

Mathematical model of informational processes of a desorption*Mathematical description of the desorption process.*

The greatest development in the processing of solutions has been the traditional sorption-precipitation methods of concentrating the useful element in the mining areas. High transport costs for the delivery of reagents, the use of expensive reagents for sedimentation, low-productivity and inefficient volumetric equipment, difficult to fully automate, occupying large areas and requiring large maintenance costs are expensive. To reduce the costs of obtaining chemical concentrates, two ways are possible to improve technology and increase productivity with the existing technology, which is most often implemented in new devices, through the use of continuous equipment. Currently, the advantages are equipment with the absence of moving parts inside the reaction zone, with full tightness, high product removal from the unit of working volume and low energy intensity.

The desorption rate in the external diffusion kinetics is determined by the film thickness and the grain surface size and is described by the following equation

$$\frac{dc}{d\tau} = \frac{DF(C_o - C)}{\delta} = \beta \cdot (C_o - C) \quad (1)$$

Where β – the kinetic coefficient $\beta = \frac{D \cdot F}{\delta}$;

C_o – the initial concentration of the substance or the concentration of the substance in the volume of the solution; C – the concentration of the substance at time τ on the surface of the sorbent; D – diffusivity of diffusible substance; F – surface of grains; δ – thickness of the diffusion film on the grain surface.

The thickness of the film δ depends on the flow regime of the solution. According to Helfferich, the film thickness is estimated, depending on the experimental conditions, at 10-100 μm ; at high flow rates of the solution, due to flow turbulence, it decreases to about 1 μm .

The desorption rate for intradiffusion kinetics is described by the following equation:

$$\frac{dc}{d\tau} = \beta \cdot (a_o - a) = \frac{\pi^2 D}{r^2} \cdot (a_o - a) \quad (2)$$

where a_o – initial concentration, equilibrium C_o at the time τ ; a – concentration, equilibrium C at the time τ ; β – kinetic coefficient $\beta = \frac{\pi^2 D}{r^2}$; r – grain radius of the sorbent.

In the case of intradiffusion kinetics, the shape of the sorbent grains is of great importance. For the most common case of spherical grains, the problem reduces to solving equation

$$\frac{da}{d\tau} = \frac{D}{r^2} \cdot \frac{d}{dr} \left(r^2 \frac{dc}{dr} \right) \quad (3)$$

where r – radius of the sorbent.

The dynamics of desorption for one substance is described by the following system of equations

$$\left. \begin{aligned} -v \frac{\partial c}{\partial x} + \kappa D \frac{\partial^2 c}{\partial x^2} &= \frac{\partial a}{\partial \tau} + \kappa \frac{\partial c}{\partial \tau}; \\ \frac{\partial a}{\partial \tau} &= f(a, c); \\ a &= f(c). \end{aligned} \right\} \quad (4)$$

This system of equations covers completely the entire variety of problems of the dynamics of desorption for a one-component system. The statement of any specific desorption problem consists in recording the corresponding initial and boundary conditions:

$c(0, \tau) = 0$; means that a solution is added to the top of the sorbent that does not contain this element ($C=0$);

$a(x, 0) = a_0$; means that at the initial instant of time the sorbent is completely worked out ($a=a_0$).

Substances, added to a given layer element by a solution stream ($-v \frac{\partial c}{\partial x}$) and longitudinal diffusion ($\kappa D \frac{\partial^2 c}{\partial x^2}$), ($\frac{\partial a}{\partial \tau}$) is allocated with grains of sorbent, ($\kappa \frac{\partial c}{\partial \tau}$) is partly spent on increasing the concentration of the substance in the solution between the grains of the sorbent.

To the reactor overall balance equation can be written as



where $(R_4N)_4[Me]$ is a saturated sorbent with a useful element; NH_4NO_3 – desorption solution; R_4NNO_3 – sorbed desorption ion in the sorbent; Me – useful element;

Let's write differential equations for each component

$$\left. \begin{aligned} V_r \frac{dC_{NH_4NO_3}}{dt} &= G_{in} C_{NH_4NO_3} - \omega_d - G_{out} C_{NH_4NO_3} \\ V_r \frac{dC_{(R_4N)_4[Me]}}{dt} &= -\omega_d \end{aligned} \right\} \quad (6)$$

$$V_r \frac{dC_{Me}}{dt} = \omega_d - G_{out} C_{Me}$$

$$V_r \frac{dC_{R_4NNO_3}}{dt} = 4\omega_d,$$

where V_p - volume of desorption column; G_{in} - inlet flow; G_{out} – outflow; K_p - reaction rate constant; $C_{NH_4NO_3}$ - concentration of the desorbing solution; $C_{(R_4N)_4[Me]}$ - concentration of saturated sorbent with a useful element; C_{Me} - concentration of a useful element; ω_d – speed of desorption process;

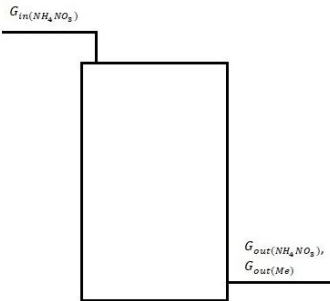


Fig. 1 – Model of desorption column

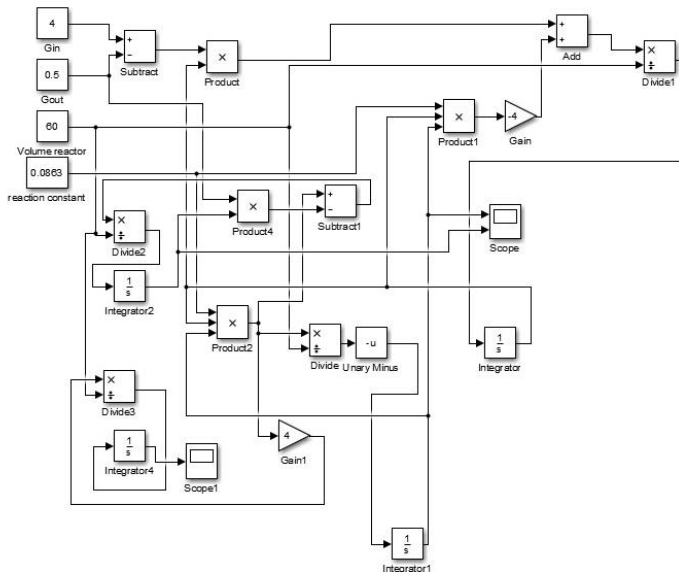


Fig. 2. Scheme of informational processes of a desorption in the Matlab

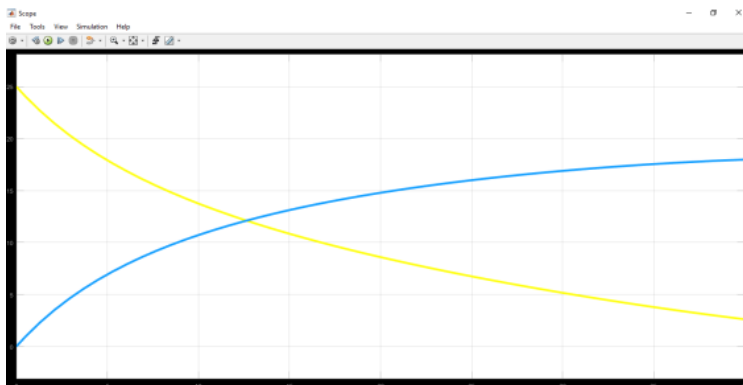


Fig. 3. Dependence of a saturated sorbent at influence of the desorption solution.

In the figure 3, blue indicates the concentration of the useful element extracted from the sorbent, and yellow indicates the concentration of the useful element in the sorbent.

Conclusion

We reviewed in detail the mathematical description of the desorption process and the chemical reaction speed. We constructed a scheme of the information flow during the desorption process.

References

1. Bugenov E. C., Vasilevsky O. V., Patrin A. P. Physical and chemical basis and technology for obtaining chemical concentrates of natural uranium. – Almaty, 2009. -518 p
2. Kudlanov V.N. Improving the redistribution of uranium desorption // Proceedings of the Tomsk Polytechnic University.- 2002. – V. 305, no.3: Problems and prospects of the nuclear industry technologies. – [FROM. 104-115 p].
3. Usheva N.V, Moises O.E, Mityanina O.E, Kuzmenko E.A. Mathematical modeling of chemical-technological processes. Publishing house of Tomsk Polytechnic University, 2014 -140 p.