On creating optimal working conditions in multi-storey buildings of concrete mixing plants

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Abstract. The article discusses industrial premises with the location of technological equipment and workplaces at different altitudes. The method of division into calculated aerodynamic volumes of premises is described. Formulas are given for calculating air exchange taking into account air overflow, taking into account the architectural and planning features of the considered industrial premises.

1. Introduction
Analysis of industrial premises in various industries made it possible to identify and combine into a separate group premises that have similar architectural and planning solutions - multi-storey concrete mixing units or stacked shops. A distinctive feature of this type of premises is the location of technological equipment and workplaces at different elevations in a single closed volume.

The group under consideration includes production facilities in various industries: production of building materials (concrete mixing departments), petrochemistry, metallurgy, chemical production and oil extraction plants.

The design of ventilation, as well as the maintenance of the standard air parameters in the industrial premises under consideration, is difficult, primarily due to the architectural and planning solution.

2. Research
In rooms with the location of working areas at different elevations, a method based on the principles of dividing a room into calculated volumes is used to calculate air exchange, the air flow inside which is described by equations (Figure 1, 2). [1-4]

The calculation of air exchange for each calculated volume is carried out taking into account the overflow of air, as well as harmfulness from one volume to another through vertical (side) holes and through horizontal (holes in the platforms) (Figure 3) [5]. The calculation should be performed sequentially. Starting from the bottom platforms, moving up. [6-8]

In view of the fact that the parameters of flows from the lower volumes wag on the parameters of the air in the upper volumes, it is necessary to redistribute the calculated air exchanges upward for the upper volumes (Figure 3). [9-11].
Figure 1. Carbon black plant (one stream). – technological equipment; - places of intense dust emission; - the boundaries of estimated volume.

Figure 2. Concrete mixing department - technological equipment - places of intense dust emission; - the boundaries of estimated volume.
Figure 3. General diagram of a multi-storey shop with heat surpluses and a diagram of the calculated aerodynamic volume.

The overflow of air masses between the technological sites is due to the ejection effect of the supply air at the site, the increasing flow rate in the ascending streams of the shaft, and the unbalance of air exchange at the site. [12,13]

Therefore, the inflow to the site must exceed the volume of air removed by the aspiration systems by the amount $L_{\text{min}}$:

$$L_{\text{min}} = L \cdot \frac{1}{2} Ar(h)$$  (1)

$L$ - flow rate in the ascending stream of the wellbore at the site level, m$^3$/h;

$Ar(h)$ - Archimedes criterion for the upward flow relative to the air at the site.

When comparing the balance of hazards[9] or air - heat balance above the volume areas, it is necessary to take into account the overflow of air:

$$L_{\text{in}} = L_{\text{in}} + L_0 + L_M$$

$L_{\text{in}}$ - the amount of air flowing into the site;

$L_0$ - the amount of supply air at the site, m$^3$/h;

$L_M$ - the amount of air removed by local suction, m$^3$/h.

Solving together the system of the equation of air-heat balances, we obtain an equation of the second degree relative to the value of the supply air. The amount of inflowed air that is included in this equation will also depend on the amount of supply air.

$$L_{\text{in}} = L_0 \cdot \left( \delta \cdot \frac{v_0}{v_{p3}} - 1 \right)$$  (2)

$v_0$ - air speed in the supply nozzles, m/s;

$v_{p3}$ - air speed in the working area, m/s;

$\delta$ - coefficient, depending on the type of air distributor and its location, characterizing the fraction $L_{\text{in}}$ of the total air ejected by the supply jets at the site. [14-15]

Adding the jet propagation laws to the obtained equations and solving the system of four equations with respect to $L_0$, we obtain
\[ L_0 = \frac{Q}{c \Delta t_{p.3}} \left[ 1 - \frac{(1-b) \cdot (1-a)}{3600 \cdot c \cdot V_{p.3} \cdot \Delta t_{p.3} \cdot S \cdot \delta \cdot x^2}{H \cdot q \cdot m_1 \cdot F_n \cdot (1-b-a)} \right] \]  

\( Q \) - heat surpluses in the entire shop, kcal/h;  
\( c \) - volumetric heat capacity, kcal/m\(^3\);  
\( b \) - the proportion of excess heat generated at the site;  
\( a \) - the share of heat carried away by the local exhaust ventilation;  
\( V_{p.3}, \Delta t_{p.3} \) - standardized speed and temperature difference in the working area on the site;  
\( H \) - shop height, m;  
\( q \) - specific heat density of the shop, kcal/m\(^3\);  
\( x \) - distance from the air distributor to the jet entrance into the working area;  
\( m_1 \) - rate of speed drop;  
\( F_n \) - floor area per air distributor;  
\( S \) - the ratio of the area of the site and the floor of the workshop.

3. Conclusions
To ensure correct air exchange in the production premises of the workshop, the method of supplying the supply air, the location of the supply air distributors and air intake openings are of great importance. The air exchange organization scheme should be adjusted depending on the period of the year, that is, a dual-mode ventilation system should be provided.

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