STUDY ON AIR CONDITIONING'THERMAL COMFORT WITH NEW-TYPE FAN

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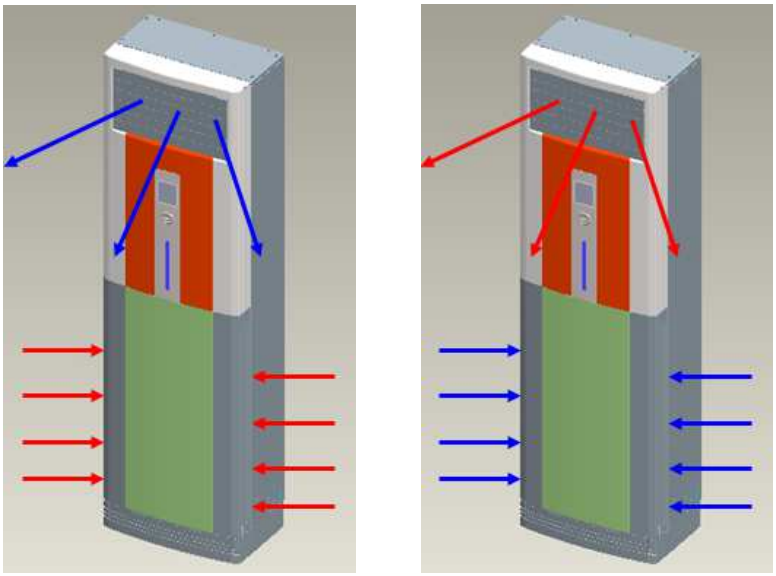
SUMMARY

The conventional static wind tunnel is changed to dynamic wind tunnel by fan. The new wind tunnel realizes the top air supply and the bottom air return for cool mode and the top air return and the bottom air supply for heat mode. It is realized by rotating propeller housing.The new wind tunnel supplies the thermal air to the human's knees below directly, it increases the room's temperature for 2-4 ℃ below 1.5m height in heat mode. The non-uniformity coefficient of temperature reduces about 70 percent.

INTRODUCTION

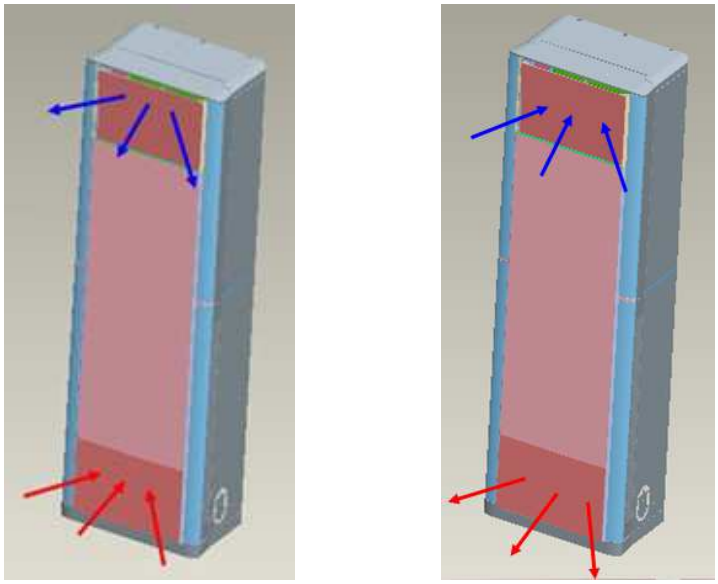
The conventional floor standing air conditioning's inlet is in the bottom and its outlet is in the top in cool mode and heat mode (as shown in fig.1), its thermal comfort is not good, it is hard to supply the thermal air to the human knees below. It is difficult to meet the human comfort requirements for thermal feet and cool head.

In order to improve the status, using new technology of wind tunnel which adds an air opening in the bottom, the air direction can switch when it is in cool or heat mode. It realizes the top air supply and the bottom air return for cooling, the flowing direction of cool air is top-down in summer(as shown in fig.2a) and it realizes the top air return and the bottom air supply for heating, the flowing direction of warm air is down-up in winter(as shown in fig.2b). It makes whole room temperature distribute fast and uniformly. It can supply warm air directly to human's knee below and improve human's thermal comfort.



1a: cool mode *1b: heat mode*

Figure 1: conventional mode



2a: cool mode *2b: heat mode*

Figure 2: conventional mode

NEW DYNAMIC WIND TUNNEL TECHNOLOGY

In order to improve the thermal comfort of the floor standing air conditioning, the conventional static wind tunnel is changed to dynamic wind tunnel. In cool mode, the bottom volute board 2 and top volute board 6 are closed. The position of rotating volute board 10 is shown in fig.3. The hot air are sucked through bottom opening 1, worked by centrifugal fan 3 driven by motor 4, then through volute 5, to heat exchanger 7. After heat transferring, the cool air flows out through top opening 8. In heat mode, the bottom volute board 2 and top volute board 6 open. The rotating volute board 10 rotates for 180 degrees, the position of it is shown in fig.4. The cold air is sucked through top opening 8. After heat transferring with heat exchanger 7, the warm air is worked by the centrifugal fan 3 driven by motor 4, then through volute 5. The warm air flows out through bottom opening 1. The op volute board 6, the bottom volute board 2 and the rotating volute board 10 are driven respectively by three different mechanisms.

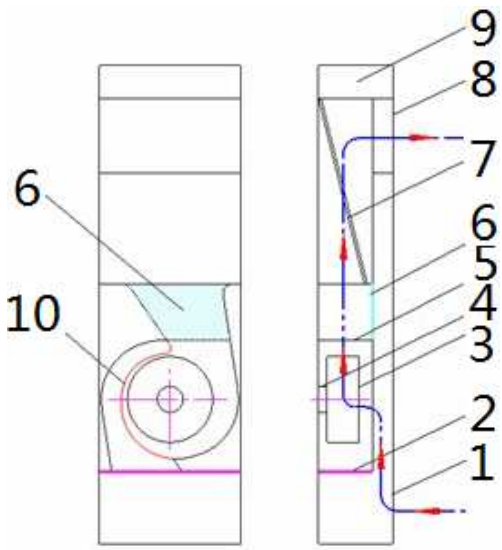


Figure 3: schematic sketch for cool mode

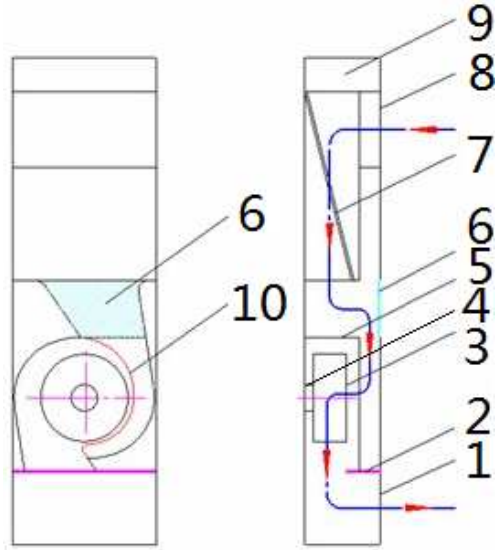
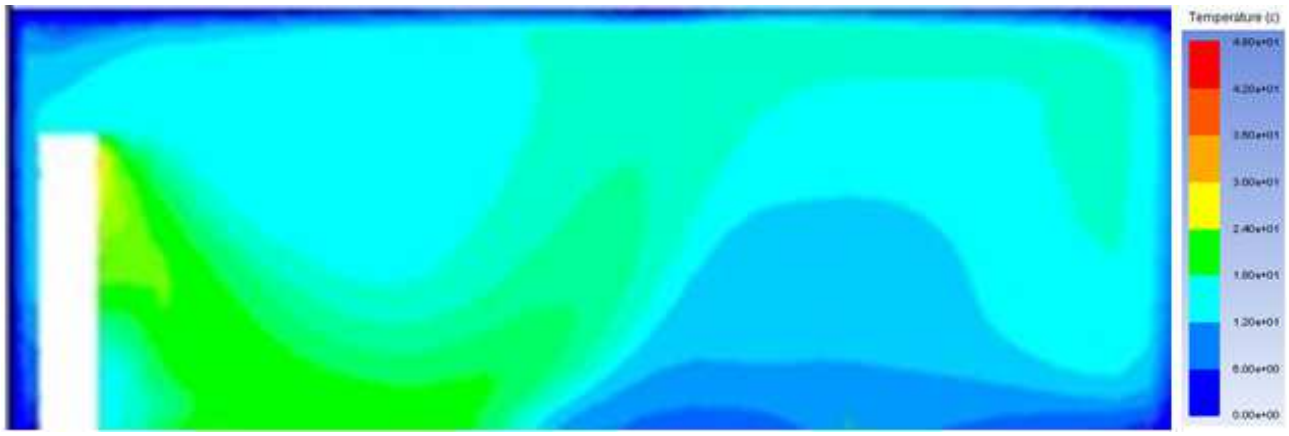


Figure 4: schematic sketch for heat mode

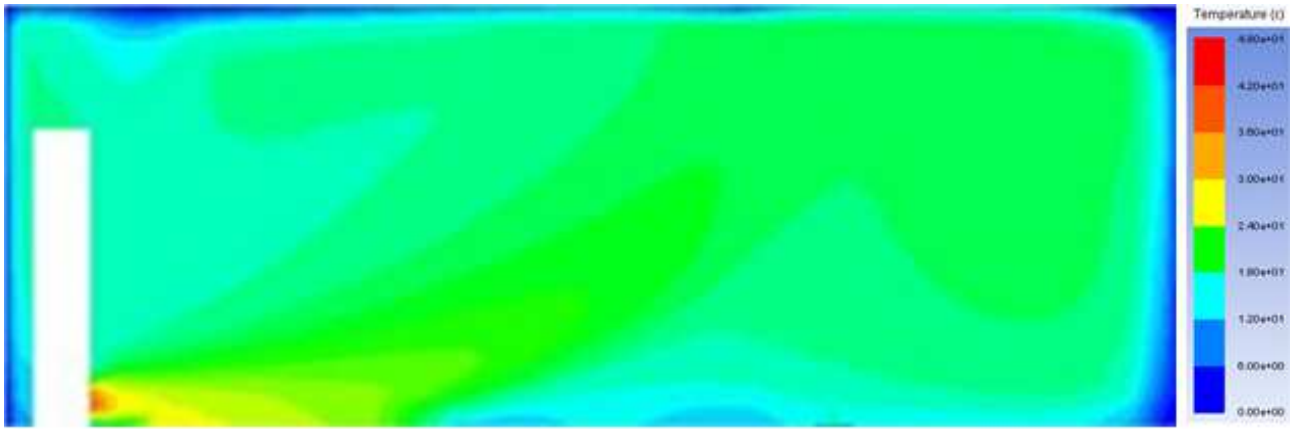
CFD AND EXPERIMENTS RESULTS

CFD

The above structures in heat mode are simulated respectively by CFD tool. Running time is for 60 minutes. The temperature contours are shown in fig.5. The fig.5a is for conventional air conditioning and the fig.5b is for new air conditioning. The results indicate that the temperature field of new air conditioning distributes more uniformly, the temperature of the knee below is higher in heat mode, and the thermal comfort is better.



5a: conventional heat mode



5b: new heat mode

Figure 5: CFD temperature contrast

Thermal Comfort Experiment

Testing room is 7 meters long, 3 meters wide and 2.5 meters high. The air conditioning is in the middle of width. Indoor condition is that dry bulb temperature is 273 K. Outdoor condition is that dry bulb temperature is 268 K. Air conditioning temperature is set 303 K. Heating capacity is 5800 W.

Indoor temperature is measured by thermocouple. There are 13 thermocouple planes arranged uniformly in X direction, 6 thermocouple planes arranged uniformly in Y direction, 5 thermocouple planes arranged uniformly in Z direction. Fig.6 is the schematic sketch of temperature field section and temperature scale.

The conventional and new temperature contour in heat mode are the same. The Fig.7 to 16 show the temperature contour contrasts with different running time and different section for conventional and new air conditioning in heat mode. The contrasts indicate that the room temperature of the new air conditioning distribute more uniformly than conventional. The mean temperature of new air conditioning increases 2-4 K. It has obvious advantage on rapid heating effect.

Fig.17 is the wind flowing area of mid section in heat mode (wind speed is greater than 0.2 m/s). The wind flowing area is between the upper curve and the lower curve. Fig.17b is the flowing area of new air conditioning. The warm wind keeps close to the ground then moves upwards. The warm wind does not flow to the human's head within 4.5 m distance. Weak wind flows to the head between 4.5 m and 5 m. Most of wind flows to the shoulders below. The thermal comfort of the new air conditioning is very good. Fig.17a is the flowing area of conventional air conditioning. The wind flows to the human's head within 5 m distance. It is hard to flows to knees below. Its thermal comfort is worse.

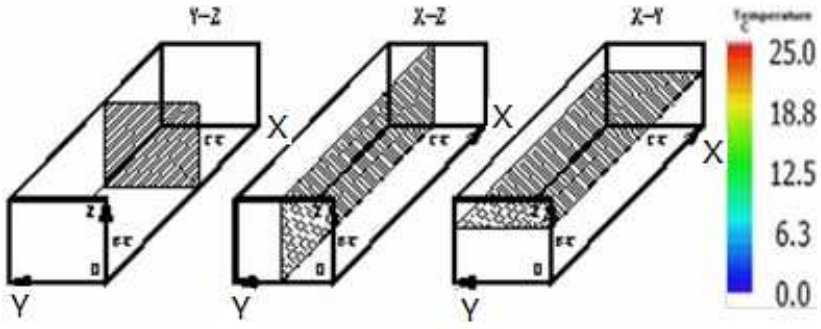
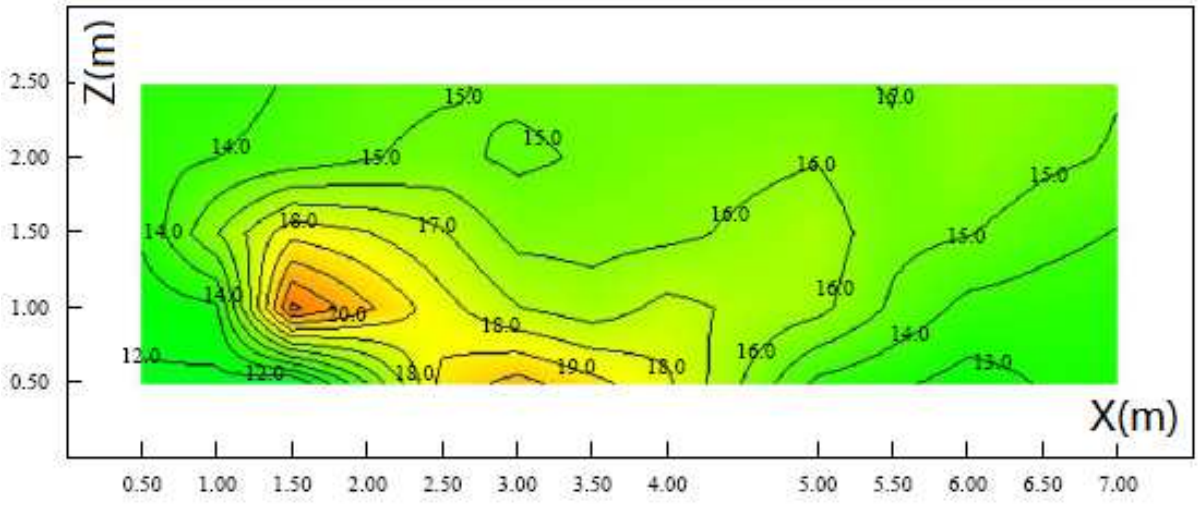
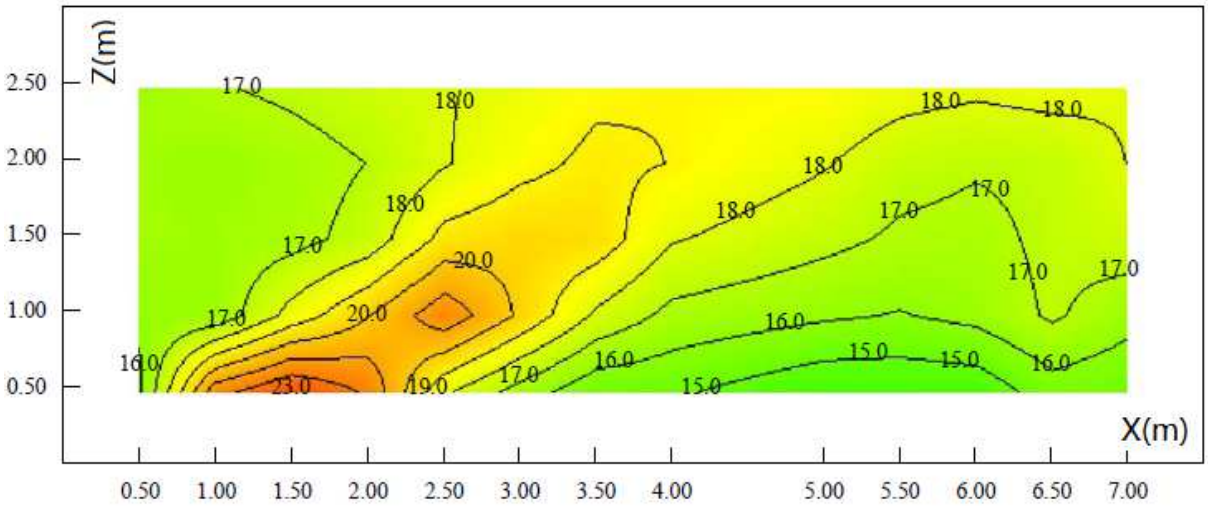


Figure 6: schematic sketch of temperature field section and temperature scale

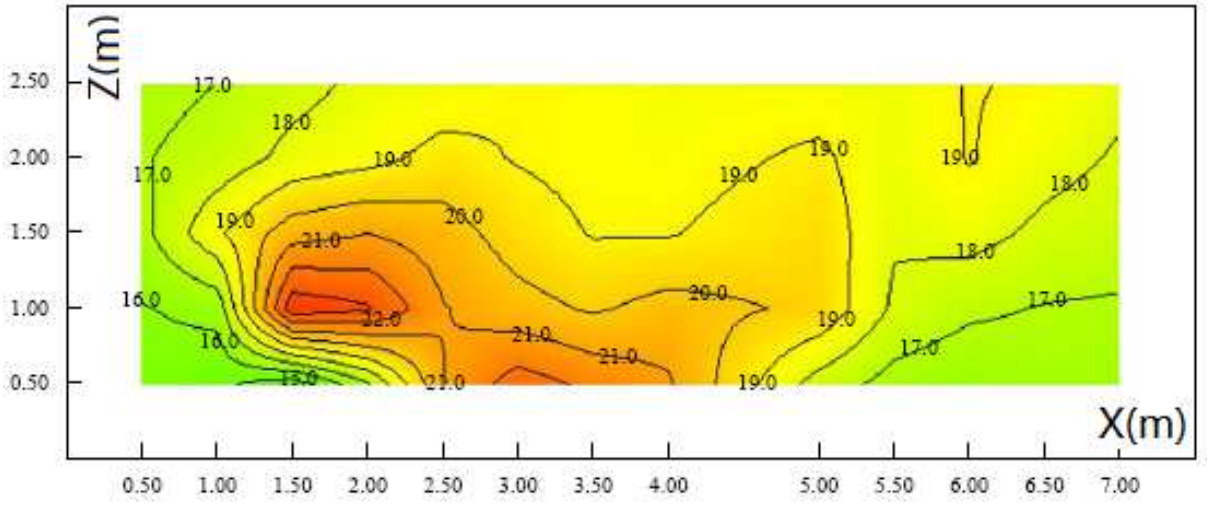


7a: conventional temperature contour

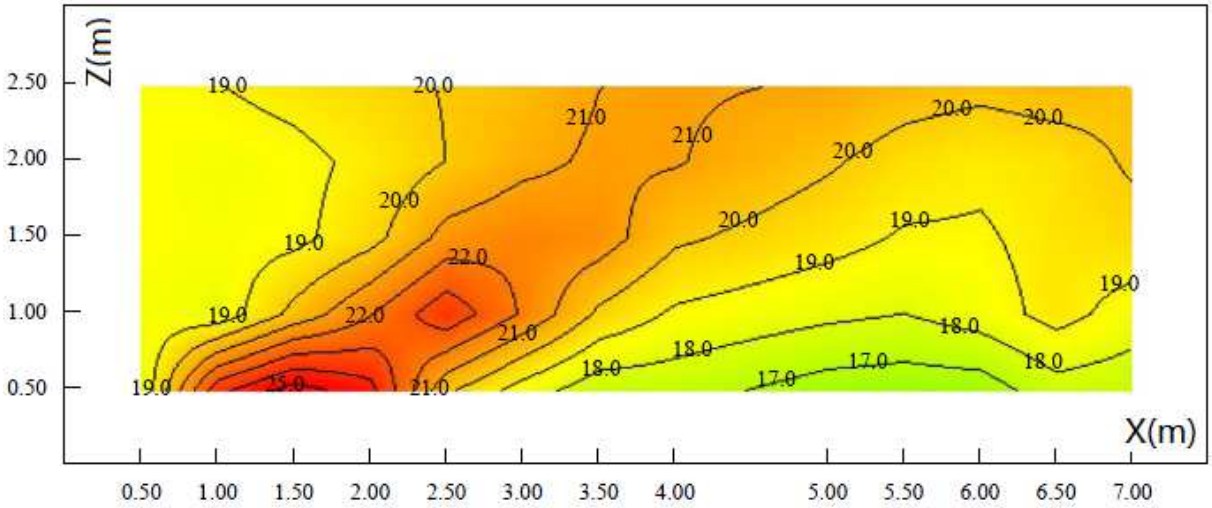


7b:new temperature contour

Figure 7: running 30 minutes in heat mode (XZ plane, Y=1.5 m)

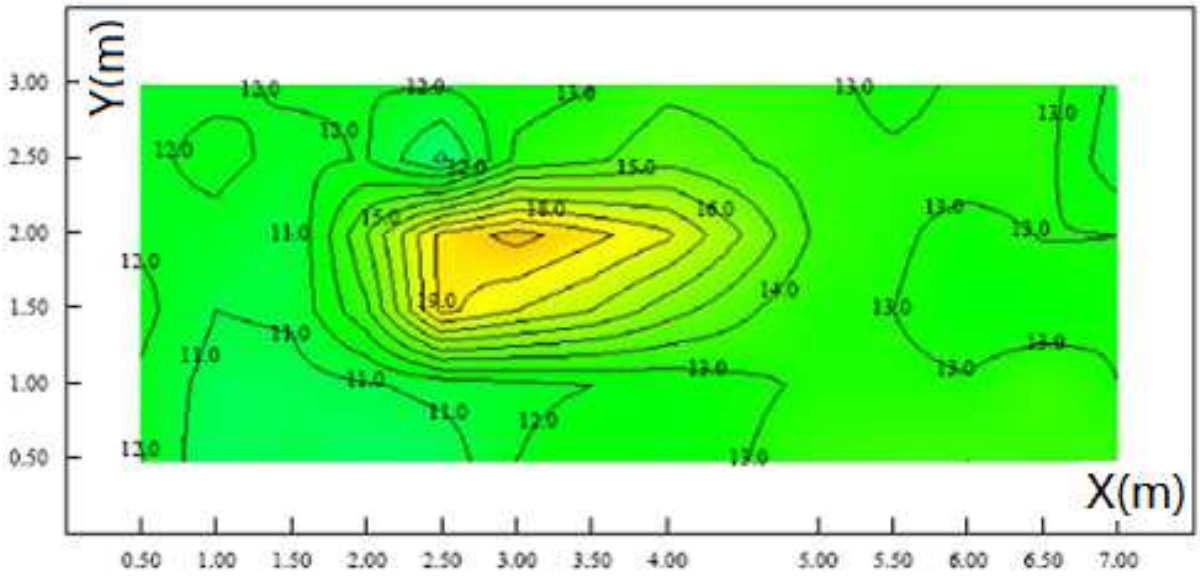


8a: conventional temperature contour

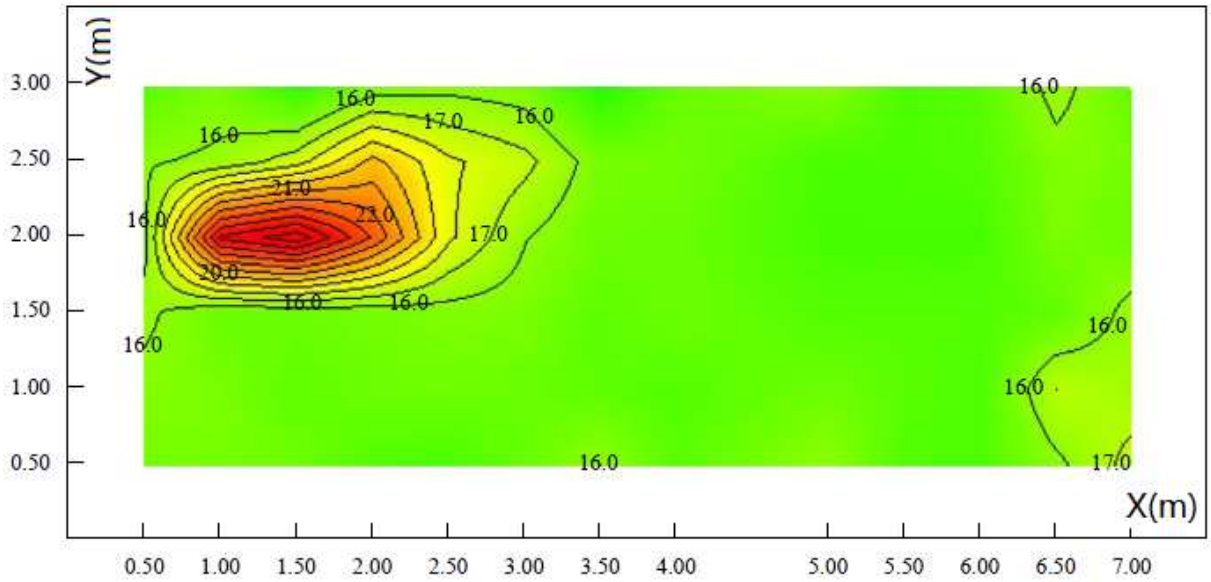


8b: new temperature contour

Figure 8: running 60 minutes in heat mode (XZ plane, Y = 1.5 m)

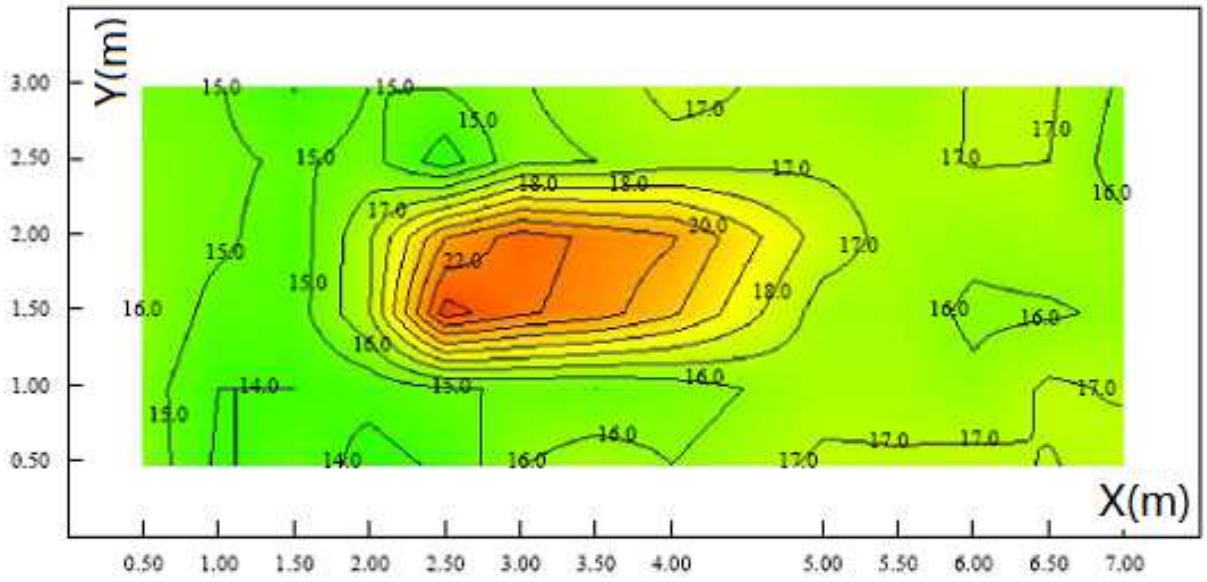


9a: conventional temperature contour

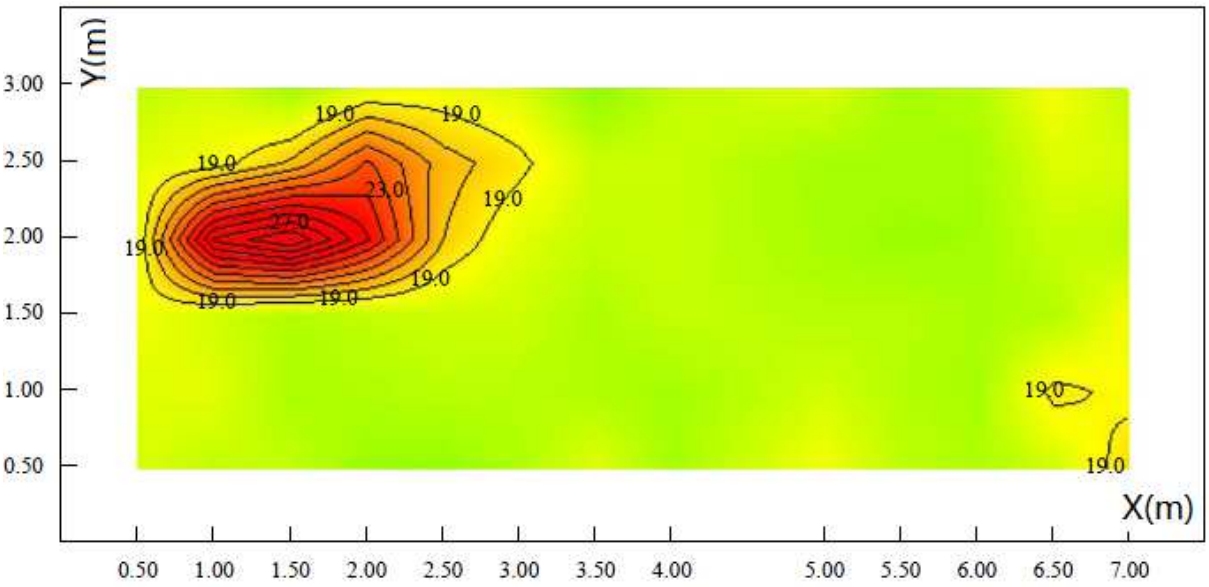


9b: new temperature contour

Figure 9: running 30 minutes in heat mode (XYplane, Z = 0.5 m)

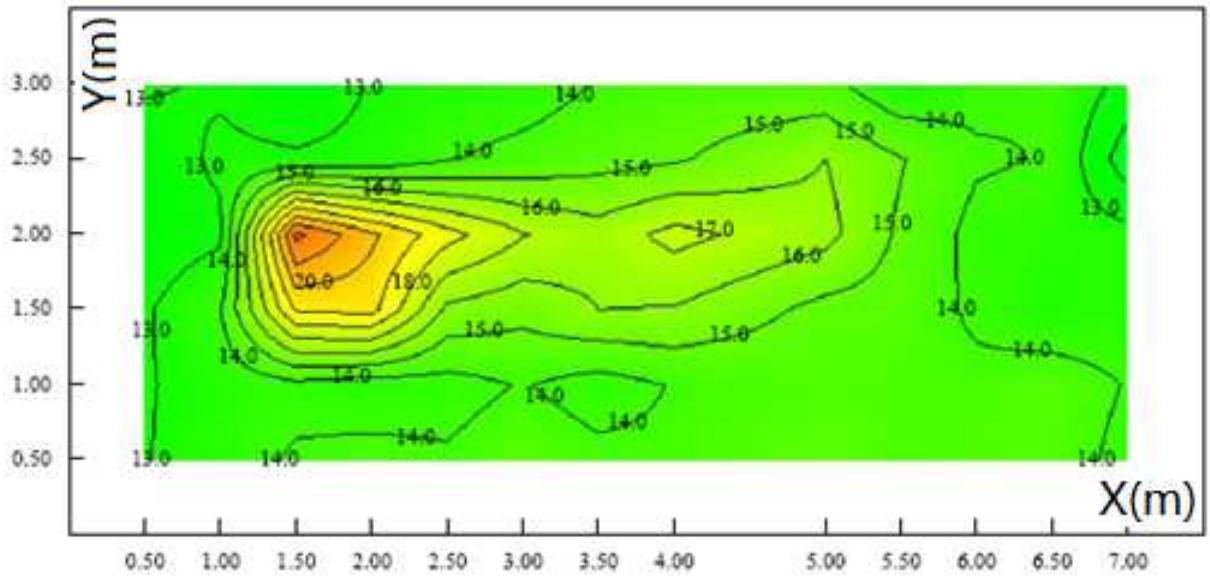


10a: conventional temperature contour

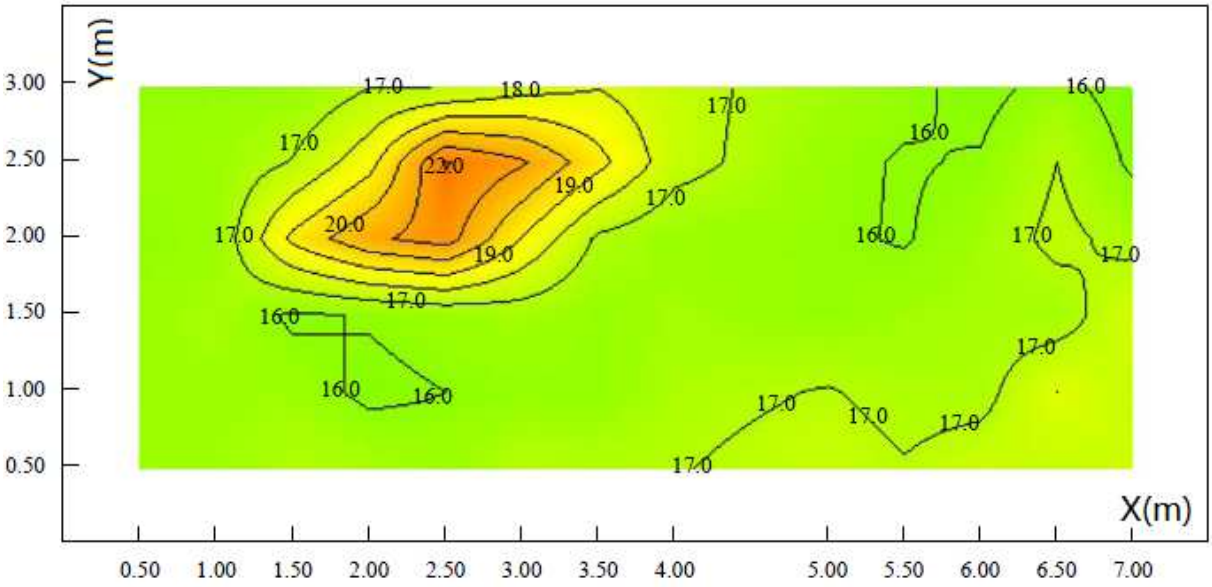


10b: new temperature contour

Figure 10: running 60 minutes in heat mode (XY plane, Z = 0.5 m)

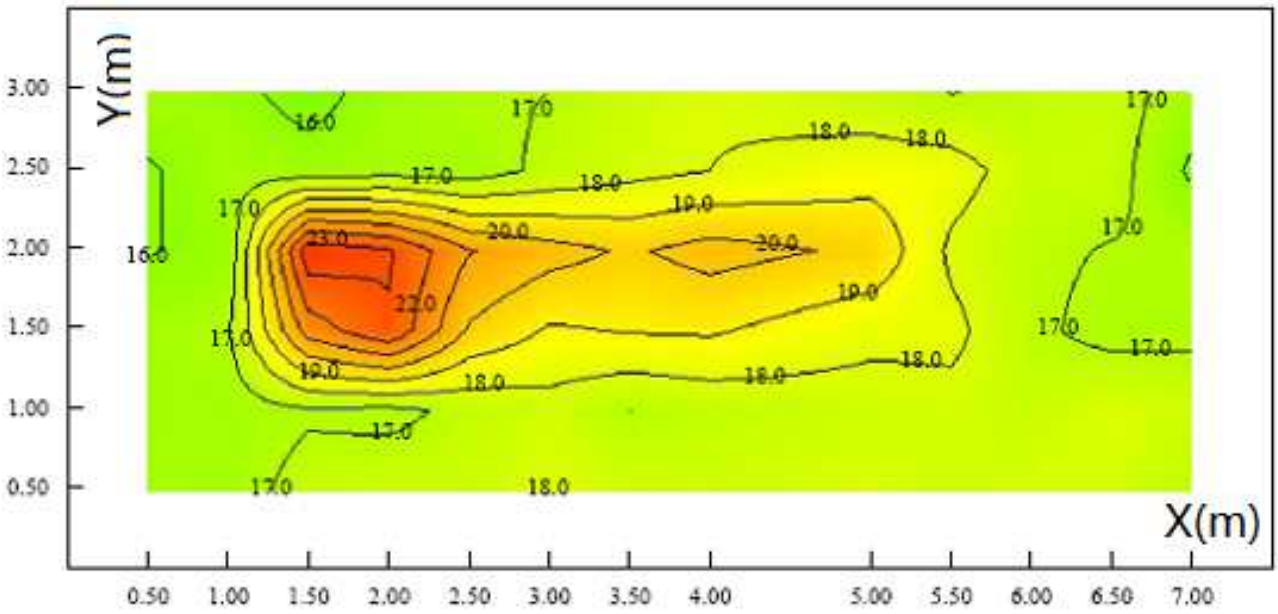


11a: conventional temperature contour

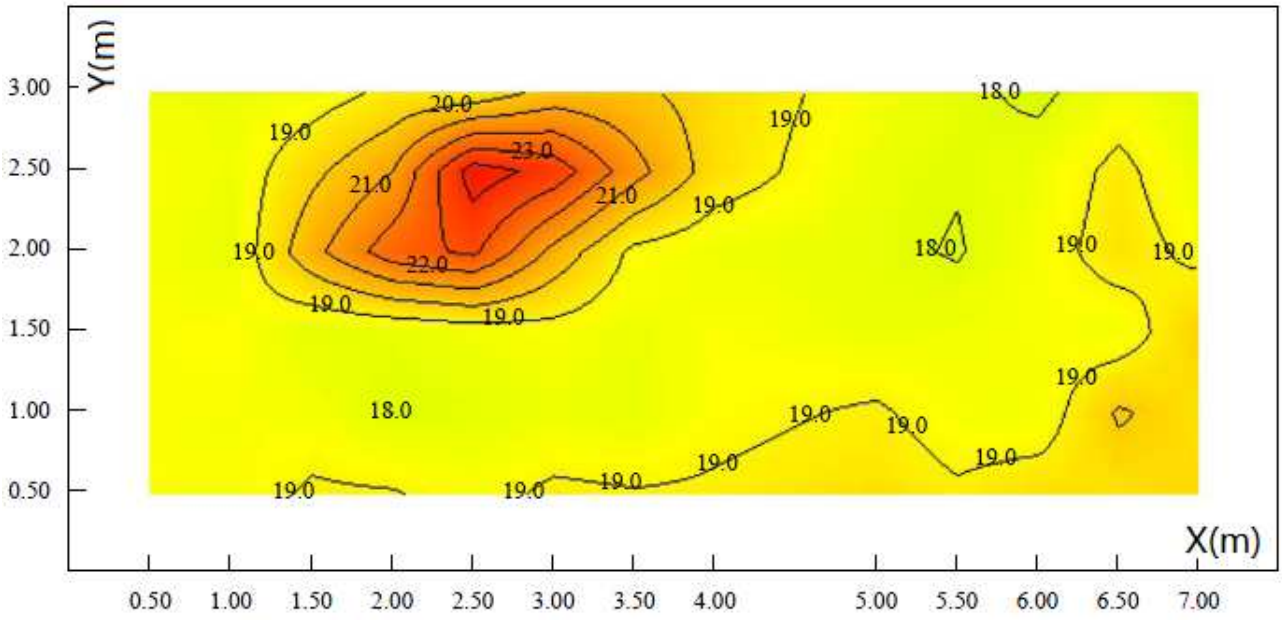


11b: new temperature contour

Figure 11: running 30 minutes in heat mode (XY plane, Z= 1 m)

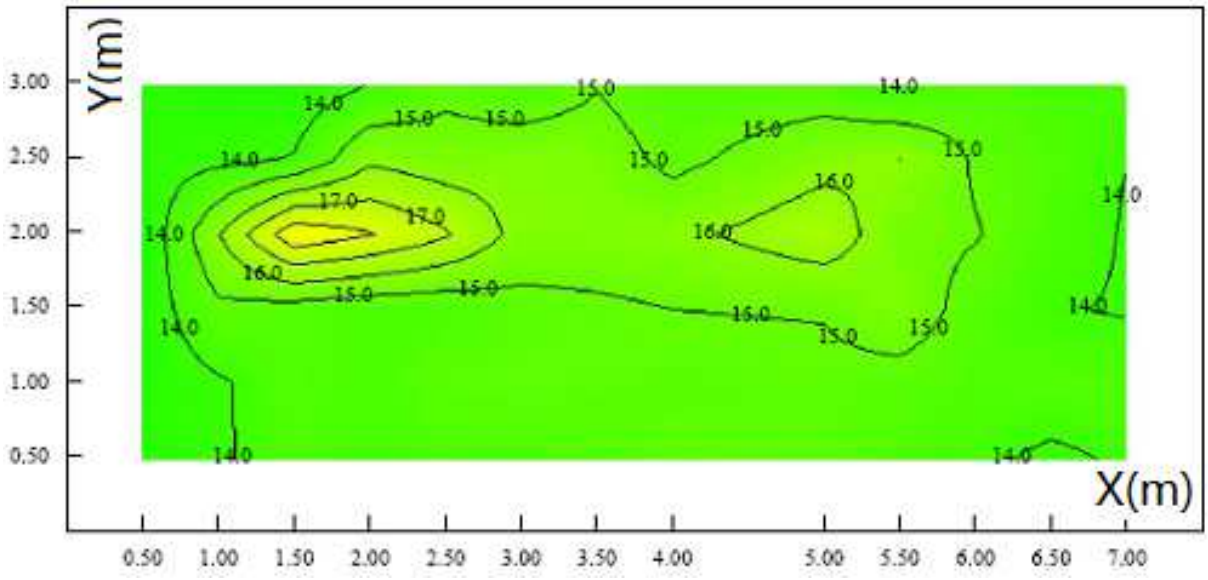


12a: conventional temperature contour

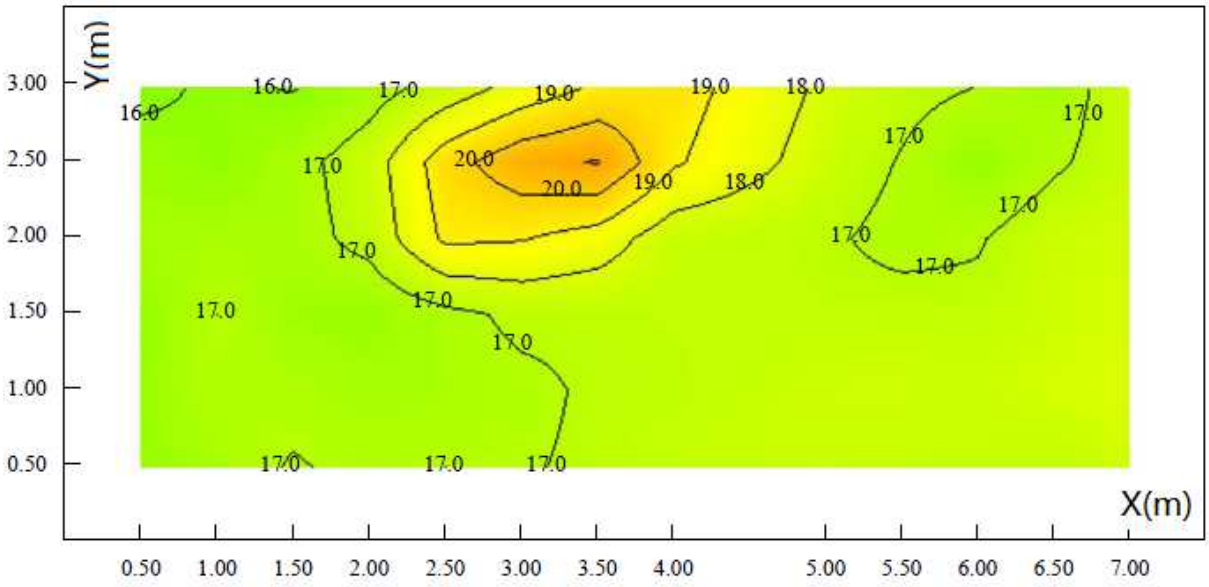


12b:new temperature contour

Figure 12: running 60 minutes in heat mode (XY plane, Z=1m)

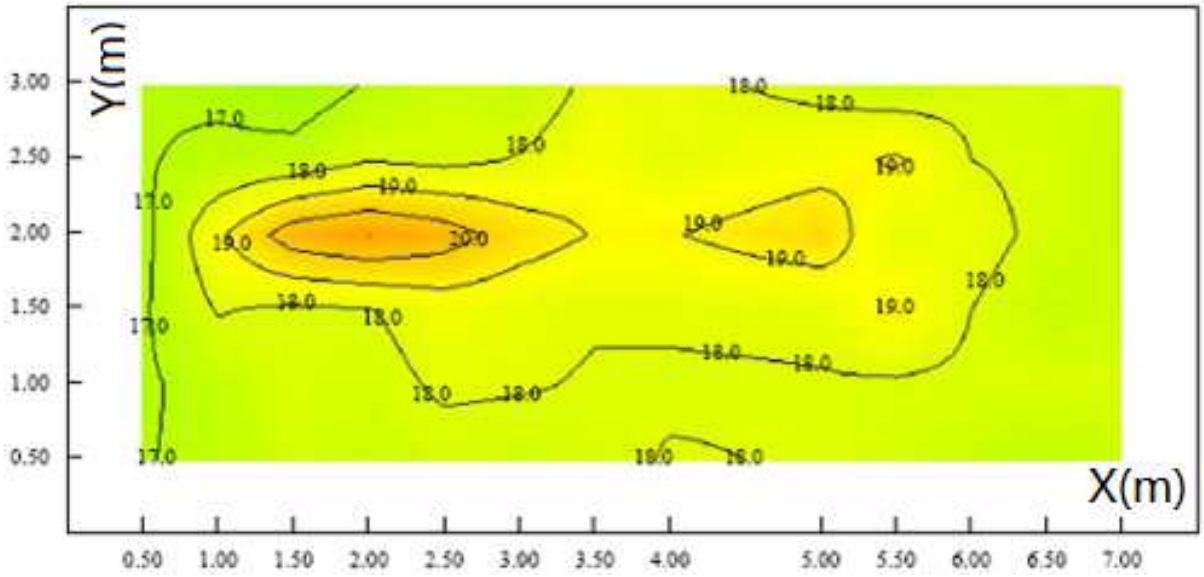


13a: conventional temperature contour

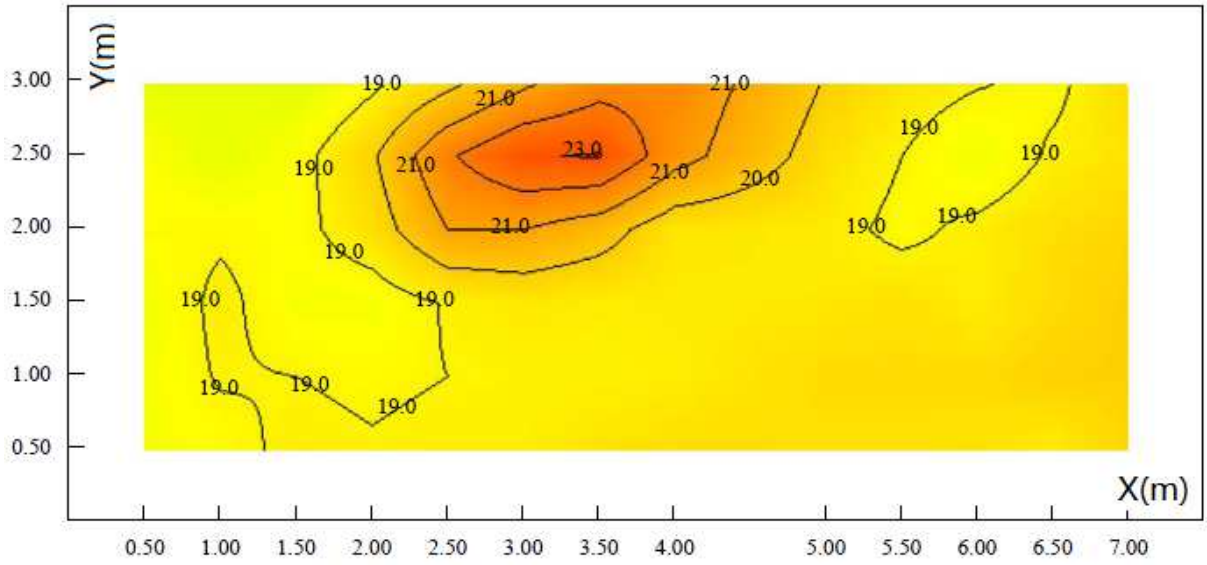


13b: new temperature contour

Figure 13: running 30 minutes in heat mode (XY plane, Z = 1.5 m)

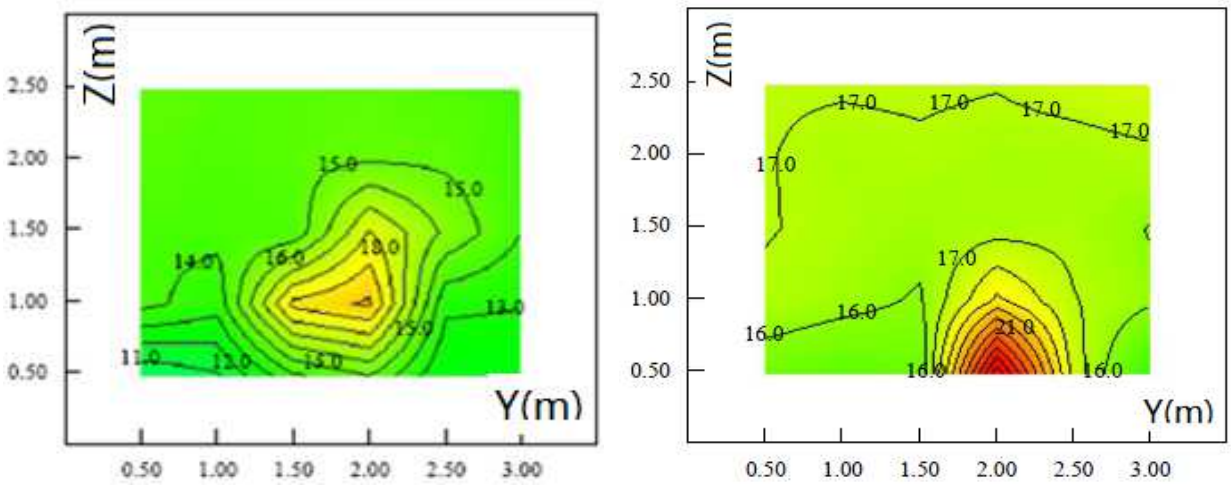


14a: conventional temperature contour



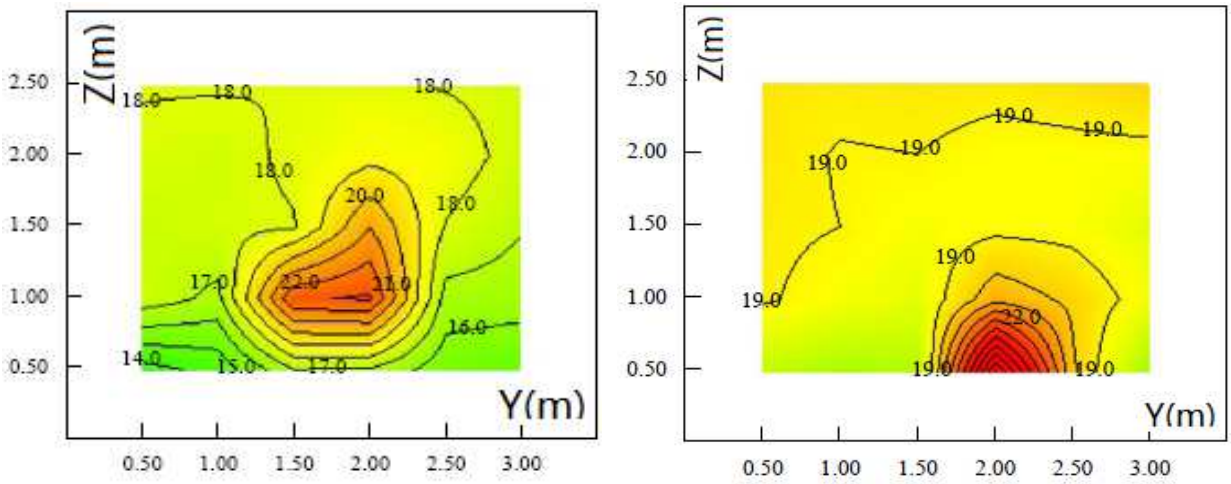
14b:new temperature contour

Figure 14: running 60 minutes in heat mode (XY plane, Z = 1.5 m)



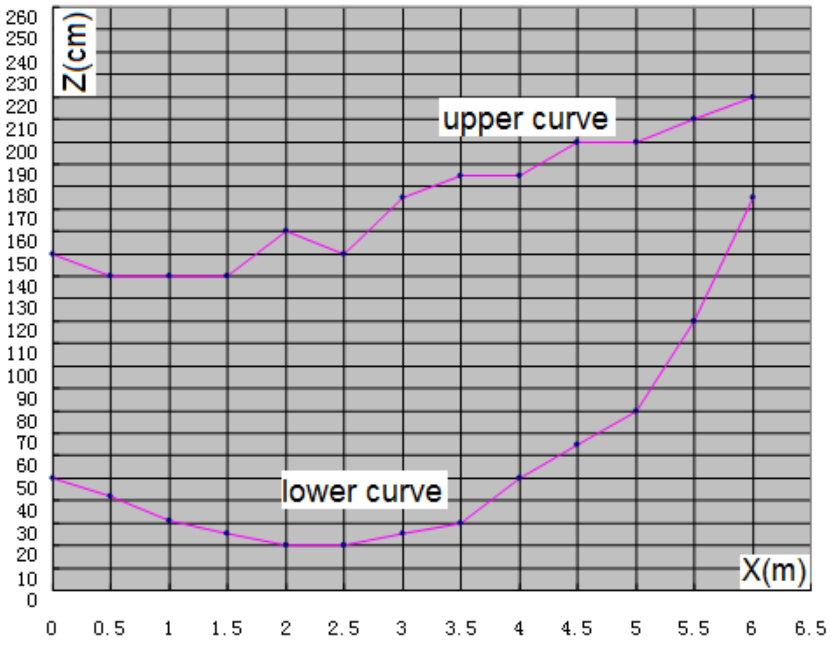
15a: conventional temperature contour *15b: new temperature contour*

Figure 15: running 30 minutes in heat mode (YZ plane, X = 1.5 m)

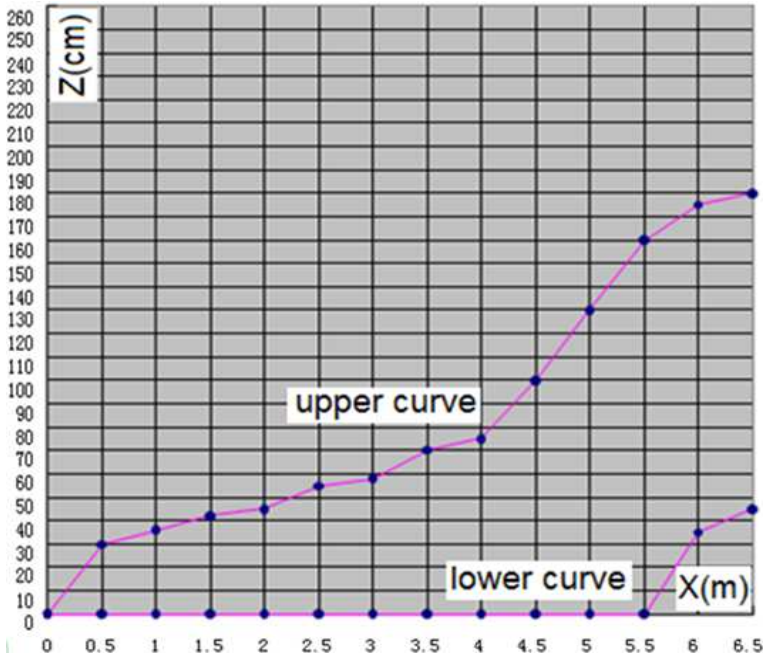


16a: conventional temperature contour *16b: new temperature contour*

Figure 16: running 60 minutes in heat mode (YZ plane, X = 1.5 m)



17a: conventional flowing area



17b: new flowing area

Figure 17: contrast of the wind flowing area of mid section in heat mode

Data Analysis

Air-flow organization is evaluated with non-uniformity coefficient of temperature. The non-uniformity coefficient of temperature is less, the uniformity of the air-flow is better. Table 1 is the contrast of the non-uniformity coefficient for different section and for different running time in heat mode. The experiment data indicates that the non-uniformity coefficient of temperature of new air conditioning reduces about 70 percent. The thermal comfort improves greatly.

$$\bar{t} = \frac{\sum t_i}{n} \tag{1}$$

where
$\bar{t}$ = temperature mean value

$$\sigma_t = \sqrt{\frac{\sum (t_i - \bar{t})^2}{n}} \tag{2}$$

where
σ_t = root-mean-square value

$$K_t = \frac{\sigma_t}{\bar{t}} \tag{3}$$

where
K_t = non-uniformity coefficient of temperature

Table 1: non-uniformity coefficient of temperature contrast in heat mode

Type	Conventional				New			
Section Name	X-Z		Y-Z		X-Z		Y-Z	
Running Time（min）	30	60	30	60	30	60	30	60
Non-uniformity Coefficient	0.179	0.162	0.299	0.225	0.051	0.044	0.091	0.083
Reduction percentage (%)	/	/	/	/	-71.5%	-72.8%	-69.6%	-63.1%

CONCLUSIONS

Using the new air conditioning technology, it can increase the temperature distribution uniformity, supply the warm wind to human's knees below and people do not feel uncomfortable. It can promote quickly the heating effect and improve the thermal comfort, improve the indoor air quality and realize the energy conservation. It has a good application value.