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AIR DISTRIBUTION BY INTERACTION OF COUNTER NON COAXIAL AIR JETS AT PULSING MODE

Air distribution by interaction of counter non coaxial air jets at pulsing mode has been considered. Dynamic parameters of air flow that is created due to interaction of counter non coaxial flat air jets at their leakage at pulsing mode and creation of dynamic indoor climate in a room has been determined.

Key words: air distribution, flat air jet, pulsing mode, dynamic indoor climate, jets interaction, counter non coaxial jets, air velocity, flow rate.

Розглянуто повітророзподіл при взаємодії зустрічних неспіввісних струмин в пульсуючому режимі. Визначено параметри результуючого повітряного потоку для створення динамічного мікроклімату у приміщенні.

Ключові слова: повітророзподіл, плоскі повітряні струмини, пульсуючий режим, динамічний мікроклімат, не співвісні струмини, швидкість повітря, витрата повітря.

Introduction

Investigations in premises of civil and industrial buildings testify that exactly variable irritants influence favorably on human's thermal sensitivity. Pulsing mode of flowing out incoming jets means the creation of dynamic indoor climate that positively reflects on the thermal regulation of human's organism.

State of problem

We can give an example of the famous research of working place ventilation system for welding shops with the pulse air flow and frequency of its oscillation in a serviced area $n = 6 - 15\,\mathrm{min}^{-1}$ and period T = 4 -10 sec. Also the appliance is known that is an air pipe divided by a lengthwise partition. Its installation gives an opportunity to ensure a periodical change of velocity of exit air jet from the nozzle at the expense quantity change of incoming air in each of two parts of this air pipe.

The aim of this work is the determination of air flow dynamic parameters, that is created by interaction of counter non coaxial flat jets at their leakage at pulse mode and creation of dynamic indoor climate in a room.

We shall consider the scheme of interaction of counter non coaxial air flat jets at their leakage at pulsing mode (fig.1), where air flow and initial velocity change in accordance with periodic regularity.

Let the jet is symmetrical relatively its axis, and the axial velocity V_x in determined point A with coordinate X_A in case of constant motion (without using pulse mode) determines from the formula of calculation of the axial velocity V_o is known.

$$V_x = V_0 \cdot m \frac{\sqrt{F_0}}{x} \tag{1}$$

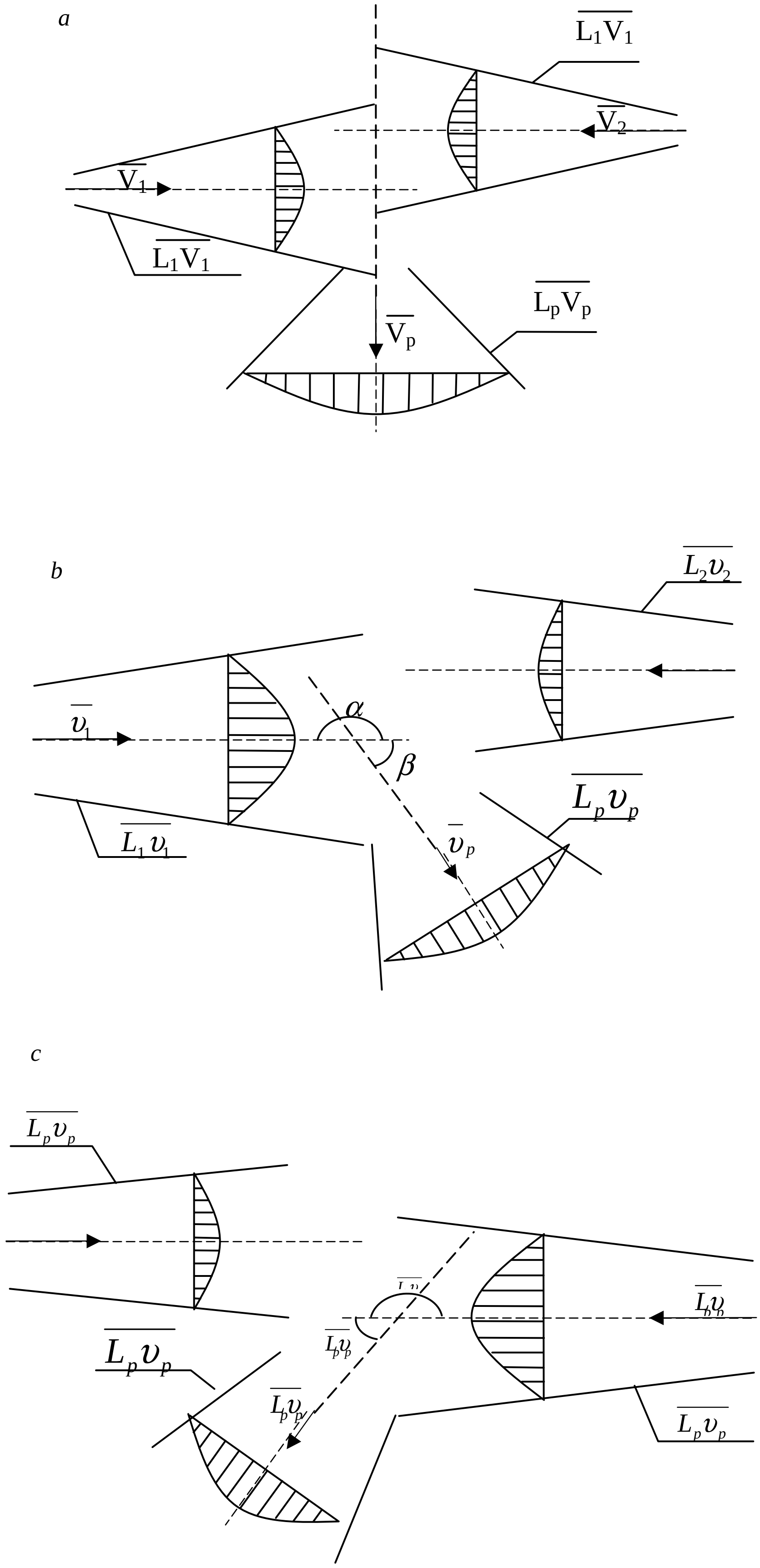

Fig. 1. Scheme of interaction of counter non coaxial flat air jets
a) $L_1 = L_2$ b) $L_1 > L_2$ c) $L_1 < L_2$

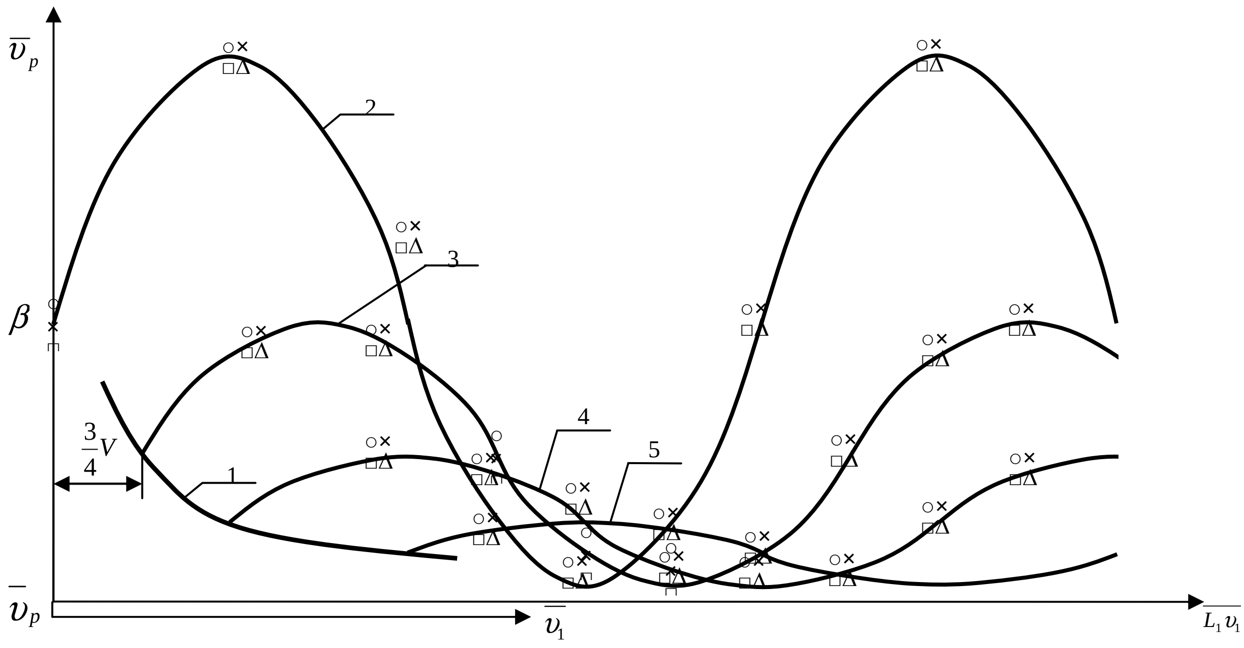

Fig. 2. Results of research: 1 – velocity dependency against coordinate at constant time;
2, 3, 4, 5 – velocity dependences against time at different coordinates.

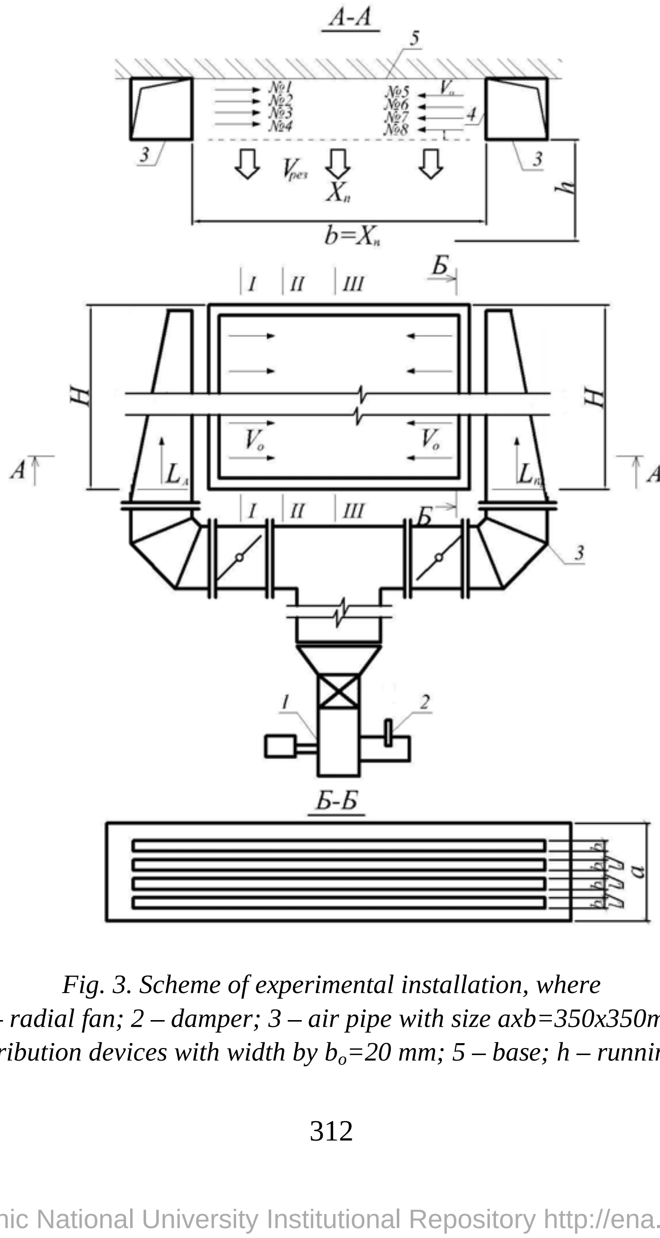

Fig. 3. Scheme of experimental installation, where
1 – radial fan; 2 – damper; 3 – air pipe with size axb=350x350mm;
4 –air distribution devices with width by b_o=20 mm; 5 – base; h – running distance

Using the pulse supply with a help of appliance [2] initial velocity V0 of jet exit from the nozzle will oscillate according to the periodical order, namely it will change within the limits from V_{0min} to V_{0max}

$$V_0 = \overline{V_0} + A \cdot \cos \omega t \tag{2}$$

where $\overline{V_0}$ - mean V_0 at period of vibration, m/s;

A – amplitude of V_0 oscillation, m/s;

ω – cyclic frequency of oscillation, s^{-1};

t- time, s.

Values $\overline{V_0}$, A and ω can be determined from the formulas:

$$\overline{V_0} = 0{,}5 \cdot \left(V_{0_{max}} + V_{0_{min}}\right) \tag{3}$$

$$A = 0{,}5 \cdot \left(V_{0_{max}} - V_{0_{min}}\right) \tag{4}$$

$$\omega = \frac{2\pi}{T} \tag{5}$$

T – period of oscillation, s.

We observe that during the initial moment of time the neutral position of partition was taken.

Similarly lets write the expression for the axial velocity oscillation when $\omega = \frac{2\pi}{T}$ is taken into consideration

$$V_x = \overline{V_x} + B \cdot cos\left(\frac{2\pi}{T}t - \varphi\right) \tag{6}$$

Since axial velocity V_x is late at phase comparatively with V_0, so initial phase comes into expression with negative sign.

Mean V_x and amplitude of its regression B are determined analogically as the initial parameters:

$$\overline{V_x} = 0{,}5 \cdot \left(V_{x_{max}} + V_{x_{min}}\right) \tag{7}$$

$$B = 0{,}5 \cdot \left(V_{x_{max}} - V_{x_{min}}\right) \tag{8}$$

After that we obtain:

$$\overline{V}_x + B \cdot \cos(\omega t - \varphi) = \overline{V}_0 \frac{m\sqrt{F_0}}{x} + A\frac{m\sqrt{F_0}}{x} \cdot \cos \omega t \tag{9}$$

Since constant mode is the partial case of the pulse supply with the amplitudes of oscillation A = 0 and B = 0, so equation (9) changes into (10) and is analogical t_o(1).

$$\overline{V}_x = \overline{V}_0 \frac{m\sqrt{F_0}}{x} \tag{10}$$

Taking into consideration (9), (10) we have:

$$B \cdot \cos\left(2\pi\frac{t}{T} - \varphi\right) = A\frac{m\sqrt{F_0}}{x} \cdot \cos 2\pi\frac{t}{T} \qquad (11),$$

from where we determine amplitude B:

$$B = A\frac{m\sqrt{F_0}}{x}\cdot\frac{\cos 2\pi\, t/T}{\cos(2\pi\, t/T-\varphi)} \tag{12}$$

Experimental investigations have been carried out at the installation, presented on fig.3 at such conditions and simplifications:

- air jets are isothermal;
- incoming nozzles are holes with width 20 mm and with legth 1,5 m;
- coefficient of velocity extinction m = 2,5;
- initial air velocities in nozzle were: V = 5 – 15 m/s;
- period of velocity change at experimental investigations was constant: T = 15 min.;
- air flow rates were: L = 200 – 500 m^3/ h.

Air velocity have been measured by thermal electrical anemometr testo-405 at using coordinate device with net of points 5x5 sm.

Conclusions

1. Air flow rate in total flow is constant, but components Li are variable at periodic regularity.
2. Direction change of total air flow from 0 to 1800 is provided.

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