The dependence of \( \varepsilon^{\text{EX}} / \varepsilon_1 \) on the parameters \( T_2 / T_1 \), \( A_1 \varepsilon_2 / \varepsilon_1 A_2 \), \( A_1 (1 / A_2 - 1) (F_1 / F_2) \), and \( \varepsilon^{\text{EX}}_1 (1 / A_2 - 1) (F_1 / F_2) \) is shown as a nomogram in Fig. 2. Each of these parameters is a quantity that is positive and greater than zero. It is clear from the nomogram (Fig. 2) that there is a complex dependence of \( \varepsilon^{\text{EX}} / \varepsilon_1 \) on the indicated parameters.

For \( A_1 \varepsilon_2 / \varepsilon_1 A_2 > 1 \), just as for \( A_1 \varepsilon_2 / \varepsilon_1 A_2 < 1 \), it is necessary to consider the cases \( \varepsilon^{\text{EX}}_1 / \varepsilon_1 < 1 \) and \( \varepsilon^{\text{EX}}_1 / \varepsilon_1 > 1 \). Thus, in the case \( A_1 \varepsilon_2 / \varepsilon_1 A_2 > 1 \) when \( \varepsilon^{\text{EX}}_1 / \varepsilon_1 > 1 \), the deviation of the experimental value from the actual value is smaller the closer to one the value of the ratio \( T_2 / T_1 \), the greater than one the value of the quantity \( A_1 \varepsilon_2 / \varepsilon_1 A_2 \), and the greater the quantity \( A_1 (1 / A_2 - 1) (F_1 / F_2) \) and the smaller the quantity \( \varepsilon^{\text{EX}}_1 (1 / A_2 - 1) (F_1 / F_2) \).

In the case \( A_1 \varepsilon_2 / \varepsilon_1 A_2 < 1 \) when \( \varepsilon^{\text{EX}}_1 / \varepsilon_1 > 1 \), the deviation of experimental value from the actual value decreases with a decrease in the quantities \( T_2 / T_1 \) and \( \varepsilon^{\text{EX}}_1 (1 / A_2 - 1) (F_1 / F_2) \), an increase in the quantity \( A_1 (1 / A_2 - 1) (F_1 / F_2) \), and a trend toward one in the value of \( A_1 \varepsilon_2 / \varepsilon_1 A_2 \); when \( \varepsilon^{\text{EX}}_1 / \varepsilon_1 < 1 \), the deviation decreases with a trend toward zero for the value of \( A_1 \varepsilon_2 / \varepsilon_1 A_2 \) and opposite changes in the other parameters.

Thus, an identical change of the same parameters does not have a unique effect on the accuracy of an experimental determination of emissivity, i.e., with realization of experimental apparatus by the two-cylinder method, one encounters considerable difficulties not only in the determination of possible deviation of the experimental value of emissivity from its actual value, but it is also extremely difficult to predict the most favorable conditions for performing an experiment in order to obtain the smallest deviation of the experimental value of emissivity from its actual value.

Only in the case \( A_2 \rightarrow 1 \) (black shell) do the quantities \( \varepsilon^{\text{EX}}_1 (1 / A_2 - 1) (F_1 / F_2) \) and \( A_1 (1 / A_2 - 1) (F_1 / F_2) \), and consequently the ratio \( F_1 / F_2 \), have no effect and the ratio \( \varepsilon^{\text{EX}}_1 / \varepsilon_1 \) is determined only by the values of the quantities \( A_1 \varepsilon_2 / \varepsilon_1 A_2 \) and \( T_2 / T_1 \). However, it is extremely difficult to predict a possible change in the quantity \( A_1 \varepsilon_2 / \varepsilon_1 A_2 \). In such a case, the most advisable experimental conditions (for non-gray bodies) must involve the realization of the smallest possible value for the ratio \( T_2 / T_1 \).

LITERATURE CITED


MODELING HETEROGENEOUS CHEMICAL REACTIONS UNDER THE ACTION OF A TURBULENT JET

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UDC 532.73-3

The chemical reaction of a solution with a metallic surface is modeled by the physical process of mass transfer. The general form of solution of the equation of convective diffusion is found and the possibility of calculating parameter values for which the process will occur efficiently is examined. The results of analysis are confirmed by experimental data.

It has been known from the time of Nernst that, when a metal dissolves in an aqueous solution, in most cases the process occurs in the diffusional region, where the effect of the molecular constant of the solution is negligible [1]. However, it has not been possible to reach a final conclusion as to the region in which heterogeneous reaction occurs when a metallic surface dissolves under the action of perpendicular turbulent jets of aqueous solution, since until recently this situation had not been studied from the appropriate point of view.

In preparing electric circuits on foil dielectrics, in particular, copper surfaces are dissolved in perpendicular turbulent jets of solutions such as CuCl$_2$, FeCl$_3$, and (NH$_4$)$_2$O$_2$S$_8$.

This process can be efficiently carried out in a jet chamber, which contains closely spaced jets of solution moving uniformly in a direction perpendicular to the reaction surface. This surface is some distance $X/d_{\text{eff}} \geq 80-100$ from the output nozzle of an atomizer ($d_{\text{eff}}$) and lies within the developed turbulent boundary layer of a system of jets; the velocity $v$ of the jets close to the reaction surface depends on their velocity of emission $U_0$. In the main portion of the turbulent-jet system, the jets overlap to the extent of half their width in the directions of the length and width of the chamber, and, as a result, the velocity and concentration distributions in the directions parallel to the reaction surface ($OY$ and $OZ$) are close to uniform, while the concentration gradient in the direction normal to the reaction surface ($OX$) is considerable.

There is considerable practical interest in understanding the kinetics of this process. Let us consider the case of a surface dissolving under the conditions indicated above, on the assumption of diffusional kinetics.

Since it has been arranged that the process is axisymmetric (involving a system of turbulent jets that are axisymmetric in the directions $OY$ and $OZ$ and uniformly overlapping), a two-dimensional investigation is possible. In this case, the mass-transfer equation in the turbulent region of an axisymmetric system of jets of aqueous solution moving perpendicularly to the reaction surface is

$$
\frac{\partial C}{\partial X} + v_x \frac{\partial C}{\partial Y} = \frac{1}{Pe} \left( \frac{\partial^2 C}{\partial X^2} + \frac{\partial^2 C}{\partial Y^2} \right).
$$

Here $v_x = v_x/U_0$ and $v_y = v_y/U_0$ are dimensionless velocity components of the solution; $X = x/(b/2)$, $Y = y/(b/2)$ are dimensionless coordinates referred to half the width of the jets ($b/2$).

Analysis of Eq. (1) shows that increase in $Pe$ decreases the right-hand side of the equation and the concentration distribution described by the equation is determined mainly by the left-hand side, corresponding to convective transfer. It is therefore of interest to find the values of the Peclet number used in practice to prepare electrical circuits in aqueous solutions.

When a metallic surface dissolves in jets of solutions of CuCl$_2$, FeCl$_3$, and (NH$_4$)$_2$O$_2$S$_8$ (for the following parameters of the process, obtained by experiment: $R = 17$ cm and $U_0 = 183$-798 cm/sec), the corresponding values of $Pe$ are: $Pe_{FeCl_3} = (0.4-2.0)\times10^9$, $Pe_{CuCl_2} = (0.5-2.0)\times10^9$, and $Pe_{(NH_4)_2O_2S_8} = (0.5-2.2)\times10^9$.

Because the values of $Pe$ for the aqueous solutions investigated are large, it is possible to assume that the reaction conforms to diffusional kinetics [1]. In the case under consideration — the turbulent boundary layer of axisymmetric flow at a surface — the process occurs by convective diffusion, and the considerable change in the state of motion in the direction $OX$ allows the change in the mass transfer by molecular diffusion in the flow cross section to be neglected. Therefore (if $\partial^2 C/\partial X^2 \gg \partial^2 C/\partial Y^2$), Eq. (1) takes the form

$$
\frac{\partial C}{\partial X} + v_x \frac{\partial C}{\partial Y} = \frac{1}{Pe} \frac{\partial^2 C}{\partial X^2},
$$

formally similar to the equation of mass transfer in the laminar boundary layer of a plate. But this purely formal similarity does not offer any possibility of finding an accurate solution of Eq. (2), because the flow picture in a turbulent flow characterized by the presence of velocity pulsations is unknown. In addition, whereas the boundary condition far from the reaction surface may be determined fairly simply ($C \rightarrow 0$ as $X \rightarrow \infty$), to find the boundary condition at the reaction surface involves establishing whether or not Stefan flow is present in the reaction. Consider a monomolecular irreversible reaction at a homogeneous metallic surface proceeding in solutions of CuCl$_2$, FeCl$_3$, and (NH$_4$)$_2$O$_2$S$_8$:

$$
\begin{align*}
Cu + FeCl_3 \rightarrow FeCl_2 + CuCl_2, & = 0, \\
Cu + CuCl_2 \rightarrow 2CuCl, & = 0, \\
Cu + (NH_4)_2O_2S_8 \rightarrow CuSO_4 + (NH_4)_2SO_4, & = 0.
\end{align*}
$$

Analysis of these equations for reaction at a surface equally accessible to all the diffusing reagents shows that the boundary condition at the surface is characterized by the absence of Stefan flow and a zero value of the concentration $C$. In fact, in accordance with