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USE OF NOMOGRAMS FOR PROGNOSTICATION PROCESSES ENERGY- AND MASS TRANSFER IN TECHNOLOGY PRODUCTIONS OF REFRACTORIES

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It is offered the nomogram method of the exposition for transfer processes of energy and mass of substance on the basic redistributions of refractories production by join of energy (temperature) and mass concentration diagrams of the indicated processes and also diagram of objective functions in single complexes, synchronously mapping the difficult transfer processes taking into account transformations, happening in refractories systems. Such nomograms define development of the real technological processes in a time and can be used by working out computer models for the control of regimes for a half-finished product forming and its burning to perfect technologies of refractory materials production.

Keywords: forming and burning of half-finished product, of energy and mass transfer, temperature- and mass concentration diagrams, diagrams of objective functions, nomograms

At creation of mature technology for production of refractory materials it is necessary to have positive methods of prognostication of its final results, in particular distributions of concentration of heat-resistant mass and physics-mineralogical constituents on the section of half-finished product and burnt refractory material accordingly. These methods must set dependences between a change fields for pressures in a press-form at forming of half-finished product and fields for temperature in burned refractory material, from one side, and field for concentrations of mass a change in pressing and field for concentrations of different components of refractory material at burning, on the other side, which are the indirect indexes for completeness of the indicated processes.

Process of compression for refractory powder mass. In work [1] on the basis of analysis of motive forces energy- and mass transfer in the powder-like systems at treatment its by pressure the diffusive model of such transfer is offered. A model examines the process of treatment of powder-like materials by pressure as diffusive transfer of energy- and mass for powder in a spatial area with the set form, sizes and final (middle on a section) closeness of half-finished product.

The stationary streams of transfer of energy $\bar{J}_p$ and the mass $\bar{J}_m$ in system are described by linear Onsager correlations which look like:

$$\vec{J}_p = -L_{pp} \cdot \operatorname{grad} P \ ; \qquad (1)$$

$$\vec{J}_m = -L_{pm} \cdot \operatorname{grad} P \ . \qquad (2)$$

In connection with that processes energy- and mass transfer of powder in the selected system are non-stationary and irreversible the local measuring of pressure and closeness on it thickness in time (τ) is described by Umov's differential equations:

$$\frac{dP}{d\tau} = -\mathrm{div}\,\vec{J}_p \ ; \tag{3}$$

$$\frac{d\rho}{d\tau} = -\mathrm{div}\,\vec{J}_m \ . \tag{4}$$

With using equations (3) and (4) connection of local changes of closeness of heat-resistant mass in pressing is found with a speed of change of pressure in these points in the direction of development for compression process, id est

$$\frac{d\rho}{d\tau} = \frac{L_{pm}}{L_{pp}} \cdot \frac{dP}{d\tau} \tag{5}$$

Because the value of relation L_{mp}/L_{pp} depends on properties of powder-like product, size of the put pressure, then it can not be certain by an analytical method. In this connection at description of processes of transfer at forming of half-finished product it is necessary in the beginning to expect the fields of averaged values of pressure on the thickness of this system (z) in time (τ), and then to determine the fields of closeness for matter mass $\rho = \psi(z,\tau)$ with use the known empiric «equations of pressing» $\rho = \varphi(Đ)$ [2,3] or additional experiments.

With the purpose of complex and synchronous reflection of processes energy- and mass transfer, what be going on in pressing at treatment pressure of the heat-resistant masses, there are executed the association of power P = φ(z,τ) and masscon-centrational ρ = ψ(z,τ) diagrams in the united nomogram system energy- and mass transfer [10].

Process of burning. For the process of burning in the case of stationary process equation for the diffusive stream of k component looks like:

$$\vec{J}_k = -D_k \cdot \rho \cdot \left[\nabla \rho_{k_0} + \frac{K_T}{T} \cdot \nabla T + \frac{K_P}{P} \cdot \nabla P \right] , \tag{6}$$

where $\vec{J}_k$ is a diffuse stream of k component; $\nabla \rho_{k_0}$, ∇T, ∇P are gradients of dimensionless concentration, temperatures and pressures, accordingly; D_k is a coefficient of diffusion of mass of k component, K_T, K_P are thermal-diffusion and barodiffusion coefficients, accordingly, K_1, K_2 are constant coefficients.

Thus the process of transfer of warmth $\vec{J}_\theta$ in k component of the multicomponent system is described by equation

$$\vec{J}_\theta = -\lambda_k \cdot \nabla T - Q \cdot D_k \cdot \rho \cdot \nabla \rho_{k_0} + \sum h_k \cdot \vec{J}_k \ , \tag{7}$$

where Q is an isothermal warmth of transfer; λ_k, h_k are heat conductivity and specific enthalpy of k component, accordingly.

In the case of non-stationary processes of transfer for warmth and mass at forming of refractory materials at conditions (1)-(4) it is possible to write down the system of equations of kind

$$\frac{\partial \rho_{k_0}}{\partial \tau} = -\mathrm{div}\left(\vec{J}_k\right) + I_{k_0} \ ; \tag{5}$$

$$\frac{\partial \theta}{\partial \tau} = -\mathrm{div}\left(\vec{J}_\theta\right) + I_\theta \ ; \tag{6}$$

where $\partial \rho_{k_0} / \partial \tau$, $\partial \theta / \partial \tau$ are local speed of change of dimensionless concentration f k component and local speed of change of concentration of warmth, accordingly; τ is duration of process; I_{k_0}, I_θ are source (flow) of concentration of mass of k component due to the chemical reactions of co-operation of separate components of refractory material and warmth in a local area due to end- or exothermic reactions; $\vec{J}_\theta$, $\vec{J}_k$ are streams of warmth and mass for k component, accordingly.

The nomogram method of presentation of processes for transfer of warmth and mass is worked out in work, what be going at forming refractory materials in the column of change, modeling as a plate of endless length, as complex of diagrams: temperature, mass-concentrational and thermal.

Conclusion. From position of thermodynamics of irreversible processes and processes heat- and mass transfer the nomogram method of presentation of processes, what be going at forming of refractory materials at its production is worked out.

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