Chapter 5

Velocity and Temperature Distributions in the Present Rubber Smoking Room

5.1 Introduction

This chapter presents the study of velocity and temperature distributions in a present rubber smoking room using CFD method since it was proved reliable by the benchmarking results in the previous chapter. The geometry, boundary conditions, and source input of the present rubber smoking room are described. Next, the simulation results such as temperature contours and velocity patterns are shown and discussed. Finally, the discussion and conclusion of simulation results are presented.

5.2 Simulation of a present rubber smoking room using FloVent program

A present rubber smoking room has been investigated by simulation using FloVent V5.2 program as in the previous chapter. A difference between this model and the model in the preceding chapter is that the hanging carts containing rubber sheets are added into the smoking room as shown in Fig. 5.1. Three carts containing 1,575 rubber sheets have filled up the space in the smoking room. Each cart contains 525 rubber sheets. Positions of the hot gas supply ducts are identical to the previous case as shown in Fig. 5.2. Details of the present smoking room components are given in Table.5.1.

5.2.1 Boundary conditions, materials, source input and grid setting

The boundary conditions and heat input rate of the simulation of the present rubber smoking room were validated in the CFD and experimental studies of an empty smoking room as demonstrated in Chapter 4.

Constant static pressure was set to zero gauge pressure to represent the system surroundings in this chapter as well as in Chapter 4. Ambient temperature was set constant at 26.7°C. Air velocity was set to zero in every direction as well. Heat input rate from firewood which was calibrated in the previous study was 16.0 kW. Material properties of the components of the rubber smoking room are also shown in Table 5.1.

Turbulence flow was used for the prediction of the flow of hot gas in the smoking room. The K-epsilon model was employed to calculate the additional parameters for solving the problem of turbulence flow as in the preceding chapter.

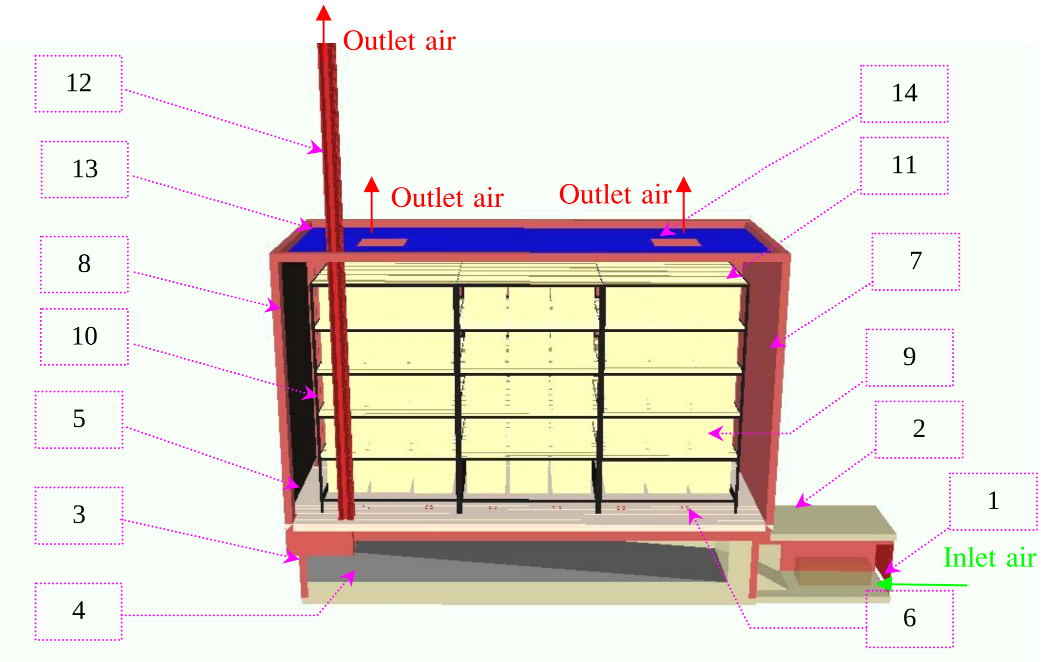


Figure 5.1 Components of a present smoking room shown from side view.

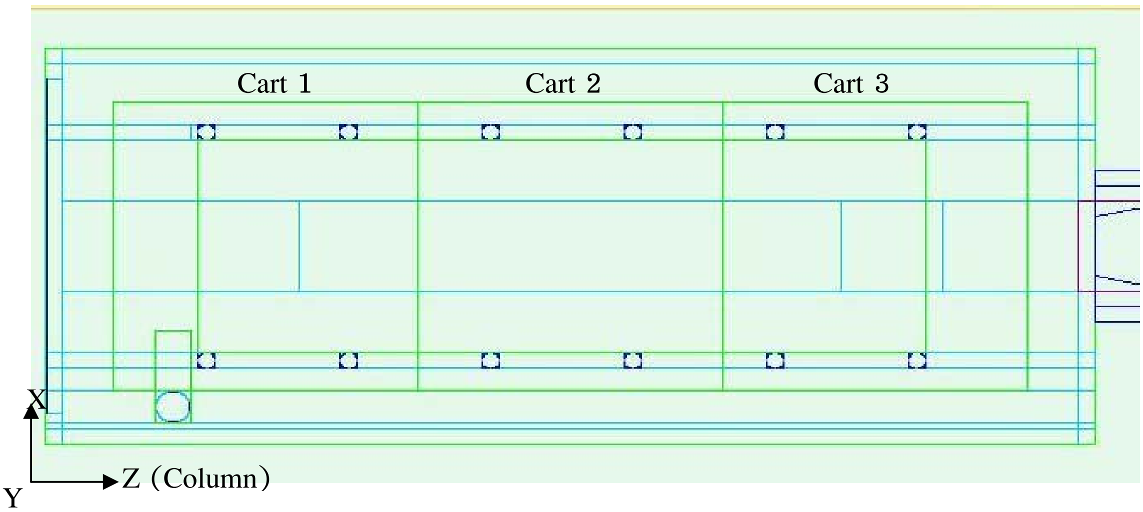


Figure 5.2 Positions of the hot gas supplying ducts of a present smoking room shown in top view.

Table 5.1 Components, materials, sizes and material properties of a present rubber smoking room.

Component	Material	Size	Material property		
			Thermal conductivity (W/mK)	Density (kg/m^3)	Specific heat (J/kgK)
1. Furnace door	Iron	0.6 x 0.8 m, thickness 5 mm	80.2	7,870	447
2. Furnace wall	Brick & cement	1.0 x 1.9 x 1.3 m, thickness 0.25 m	1.0/0.72	2,645/ 1,860	960/780
3. Wall of supply gas room	Brick & cement	2.0 x 6.2 x 1.1 m, thickness 0.25 m	1.0/0.72	2,645/ 1,860	960/780
4. Slope floor	Concrete (stone mix)	1.1 x 6.0 x 0.5 m	1.4	2,300	880
5. The smoking room floor	Cement	2.4 x 6.0 m, thickness 0.1 m	0.72	1,860	780
6. Supply ducts	Iron	Diameter 4 inch, thickness 2 mm, 12 ducts	80.2	7,870	447
7. Enclosure of smoking room	Brick	2.6 x 3.7 x 6.2 m, thickness 0.1 m	1.0	2,645	960
8. Door of the smoking room	Iron	2.4 x 3.3 m, thickness 3 mm	80.2	7,870	447
9. Bamboo hanger for rubber sheets	Wood	Diameter 0.03 m, long 1.8 m, 525 pieces	0.10	500	1,000
10. Structure of carts	Iron	Equal angle, 0.05 x 0.05 m, thickness 5 mm	80.2	7,870	447
11. Draft tube	Iron	Diameter 8 inch, long 8 m, thickness 3 mm	80.2	7,870	447
12. Ceiling	Ceiling tiles	2.4 x 6.0 m, thickness 5 mm	0.056	380	1,000
13. Ventilating lids	Ceiling tiles	0.6 x 0.6 m, thickness 5 mm	0.056	380	1,000

Localized grid scheme was used for setting fine grids where high accuracy is needed and coarse grids (maximum distance is 35 cm) were used elsewhere. Locations of fine grids which include air inlet, heat source, air supply ducts, the carts of rubber sheets and air outlets have the maximum size of 2.5 centimeters. In the y and z axis, maximum size of local grid of the carts of rubber sheets was 7.5 centimeter. In the x-axis, maximum size of local grid of the carts of rubber sheets was 0.6 centimeters. The total number of grids of the current model is 1,324,789. Moreover, this grid setting will be also employed for the model of next study.

5.2.2 Simulation results and Discussion

The temperature and flow patterns of a model rubber smoking room were investigated. Temperature contours were described in 3 planes as shown in Fig 5.3a. Temperatures in the smoking room are represented by the values at 81 positions as shown in Fig.5.3b.

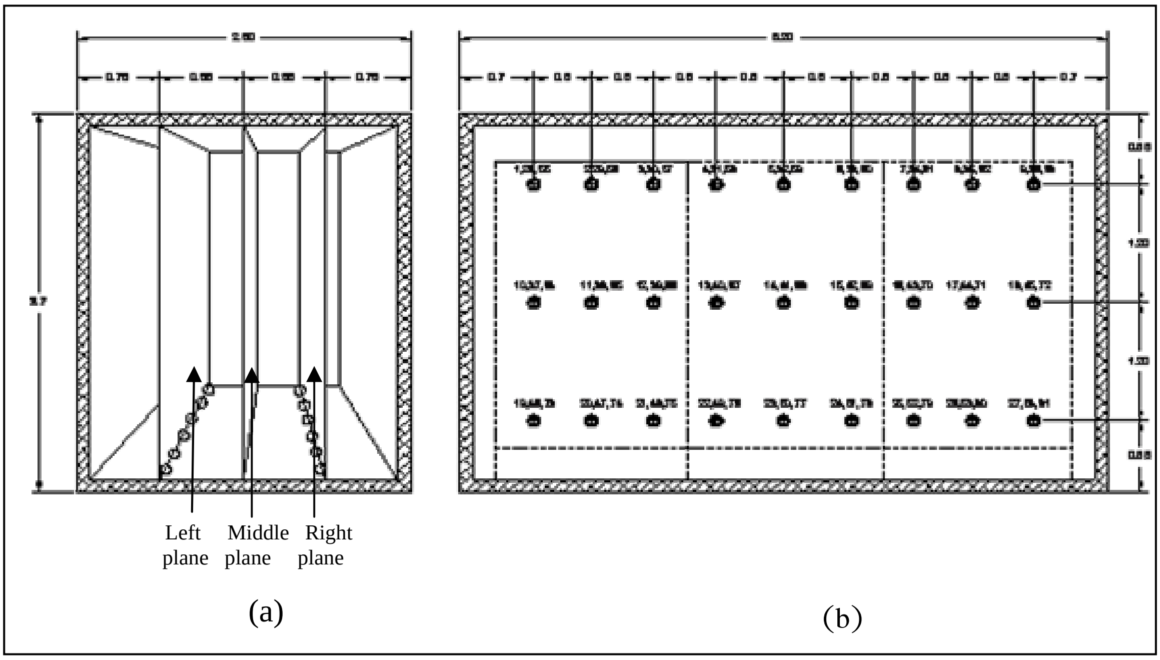


Figure 5.3 Positions of temperature measurement in the rubber smoking room.
(a) Positions of three planes of temperature shown from the front view.
(b) Positions of 81 positions of temperature measurement shown from the side view.

Flow pattern

Velocity profiles at the right, middle and left planes of a model rubber smoking room are shown in Figs. 5.4, 5.5 and 5.6, respectively. The highest velocity occurred near the rear room wall as shown in Fig 5.4 and 5.6, especially above the gas supply ducts.

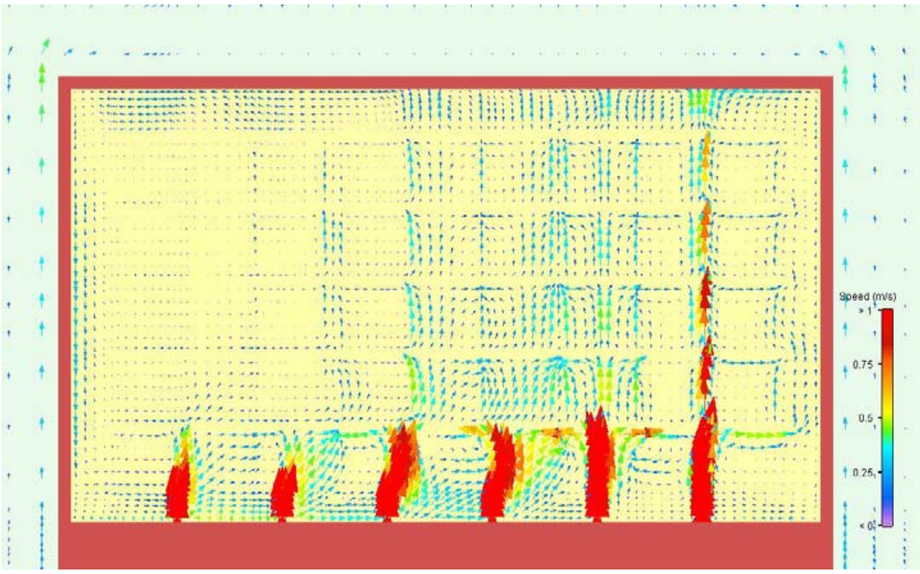


Figure 5.4 Flow pattern of a right plane of the present smoking room.

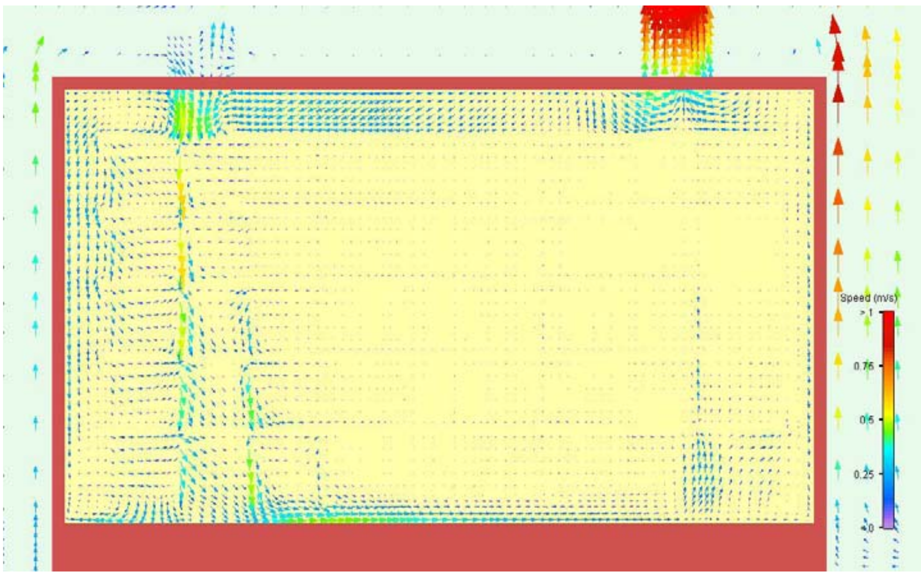


Figure 5.5 Flow pattern of a middle plane of the present smoking room.

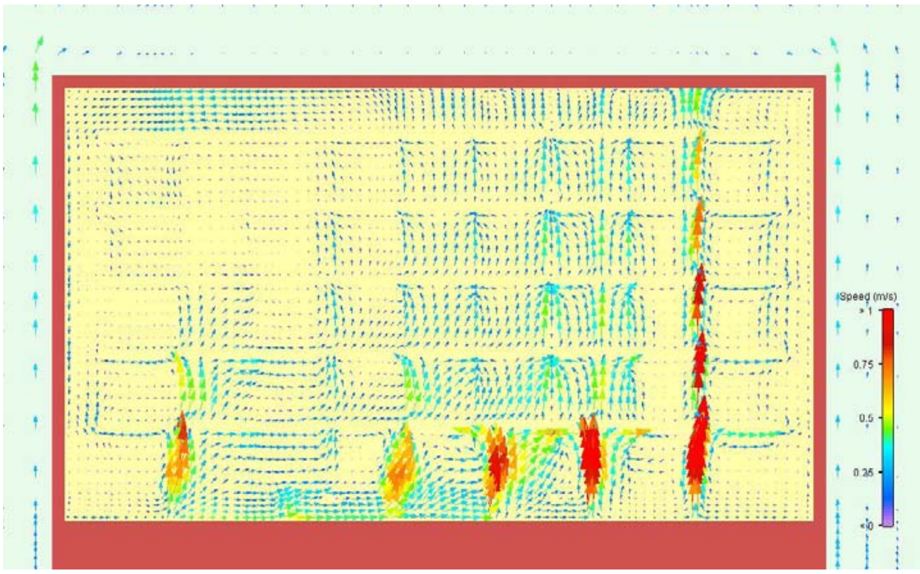


Figure 5.6 Flow pattern of a left plane of the present smoking room

However, velocity at a middle plane (particularly at the center of plane) is lowest. It can also be seen that the flow of air at the front ventilating lid is in reverse direction as shown in Fig. 5.5. Velocities at the position on the left plane above the supply ducts are lower than the right plane as shown in Figs. 5.5 and 5.6. This is because the draft tube is placed on the right side, and most of the gas flows through the draft tube, so velocity of hot gas at the outlet of the supply duct on the left side is then low.

Temperature

Temperature contours of the right, middle and left planes are shown in Figs. 5.7, 5.8 and 5.9, respectively. The right and left planes are placed through the center of hot gas supply duct rows on both sides as shown in Fig 5.3a. The middle plane is placed on the center of the smoking room. At the middle plane, it is seen that low temperature occurs near the front part of the smoking room, particularly on the section below the front ventilating lid. It is also seen that high temperature occurs near the rear part of the smoking room.

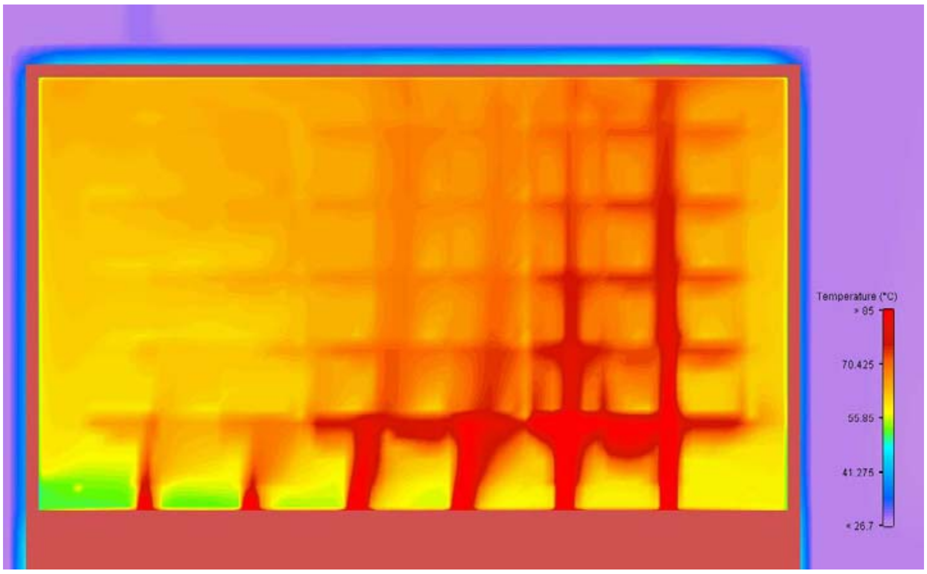


Figure 5.7 Temperature contour of a right plane of a present smoking room.

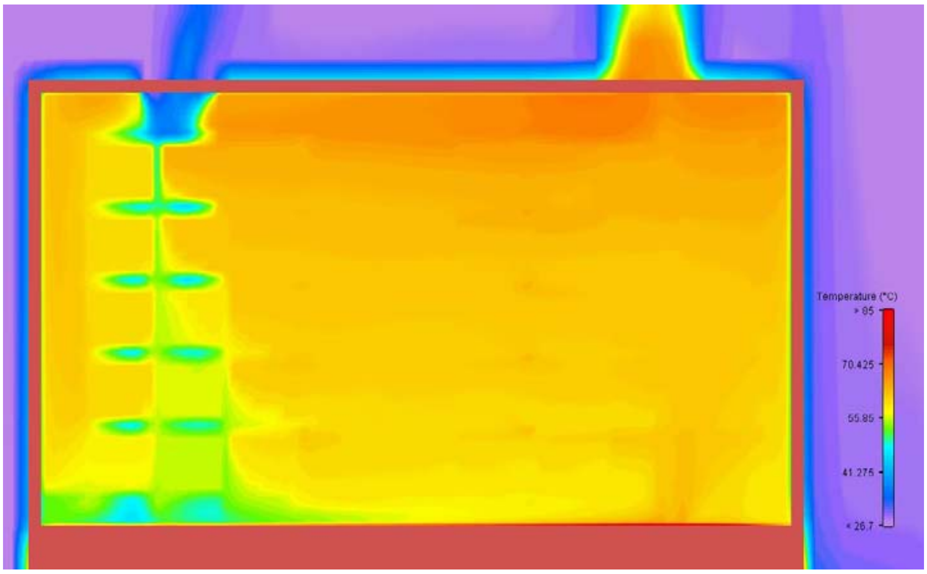


Figure 5.8 Temperature contour of a middle plane of a present smoking room.

At the right and left planes, it is seen that, high temperature occurs near the rear part of the smoking room, especially in the areas above the positions of the gas supply ducts. Low temperature occurs near the floor at the front part of the smoking room.

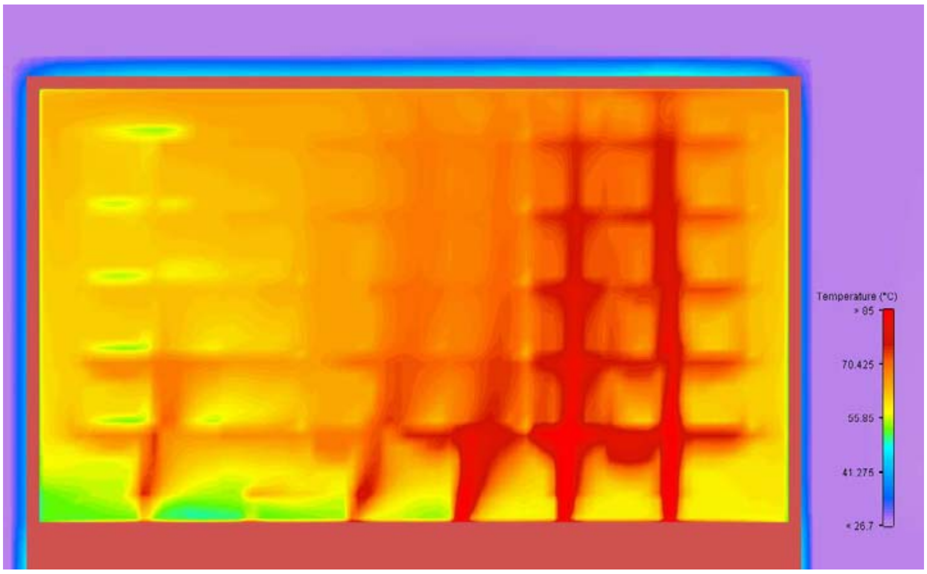


Figure 5.9 Temperature contour of a left plane of a present smoking room.

Furthermore, the asymmetry behavior between the left and right planes result from the presence of an 8 inch-diameter draft tube (not shown) used for exhausting the gas when producing air dried sheets (ADS) but it was usually left open by worker to enhance flow of hot gas into the smoking room.

Details of temperature distribution at 81 positions in the smoking room are shown in Fig. 5.10. It can be seen that the temperature variation in the room is as large as 15°C (50-65°C). This affects the quality of the dried rubber sheets and fuel usage. The position of high temperature occurs on the upper left side near the rear part of the smoking room (at positions 61 and 62). Low temperature occurs on the center near the front part, particularly near the floor, of the smoking room below the front ventilating lid (at position 46). It can be seen that the temperature in the region of front ventilating lid is quite low. This resulted from back-flow of outside air to the room.

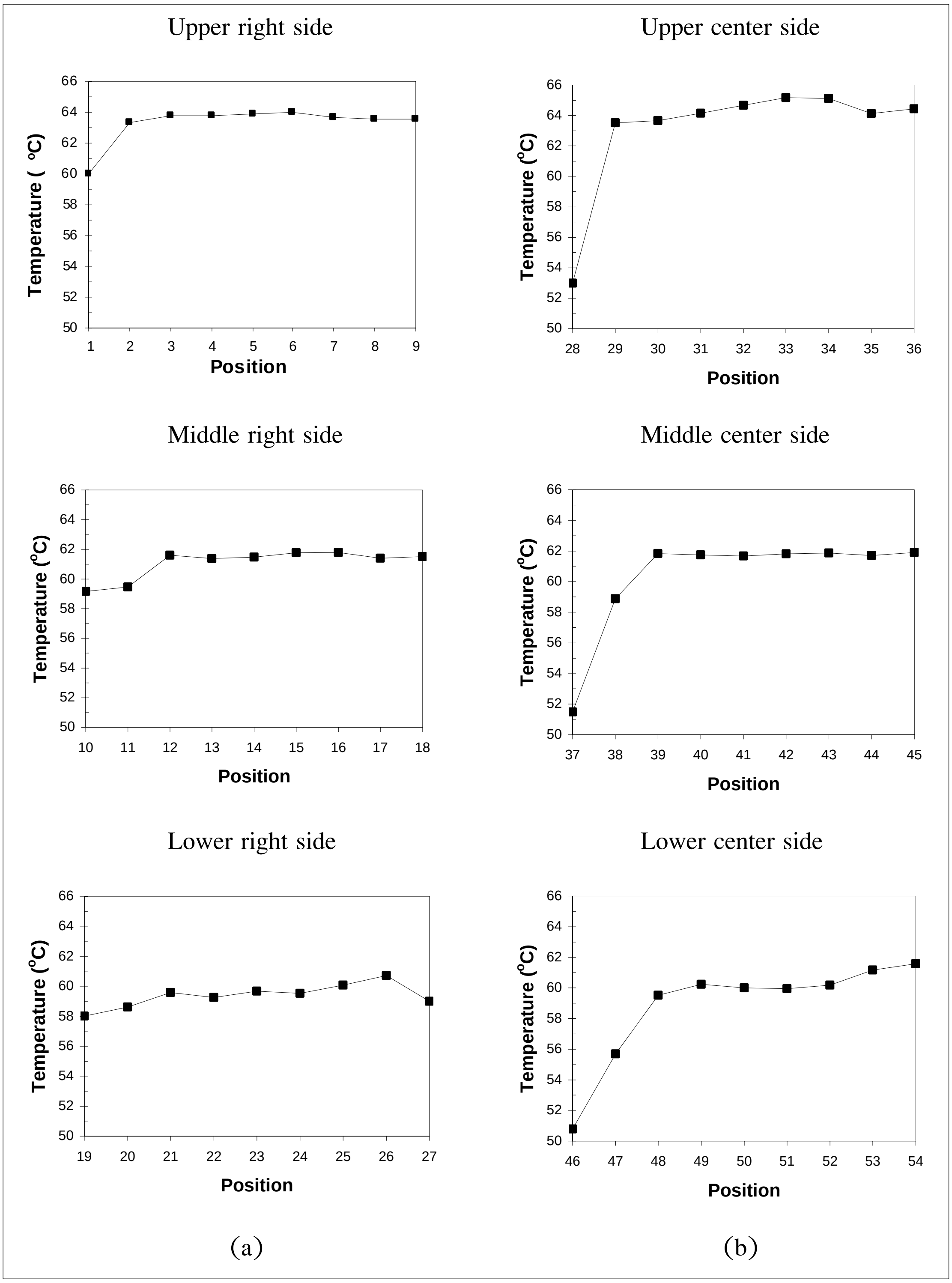
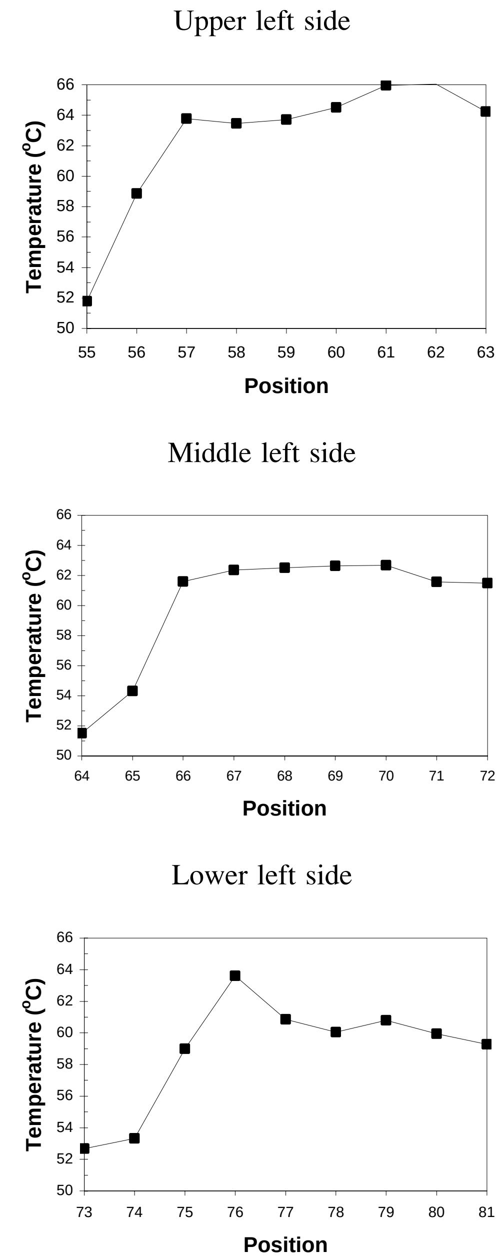


Figure 5.10 Temperature distribution in the rubber smoking room.
(a) At the right side. (b) At the center side.



(c)

Figure 5.10 Temperature distribution in the rubber smoking room. (Continued)
(c) At the left side.

5.3 Conclusions and Recommendation

Variation of temperature from the simulation in the rubber smoking room is as large as 15°C. Variation of gas velocities in the rubber smoking room is also large. Most of hot gas flows out of the room from the back ventilating lid, while air from outside flows into the room through the front ventilating lid. Gas supply ducts of this room causes uneven distribution of hot gas inlet. Position of the draft tube affects the flow of hot gas inlet in the smoking room. Results show that the size and positions of the gas supply duct and ventilating lids are not suitable. These results will be used to make improvement of the flow in the rubber smoking room in the next chapter.