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METHOD OF ENGINEERING CALCULATION OF TEMPERATURE MODES FOR BURNING OF RAW PRODUCT REFRACTORIES IN TUNNEL FURNACES

(Report 1)

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On the basis of decision of differential balance equation of heat conductivity in backward flow the method of engineering calculation is offered for the correction of temperature mode of burning of raw product refractory's in charging on the furnace tubs. the methods of calculation of coefficients of heat transfer agent in operating tunnel furnaces In detail are stated. Calculations on the correction of the temperature modes of burning allow to provide stabilizing of high-quality factors of the finished products.

Keywords: tunnel furnace, raw product of refractory's, temperature mode of burning, equation of heat conductivity in backward flow, correction of expense of heat-transfer, high-quality factors of the finished products

Entry. At work of tunnel furnaces quite often there is a necessity of change of their productivity without the change of loading of raw product on the furnace tubs, that causes a necessity to carry out the correction of temperature mode for work of furnaces.

In this connection it is necessary to find the acceptable engineering mathematical model of processes of heat exchange in tunnel furnaces and work out the methods of calculation of parameters, characterizing heat work of these heat engineering aggregates.

An analysis shows that heating of material in tunnel furnaces at strict approach must be examined as warming in a static layer with the step-like bed of initial and border conditions.

At development of engineering mathematical model of heating of material in tunnel furnaces it is possible to inject next assumptions:

- the seamless continuous moving of material in the opposite direction heat transfer agent with middle speed equal $\omega = \ell_{fur}/\tau$, where ℓ_{fur} - length of a tunnel furnace, m; τ - duration of material stay in a furnace;
- absence of heat exchange of the work volume of furnace with an medium;
- absence of heat exchange between bath of raw products and material of fettling of furnace walls;
- absence of heat-eliminating influence of tubs bottom on heating of lower layers of bath.

These reasons allow to use for a decision the set problem the model of the cross-current heating of material in a layer.

The decision of balance differential equation of heat exchange in cross-current is expression [1]:

$$\frac{\bar{O}_{\mathrm{m}}}{\grave{O}_{\mathrm{hta}}} - 1 - \exp\left[-\frac{\alpha_{\Sigma} \cdot F_{\ddot{\imath}} \cdot V_{\mathrm{m}}}{G_{\mathrm{m}} \cdot c_{\mathrm{m}}} \left(1 - \frac{G_{\mathrm{m}} \cdot c_{\mathrm{m}}}{G_{\mathrm{hta}} \cdot c_{\mathrm{hta}}} \right) \cdot \frac{\tau}{m} \right], \tag{2}$$

where $\bar{O}_{\mathrm{i}}$ - a temperature of material, middle on the section of bath column, K, at any moment heating; $\grave{O}_{\mathrm{\grave{o}}}$ - a temperature of heat transfer agent on entranced in cross-current, K; α_{Σ} - a total coefficient of heat radiation, kJoul/(m^2 K); $F_{\ddot{\imath}}$ - a specific heat exchange surface of material in cross-current, attributed to unit of volume m^2/m^3, V_{i} - volume expense of material in cross-current, м^3/s; G_{i}, $G_{\mathrm{\grave{o}}}$ - a gravimetric expense of material, kg/s, and volume expense of heat transfer agent, m^3/s, respectively; c_{i}, $c_{\mathrm{\grave{o}}}$ - heat capacity of material, middle in the interval of temperatures 0-$\bar{O}_{i}$, kJoul/(kg·K) and heat capacity of heat transfer agent, middle in the interval of temperatures 0-$\grave{O}_{\mathrm{\grave{o}}}$, kJoul /(m^3 K), respectively; m - a correction coefficient which takes into account massiveness of column of bath $m = 1 + K \cdot Bi$; Bi - a criterion of massiveness Bio; K - a coefficient of form for body; τ - duration of burning, s.

The decision of equation (2) in relation to the desired quantity after sizes after some transformations looks like:

$$\grave{O}_{\mathrm{hta}} = \frac{\bar{O}_{\mathrm{m}} = \mathrm{edem}}{1 - \exp\ \eta}\ ; \tag{3}$$

where

$$\eta = \frac{\alpha_{\Sigma} \cdot F_{\Sigma} \cdot n}{G_{\mathrm{hta}} \cdot c_{\mathrm{hta}} \cdot\ 1 + m} \cdot \left(\frac{G_{\mathrm{hta}} \cdot c_{\mathrm{hta}}}{\grave{I}_{m} \cdot c_{\mathrm{m}}} - 1 \right).$$

At determination of temperature of heat transfer agent $\grave{O}_{\mathrm{hta}}$ on *i* position of area of burning for furnace we took into account that radiation pyrometers which measure temperature in the work volume of this area fixed the total stream of radiation of primary radiator (heat transfer agent) and secondary achromatic radiator (material), id est. temperature of average radiator, which is accepted as a temperature of furnace T_{fur}.

For engineering calculations on a formula (3) inject assumption, that $T_{hta} \cong T_{fur}$, which injects in a definite defect to the estimation of temperature of heat transfer agent, and, consequently, and calculation values of temperature of material T_m, as $T_{hta} > T_{fur} > T_m$.

Consequently, equation (3) can be written down in a kind

$$\grave{O}_{\mathrm{fur}} = \frac{\bar{O}_{\mathrm{m}} = \mathrm{edem}}{1 - \exp\ \eta}\ . \tag{4}$$

Degrees of blackness of heat transfer agent $\varepsilon_{\mathrm{hta},i}$, $\varepsilon_{\mathrm{hta.m},i}$ determine by value partial pressure of triatomic gases and the size of middle motion of ray with the use of charts of radiation of gases [2].

Total the heat exchange surface of bath for raw material of refractory's F_{Σ} on a tub determine as

$$F_{\Sigma} = 2 \cdot \ell_{\mathrm{col}} \cdot h_{\mathrm{\tilde{n}ol}}\ , \tag{8}$$

where n_{col} - an quantity of columns in bath; $\ell_{ñol}$, $h_{ñol}$ - length of column and height of column, m, respectively.

For bath, consisting of columns with clearances:

$$F_{\sum} = F_{ext,\sum} + F_{int,\sum} \quad , \tag{9}$$

where $F_{ext,\sum}$, $F_{int,\sum}$ - external and internal to the heat exchange surface, m^2, respectively.

According to the expounded method temperature mode of burning for sixcolumn bath of periclass-shpinel refractory's for the different variants of the productivity of tunnel furnaces for the production of magnesia refractories were expected. Thus the average mode of burning of periclass-shpinel refractories, which corresponds to fifteen propulsion of tubs in twenty-four hours was fixed in basis of calculations. The mentioned mode allows to get, as practice, refractories of stable quality, which grant sob's demand standard, shows. The analysis of the got results specifies on capability for realization of temperature modes in operating tunnel furnaces at the rate of motion of tubs equal seventeen in twenty-four hours at providing of stable enough quality of the finished products.

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