

THE INFLUENCES OF MOVING HUMAN IN A VENTILATION ROOM

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ABSTRACT

The moving human (MH) influences the airflow and contaminant distribution, this paper use the commerce software FLUENT6.2 to simulate the influences of the MH to the airflow and TVOCs distribution in both mixing ventilation and placement ventilation. In a three-dimension ventilation room, a pollutant source (TVOCs) was located on the floor and a flesh in a certain zone moving was assumed, and the unsteady, $k-\xi$ turbulent model be used, According to the simulation results, we studied the influence of MH in the indoor air quality in both mixing ventilation and displacement ventilation. The results of contaminant distribution have a MH or not in two difference ventilations were compared, the results indicate that the single MH's influence is not obvious all of space, but in the moving zone, there were some difference with have MH or not in two different ventilations. The MH made the high TVOCs concentration at the bottom of room diffused to the low TVOCs concentration at the top of room with a displacement ventilation, which made the layered of contaminant lifted up, and the TVOCs distribution more uniformity at the bottom of the room with mixing ventilation. At the same time, the influence in mixing ventilation is larger than in placement ventilation. And the influence is not disappeared in a short time in both deferent ventilations.

KEYWORDS

Technique of dynamical mesh, airflow, contaminant distribution, CFD, TVOCs

INTRODUCTION

It is reported that the 90% of our life time is spend in the room, and the characteristic of human behavior is influence the indoor air quality. The most effective method of improve the indoor air quality is mechanical ventilation which dilute the contaminant concentration in the room. Various ventilation types are presented for make indoor environment more comfortable, more health and more effective, and two of the most representational type is mixing ventilation and placement ventilation (Yuan X et al. 1998) .

TVOCs is one of the most contaminant in the room, and 60% of it comes from the building material and furniture (L.Z.Zhang and J.L.Liu 2004, J.Sundell 2004, De Bellie et al. 1995), the process of emit in dry material is interior diffuse mode, and influence the occupier's health in a long time (Hongyu Huang

and Fariborz Haghighat 2002, S. Murakami et al. 2003). a mass of article which study of the influence the indoor air quality in various ventilation is published, for example, Yang.X (X.Yang and Q.Chen 2001) studied the amount of the inhale TVOC dose in two different ventilations, Zhang Y (ZHANG Yinping et al. 2006) analysis the contaminant distribution and in further optimize it by alter the location of pollutant source, intake and outtake and so on. Zhang L (Lin Z et al. 2002, Zhang Lin and T.T. Chow 2005) studied the influence of layout different location inlet or door too. And Zhang Q (Quan Zhang et al. 2005) studied the contribute ratio which indicate the TVOCs inhaled dose from difference zones. But all of these didn't consider the influence of the MH. So, this paper is merely study the influence of the MH to the indoor air quality with different ventilations.

In the really life, the disturb of indoor airflow is uncertainty, for example, the move line may be ahead or backward suddenly, at the same time, the moving time and intension is different, so consider all of this factor in the models is reasonless. At present, the mostly method for study the influence of MH is experiment(Mattsson M and Sandberg M 1996, E BjØrn and P V Nielsen 2002, Erik BjØrn et al. 1997, Mattsson M 1999), and it do in a all-scale ventilation room, a dummy is moving by dragging. At the method of the simulation, there have some article are public .for example, Yang, Cheng Shih(Yang-Cheng Shih et al. 2006) and H.Brohus(H. Brohus et al. 2006) studied the influence of the doctor or nurses moving to the infection of the patients. In this paper, a single person in a fixed zone regular moving is simulated by technique of dynamical mesh. And the influence of MH to the TVOCs concentration distribution is studied in a room. Further, the influence of MH or not under two different ventilations is compared and analyzed.

PHYSICS MEDAL

The physics models as show fig.1, this paper simulate two persons in a ventilation room, one is static all the time in a point (1.88, 1.31), another is moving, and the human moving velocity in the room is about 0.8m/s-2.5m/s. in this paper, the moving velocity is 1.5m/s is assumed. The person at first moving started at the point (5.1, 1.825), then moving along with the direction of $-x$, arriving at the point (0.8, 1.825). After stopped 1 s. the moving body moved along with x direction and back to the formerly point, all of the moving time is 10s, At the

case of the displacement ventilation, the supply air intake location at a point (1.85, 1.825, 2.7) and (4.1, 1.825, 2.7) respectively, and the central of outtake is located at the point (0, 1.5, 0.3). At the case of the mixing ventilation, the intake lay out is opposite. 6 lamps are distribution on the top of room uniformly; and two cupboards steadied in the cornel in physics model. At the bottom of the room, the TVOCs emitted from it, and assumed that the emit ratio is constant, 0.8ug/m2*s. the contaminant concentration in air supply intake is 0, And another detailed parameter show table 1.

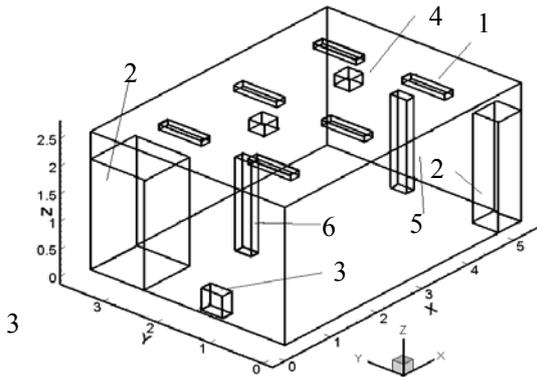


Fig.1 the physics model of ventilation room

(1-lamps, 2-cupboard, 3-the intake of the displacement ventilation and the outtake of the mixing ventilation, 4- the intake of the mixing ventilation and the outtake of the displacement ventilation, 5-MH, 6-static human)

MODEL OF MH

Simplest model of human

Flesh is a complicated body, and must predigest it in a numerical simulation. The simple model is different for the diverse intention (E BjØrn and P V Nielsen 2002, Erik BjØrn et al. 1997); Brohus (1997) look back the simple model in the numerical simulation field. The simple human model show as follow, in this paper, the aimed is influence of the moving process to the airflow in the ventilation room, so the simplest model (SCSP model 1) is used.

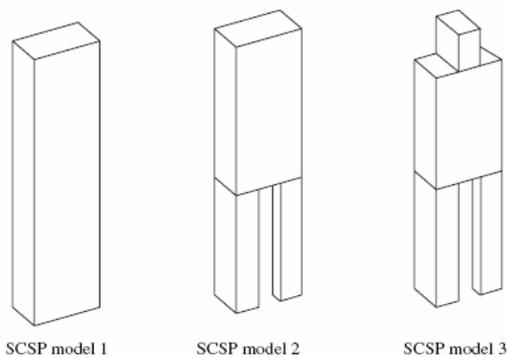


Fig.2 the simple human model

Techniques of dynamical mesh and govern equation

The MH is achieved by the dynamic mesh in the simulation; and it can solve the problem about the variation boundary field such as the moving of boundary. The characteristic of it is that the grid system is moving. And the boundary location of next time steps is determined by the boundary location of currently time steps and velocity increment (Fluent Corporation 2005) The method include function of girding adjust, and afresh set of grit to disappear the aberrance cell, it very effective to resolve the moving object's boundary in this way (Yang, J and Wu J 2001, Cheng ML and Cheng XM 2004)

When human is static, the model is steady and the govern equation can describing as follow:

$$\frac{\partial(\rho\phi)}{\partial\tau} + \text{div}(\rho U\phi) = \text{div}(\Gamma \text{grad}\phi) + S \quad (1)$$

The ρ is the density, u is the vector of three direction, S_ϕ is the source of scalar quantity, in this paper, in the continue equation $\phi = u_j(j=1, 2)$, on airflow of kinetic energy $\phi = k$, the turbulent of dissipation is $\phi = \xi$, if consider temperature equation, $\phi = h$, at TVOCs concentration equation, the diffuse coefficient is assumed 7.35e-6.

In the dynamic mesh model, any of the control volume in the moving boundary is show as below:

$$\frac{d}{dt} \int_V \rho\Phi dV + \int_{\partial V} \rho\Phi(\vec{u} - \vec{u}_g) \cdot d\vec{A} = \int_{\partial V} \Gamma \nabla\Phi \cdot d\vec{A} + \int_V S_\phi dV \quad (2)$$

And the differential coefficient of time can describe as one rank backwards difference forms, show as:

$$\frac{d}{dt} \int_V \rho\Phi dV = \frac{(\rho\Phi V)^{n+1} - (\rho\Phi V)^n}{\Delta t} \quad (3)$$

The u_g is the boundary velocity, δV is the boundary of the control volume. n and $n+1$ is the flow current time steps and next time steps, the V^{n+1} and is representation the different time interval, which can be obtained by :

$$V^{n+1} = V^n + \frac{dV}{dt} \Delta t \quad (4)$$

dv/dt is the differential coefficient of time, in order to satisfy the conversation law, the control of the differential coefficient of time is calculated by :

$$\frac{dV}{dt} = \int_{\partial V} \vec{u} \cdot d\vec{A} = \sum_j^n \vec{u}_{g,j} \cdot \vec{A}_j \quad (5)$$

n_f is the control girding, and is the vectors of area, and can obtained by :

$$\vec{u}_{g,j} \cdot \vec{A}_j = \frac{\delta V_j}{\Delta t} \quad (6)$$

δV_j is the space volume which j sweep crossed in the interval Δt .

The setting of the time step

The setting of the time step is key to deal with the dynamical mesh, in the distortion zones, the distance of the MH in time steps must less than the length of the grid, in namely, $\Delta t \times v < L$, and Δt is time step, v is the velocity of the MH. L is the least length of the grid in the distortion zones. If $\Delta t \times v > L$, it would be lead to the distorted grid become negative and the computing would be stopped. in this paper, the time steps setting as 0.05s for the velocity of MH is 1.5m/s. when the human is static, we can regarded this model as steady situation for calculation.

Computing process

The turbulent model $k-\zeta$ are used, the velocity and contaminant distribution in the fields is calculate by steady situation before of the human moving. And assume $t=0$ in this movement. then the model is set as unsteady situation while the steady results as the initialization of unsteady, and calculate the velocity and contaminant concentration in every time steps.

RESULT ANALYSES

The influence of the MH to the velocity and TVOC distribution in a room with a mixing ventilation

Fig.3 is a serial of vector distribution at influence of the MH, we can see that the flow is steady at the $t=0$ movement, the velocity of the supply air intake is 0.8m/s, the velocity distribution of the section $Y=1.825m$ is uniformity, At $t=0.5s$, is after the human moved 0.5s, velocity at the moving zone become larger, at the $t=2s$ and $t=5.75s$, the influence of the MH is the most larger. At the $t=10s$, the MH is keep static on 3s, but the influence of it to all the zone are not disappear, and all of the section vector becomes larger. From a serial of vector field in discrete times, we can clearly visual the MH influences the vector field.

Fig.4 is the contaminant distribution of $y=1.825$ in discrete times at the mixing ventilation, the concentration is low near the supply air intake for the diluted by ventilation, and it become more and more larger out of the intake, the concentration are higher at the cornel and the two of the walls, and the TVOS distribution at all the zone is uniformly, the concentration of near the MH is larger, when the human moved, the concentration is bring along by MH, which made the TVOC more uniformly and the volume of the high concentration more larger at the bottom of the room. At the movement of $t=10s$, the moving body is stopped and the contaminant distribution not restore the situation of begin, which indicate that the influence of the MH is not disappear in a short time.

Fig.5 is a serial of vector and TVOCs distribution nephogram at the section of $z=1.6m$ with the placement ventilation, at the movement of the $t=0s$, the model is steady, and the velocity and contaminant distribution is uniformly too. The $t=2s$ and $t=4.5s$ is the movement that the MH crosses the near of the static person sequentially. While MH crosses nears the static human sequent, the local velocity becomes larger, but all over the section, there is tiny influence. There have the similar situation At the TVOC concentration distribution. At the mixing ventilation, the change of the vector and contaminant distribution at the moving and static human is small too.

The influence of the MH to the contaminant distribution with a displacement ventilation

Fig.6 is the contaminant distribution at the section of $y=1.825m$ with a serial of the discrete times. When $t=0s$, the MH is static, the concentration is layered, which the concentration of the bottom of the room is high and the inhale zone of the occupied is low relatively. With the human moving, the layered distribution is obvious, but the high concentration in the bottom diffused to the low concentration in the top of the room. Compare the concentration at the movement of the $t=0s$ with the movement $t=6.25s$. The influence on the top is small. But the influence of the layer of concentration in the bottom is large relatively, with the human moving; the high concentration zone becomes larger. Compare the movement of $t=0s$ with $t=10s$, the TVOCs distribution is different, which indicate that the influence of the MH to contaminant is not disappear in a short time.

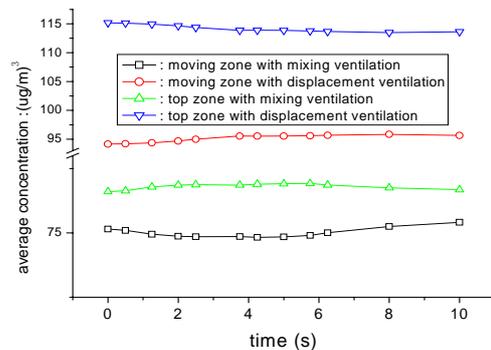


Fig7 the average concentration in different zones

This is the compare of the TVOC average concentration at the different zones in two ventilation style, one zone is the over the $z=1.8$, which consider as top zone, another zone is the $0.1m < z < 1.8m$, which consider as the moving zone. Form the fig we can see that the variety of concentration distribution at all of the zone in the room is small, which indicate that the influence of the MH to all of the zone are small too, in the other hands, this fig showed that the layout of the concentration with the displace ventilation is better than with the mixing ventilation.

CONCLUSIONS

This paper used technique of dynamical mesh to simulate the influence of MH to the velocity field and contaminant concentration distribution with two different ventilation styles. This paper is merely study on the single human is routine moving in a local zone, but in the really life, there have adequate complex and violence moving influence the characteristic of the ventilation, which influence evaluate of the indoor air quality with different ventilation. So it is needed to give enough consider it in the further study. There have some conclusion as follow:

1 the MH influence the velocity field and contaminant distribution at a moving zone is not disappears in a short time.

2 the MH made the contaminant concentration more uniformity and TVOCs concentration higher in the moving zone with a mixing ventilation. at the same time, the high concentration zone diffusion to the low concentration with the displacement ventilation and made the layer of the concentration lift up. Namely, the MH weaken the characteristic of displace ventilation and mixing ventilation, which the influence of MH to the indoor air quality is bad.

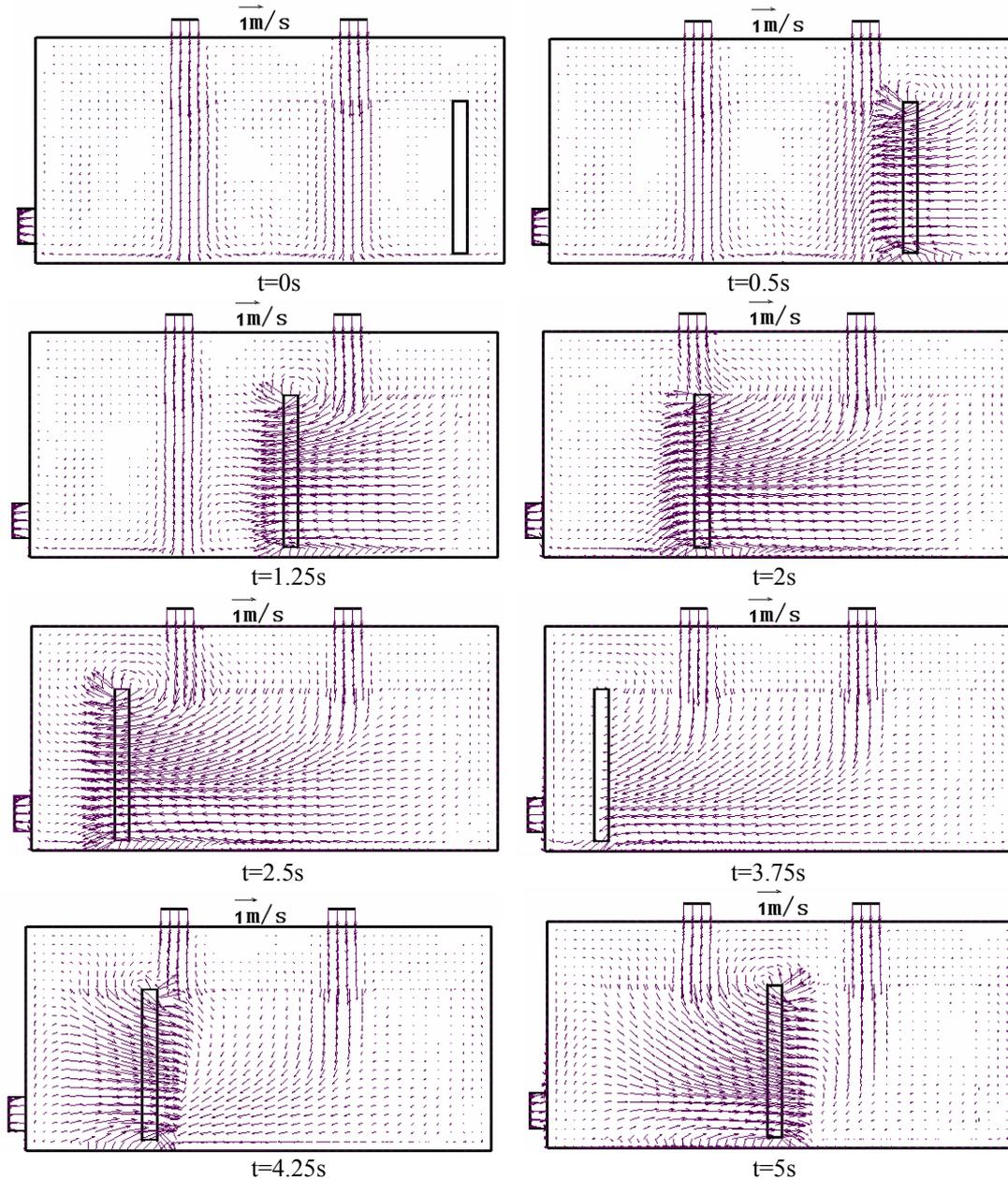
3 the influence of the MH to the distribution of velocity filed and contaminant concentration with mixing ventilation is larger than with the displacement ventilation.

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Table.1 detailed parameter and dimension of the model

Length , width and height of the room (m)	5.16*3.65*2.5	Length , width and height of the simple human model (m)	1.7*0.3*0.16216*2
Length , width and height of the lamps (m)	0.15*0.15*0.8*6	Velocity of the MH(m/s)	1.5
The area of intake of the mixing ventilation and the outtake of the displacement ventilation (m ²)	0.3*0.3*2	The area of intake of the displacement ventilation and the outtake of the mixing ventilation (m ²)	0.6*0.6*1
Length , width and height of the larger cupboard (m)	1*1*2	Length , width and height of the small cupboard (m)	0.6*0.6*2
Velocity of the supply air intake(m/s)	0.8	Emit ratio of the TVOC(ug/m2*s)	0.8
Turbulent intensity of intake and outtake	10%	hydraulic radius of intake and outtake (m)	0.3/0.4



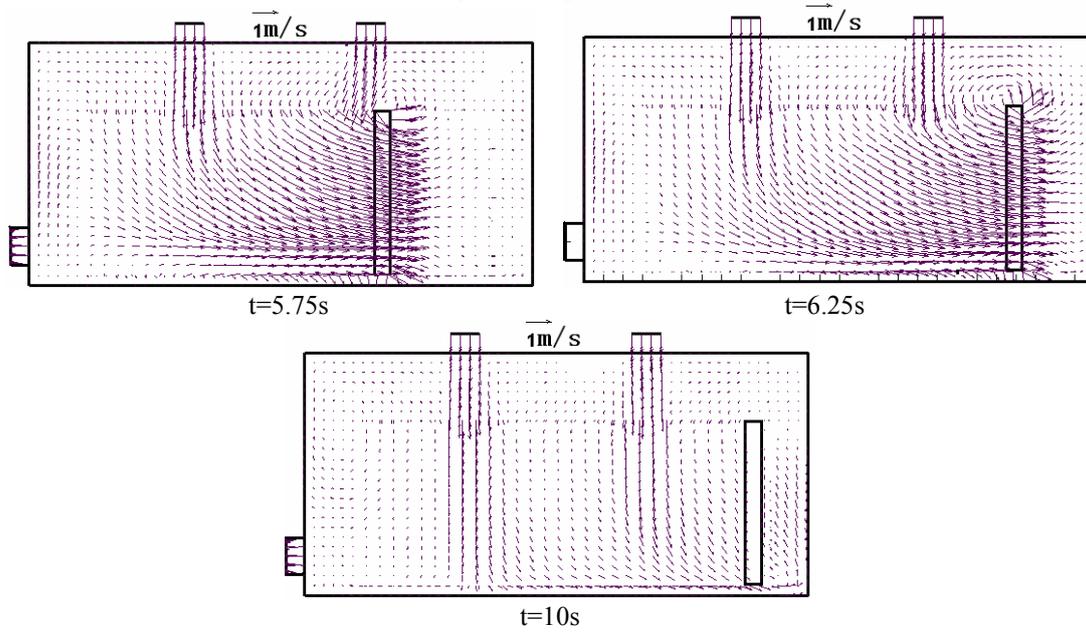
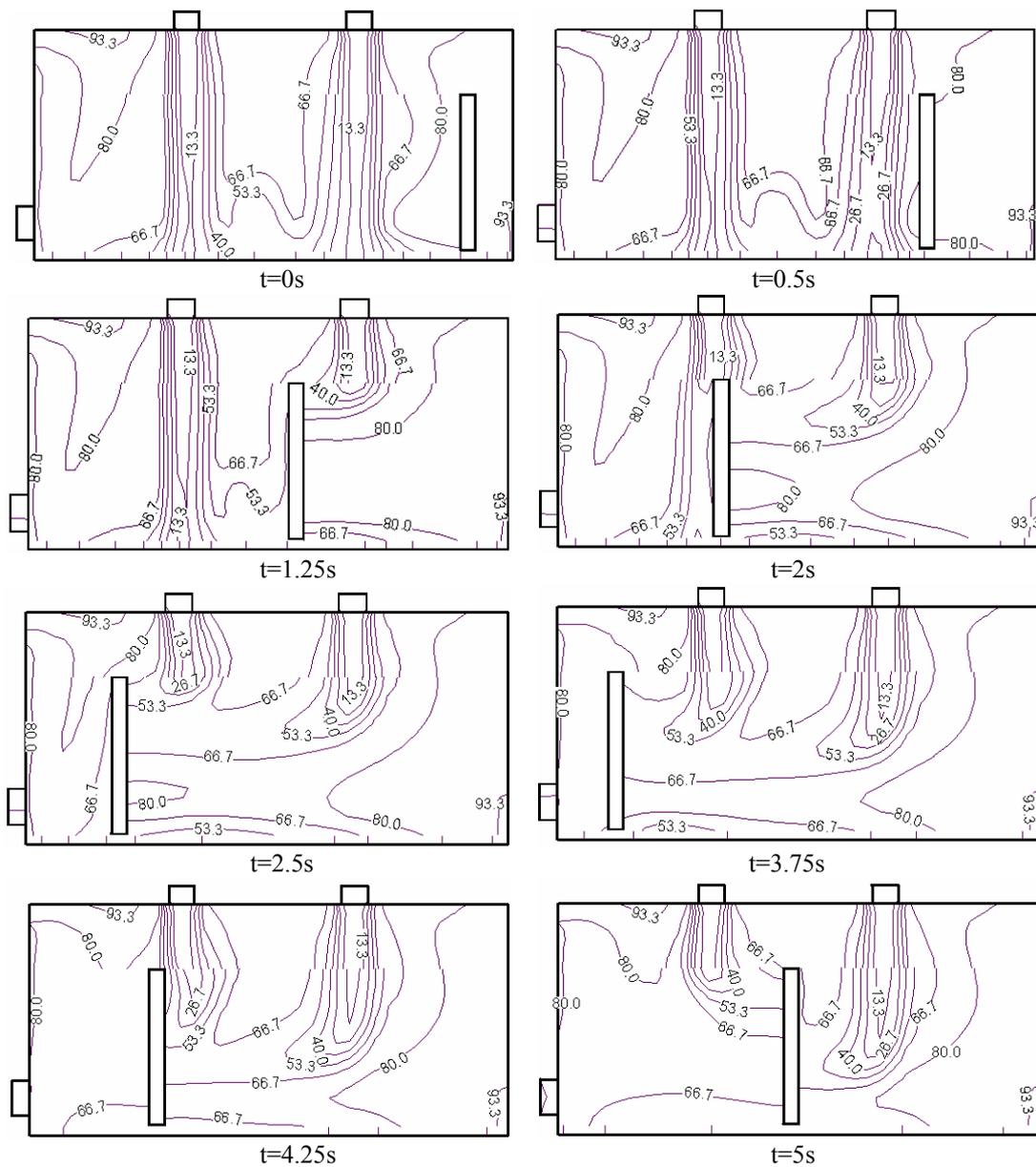


Fig 3 the vector distribution at section $y=1.825$ at discrete times with mixing ventilation



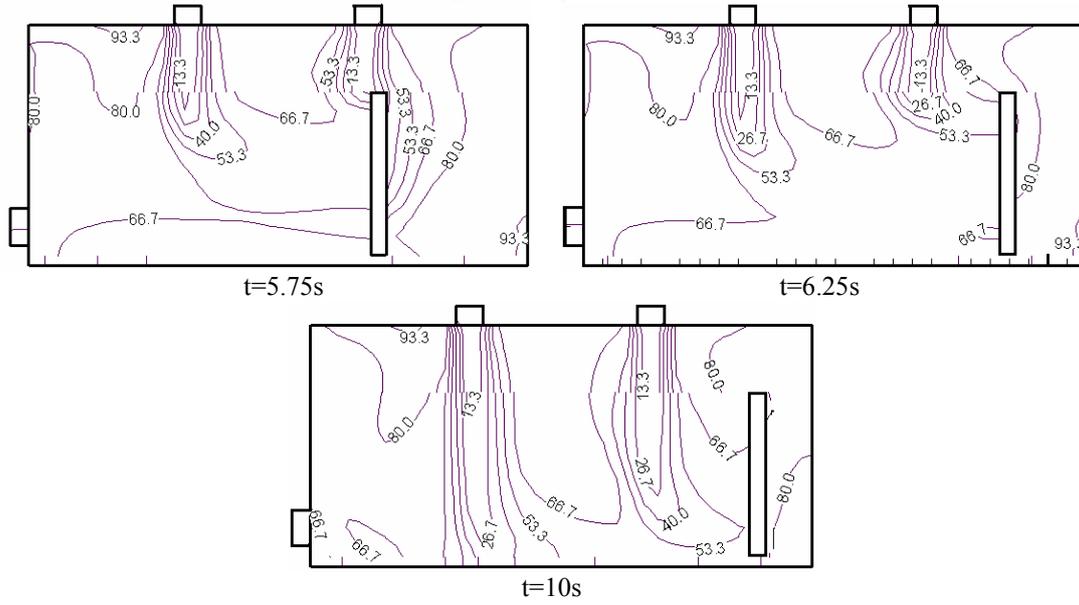


Fig 4 the TVOC distribution at section $y=1.825$ at discrete times with mixing ventilation

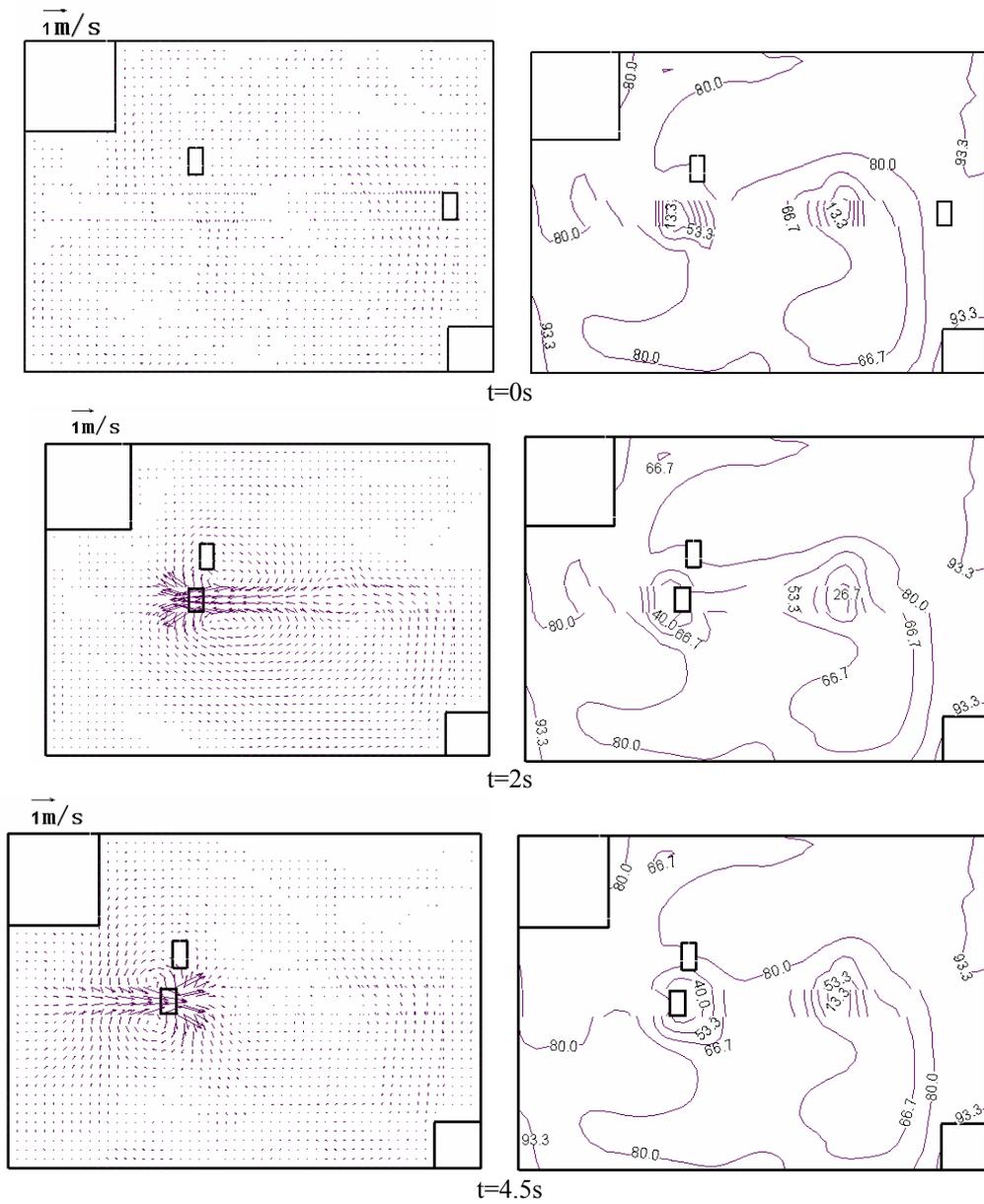


Fig 5 the vector and TVOC distribution at section $Z=1.6$ at discrete times with mixing ventilation

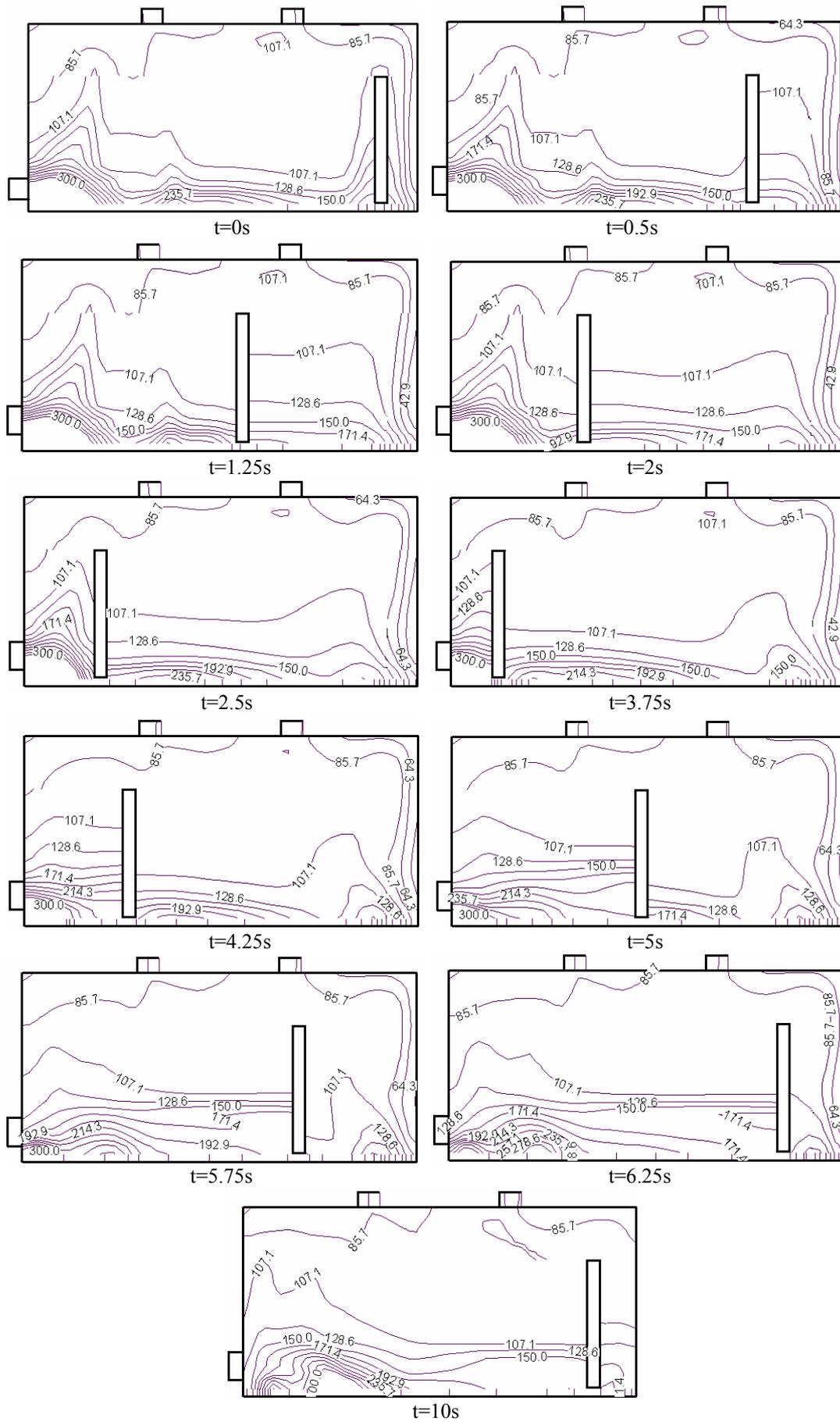


Fig 6 the TVOC distribution at section $y=1.825$ at discrete times with displacement ventilation