Numerical simulation of indoor fire based on FLUENT

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Abstract

In a variety of fire, indoor fire has the biggest and most direct harm to people. Building all types of people engaged in production and life of the main premises, property is also extremely concentrated areas, because the construction of indoor fire damage caused very serious and direct impact on human life and safety. How to advance the difficult problem to fire science and validity of indoor fire protection is a science researcher. It is the most needed solution to research the process and aracteristic of fire and to use it during design by starting from fundamental study[1].

Keywords

Smoke spread, Smoke control, Fire simulation.

1. Introduction

For the process of indoor fire, the software FLUENT is used to analyze the typical indoor structure and fire load. Field simulation software FLUENT was used to study the effects of switching doors, objects and smoke control on flue gas flow and temperature.

1.1 Fire simulation scene setting

1.1.1 Building single room structure

Simulate the single-room structure of the building: as shown in Figure 1, the room is 4m * 4m * 3m and has a 2m * 1.2m door to the outside. The room is arranged as follows: a bed in the direction of the right wall, two wardrobes in the direction of the left wall, a sofa in the direction of the back wall and curtains in the middle of the window.

Simulated content: Because of some reasons, a fire occurs in the bedroom. In order to simulate more real and more like the real fire situation, a burning object is set up [2]. Because of the heat of combustion, other objects reach the burning point of the object, ignite the objects around the burning object, and finally make the whole bedroom fire, output model. Quasi results. Among them, the combustion material is mainly wood products and fiber products.

1.1.2 Building multi room structure

The size of the room is as follows: the simulation room is divided into two layers, room ① and ②5 m * 4 m * 3 m, room ③5 m * 3 m. Rooms ⑤ and ⑥5m* 5. 5m* 3m. There is a door to 2m*1. 2m in the corridor. The corridor is connected with rooms ②, ③and ⑥. The room has two floors and a large space. 12m* 11m* 3m, and corridor 4 vertical connection through staircase. The visual map is shown in Figure 2.

Simulated Content: For some reasons, a fire broke out in the room, set the TV as the fire source, because of the heat of combustion, so that sand developed to the ignition point, ignite the sofa, and finally make the whole room fire. Assuming that the doors in the building are open and the sprinkler system is started, the simulation results of flue gas and temperature are obtained.

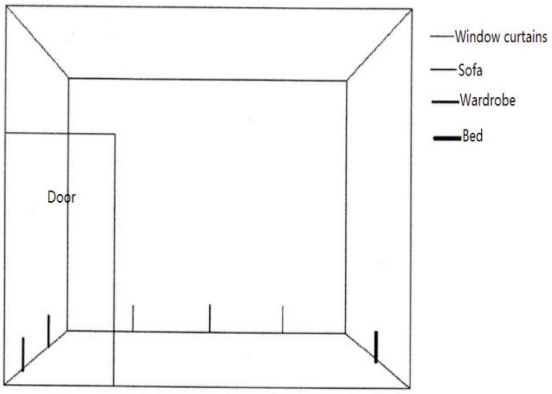


Figure1

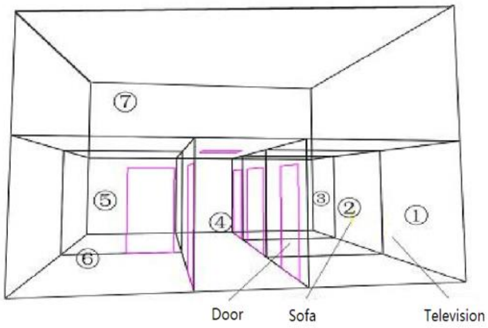


Figure 2

1.2 Model establishment and mesh generation

FLUENT is used to simulate the fire in a single room and a simple three-storey model [3]. The distribution of flue gas pressure, velocity and temperature is obtained. Three models are given in the single-compartment simulation. Under the same external conditions, the same material emits the same temperature (the same ignition source). Comparing the simulation results of the three models, the distribution of smoke pressure, velocity and temperature is analyzed. In the simulation of a simple three-storey building, the influence of chimney effect on flue gas velocity and heat distribution before and after the application of flue gas management and flue gas control methods was compared [4].

1) The fire source is in the corner of a single room. The main purpose of this simulation is to understand the effect of the opening and closing of a single room door on fire smoke and whether there are objects in a single room on fire. As shown in Figures 3, 4 and 5.

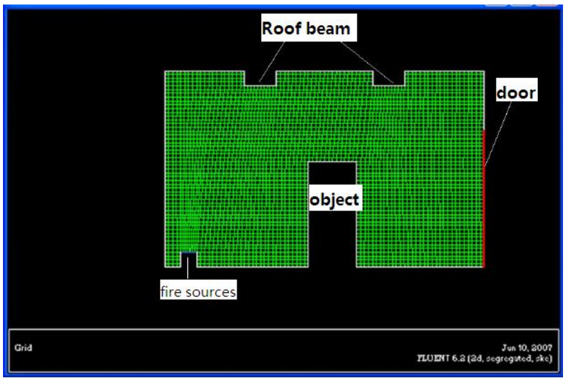


Figure 3

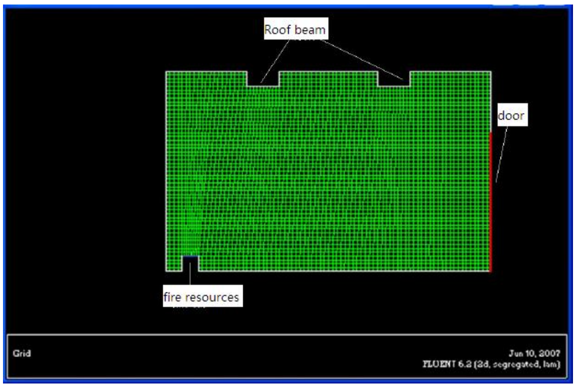


Figure 4

Figure 5

Fig. 3 is a model of indoor objects with a single room open. Fig. 4 is a model of indoor objects without a single room open. Fig. 5 is a model of indoor objects with a single room closed.

2）The fire simulation of multi-storey (three storey) building structure model is carried out. The effects of fire curtain opening and closing and flue gas control on flue gas flow and heat transfer were compared. As shown in Figures 6, 7 and 8.

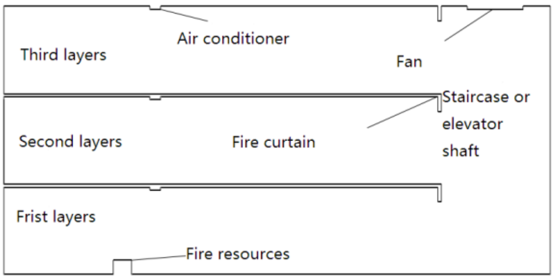


Figure 6

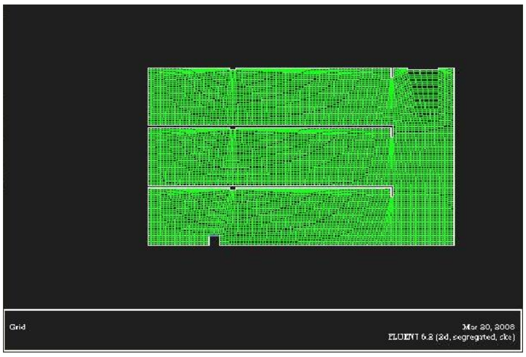


Figure 7

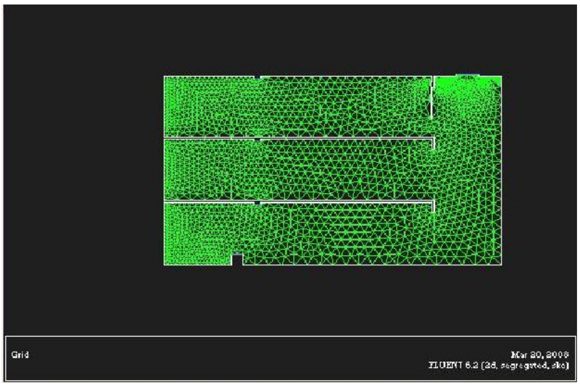


Figure 8

Fig. 6 is a three-storey building structure diagram, Fig. 7 is the fire curtain is not opened and the smoke control is not model, Fig. 8 is the fire curtain open and smoke control model.

2. Simulation results and analysis

2.1 Single chamber simulation results

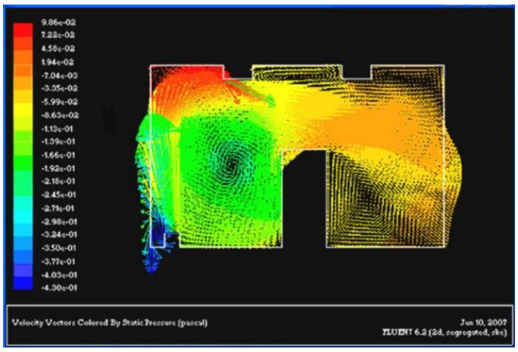


Figure 9

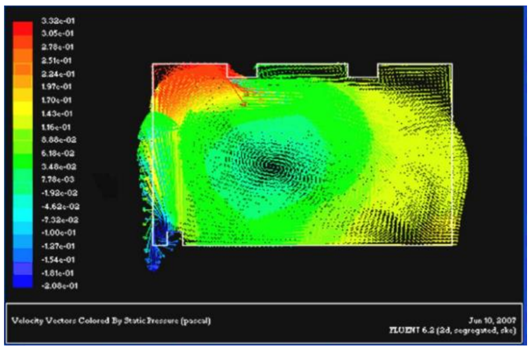
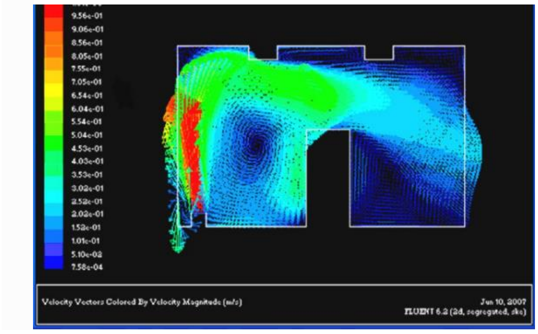


Figure 10

Figures 9 and 10 simulate the pressure vector of a model with or without objects in the open door. In the same simulation, the effect of objects in a single room on the pressure of a building in the event of a fire. In the case of an object in the room, as can be seen from Figure 9, two turbulent flows occur in a single room due to the obstruction of the object. Fig. 10 shows a turbulent flow in a single chamber in the absence of objects inside the room. The common point of the two pictures is that the pressure above the ignition source is the greatest, which is due to the velocity of air buoyancy generated by combustion at the ignition source.



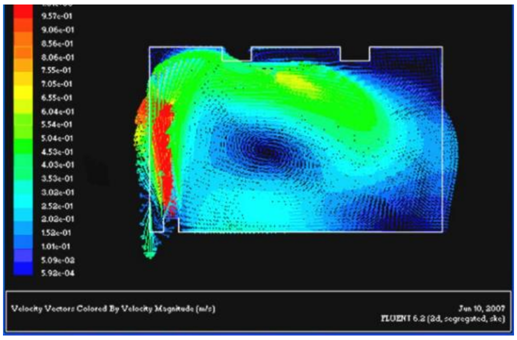
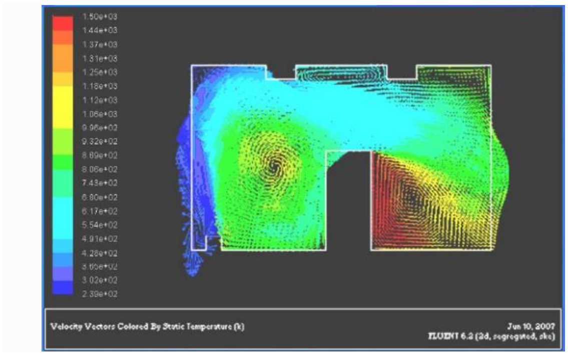


Figure11 Figure 12

Figures 11 and 12 simulate the velocity vector diagram of a model with or without an object. Under the same initial conditions, the turbulence generated by the two velocity vectors is different, resulting in different temperature distributions. Smoke is blocked by the object, the velocity changes, the outflow to the door slows down, and the object is present. On the right side of the body, there is no obvious velocity of air flow. In a single room where there is no object, the flow of smoke in the room corresponds to the actual flow direction, and the smoke in the single room does not show any obvious speed because the smoke goes out at the door.



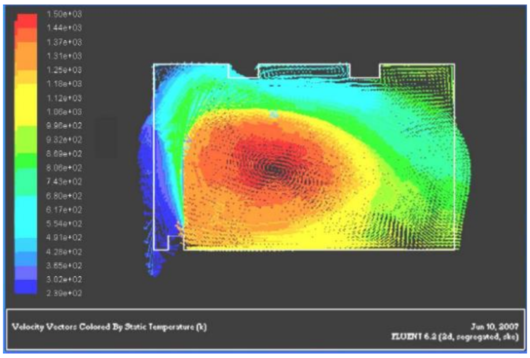


Figure 13 Figure 14

Figures 13 and 14 simulate the temperature vector diagram of a model with or without objects in the open door. The distribution of the influence of objects on temperature can be compared. The lower left corner of a single room is set as the ignition source. The surface appears blue and the temperature is very low; in both models, a high-temperature turbulence is generated, unlike a high-temperature turbulence in the lower-right corner of the object in the room where the object is located; in a single room where there is no object, a high-temperature turbulence occurs next to the fire source. The temperature of the two pictures is decreasing when they open the door.

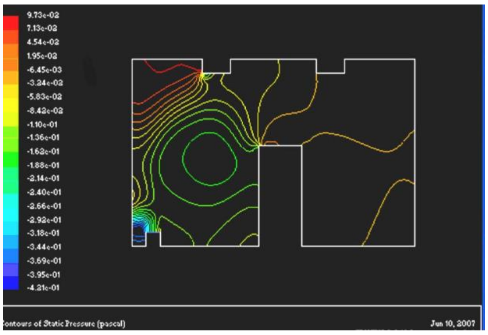


Figure 15 Figure16

Figures15 and 16 simulate a pressure line diagram of a model with an object in the door closing and opening. In the same simulation, the highest pressure is in the upper left corner of the room. But in the closed room, the pressure line on the left side of the object is higher, and the pressure line is denser than that in the open room. On the right side of the object, the closed room The pressure line is closed, and the door opening is connected with the outside world, and the pressure is relatively low.

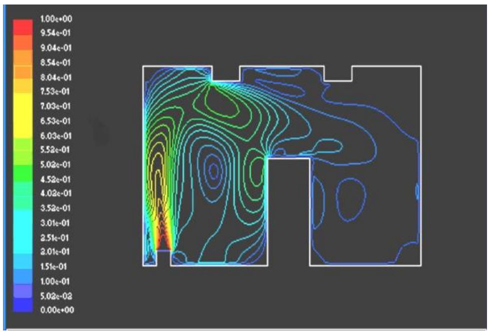
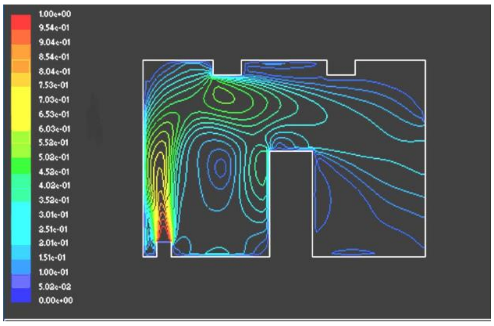



Figure 17 Figure 18

Figures17 and 18 simulate the velocity line diagram of a model with an object in the closed and open doors. Under the same simulated conditions, when the door is opened, there is a distinct smoke flow line. In the closed room, the smoke flow is obstructed by objects and walls, and the direction changes, resulting in the basic lines in the velocity line diagram. Keep closed. This shows that the flow velocity of smoke is different from that of open door and open door.

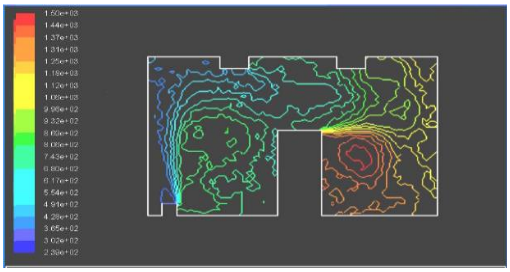
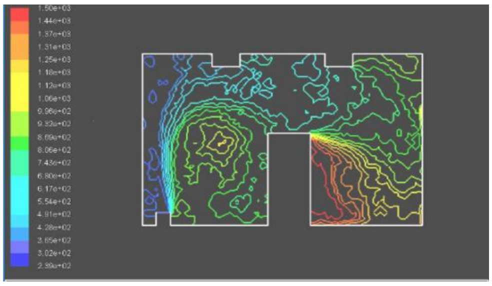



Figure 19 Figure 20

Figures 19 and 20 simulate a temperature profile of a model with an object closed and an object open. Under the same simulation, the temperature distribution is roughly the same. The difference between opening and closing is the size of the high-temperature distribution area. When the door is closed, the wall prevents the loss of heat, the heat accumulates, and the situation when the door is opened. In fact, the heat is lost at the door, so the temperature at the opening is lower than that in the closed.

2.2 Flue gas management simulation

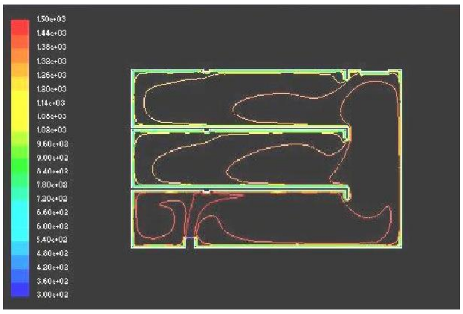
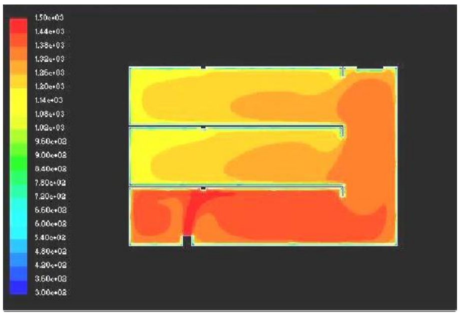



Figure 21 Figure 22

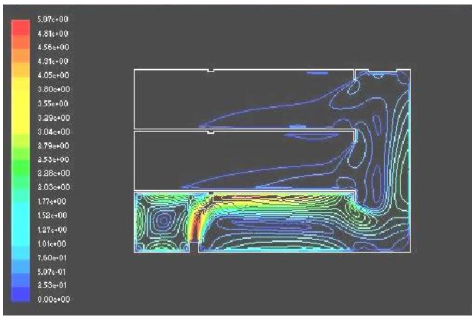
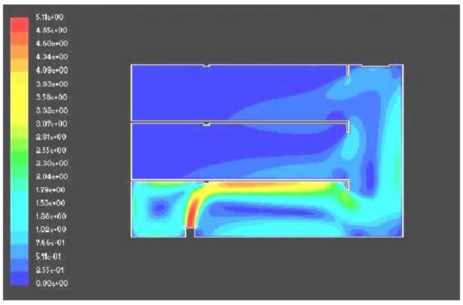



Figure23 Figure24

It can be seen from Figures 21 and 22 that the smoke temperature of each floor is very high before flue gas control.

It can be seen from Figures 23 and 24 that the velocity of flue gas flows very fast in stairs or elevator wells. The smoke soon filled the floors. The main focus of smoke control in building fires is stairwell and fire area, because the smoke control in these two areas is the key point to protect the safety of life and property. The method of flue gas management and flue gas control is set at three after fire.

The fire curtain on the floor is automatically lowered. Figs. 25, 26, 27 and 28 show that the fire curtain is not completely lowered, and there is still a certain distance from the ground. Fire monitors sense that after a fire, the central air-conditioning system is used to enhance the air supply speed, so that the air pressure in the floor is greater than that of stairs or elevator wells; at the same time, the mechanical ventilation device at the top of stairs or elevator wells is activated to exhaust air. After the fire, the air conditioning system on the floor is closed automatically.

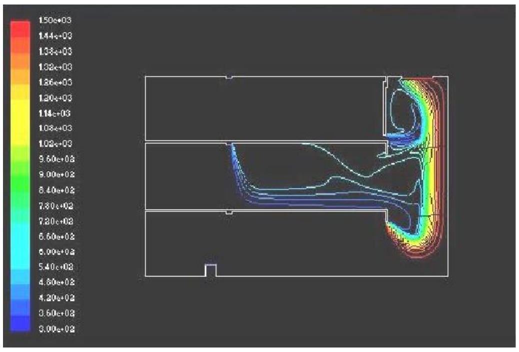


Figure25

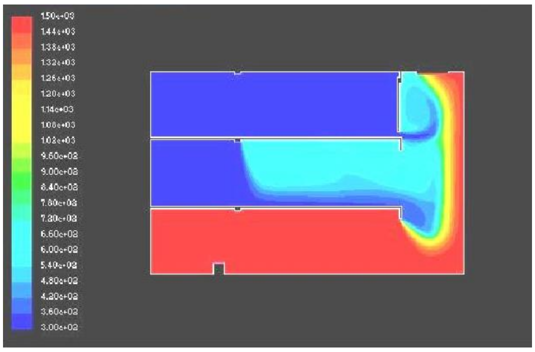


Figure26

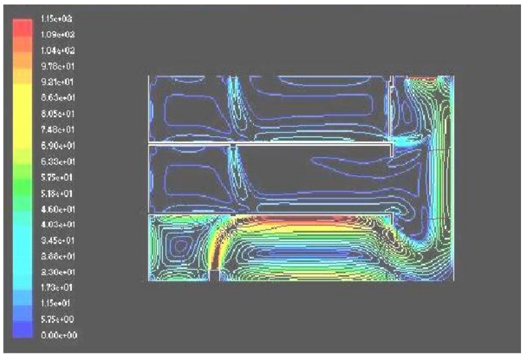


Figure 27

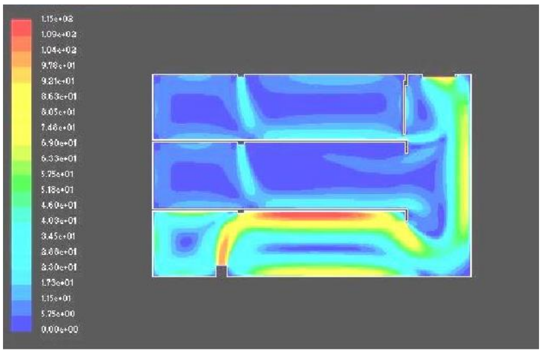


Figure 28

As can be seen from Fig. 25 and Fig. 26, the air temperature of the fire floor and stairs or elevator wells is very high. Under the action of air conditioning and strong air supply and fire curtain, the temperature of the three stories has not changed much, the fire curtain on the second floor has not been lowered, and the room temperature has increased. If the two story fire curtain is lowered, it will produce the same effect as three layers. If the fire curtain on the first floor is lowered, it will soon be extinguished without air entering and automatic fire extinguishing system. As can be seen from Fig. 27 and Fig. 28, after the fire, the air supply of the two and three layers of air conditioning system is strengthened, so that the air pressure of the two and three layers increases, and the toxic smoke can not enter the three layers. This shows that the pressure difference formed on both sides of the fire curtain inhibits the spread of smoke. The high-pressure side of the fire curtain is both a refuge and an evacuation channel, while the low-pressure side is in the smoke from the fire area. At this time, the air flow under the fire curtain is very fast, and the air flow through the cracks under the fire curtain and other building structures can effectively prevent the smoke from seeping into the high-pressure side. Because the air conditioning system on the second floor strengthens the supply of air, the fire curtain on the second floor is not lowered, and the toxic smoke is not easy to enter. Because of the mechanical strong exhaust equipment above the staircase or elevator shaft, after the fire, stairs and elevators are installed. The flue gas between wells is quickly discharged outside the building, effectively preventing toxic fumes from spreading to other floors.

3. Conclusion

In this paper, numerical simulation of indoor fire process is carried out. The study shows that it has important application value for indoor fire hazard analysis and fire prevention design and evaluation in architectural design.

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