on the force of resistance. In particular, it is not possible to obtain from [3] a direct connection between the force of resistance and the velocity of the dispersed medium relative to the body.

## NOTATION

d, D, diameter of the particles of the dispersed medium and the diameter of the midsection of the body, respectively; u, velocity of displacement of body; $u_0$, $u_1$, velocities of the beginning of fluidization and filtration, respectively; $N = u/u_0$, fluidization number; $\rho$, density of particles of solid phase; g, acceleration due to gravity; F, force-resisting motion of body in fluidized bed; $F_{av}$, average vertical force acting upon a body in a fluidized bed; $Eu = F/\rho u^2 D^2$, Euler number; $Fr = gd/u^2$, Froude number.

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# MASS EXCHANGE BETWEEN A SOLID SPHERE AND A LIQUID IN CROSSED ELECTRIC AND MAGNETIC FIELDS

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The results of an experimental investigation of the effect of the magnitude and direction of the ponderomotive force [j × B] on the coefficient of mass transfer from an electrically nonconducting sphere to a liquid are described.

The method considered here consists essentially in using crossed electric and magnetic fields to change the effective density of a current-carrying liquid by means of interaction between an external magnetic field and the liquid [1]. As is known, under the action of a magnetic field, a current-carrying liquid becomes effectively heavier or lighter, depending on the direction of the field. For certain geometric characteristics of the system (dissolution apparatus design), this may result in liquid motion. External mass exchange between a solid particle and the liquid is accelerated under these conditions due to forced convection. Moreover, intensification of mass exchange is connected with the translational motion of the liquid. Theoretical investigations [2] show that circulation flow, which promotes mass exchange, arises near curved surfaces of an object immersed in a current-carrying liquid.

Our aim was to investigate experimentally the intensification of external mass exchange in crossed electric and magnetic fields on the example of the dissolution of pressed spherical specimens of $KNO_3$ salt in a 10% solution of $KNO_3$.

The experiments were performed by means of a device (Fig. 1) based on an electromagnet [3], where a transparent-plastic vessel (200 × 200 × 25 mm) containing the operating solution is placed between the pole pieces of the electromagnet. Stainless-steel electrodes (40 × 18 × 1 mm), spaced at 42 mm, are fastened in the upper part of the vessel (Fig. 2). With the superposition of a crossed field, the liquid between the electrodes either drops or rises, depending on the direction of the current. As a result, the solution in the vessel

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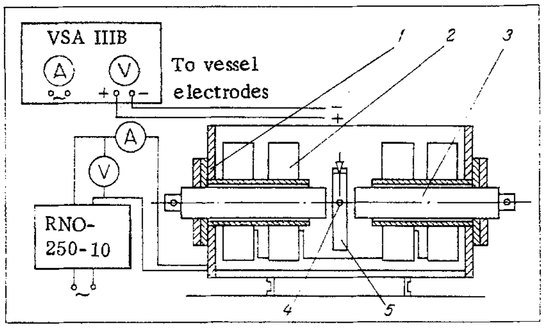

Fig. 1

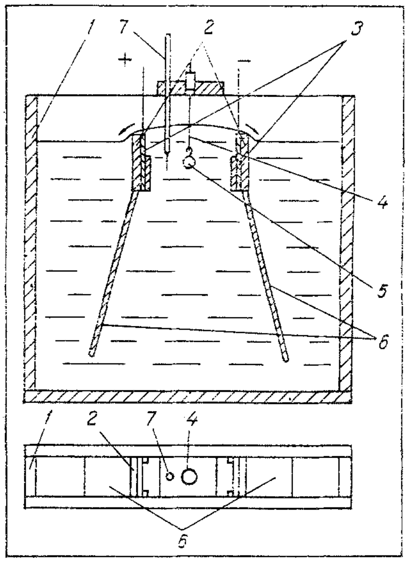

Fig. 2

Fig. 1. Schematic diagram of the experimental device. 1) Magnetic circuit; 2) magnetizing coils; 3) electromagnet poles; 4) particle under investigation; 5) vessel.

Fig. 2. Vessel for dissolving specimens. 1) Vessel frame; 2) pocket for electrodes; 3) electrodes; 4) adapter for fastening particles; 5) particle under investigation; 6) baffles aiding circulation of the solution; 7) thermometer.

circulates in the interelectrode space. For the dissolution process under isothermic conditions, the vessel is provided with internal baffles, which do not reach the bottom, whereby the circulation contour in the vessel is greatly increased. The electrodes in the vessel and the electromagnet windings are supplied with dc current from separate rectifiers. The strength of the magnetic field is measured by means of a Hall data unit and is controlled by varying the gap between the pole pieces and the current in the electromagnet windings.

The experimental method consisted in the following. Cylindrical billets were pressed under a pressure of $1200 \cdot 10^5$ N/m$^2$, from which spherical specimens with a diameter of 7-8 mm were cut. In order to eliminate the surface roughness, the particles were treated carefully with distilled water and ethyl alcohol and were then dried in a drier. After the necessary parameters of the electric and the magnetic fields were secured, the specimen was immersed in the vessel by means of a special adapter. After dissolution over a period of 120 sec, the specimen was dehydrated with alcohol and dried additionally in a drier until its weight remained constant.

The mass-transfer coefficient K is determined with respect to the weight loss of the specimen after dissolution:

$$K = \frac{\sqrt[3]{\frac{6}{\pi\rho}}\,\rho}{2t\,(c_s - c_0)}\left(\sqrt[3]{G_1} - \sqrt[3]{G_2}\right). \qquad (1)$$

The temperatures in the interelectrode space, the current through the electrolyte solution, and the current through the electromagnet windings were recorded during the experiment. On the average, the solution temperature during an experiment rose by 0.5-3°C. The experiments were performed under conditions of weighting and lightening of the current-carrying liquid, while the current density varied in the range $0\text{-}3.7 \cdot 10^3$ A/m$^2$ and the magnetic induction in the range 0-1.25 T.

The experimental data are shown in Fig. 3, which represents the mass transfer coefficient K as a function of the ponderomotive force $[j \times B]$. An estimate of the velocity showed that the Re number varied in the range from 0 to 20. According to the data provided by Garner and Hoffman [4], the mass-transfer coefficient K differs slightly from its value under conditions of natural convection in the range of Re numbers under consideration (this value is smaller for an ascending flow and larger for a descending flow). A similar pattern of changes in the mass transfer coefficient was also observed in our experiments (Fig. 3). However, the mass-transfer coefficient K exceeded considerably (by a factor as large as 4) its value for natural convection.

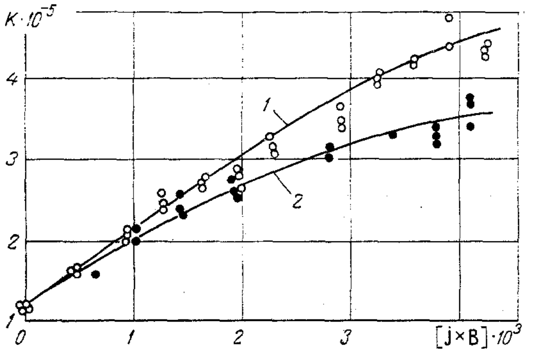

Fig. 3. Mass-transfer coefficient K (m/sec) as a function of the ponderomotive force [j × B], $N/m^3$. 1) The ponderomotive force acts in the direction of the force of gravity; 2) the direction of the ponderomotive force is opposite to that of the force of gravity.

This could probably be explained by the contribution of the vortex motion of the liquid to the process of mass exchange.

The experimental data have also shown that the mass-transfer coefficient is determined by the product [j × B], while it is independent of the values of these quantities taken separately.

We also performed experiments to determine separately the effect of the magnetic and the electric fields on the mass exchange process. It has been found experimentally that a constant magnetic field with $B = 1.25$ T does not affect the mass exchange in spite of the data obtained in certain experiments [5], where an increase in the dissolution rate of up to 10% was observed.

Passage of an electric current hardly exerts any specific effect on the mass exchange process, but it acts indirectly as a result of the rise in temperature.

Thus, only the combined effect of both fields produces significant results.

## NOTATION

j, electric current density; B, magnetic field induction; $\rho$, density of the specimen; $c_S$, $c_0$, saturation concentration and operating concentration, respectively; t, time; $G_1$, $G_2$, specimen weight before and after dissolution, respectively.

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