UDC 666.76.041:519.28

Ivanov V., senior staff scientist
Nesterenko T., associate professor, c.t.s.
Zinchenko V., associate professor, c.t.s.
Cheprasov A., professor, c.t.s.

METHOD OF ENGINEERING CALCULATION OF TEMPERATURE MODES FOR BURNING AND COOLING OF HALF-FINISHED PRODUCT REFRACTORIES IN HIGH TUNNEL FURNACES

(Report 2)

Zaporozhe state engineering academy

On the basis of decision of differential equation of heat exchange of plate in backward flow the methods of engineering calculation are worked out for correction of interval between pokes of trams on the channel of a tunnel furnace, and also expense of air for cooling of the burned refractory. The methods of calculation of coefficients of heat emission in the cooling zone of furnace in detail are stated. The use of the state methods will allow to raise the high-quality factors of the finished products.

Keywords: a high temperature tunnel furnace, refractories, equation of heat exchange of plate in backward flow, interval between pokes of trams, expense of air on cooling, correction

Introduction. At the conditions of unchanging temperature mode of tunnel furnace change of its work to the new chart charges of half-finished product on the furnace trams needs correction intervals of time between their pokes by channel of furnace.

Main part of researches. For determination of character of such correction we use the decision of differential equation of heat exchange of plate in backward flow with introduction of correction on its massiveness [1] in a kind

$$\frac{\bar{O}_m}{\grave{O}_{ht}} = 1 - \exp\left[\left(-\frac{\alpha_\Sigma \cdot F_\Sigma \cdot n}{G_m \cdot \bar{c}_m \cdot m}\right) \cdot \left(\tau - \frac{G_m \cdot \bar{c}_m}{V_{ht} \cdot \bar{c}_{ht}}\right)\right], \qquad (1)$$

where $\bar{O}_m$ – a temperature of half-finished product which is averaged on a charges cut on any moment of its heating, K; $\grave{O}_{ht}$ – a temperature of heat transfer agent (air) on an entrance to backward flow, K; α_Σ – a total coefficient of heat emission, W/(m^2·K); F_Σ – a specific surface of half-finished product in backward flow which receives a warmth and is attributed to unit of its volume, m^2/m^3; n – a quantity of the furnace trams in the zones of heating and burning of furnace; G_m – a mass expense of half-finished product, kg/s; $\bar{c}_m$ – a heat capacity of half-finished product which is averaged in the interval of temperature 0-$\bar{O}_m$, kJou/(kg·K); m – a correctional coefficient which takes into account massiveness of column charges of half-finished product; τ – duration of interval between pores of trams in a furnace, s; V_{ht} – a volume expense of heat transfer agent in the zone of burning of furnace, m^3/s; $\bar{c}_{ht}$ – a heat capacity of heat transfer agent which is averaged in the interval of temperatures 0-T_{ht}, kJou/(m^3·K).

Then duration of interval between pokes of trams with a new (*j*) chart charges of half-finished product by the channel of furnace it is possible to define as

$$\tau_j = \frac{\vartheta \cdot \ 1+m_j}{\alpha_{\Sigma,j} \cdot F_{c\Sigma,j}} \cdot \Omega_1 + \Omega_2 \ , \qquad (2)$$

where

$$\vartheta = \frac{\alpha_{\Sigma,j} \cdot F_{\Sigma,j} \cdot n}{G_{ht} \cdot \bar{c}_{ht} \cdot \ 1+m_j} \cdot \left(\frac{V_{ht} \cdot \bar{c}_{ht}}{G_m \cdot \bar{c}_{\grave{o}}} - 1 \right); \quad \Omega_1 = \frac{G_m \cdot \tilde{n}_m}{n} \ ; \quad \Omega_2 = \frac{G_m \cdot \tilde{n}_m}{V_{ht} \cdot \bar{c}_{ht}} \ .$$

It is known that at burning of half-finished product of the zone of cooling for tunnel furnace assents the set mode of cooling of burned refractory materials, and also supply of zone of burning by air for burning of fuel.

Therefore there is a necessity of stabilizing of quality of refractory materials on the stage of cooling in tunnel furnaces at different intervals of time between pores of trams.

To the base of control by work of zone of cooling of furnaces of this type it can be fixed decision of transcendent equation, got from differential equation heat exchange in backward flow [1]. Its use allows to carry out the correction expense of air V_a, which give to the channel furnaces for assenting of the set mode of cooling of burned refractory materials during treason of interval between pokes of trams on a shift, :

$$V_a = \frac{\theta \cdot \left\langle V_a \cdot \bar{c}_a - \frac{G_b \cdot}{\tau} \cdot \exp\left[\Phi \cdot \left(\frac{G_b \cdot \bar{c}_b}{V_a \cdot \bar{c}_a} - \tau \right) \right] \right\rangle}{\bar{c}_a \cdot \left\langle 1 - \exp\left[\Phi \cdot \left(\frac{G_b \cdot \bar{c}_b}{V_a \cdot \bar{c}_a} - \tau \right) \right] \right\rangle} \ , \qquad (4)$$

where θ – a dimensionless temperature of burned refractory materials on an exit from the zone of cooling of furnace; $\theta = \bar{O}_{b,0} - \bar{T}_b \ / \ \bar{O}_{b,0} - T_a$; $\bar{O}_b$, $\bar{T}_b$ – a averaged mass temperature of burned refractory materials on an entrance and on the output of zone of cooling of furnace, K, respectively; T_a – a temperature of air on an exit from the zone of cooling, K; $\bar{c}_a$ – a averaged heat capacity of air in the zone of cooling, kJou/(m^3·K); G_b – mass charges of burned refractory materials on the furnace trams in the zone of cooling, kg; $\bar{c}_b$ – a averaged heat capacity of burned refractory materials, in the interval of temperatures $\bar{O}_{b,0}$-$\bar{T}_b$, kJou/(kg·K); $\Phi = \bar{\alpha} \cdot F_m \cdot V_a \cdot n \,/\, G_b \cdot \bar{c}_b \cdot \ 1+\mathrm{Bi}$; $\bar{\alpha}$ – averaged on length of zone of cooling of furnace coefficient of heat emission from a surface charges of half-finished product to the air flows, which give to the furnace, W/(m^2·K); F_m, V_a – a total surface charges of burned refractory materials, that receives a warmth in the zone of cooling, m^2, and volume charges, m^3, respectively; Bi – a criterion of massiveness charges of burned refractory materials; $\mathrm{Bi} = \bar{\alpha} \cdot S_p / \lambda_b$; S_p – a calculation thickness of column charges of refractory materials, m the form of which is given as an unlimited plate; λ_b – a coefficient of heat-conducting of burned refractory materials, which conforms it to the averaged temperature in the zones of burning, kW/(kg·K); its values determine from experimental data [2], and also by calculations [3,4].

In accordance with the offered method a calculation charges of air, which give to the zone cooling of tunnel furnace of shamotte workshop of OAJ «Zaporozhrefractory» at burning of half-finished product of mark LSHA-16 for five and sixcolumellar charts charges was executed.

The analysis of the got results testifies that total power of ventilators, set in the zone of cooling of tunnel furnace, is sufficient at the increase of its productivity to eleven pokes of trolleys on a shift, both for a five column chart charges of refractory materials of mark LSHa-16 and six column charts. For the increase of quantity of pokes of trams in a furnace to twelve and thirteen on a shift necessary is armoting of zone of cooling more powerful furnace ventilators.

Conclusions. The methods of engineering calculation of correlation of interval are offered between pokes of trams by the channel of tunnel furnace, and also expense of air to its zone of cooling of furnace which will allow to assent stability of high-quality factors of burned refractory materials.

REFERENCES

1. **Китаев, Б. И.** Теплообмен в шахтных печах [Текст] / Б. И. Китаев, Ю. Г. Ярошенко, В. В. Сучков. – М. : Металлургия, 1957. – 279 с.
2. **Харченко, И. Г.** Теплофизические свойства магнезиальных огнеупоров в процессе обжига [Текст] / И. Г. Харченко, В. И. Иванов, В. С. Баздырев // Металлургия и коксохимия : темат. научн.-техн. сборник – Киев : Техника, 1982. – Вып. 84. – С. 6-10.
3. **Миснар, А.** Теплопроводность твердых тел, жидкостей и газов и их композиций [Текст] / А. Миснар. – М. : Мир, 1968. – 463 с.
4. **Литовский, Е. Я.** Теплофизические свойства огнеупоров [Текст] / Е. Я. Литовский, Н. А. Пучкелевич ; справочник. – М. : Металлургия, 1982. – 150 с.