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TO CALCULATIONS OF VENTILATION OF DERIVED PLACINGS OF METALLURGICAL WORKSHOPS TAKING INTO ACCOUNT LOSSES OF WARMTH

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The equations describing the change of air temperature in the working area of derived placing for metallurgical workshops during operation, taking into account the overall ventilation heat loss through the building envelope's surfaces.

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One of main harmful productive factors in the working areas of derived placing, especially in metallurgical workshops, is a presence of surpluses of warmth.

The most effective mean of struggle against the increased temperature of air of working area of apartments is general (metathetical) ventilation. The methods of calculations of charges of a vent air for support of the set temperature of working area of derived placing are well worked out and well-known [1]. Complications appear up during the analysis of work of a vent system in the conditions of treason of temperature of air, id est. at the non-stationary conditions of heat generation.

For description of ventilation process at moving away of surpluses of warmth from an placing it is possible to use the modified main differential equation of ventilation [2]:

$$N\,d\tau + Q\cdot i_{í.ñ}\,d\tau - Q\cdot i\;d\tau = V\,di\ , \tag{1}$$

where N – power of heat generations, kW; Q – charges of a vent air (productivity of a vent plant), m^3/s; V – an internal volume of placing, m^3; $i_{a.e}$, i – enthalpy of air of environment and enthalpy of air in an placing (middle on its volume), kJoul/m^3, accordingly; τ – time, s.

Taking the heat capacity of air as a constant size, that possibly in the range of vent temperatures, will get:

$$N\cdot c^{-1}\,d\tau + Q\cdot t_{í.ñ}\,d\tau - Q\cdot t\;d\tau = V\,d\tau\ , \tag{2}$$

where c – a heat capacity of air, kJoul/(m^3 K); $t_{a.e}$, t – temperature of environment air and temperature into a placing (middle on its volume), °C, accordingly.

In work [3] common solution of equation (3) which describes treason of temperature in a placing for works of metathetical ventilation is offered:

$$t = \exp\left(-\int\frac{Q\,d\tau}{V}\right)\cdot\left[\int\left(\frac{N}{c\cdot V}+\frac{Q\cdot t_{í.ñ}}{V}\right)\cdot\exp\left(\int\frac{Q\,d\tau}{V}\right)d\tau + K\right]\ , \tag{3}$$

where K – constant integration.

Particular decision of part, which answers initial conditions τ = 0, $t = t_1$, at the constant values of Q, V, $t_{a.e}$, after transformations looks like :

$$t=\frac{1}{c\cdot V}\cdot\exp\left(-\frac{Q\cdot\tau}{V}\right)\cdot\int\limits_0^\tau N\cdot\exp\left(\frac{Q\cdot\tau}{V}\right)d\tau+t_{í.ñ}+\ t_1-t_{í.ñ}\ \cdot\exp\left(-\frac{Q\cdot\tau}{V}\right), \qquad (4)$$

where t_1 – a temperature of air in a placing at the beginning of ventilation work, °C.

At conditions, when power of heat generation is constant size, id est. N = constant of equation decision (4) can be written down

$$t=t_{í.ñ}+\frac{N}{c\cdot Q}+\left(t_1-t_{í.ñ}-\frac{N}{c\cdot Q}\right)\cdot\exp\left(-\frac{Q\cdot\tau}{V}\right). \qquad (5)$$

It is known that when heat generation in air of working area originates only from objects, which cool down into an placing, for example, of warmed-up metal, then cooling process with sufficient exactness it is possible to give exponential dependence:

$$N=N_0\cdot\exp\ -a\cdot\tau\ \ , \qquad (6)$$

where N_0 – initial power of heat generation, (at τ = 0), kW; a – constant, what is determined the conditions of heat exchange, s^{-1}.

In the case when N = constant, equation (4) taking into account the losses of warmth to the environment looks like:

$$t=t_{í.ñ}+\frac{N}{c\cdot Q+k\cdot F}+\left(t_1-t_{í.ñ}-\frac{N}{c\cdot Q+k\cdot F}\right)\cdot\exp\left[-\left(\frac{k\cdot F}{c\cdot V}+\frac{Q}{V}\right)\cdot\tau\right]. \qquad (7)$$

Time during which a temperature changes from t_1 to t_2 at works of ventilation with the constant productivity get from equation (7), if to accept $t = t_2$:

$$\tau=\frac{cV}{c\cdot Q+k\cdot F}\cdot\ln\left[\frac{t_1-t_{í.ñ}-N/\ c\cdot Q+k\cdot F}{t_2-t_{í.ñ}-N/\ c\cdot Q+k\cdot F}\right]. \qquad (8)$$

There are calculated treason of temperature in a placing at times taking into account the losses of warmth through a protection, if power of heat generation changes on a exponential law (6). Thus equation (4) has a decision:

$$t=t_{í.ñ}+\frac{N_0}{c\cdot\ Q-a\cdot V\ +k\cdot F}\cdot\exp\ -a\cdot\tau\ +\left[t_1-t_{í.ñ}-\frac{N_0}{c\cdot\ Q-a\cdot V\ +k\cdot F}\right]\cdot\exp\left[-\left(\frac{k\cdot F}{c\cdot V}+\frac{Q}{V}\right)\cdot\tau\right]. \qquad (9)$$

For determination of dependence of work-time for a vent plant from a temperature that it is needed to set in a placing, it is possible to give equation (9) in a kind:

$$t=t_0+\alpha\cdot\exp\ -a\cdot\tau\ +\beta\cdot\exp\ -b\cdot\tau\ \ , \qquad (10)$$

where $\alpha=\frac{N_0}{c\cdot\ Q-a\cdot V\ +k\cdot F}$; $\beta=t_1-t_{í.ñ}-\frac{N_0}{c\cdot\ Q-a\cdot V\ +k\cdot F}$; $b=\frac{k\cdot F}{c\cdot V}+\frac{Q}{V}$.

There are presented exponents in a kind: $\exp\ -a\cdot\tau\ =1+x$; $\exp\ -b\cdot\tau\ =\ 1+x\ ^{b/a}$

Then equation (10) looks like

$$t = t_0 + \alpha \cdot \exp\left(-a \cdot \tau\right) + \beta \cdot \exp\left(-b \cdot \tau\right)^{b/a} . \qquad (11)$$

According to formulas for the rotation of power (-law) row [4], limited it by the first three members and designating *b*/*a* = *B*, and also passing to the variable τ, after transformations, will get:

$$\tau = \frac{1}{a} \cdot \ln \left\{ 1 + \frac{t - t_1}{\alpha + \beta \cdot B} - \frac{\beta \cdot B \cdot (B-1)}{2(\alpha + \beta \cdot B)^3} \cdot (t - t_1)^2 + \right.$$

$$\left. + \frac{0{,}5\beta^2 \cdot B^2 \cdot (B-1)^2 - 1/6\beta \cdot \left[(\alpha + \beta \cdot B) \cdot B \cdot (B-1) \cdot (B-2) \right]}{(\alpha + \beta \cdot B)^5} \cdot (t - t_1)^3 + \ldots \right\}^{-1} . \qquad (12)$$

After the estimation of exactness of calculations a formula for the calculation of work-time of ventilation finally accept in a kind:

$$\tau = \frac{1}{a} \cdot \ln \left[1 + \frac{t - t_1}{\alpha + \beta \cdot B} - \frac{\beta \cdot B \cdot (B-1)}{2(\alpha + \beta \cdot B)^3} \cdot (t - t_1)^2 \right]^{-1} \qquad (13)$$

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