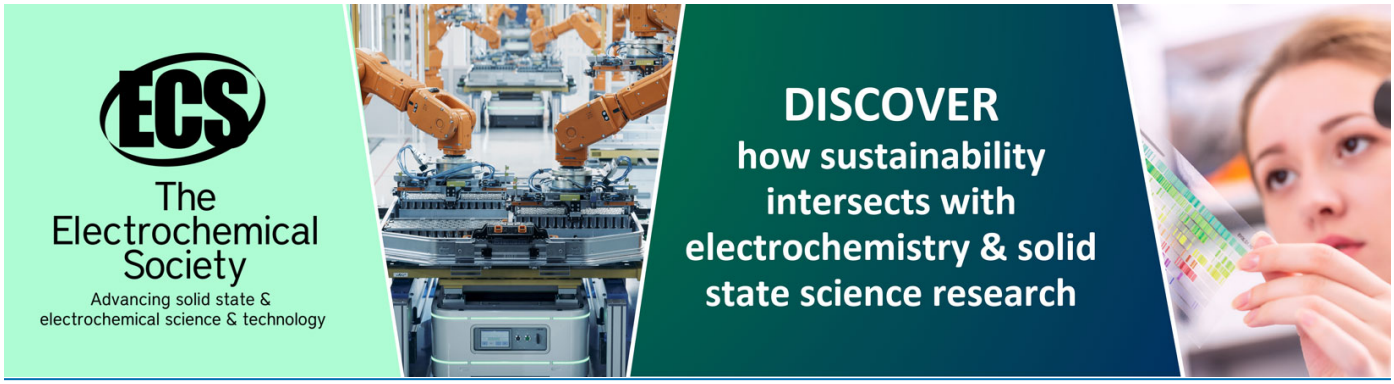
The personalized supply ventilation system design in the office space



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The personalized supply ventilation system design in the office space

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Abstract. The paper is devoted to the present-day problem - improving air quality in the office space working area. A design feature of such premises is small height (about 3 meters). This makes difficult to supply the required amount of air without creating drafts in the working area. It can be noted that such a problem solution is related with the new materials and technologies use in practice. These include textile terminals made of 100% polyester woven with carbon fiber. This material has the following properties: high strength and wear resistance, minimal particles entrainment from the surface. Unlike steel galvanized air ducts, in the textile air duct it is possible to laser-cut precise holes with melted edges with the necessary pitch and diameter. A diagram of the personalized ventilation organization in the office space is presented on the basis of the developed air-distributing device with a micro-perforated textile liner. This device allows to adjust the air flow depending on the individual needs of the person up to shutting down the system in the absence of an employee. Reducing the flow of fresh air contributes to the ventilation system energy efficiency.

Introduction

One of the main tasks of designing the systems for heating, ventilation and air conditioning of the premises is to provide normalized and comfortable environmental parameters in the working area of the room. The health and performance of people in it directly depends on the quality of the ventilation system.

Office premises are distinguished by the presence of a large number of heat sources coming from people, office equipment, and household appliances. In such premises, most often, they use forced-air and exhaust ventilation according to the “top-up” scheme. At the same time, a relatively small height of office premises (about 3 meters) makes it difficult to supply the required volume of fresh air to the work area with a normalized speed (from 0.1 - 0.25 m / s). Employees often receive complaints about drafts in the workplace, as well as about the lack of fresh air, the feeling of stuffiness.

Over the past 100 years, the ventilation industry of science has received a powerful development in terms of the theory and practice of the use of ventilation equipment, modern materials and technologies. The development and improvement of the efficiency of the ventilation and air conditioning systems of the premises is associated with the use of new air supply devices. These include textile polyester diffusers in which holes with a given diameter and pitch are burned with a laser. For distributed air supply, textile air ducts with pinholes (diameter about 0.2-0.6 mm) are used. The analysis of the air distribution features using this duct type [1-5] allows to conclude that they can be placed near

workplaces due to the rapid decrease in the speed of the jets to the standard value. This scheme of organization of air exchange increases the efficiency of the use of fresh air when it is supplied to the human breathing zone, providing normalized and comfortable parameters of the microclimate in the working area of the room.

The problem analysis

The global problem of the 21st century is the deterioration of the parameters of the indoor environment, which affects the well-being and productivity of people's work. In the works of domestic and foreign authors presents the results of studies relating to this issue [6-10]. It is noted that the reason for the decrease in air quality is an increase in the degree of tightness of the premises due to the installation of plastic windows, the use of toxic materials for finishing, as well as an increase in the number of office equipment and household appliances - sources of additional heat generation. The influence of the above factors on the health and working capacity of people has been defined by foreign scientists as "sick building syndrome", the study of which is devoted to a number of works [7–9].

According to various studies, the thermal comfort of a person varies widely [11-15]. Creating the standardized and comfortable microclimate parameters in the working area of the room, taking into account the individual needs of workers, is an important task. The use of a personalized air distribution device with individual regulation of air flow [16], developed by the authors, makes it possible to effectively solve this problem.

The purpose of this work is to study the issue of organizing a personalized intake ventilation system based on the developed air-distributing device with a micro-perforated textile insert [16] in an office room. This system allows to increase the level of satisfaction of office space workers with the parameters of the environment of the room.

Results of the study

The personalized ventilation system arrangement. The personal seat in the administrative building in the administrative premises is the space of the premises ranging from 4.5 to 6 m^2 in accordance with SanPiN 2.2.2 / 2.4.1340-03, where there is a table with a chair that the specialist works with during the whole working day. At the same time, a person's breathing zone is located in the space above the surface of the table, where a person writes, reads, and which can be called a person's breathing zone, in which air must meet the required parameters in terms of temperature, relative humidity, speed and gas composition, which also applies to the whole room.

Earlier, we developed a personalized air-distributing device designed to supply fresh air by micro-jets to the human breathing zone. This device is a rigid box, inside of which is located a rectangular textile liner with micro perforation (hole diameter 0.2 - 0.6 mm) (Figure 1). The front wall of the box is made in the form of a grid for organizing the supply of fresh air to the human breathing zone through micro holes located on the surface of the textile liner (Figure 2). The schematic diagram of this device is presented in article [16].

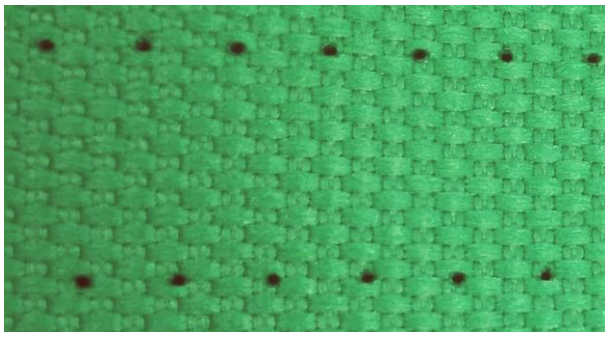

Figure 1. Section of textile liner with micro-holes

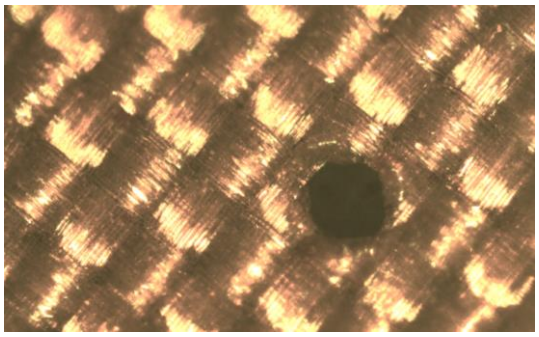

Figure 2. Veiw of micro-hole

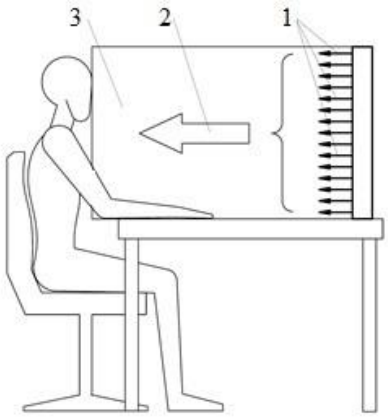

Figure 3. Schematic diagram for feeding supply air to the breathing area of a person: 1 - micro jets; 2 - air flow rate equal to normalized value per 1 person; 3 - person breathing area

The advantage of the developed device is the ability to supply fresh air to the working area, displacing heat surpluses (coming from people, office equipment, etc.), carbon dioxide and harmful impurities from the office worker's breathing zone. It is possible to control the rate of air supply depending on the individual needs of the person, as well as turning off the device in the absence of an employee at the workplace.

Consider an example of the organization of a personalized ventilation system in an office room in which 10 workplaces are located, where people sit at a table during the day and work with necessary breaks.

Figure 4 shows a room plan with the organization of a personalized ventilation system with supply air for each table in a normalized volume (60 m^3 / h).

In figure 5 shows a diagram of a personalized intake ventilation system in an office space for 10 workplaces. The total inflow of fresh air into the administrative room is 600 m^3 / h, based on the sanitary standard per person. The hood can be located under the ceiling, taking into account the uniform removal of the exhaust air.

The system under consideration involves supply of chilled / fresh air into the area of person breathing - space above each desk. The supply air moves towards the person, flows around the person and moves in the aisles between the desks; then the air rises to the upper zone, moves in the direction of exhaust hoods where it is removed by exhaust ventilation system of the building. Balance on inflow and exhaust air for the room with a personalized ventilation system can be written as follows (individual inflow, with general exchange ventilation):

$$\sum_1^n L_{si} = L_r \quad (1)$$

where L_{si} is air consumption for each workplace, m^3/h; n - is number of workplaces in the room, pcs;, L_r – amount of air removed from the room, m^3/h.

If there is an additional general ventilation system in the room, the inflow and exhaust air balance in the room can be defined as follows:

$$\sum_1^n L_{si} + L_s = L_r \quad (2)$$

When forming an individual inflow and exhaust for each workplace, the inflow and exhaust air balance in the room can be written as follows:

$$\sum_1^n L_{si} = \sum_1^n L_{ri} \quad (3)$$

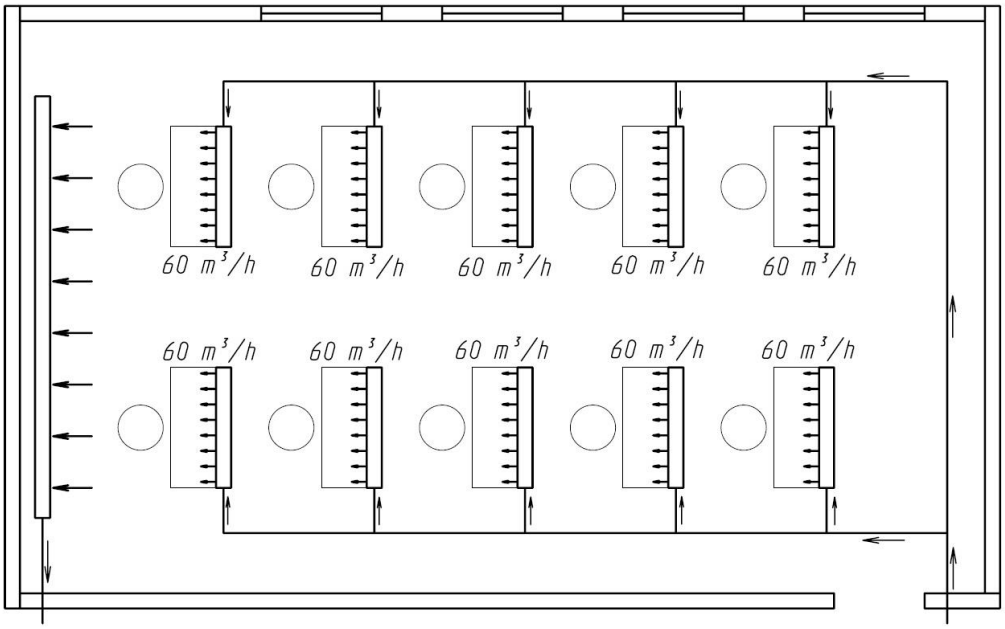

Figure 4. Plan of administrative room for 10 workplaces with personalized ventilation system

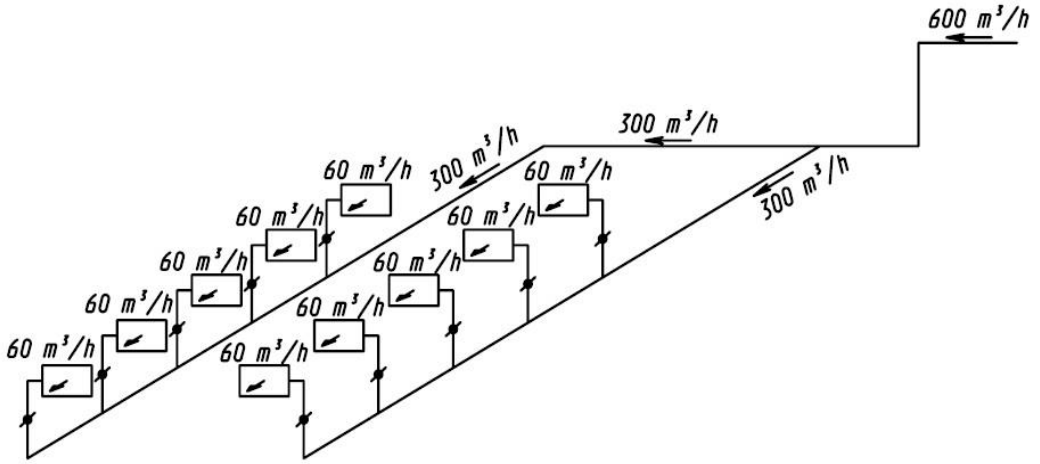

Figure 5. Diagram of personalized supply ventilation system in administrative premises for 10 workplaces

It is convenient that individual inflow and exhaust devices for each workplace coincide with a separate workplace in the premises of office buildings of "open space" type.

Summary

A scheme for the organization of a personalized ventilation system in an office space on the basis of an air distribution device with a micro-perforated textile insert that supplies fresh air by micro jets with a small impulse has been proposed. This system allows to provide normalized indicators of the microclimate in the zone of human breathing, effectively removing exhaust air by displacing without creating drafts at workplaces. It is possible to regulate the supply of fresh air depending on the office worker's individual needs, as well as the ability to turn off the device in the absence of an employee in the workplace. These factors contribute to improving efficiency and reducing the incidence of office workers, as well as improving the economic efficiency of the ventilation system by reducing the flow of outdoor air.

The prospects for further development of this direction are in the design substantiation of the economic efficiency of using a personalized ventilation system in the premises of office buildings

compared to the general exchange system, as well as the study of heat and mass transfer processes in the human respiration zone.

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