the wind, evacuate pollutants in the city, so that pollutants cannot gather. Thus formation of haze is curbed.
- 3) According to the FLUENT simulation results, the installation of fans in high-rise buildings can effectively improve the urban wind environment.

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