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Voronezh State University of Architecture and Civil Engineering

Ph. D. in Engineering, Assistant lecturer of Fire Safety Department

K. A. Sklyarov

Assistant lecturer of Fire Safety Department

A. V. Cheremisin

Assistant lecturer of Fire Safety Department

S. P. Pavlykov

Russia, Voronezh, tel.: +7(4732)71-53-21;

e-mail: vgasupb@mail.ru

K. A. Sklyarov, A. V. Cheremisin, S. P. Pavlyukov

TWO-DIMENSIONAL STATIONARY MOVEMENT OF AIR FLOW IN PREMISES WITH PARTITIONS

Air movement in premises with partitions is considered. Basic equations of mathematical model of the process are described. The algorithm of numerical calculation of mathematical model is carried out in the form of the program in Microsoft Visual C++ medium with the use of modules of package MatLab.

Keywords: air movement in premise, divided by partition, program in medium Microsoft Visual C++ with the use of modules of package MatLab.

Currently light partitions are widely used in offices and shops. Partitions substantially alter air distribution in premise. Analysis of effect of partitions on air flows is urgent task of ventilation.

In this paper air flows in premises with partitions are analyzed using methods of numerical modeling of gas dynamics processes.

Consider equation of two-dimensional stationary model of air flow movement in premises [1, 2, 4].

Continuity equation:

$$\frac{\partial}{\partial x_i}\ \rho u_i\ = 0, \tag{1}$$

where ρ is the density of air, kg/m^3; t is the time, sec; x_i is the i spatial coordinate, m; u_i is the i — component of air velocity, m/ sec.

Navie-Stoks equations, averaged by Reynolds:

$$\begin{gathered}\frac{\partial\ \rho u_i u_j}{\partial x_i} = -\frac{\partial p}{\partial x_i} + \frac{\partial}{\partial x_i}\left(\Gamma_{eff}^{u}\left(\frac{\partial u_i}{\partial x_j} + \frac{\partial u_j}{\partial x_i}\right)\right) - \\ -\frac{2}{3}\frac{\partial}{\partial x_i}\left(\Gamma_{eff}^{u}\frac{\partial u_j}{\partial x_j}\right) - \frac{2}{3}\frac{\partial}{\partial x_i}\ \rho k\ - \delta_{i3}\rho g\end{gathered}, \tag{2}$$

where p is the pressure, Pa; Γ_{eff}^{u} is the coefficient of diffusion for variable u, kg/m·sec; k is the kinetic energy, square m/square sec; g is the gravitational acceleration, m/square sec.

Transfer of kinetic energy of turbulence is defined by equation

$$\frac{\partial\ \rho u_i k}{\partial x_i} = \frac{\partial}{\partial x_i}\left(\Gamma_{eff}^{k}\frac{\partial k}{\partial x_i}\right) + G^k + G^b - \rho\varepsilon, \tag{3}$$

where ε is the velocity of turbulent energy dissipation, square m/cubic m.

Velocity of turbulent energy dissipation is defined by equation [2]:

$$\frac{\partial\ \rho u_i \varepsilon}{\partial x_i} = \frac{\partial}{\partial x_i}\left(\Gamma_{eff}^{\varepsilon}\frac{\partial \varepsilon}{\partial x_i}\right) + \frac{\varepsilon}{k}\ C_1\ G^k + G^b\ - C_2\rho\varepsilon\ , \tag{4}$$

where C_1, C_2 are constants of $k-\varepsilon$ model of turbulence.

$$G^k = 2\mu_t\left(\sum_i\left(\frac{\partial u_i}{\partial x_i}\right)^2\right) + \mu_t\left(\sum_{i>j}\left(\frac{\partial u_i}{\partial x_j} + \frac{\partial u_j}{\partial x_i}\right)^2\right), \tag{5}$$

$$G^b = \mu_t g\frac{1}{\rho}\frac{\partial \rho}{\partial x_3}, \tag{6}$$

where μ_t is the turbulent dynamic viscosity, kg/m·sec.

$$\mu_t = C_\mu \frac{\rho k^2}{\varepsilon}, \tag{7}$$

$$\mu_{eff} = \mu_l + \mu_t, \tag{8}$$

$$\Gamma^{\Phi}_{eff} = \frac{\mu_{eff}}{\sigma^{\Phi}}, \tag{9}$$

where C_μ is the empirically determined coefficient; μ_{eff} is the effective dynamic viscosity, kg/m·sec; μ_l is the laminar dynamic viscosity, kg/m·sec; σ^{Φ} is the Schmidt number.

Boundary conditions are formulated on the basis of impermeability and zero velocity on the building structures. Implicit finite-difference splitting scheme for directions and physical processes [3] and equation of internal energy transfer in the form of equation for pressure were used to obtain numerical solution of the system of equations.

This increased computational efficiency of the numerical scheme and provided an opportunity to use numerical schemes conservative by mass. Algorithm for numerical calculation of the mathematical model is implemented in the form of the program in Microsoft Visual C++ medium using the package of modules MatLab. The program obtained was used to calculate stationary air flows of the premise with height 5.0 m and length 20.0 m (see Fig. 1).

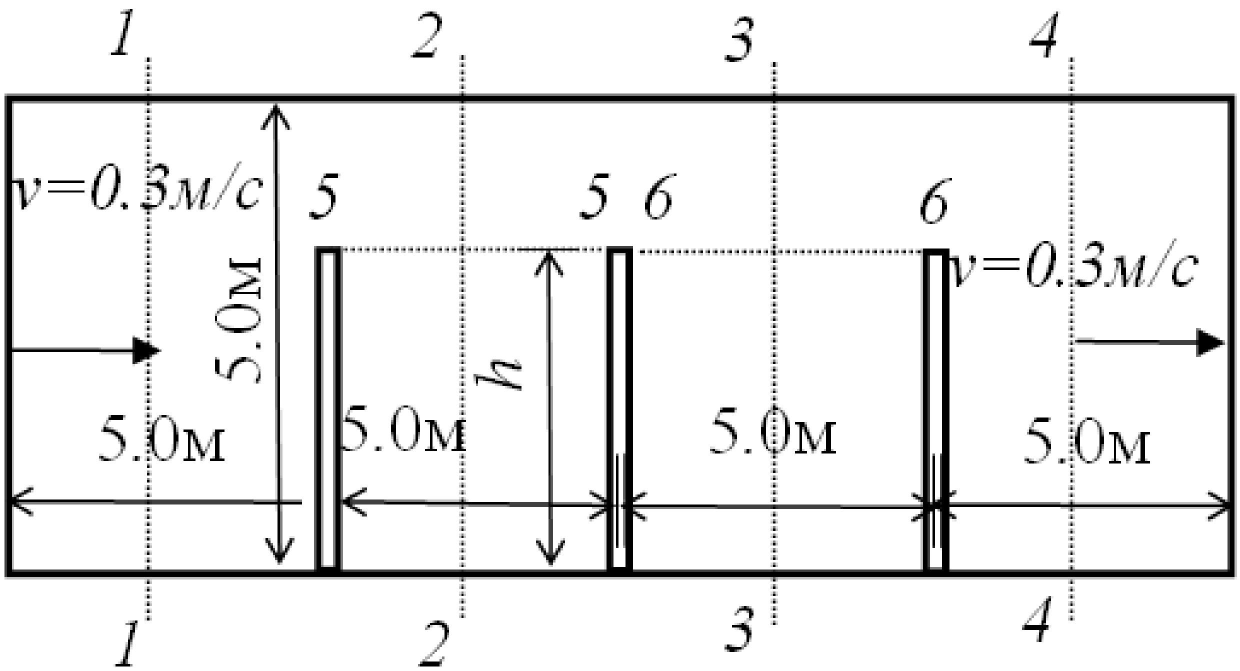


Fig. 1. Plan of the premise divided by partitions

The premises is divided by three partitions. Air is fed evenly from one side of the premise and removed from the opposite side at speed 0.3 m/sec. Height of partition in the first case was 2.0 m, in the second case — 3.0 m, in the third case — 4.0 m. The distance between the partitions is 5.0 m. The results are presented on Fig. 2—4.

a)

b)

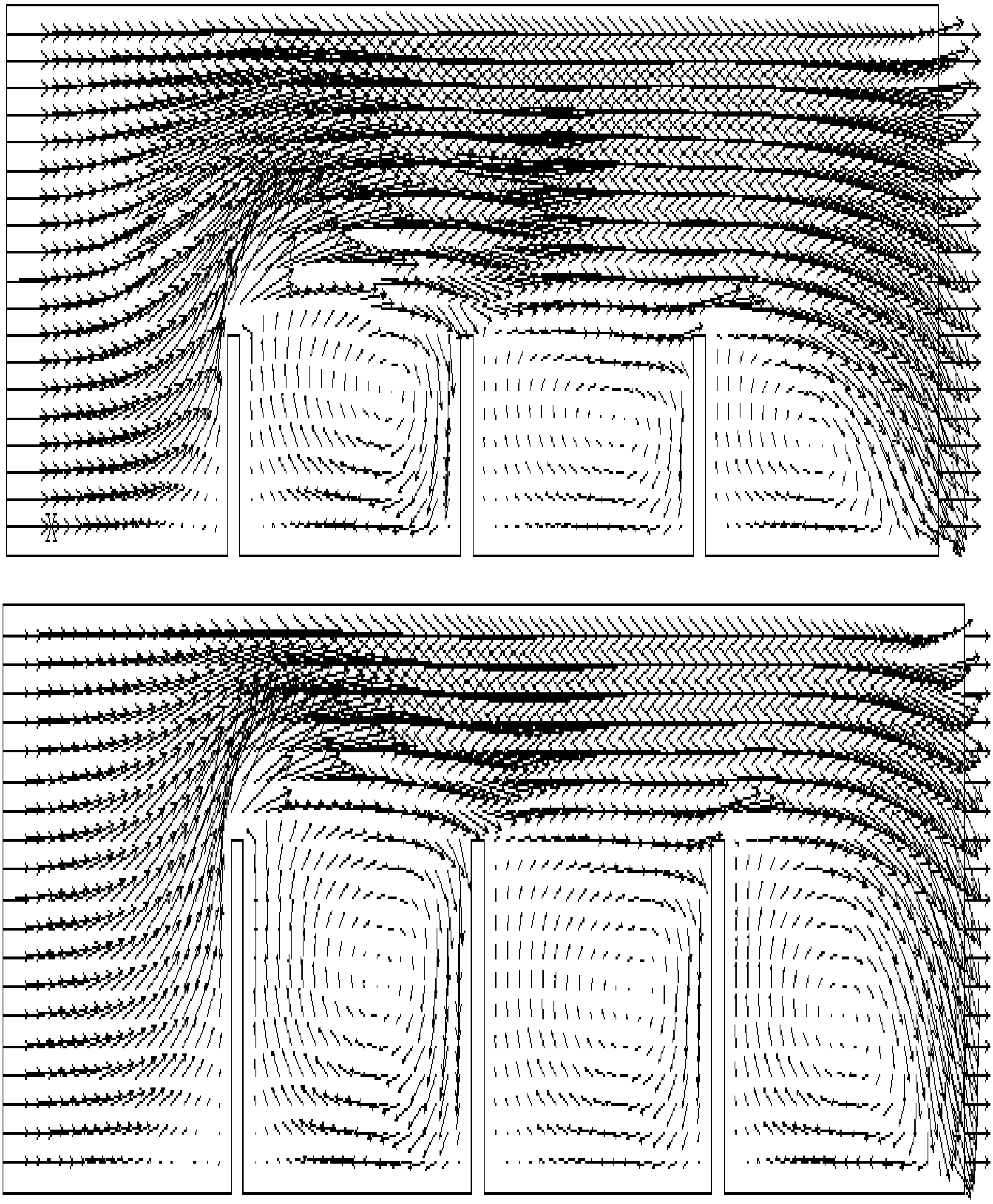


Fig. 2. Air flows directions in the premise with partitions:
a) height is 2.0 m, air velocity changes from 0 to 0.70 m/sec;
b) height is 3.0 m, air velocity changes from 0 to 1.19 m/sec

c)

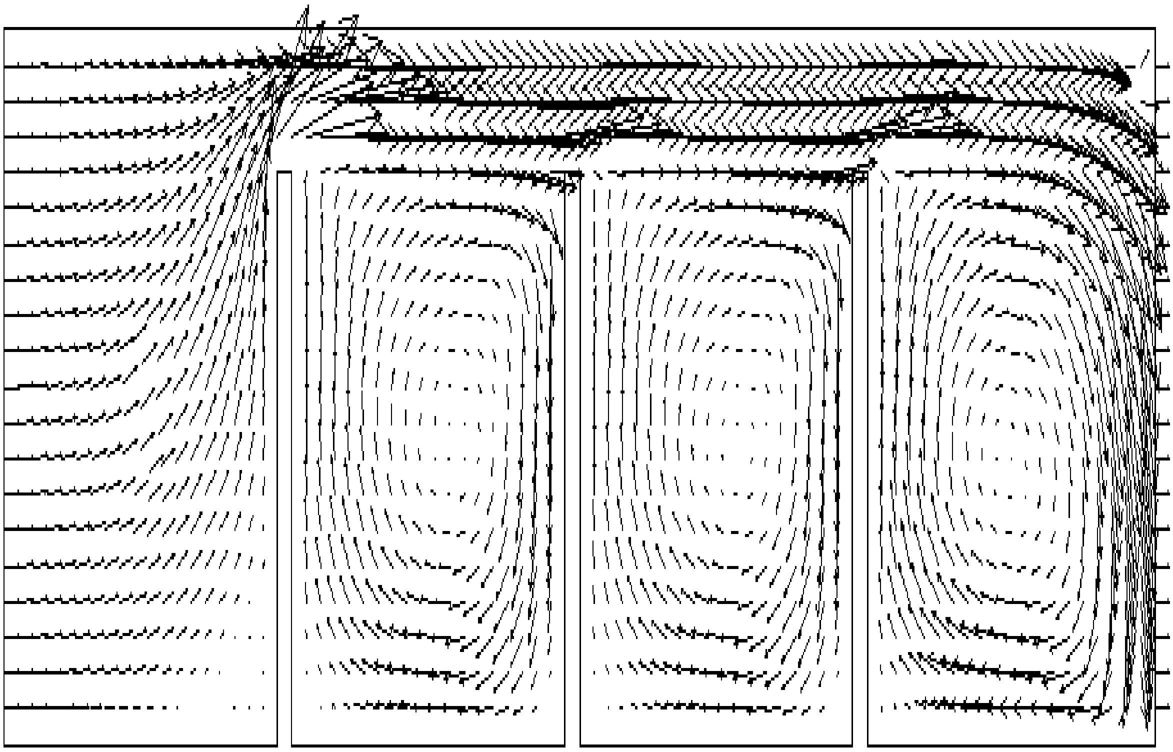


Fig. 2. Air flows directions in the premise with partitions:
c) height is 4.0 m, air velocity changes from 0 to 2.49 m/sec

a)

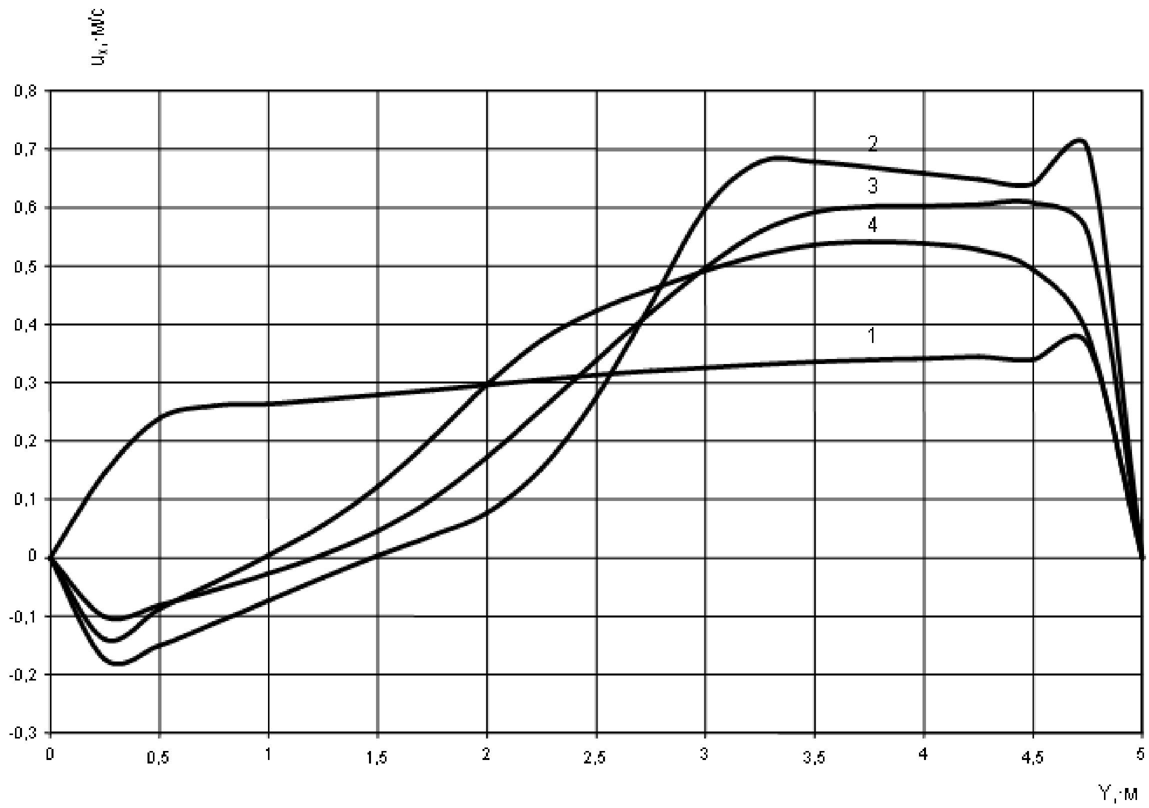
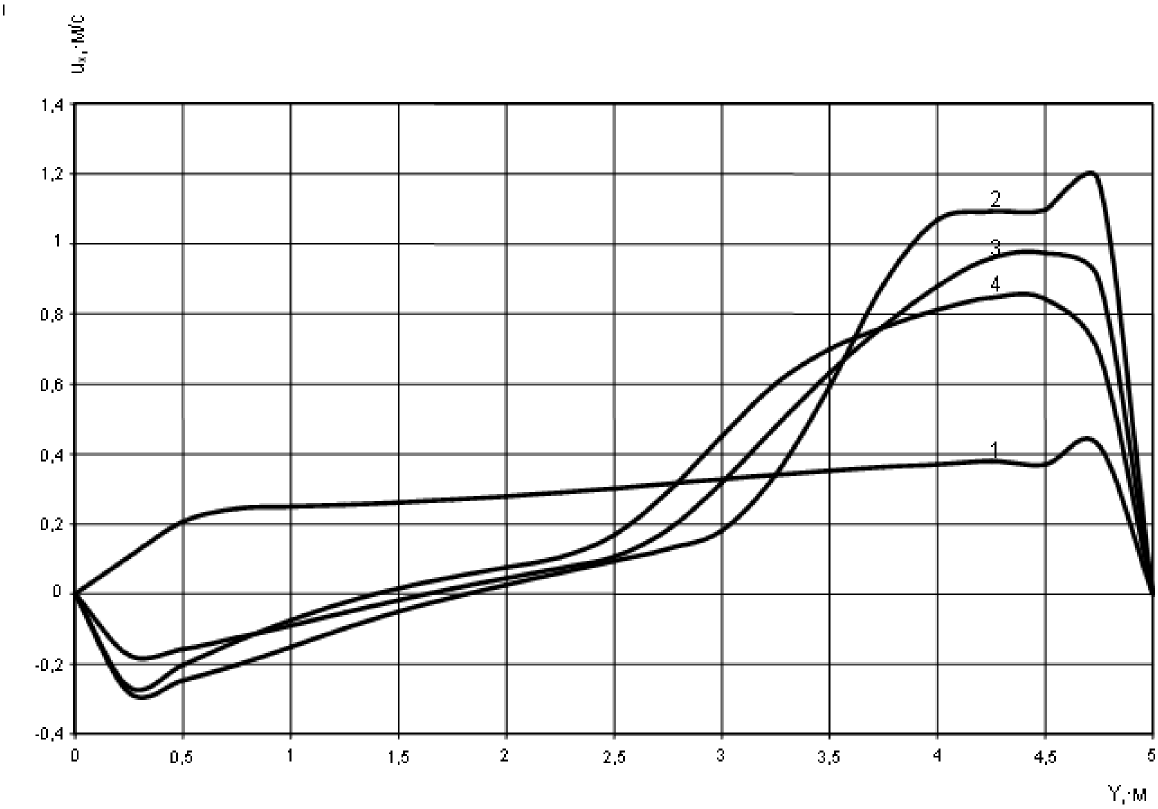


Fig. 3. Air flows velocity u_x in the sections: 1—1—1; 2—2—2; 3—3—3; 4—4—4.
Height of premises: a) 2.0 m

b)



c)

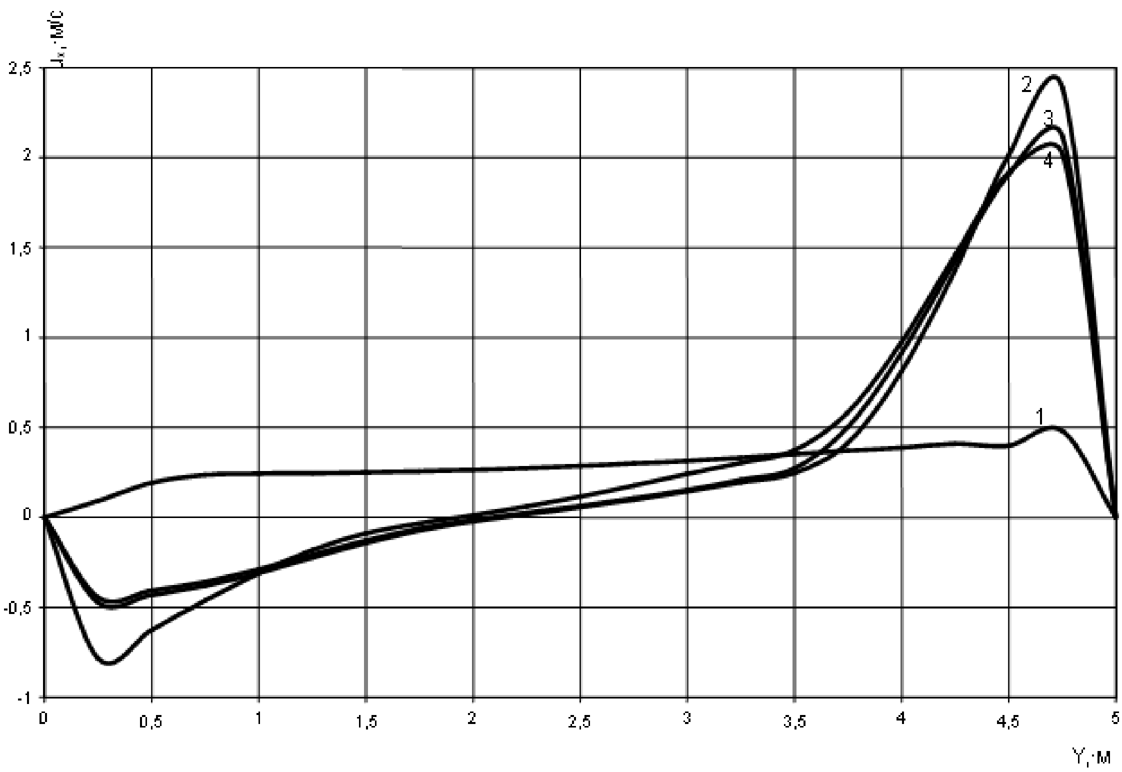
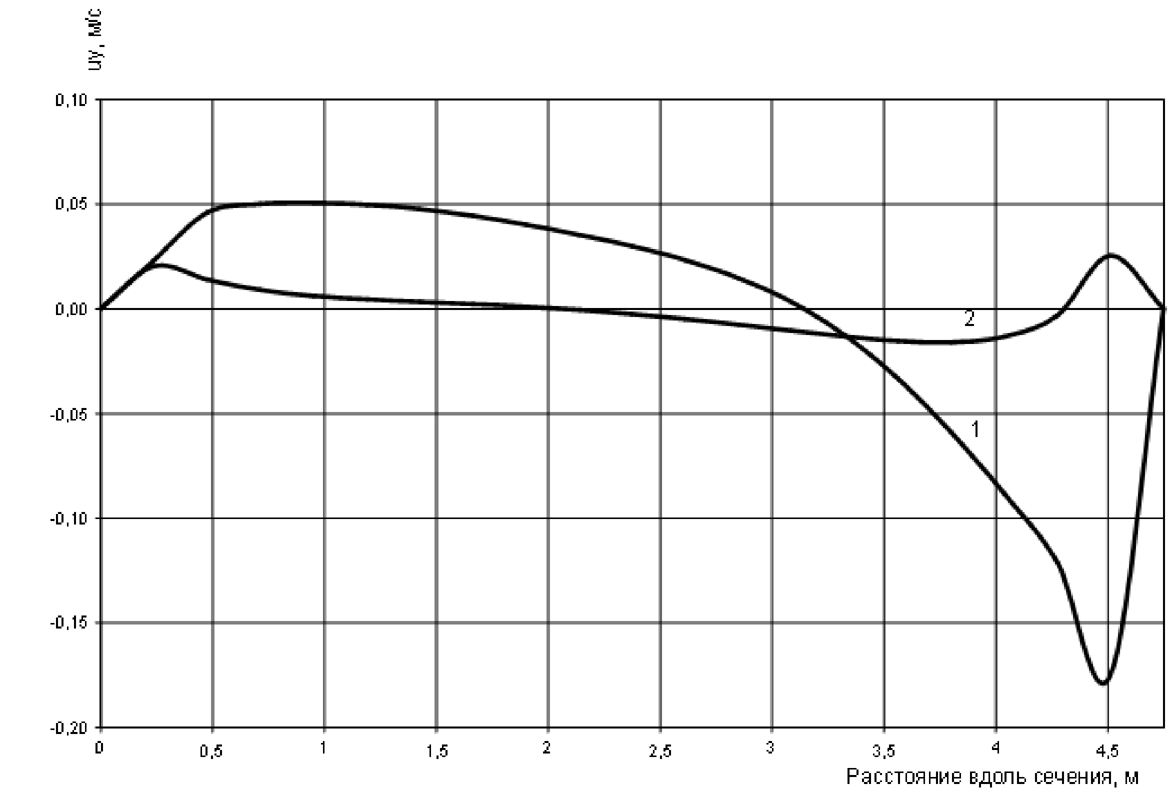


Fig. 3 (end). Air flows velocity u_x in the sections:
1—1—1; 2—2—2; 3—3—3; 4—4—4.
Height of premises: b) 3.0 m; c) 4.0 m

a)



b)

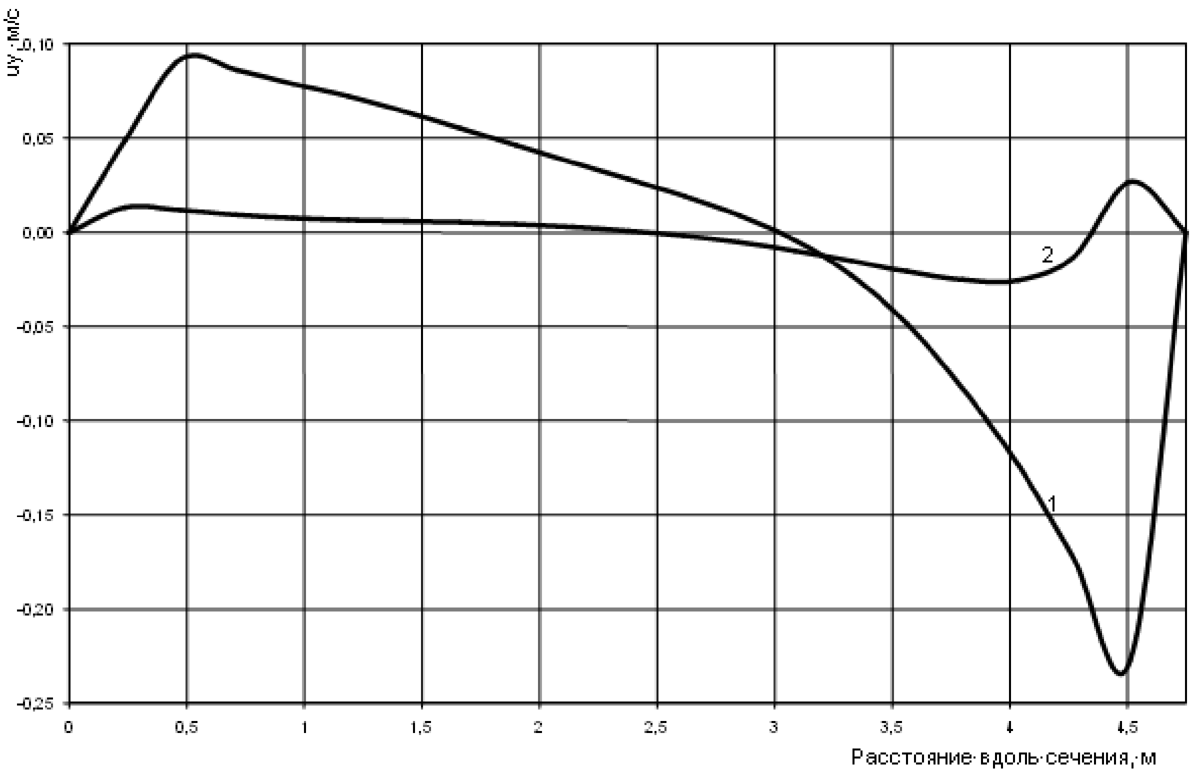


Fig. 4. Air flows velocity u_x in the sections: 1—5—5; 2—6—6.
Height of premises: a) 3.0 m; b) 4.0 m

c)

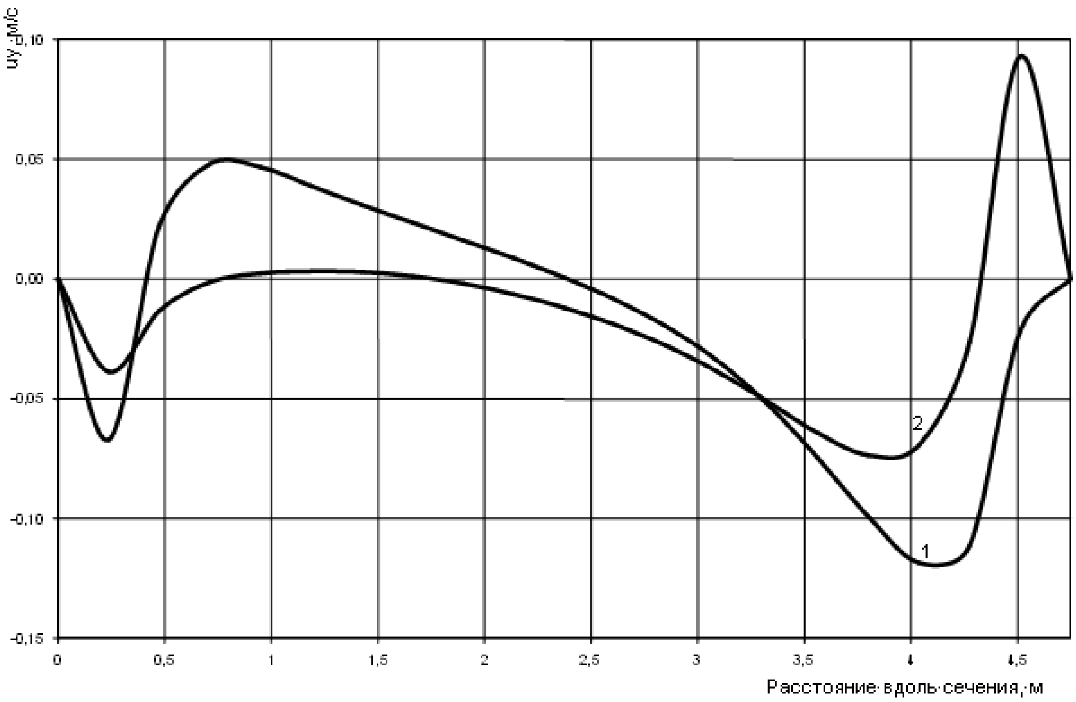


Fig. 4 (end). Air flows velocity u_x in the sections: 1—5—5; 2—6—6.
Height of premises: c) 5.0 m

The results show that change in the height of the partitions from 2 m to 4 m leads to a sharp increase in air velocity from 0.6 m/sec to 1.8 m/sec.

However, the height of partitions has little effect on the air mobility in a space partitioned off, air mobility is constant and close to 0.1 m/sec.

Thus, ventilation systems designed for premises without partitions can be used in premises with partitions.

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