Displacement ventilation application for living quarters

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Abstract. The displacement ventilation applied in industrial and nonindustrial premises is considered. It is noted that there are no studies for residential buildings. The main patterns of indoor air flow in such ventilation systems are defined according to the literature data for non-industrial premises. A study was conducted on displacement flow ventilation in a living space. Air is supplied to the lower zone and extracted from the upper zone. Simulation of the room in the Star SSM+ software package was performed, and the air temperature distribution in the room volume was determined. It was found that the displacement ventilation in the dwelling provides on average comfortable air temperature in the volume of the dwelling. However, the air temperature of ~15-20 °C at human feet causes discomfort to the person.

1 Introduction

According to the principle of organizing air exchange in quarters, two types of ventilation can be distinguished [1-9]:

- mixing ventilation - air supply by turbulent jets, providing mixing of supply air with quarter air; supply air enters the upper zone of the quarter, mixed with the quarter air, assimilating harmful substances, and removed from the upper zone;
- displacement ventilation - air supply by low-velocity flows that do not mix with quarter air towards the service area; the supply air flow enters the lower zone of the quarter and, displacing excess heat and harmful substances upwards, is removed in the upper zone.

Schemes of the movement of air flows in quarters ventilated by displacement ventilation are shown in Figure 1 [1]. In quarters with displacement ventilation, the air flow pattern is determined by convective flows from heat sources. The position of the zones of heated air along the height of the quarter is determined by the ratio of cold and warm convective flows.

Displacement ventilation is mainly used in industrial and non-industrial quarters with high thermal loads. For living quarters, such studies have not been performed. Therefore, the task was set to investigate displacement ventilation for living quarters during the cold season.

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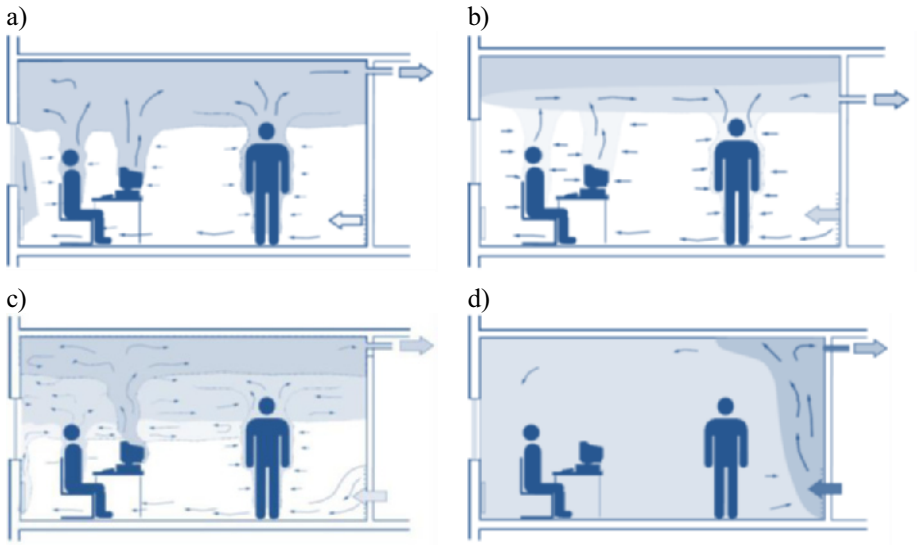


Fig. 1. The movement of air flows in quarters with displacement ventilation. Where: a) cold supply air flow and downdraft from glazing; b) cold supply air flow; c) cold supply air flow and warm air flow from the heater; d) warm supply air flow.

2 Materials and methods

The object of the study was a living room with two outer walls and two windows, located on the second floor of a four-story residential building (Figure 2).

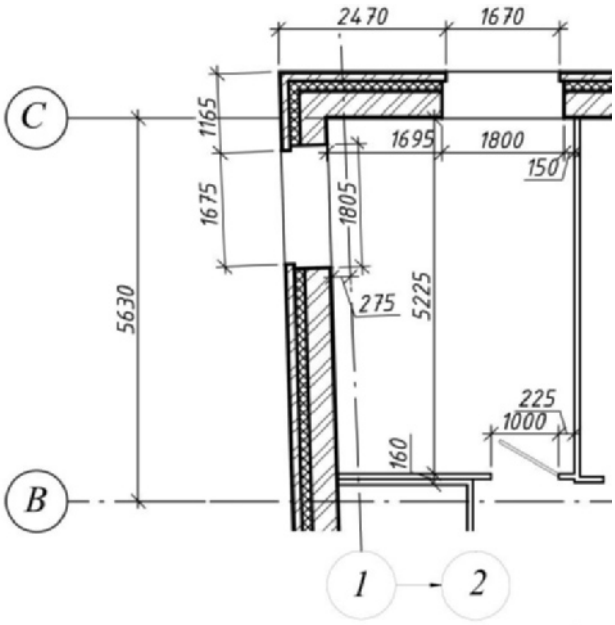


Fig. 2. Plan of the study quarter.

The quarter was modeled in the Star SSM+ software package, which allows you to visually see and analyze the temperature distribution throughout the entire volume of the quarter [10-12].

Initial data for calculation:

- supply of outside air to the lower zone of the quarter; removal of internal air from the upper zone; air is supplied and removed opposite the window on the long side of the quarter;
- outside air temperature - minus 24°C;
- heat transfer coefficient of external walls - 0.211 W/(m^2·°C);
- heat transfer coefficient of windows - 1.639 W/(m^2·°C);
- temperature of supply air entering the quarter - plus 15 °C; air is supplied from the supply unit with a heat recovery unit for the removed ventilation air;
- calculated air exchange - 50 m^3/h;
- heat input from people (2 people) - 180 W;
- heat inputs from household equipment were not taken into account.

3 Results

The calculation was performed with the household equipment turned off in the quarter, while taking into account heat gains from people and heating devices.

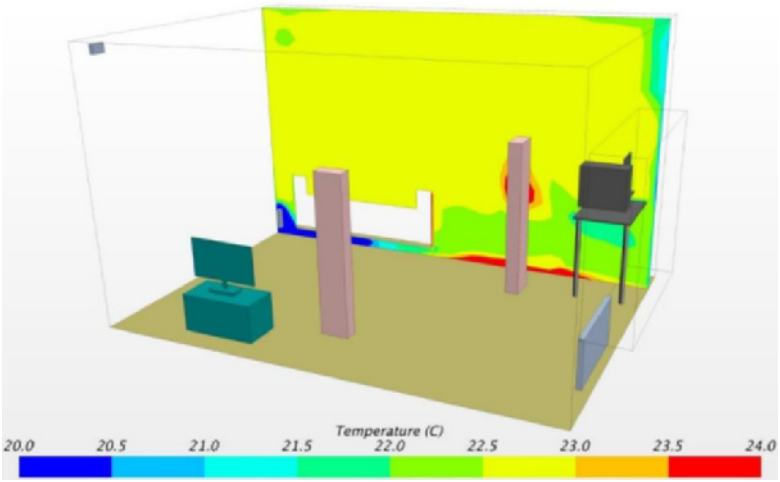
Simulation results for displacement ventilation in a living quarter:

- temperature of the removed air - 22.5 °C;
- average air temperature in the quarter - 22.4 °C;
- heat losses - 508 W;
- heat flow of heating devices - 450 W.

The temperature distribution of the indoor air is shown in Figure 3.

4 Conclusions

Displacement ventilation in a living quarter allows to provide a comfortable air temperature on average for the volume of the quarter. However, during displacement ventilation, air with a temperature of ~15-20 °C enters the floor. Such an air temperature at the feet of a person causes an uncomfortable state of a person.



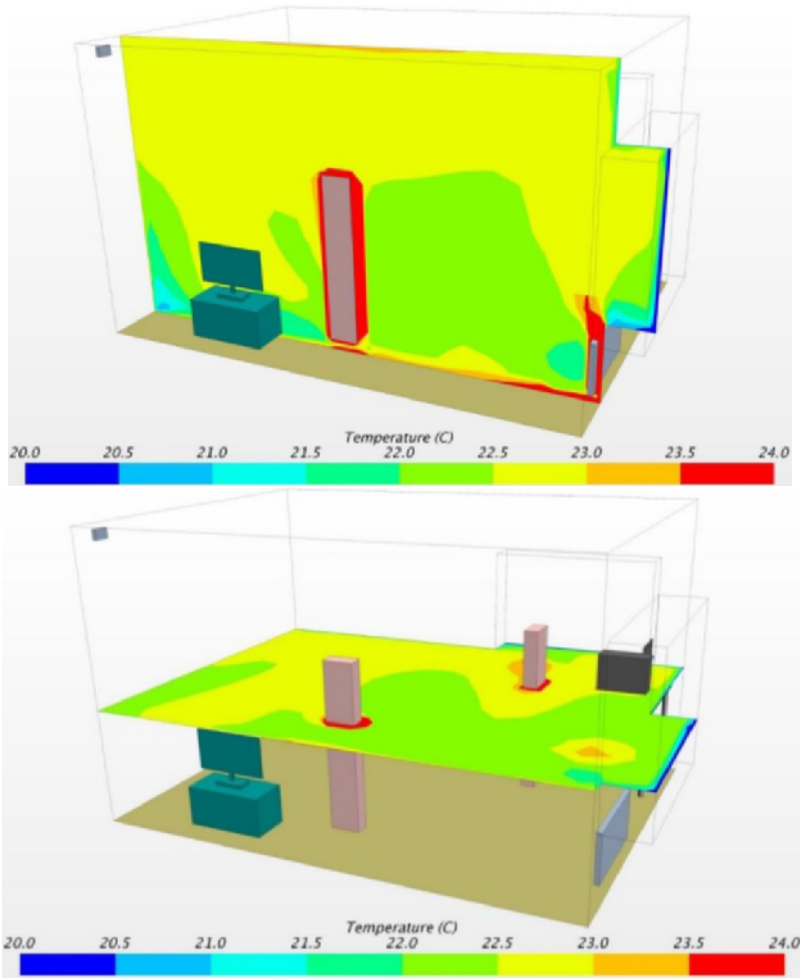


Fig. 3. Distribution of air temperature in the quarter during displacement ventilation with household equipment turned off.

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