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Research on Desk Personalized Ventilation in Winter Based on CFD

Liu Fei* and Zhang Dongliang

Guilin University of Aerospace Technology, Guilin 541004, P.R. China

Abstract: The excellent desk personalized ventilation scheme is found in this paper by the way of comparing the four winter air supply schemes, basing on the numerical simulation software of CFD. We find that air supply quality and air supply angle are both the important factors to personalized ventilation individual comfort in winter. The air temperature and velocity surrounding the human body of the excellent desk personalized ventilation scheme are discussed. It comes to the conclusions that under simulated conditions the excellent desk personalized ventilation scheme can better satisfy the human body comfort on the surrounding air temperature and healthy than the traditional air conditioning, and it is easier to achieve energy saving too.

Keywords: Air supply angle, air supply quality, air velocity, personalized ventilation, temperature.

1. INTRODUCTION

Traditional air conditioning strive to create a steady and uniform thermal environment, it is difficult to meet the thermal comfort requirements of all people. The hot air will rise and the ground temperature increase slowly in winter as far as this kind of air conditioning is concerned. It will lead to air conditioning syndrome living in a closed air conditioning environment for a long time. Improve thermal comfort of human body and improve indoor air quality has always been the goal of air conditioning technology progress. Personalized ventilation is a new type of air conditioning in order to meet individual thermal comfort and health requirements.

Desk personalized ventilation research intended to put forward energy-saving personalized ventilation scheme for satisfying the individual thermal comfort requirements, without background air conditioning [1]. According to the user's activity space form local air conditioning and comfortable space, using health and natural ventilation, without considering fresh air supply and uniform temperature field problem, can save air conditioning energy consumption [2].

2. MODEL

According to the characteristics of human body, that the hands and feet are the most afraid of cold parts during the winter, the location of the air supply outlet is best close to human hands and feet. The desk personalized ventilation model [3, 4] is shown in Fig. (**1**).

In Fig. (**1**), the desktop is 0.75 m high and 1.2 m long; the upper air supply outlet is adjacent to the desktop, its size is 0.54 m×0.08 m and the distance from it to the desk front edge is 0.45 m; the bottom air supply outlet is adjacent to the ground and 0.45 m from the desktop, and the chest of the human is 0.55 m from the upper air supply outlet.

Fig. (1). Desk personalized ventilation model.

In order to study the personalized ventilation effect on the surrounding air temperature field of the human body, put the model of Fig. (**1**) in a room, whose length is 4.5 m, width is 4 m, and height is 3 m. It is shown in Fig. (**2**).

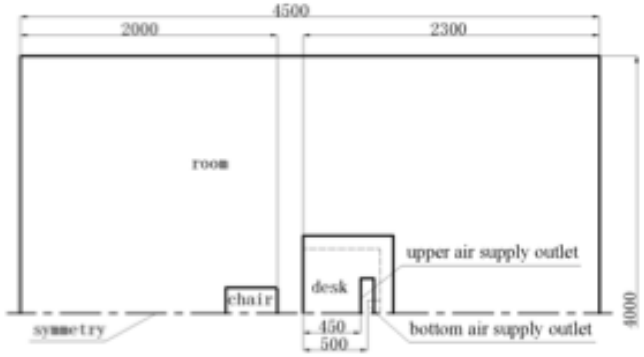

Fig. (2). Desk personalized ventilation floor plan.

*Address correspondence to this author at the Guilin University of Aerospace Technology, Guilin 541004, P.R. China; Tel: 15878350053; E-mail: 28455208@qq.com

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3. SIMULATION

The air density in the simulation uses the boussinesq hypothesis, its reference value for 1.22 kg/m^3. Heat in the air is all supplied by the upper and bottom air supply outlet without background air conditioning. The temperature of the supplying air is 313 K (40 °C) and the temperature of the room wall is 276 K (3°C). Don't consider the influence of the wind outdoor, regardless of the human body heat and human respiratory effects.

By the simulation of a multiple models of different air supply quality and air supply angle, found it can better satisfy the human body comfort when air supply quality is in 0.015 kg/s ~ 0.025 kg/s, air supply angle is under water level 5 ~ 15 degrees and about 40 degrees by the roll. The following four schemes are all simulated when their upper and bottom air supply outlet air supply angle is 40 degrees by the roll.

3.1. SCHEME 1. The Upper and Bottom Air Supply Outlet Air Supply Quality are Both 0.02 kg/s, Air Supply Angle are Both Under Water Level 5 Degrees

The temperature contours of scheme **1** are shown in Fig. (**3**).

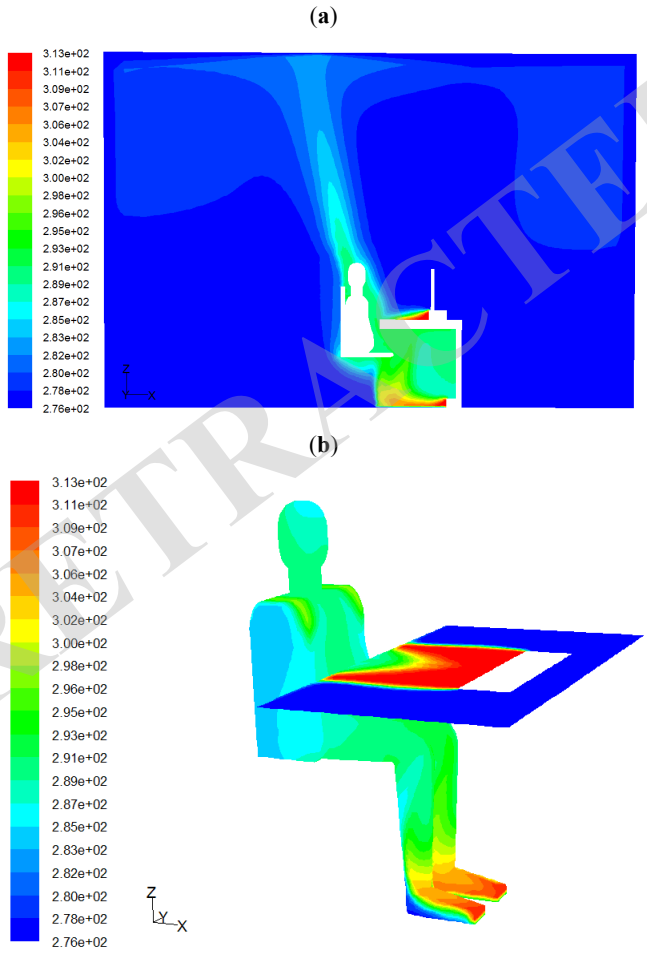


Fig. (3). Temperature contours of scheme **1**. (**a**) Temperature contours of symmetry. (**b**) Temperature contours of person surface and desktop.

You can see from Fig. (**3**), the human head, body and legs are all in comfortable temperature field, the hands workspace area and temperature are also suitable [5]. But the bottom of the feet will feel cold and has certain influence to human comfort.

3.2. SCHEME 2. The Upper and Bottom Air Supply Outlet Air Supply Quality are Both 0.02 kg/s, Air Supply Angle are Both Under Water Level 10 Degrees

The temperature contours of scheme 2 are shown in Fig. (**4**).

You can see from Fig. (**4**), the human head, body, legs and feet are all in comfortable temperature field, the hands workspace area and temperature are also suitable. The whole body is involved in the warm air supply region. Scheme **2** meets the requirements of the human body thermal comfort in winter.

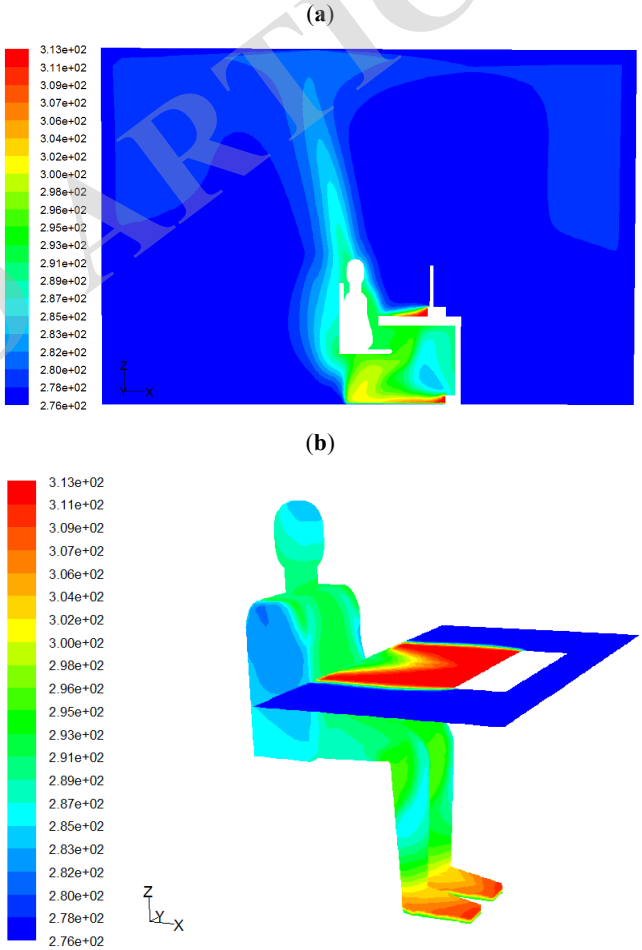
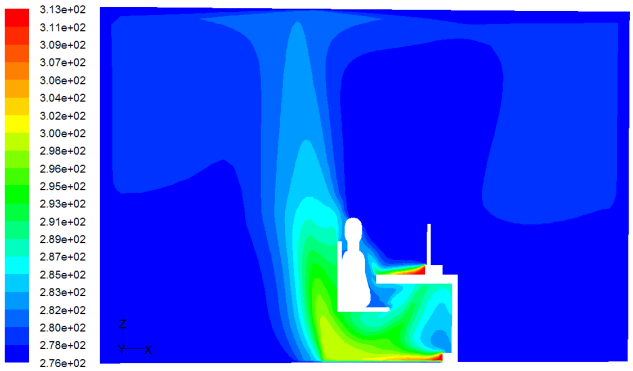


Fig. (4). Temperature contours of scheme **2**. (**a**) Temperature contours of symmetry. (**b**) Temperature contours of person surface and desktop.

3.3. SCHEME 3. The Upper and Bottom Air Supply Outlet Air Supply Quality are Both 0.02 kg/s, Air Supply Angle are Both Under Water Level 15 Degrees

The temperature contours of scheme **3** are shown in Fig. (**5**).

(**a**)



(**b**)

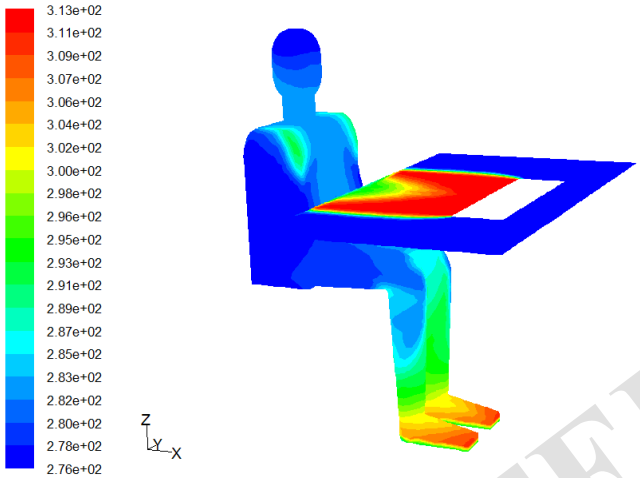


Fig. (5). Temperature contours of scheme **3**. (**a**) Temperature contours of symmetry. (**b**) Temperature contours of person surface and desktop.

You can see from Fig. (**5**), the air temperature surrounding the human head, body and legs are still cold, the hands workspace area and temperature are suitable, and the whole feet are in the warm air supply region. For the warm air supply region mainly concentrated to the behind of human body, the energy is not only used effective, but also can not meet the requirements of the human body thermal comfort.

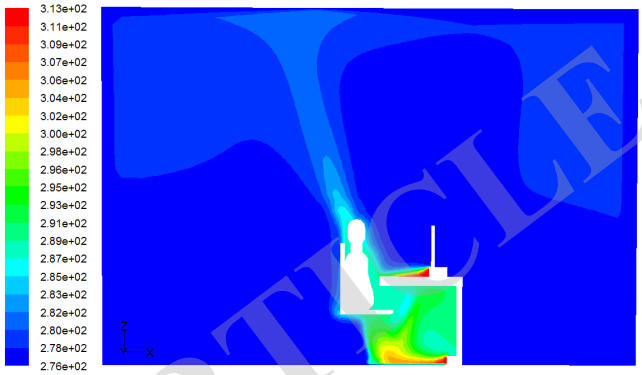
3.4. SCHEME 4. The Upper Air Supply Outlet Air Supply Quality is 0.02 kg/s, the Bottom Air Supply Outlet Air Supply Quality is 0.015 kg/s, Air Supply Angle are Both Under Water Level 15 Degrees

The temperature contours of scheme **4** is shown in Fig. (**6**).

You can see from Fig. (**6**), the human head, body and legs are all in comfortable temperature field, the hands workspace area and temperature are also suitable. But the bottom of the feet and back of the lower leg will feel cold, these will have great influence to the human body thermal comfort.

Comparing the temperature fields of the four schemes, scheme **2** is the excellent desk personalized ventilation scheme, for it can provide the most comfortable temperature field. Scheme **1** is a good scheme too, but it than those of scheme **2** is a bit poor. Scheme **3** is the worst scheme that is not wanted to appear. Scheme **4** can not provide the desire comfortable temperature field, for it's bottom air supply outlet air supply quality is not adequate. It can be seen that factors affecting the personalized ventilation comfortable in winter are not only air supply quality, but also air supply angle [6].

(**a**)



(**b**)

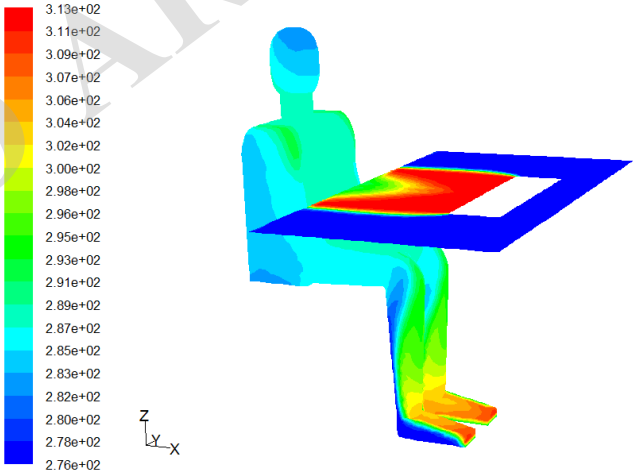


Fig. (6). Temperature contours of scheme **4**. (**a**) Temperature contours of symmetry. (**b**) Temperature contours of person surface and desktop.

4. AIR TEMPERATURE AND VELOCITY

When choose the excellent desk personalized ventilation scheme, air temperature and velocity around human body are shown in Table **1**.

When choose the excellent desk personalized ventilation scheme, the temperature contours of the air locating on both sides of the body is shown in Fig. (**7**) and the velocity contours of the air surrounding the body are shown in Fig. (**8**).

Observing Figs. (**4**, **7**, **8**) and Table **1**, it can be find that the air temperature and velocity surrounding the human body meet the requirements of comfort when choose scheme 2, and it can ensure the air temperature around feet and hands comfortable especially.

Table 1. Air temperature and velocity around human body when choose scheme 2.

Body Parts	Contents	Units	Values
Upper part of the human body	Maximum temperature	°C	20.7
	Minimum temperature	°C	10.9
	Average temperature	°C	16.6
	Maximum velocity	m/s	0.74
	Average velocity	m/s	0.38
Bottom part of the human body	Maximum temperature	°C	37.5
	Minimum temperature	°C	8.3
	Average temperature	°C	18.5
	Maximum velocity	m/s	1.69
	Average velocity	m/s	0.30

5. HEAT NEEDED

The quantity of heat needed when choose the excellent desk personalized ventilation scheme is,

$$Q = amc_p\Delta t = 1.15\times(0.02+0.02)\times1004\times(40-3)$$
$$=1719W$$

here $a=1.15$ is the coefficient of heat transfer.

By the calculation result, it can be known that the quantity of heat needed when choose scheme **2** is about 1700 W, only half of the heat release of 1 HP heat pump.

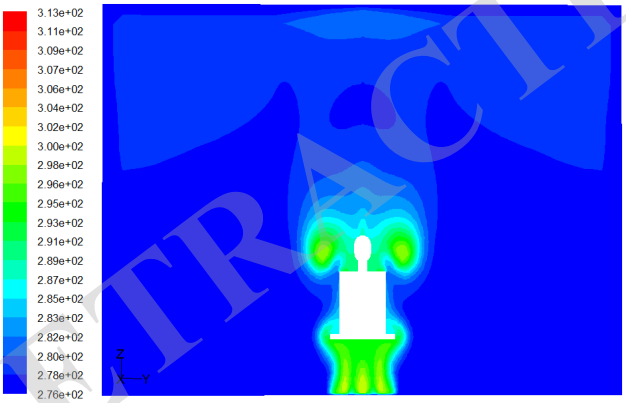


Fig. (7). Temperature contours of the air locating on both sides of the body when choose scheme 2.

CONCLUSION

Under the simulated condition, the excellent desk personalized ventilation scheme can better satisfy the human body comfort on the surrounding air temperature and healthy than the traditional air conditioning, and it is easier to achieve energy saving too. Air supply quality and air supply angle are both the important factors to personalized ventilation individual comfort in winter.

Personalized ventilation is a challenge in body comfort and energy saving to traditional air conditioning and ventilation. Desk personalized ventilation can satisfy the individual needs in air temperature and velocity, it have energy saving, action quick, health, comfortable and other obvious advantages. Research on desk personalized ventilation based on CFD can provide important information for desk energy-saving air conditioning design. Desk personalized ventilation will have broad market prospects.

(**a**)

(**b**)

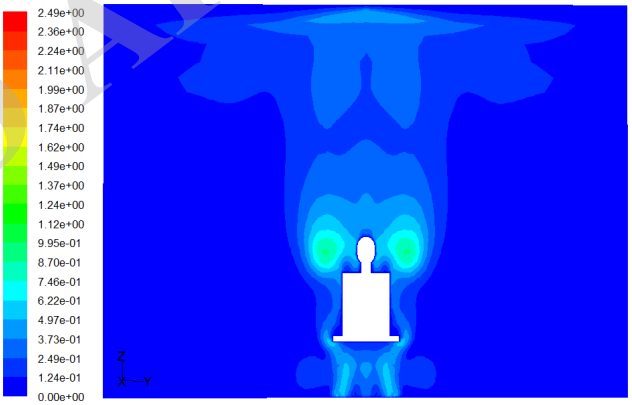


Fig. (8). Velocity contours of the air surrounding the body when choose scheme **2**. (**a**) Velocity contours of symmetry. (**b**) Velocity contours of the air locating on both sides of the body.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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