NOTATION

c, concentration; Δc, concentration change, τ, time; $\theta = H^2\tau/mK$, $H = g\rho^2\beta\delta^3(\Delta T)^2Bs/6!\eta$, $K = g^2\rho^3\beta^2\delta^7\cdot(\Delta T)^2B/9!\eta^2D$, $m = \rho B\delta$; B, perimeter of separating slot; δ, gap; ΔT, temperature difference between hot and cold surfaces; s, Soret coefficient; $y = Hz/K$; z, vertical coordinate; $\omega = M/mL$; M, mass of mixture in tank; L, working length of a column. Indices: e, i, positive and negative ends of a column; 0, initial value.

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MODEL OF DIFFUSION TAKING INTO ACCOUNT SORPTION

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The problem of the diffusion of a material in an adsorbing porous medium is considered. In the equation for the concentrations in the porous medium and the sorption layer a delay time is introduced.

The problem of the diffusion of material in an adsorbing porous medium is considered. Henry's law is assumed to hold for equilibrium values of concentration in the porous medium and in the sorption layer. This problem is considered, in a linear formulation, in a number of works where the kinetics of the process and diffusional transfer are taken into account; a review of such works appears in [1, 2].

The formulation of the problem outlined in the present paper differs from previous accounts in that a delay time is introduced in the equation relating the concentrations of the material in the porous medium and in the sorption layer.

If the concentration of the material in the sorbent layer is assumed to attain its equilibrium value at once, then Henry's law implies that its distribution will follow the distribution of the material in the porous medium. It is more general to assume that the distribution of material in the layer follows the distribution in the porous medium with some delay. The basis for this assumption is given in [3].

We introduce a delay time τ, assumed to be identical at all points of space. We denote the concentration of material in the flow by $\Theta(t, x)$ and the concentration in the sorption layer, by $a(t, x)$. On the basis of the given assumptions, the following relation exists between these functions:

$$a(t, x) = \Gamma\Theta(t-\tau, x),\ t \geqslant \tau,\ a \equiv 0,\ t < \tau. \tag{1}$$

Thus, the function $a(t, x)$ defined by Eq. (1) vanishes for $t < \tau$, and reaches its equilibrium value corresponding to the concentration of the material $\Theta(t, x)$ not at once, but τ units of the argument t later.

We shall show that for small values of the delay time τ, Eq. (1) gives the kinetic equation. To this end, we expand the function $\Theta(t-\tau, x)$ in a Taylor series in t:

$$\Theta(t-\tau, x) = \Theta(t, x) - \left(\frac{\partial\Theta}{\partial t}\right)_{\tau=0}\tau + \ldots. \tag{2}$$

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For $\tau = 0$, we have $da/dt = \Gamma(d\Theta/dt)$. Therefore, from Eqs. (1) and (2) we obtain

$$\frac{da}{dt} = \frac{1}{\tau}(\Gamma\Theta - a). \tag{3}$$

As an example of the use of Eq. (3), we consider the filling of a porous medium by material adsorbed at the surface of the pores. The distribution of the material in the pores will be described by the following equation:

$$m_0 \frac{\partial\Theta}{\partial t} + u\frac{\partial\Theta}{\partial x} + \frac{\partial a}{\partial t} = 0,\ \Theta = \Theta(t, x),\ a = a(t, x),\ 0 < m_0 < 1. \tag{4}$$

In this equation longitudinal diffusion of the material is neglected.

The initial and boundary conditions of the problem are

$$\Theta(0, x) = 0,\ \Theta(t, 0) = 1,\ \Theta(t, \infty) = 0,\ a(0, x) = 0. \tag{5}$$

We construct an approximate solution of the problem. For times $t \gg \tau$, the delay may be disregarded. Then

$$a(t, x) = \Gamma\Theta(t, x). \tag{6}$$

In this case, Eq. (4) takes the form

$$\frac{\partial\Theta}{\partial t} + w\frac{\partial\Theta}{\partial x} = 0,\ w = \frac{u}{m_0 + \Gamma}. \tag{7}$$

The solution of this equation for the conditions in Eq. (5) is a plane wave, the front of which moves with velocity w. At the wave front, and everywhere in the region $x < wt$, the concentration Θ is equal to unity, while outside this region the concentration is zero.

This solution neglects the effect of the delay, which appears most completely close to the wave front, and therefore the solution must be refined in the region of the wave front. To this end, we represent the last term in Eq. (4) in the form

$$\frac{\partial a}{\partial t} = \Gamma\frac{\partial\Theta}{\partial t} - \Gamma\tau\frac{\partial^2\Theta}{\partial t^2} + \ldots. \tag{8}$$

We restrict ourselves to linear delay. Then Eq. (4) is written as follows:

$$\frac{\partial\Theta}{\partial t} + w\frac{\partial\Theta}{\partial x} - \frac{\Gamma\tau}{m_0 + \Gamma}\frac{\partial^2\Theta}{\partial t^2} = 0. \tag{9}$$

In the region of the wave front, the solution is written in the form

$$\Theta(t, x) = f(x - wt). \tag{10}$$

Therefore, the second derivative with respect to t can be written in the form

$$\frac{\partial^2 f}{\partial t^2} = w^2\frac{\partial^2 f}{\partial x^2},\ f = f(x - wt). \tag{11}$$

Taking this into account, the last term in Eq. (9) is written in the form $D(\partial^2\Theta/\partial x^2)$, where $D = \Gamma\tau w^2/(m_0 + \Gamma)$. Then Eq. (9) can be written as follows:

$$\frac{\partial\Theta}{\partial t} + w\frac{\partial\Theta}{\partial x} - D\frac{\partial^2\Theta}{\partial x^2} = 0,\ \Theta = \Theta(t, x). \tag{12}$$

We rewrite Eq. (12) in the moving coordinate system $z = x - wt$:

$$\frac{\partial\Theta}{\partial t} - D\frac{\partial^2\Theta}{\partial z^2} = 0,\ \Theta = \Theta(t, z). \tag{13}$$

We seek the solution of this equation satisfying the Cauchy condition

$$\Theta(0, z) = \begin{cases} 1, & z < 0, \\ 0, & z > 0. \end{cases} \tag{14}$$

This solution takes the form

$$\Theta = \frac{1}{2}\operatorname{erfc}\frac{z}{2\sqrt{Dt}}. \tag{15}$$

As $z \to \infty$, Eq. (15) tends asymptotically to zero, and for values of the argument ≤ -3 it is close to unity.

An approximate solution of the initial problem in Eqs. (4) and (15) can be constructed as follows. For fixed t, the concentration Э is equal to unity on a section from 0 to x_*, where x_* is the value of x for which $z/2\sqrt{Dt} = -3$. For $x > x_*$, the distribution of the concentration is described by Eq. (15).

NOTATION

Э, concentration of material in porous medium; a, concentration of material in sorption layer; Γ, Henry constant; D, diffusion coefficient; m_0, porosity; τ, delay time; t, x, time and space coordinates; u, filtration velocity.

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CONVECTIVE MASS EXCHANGE OF A CONE AND DYNAMIC CHARACTERISTICS OF AN ELECTRODIFFUSION ANEMOMETER IN A NONLINEARLY VISCOUS FLUID FLOW

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The results of a theoretical and experimental investigation of the nonstationary mass exchange of a cone in a nonlinearly viscous fluid flow are presented. The amplitude – frequency characteristics of an electrodiffusion anemometer are plotted from the results obtained.

Electrodiffusion anemometry, an electrochemical method now widely used for studying heat- and mass-exchange processes, forms the basis of a new trend in the measurement of the velocities of fast-flowing media [1-5].

The essence of this method of measurement is that the mass transfer in the electrolyte solution is due to the diffusion of electrically charged particles, i.e. to the simultaneous transfer of mass and electrical charge. It is then possible, depending on the magnitude of the limiting diffusion current, to make a judgment about the intensity of mass transfer towards the transducer and, ultimately, to determine the local instantaneous velocity of the fluid flow. The transducer-electrode used in these measurements usually has a conical, wedge-shaped, cylindrical, or spherical surface, and a number of problems related to the selection of optimum electrode dimensions – its sensitivity, the nature of the dependence of the current on velocity, and the statistical and dynamic characteristics – are determined by the principles governing stationary and nonstationary convective diffusion. None of these problems has been studied in any depth so far even with reference to the simplest case – the flow of purely viscous linear fluid electrolytes around an electrode.

In practice, however, it is often a question of fluids possessing non-Newtonian properties and this cannot be taken into account in calculating the convective diffusion processes. Thus, a theoretical and experimental

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