$$a_s = \int_0^\infty aP(a)\,da,$$

then Eq. (12) can be used to calculate the average rate of sedimentation.

NOTATION

Here a is the diameter of the drops; r is the radius of drops or the coordinate; P is the pressure; U is the rate of sedimentation of the drops; v_c is the velocity of the drops; σ is the surface tension at the interface of the phases; μ is the dynamic viscosity; ρ is the density; Δρ is the difference of the densities of the dispersed particle and the medium; φ is the volume fraction of particles. The index φ designates a dispersed plane and the index c designates a continuous phase.

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INFLUENCE OF ADSORBED LAYERS ON THE ELECTRICAL CONDUCTIVITY OF DISPERSED SYSTEMS

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UDC 537.311:542.937

We present the results of an experimental investigation of the effects of adsorbed layers on the conductivity of a charge of finely divided nickel particles.

The use in technology and industry of an increasing number of dispersed working media requires a satisfactory theoretical description of the physical and physicochemical processes which occur in them. The transport of heat, mass, and electrical charge in dispersed media are of considerable interest. There is a broad literature devoted to a description of transport phenomena in dispersed media, some examples of which are found in [1-3]. In turn, the shortage of experimental material prevents a realistic description of the physical processes.

The goal of the present work is to clarify the effect of adsorbed layers on the transport of electrical charge in dispersed media.

Different physical mechanisms contribute to the electrical conductivity of a dispersed medium. One is metallic conductivity along individual particles and across the metallic contacts between them. Another is activation conductivity, resulting from gaps between particles, with adsorbed gases oxidized on the particle surfaces. In contrast to metallic conductivity, activation conductivity is characterized by a negative temperature coefficient of resistivity. The dynamics of the dependence of the electrical resistivity of a dispersed medium upon temperature will be investigated in the experiments described below.

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The experimental investigation of the effect of adsorbed layers on the electrical conductivity of dispersed systems was performed in electrolytic nickel powders of average particle size 0.45 and 0.9 μm and in nickel carbonyl powders of average particle size 1 μm (PNK-IL8). The experimental samples were prepared by hydraulic extrusion of a powdered charge in a water medium at a pressure of 10^7 Pa for samples from electrolytic nickel and at a pressure of 4×10^5 Pa for samples of nickel carbonyl. The prepared samples had the shape of cylinders with diameter 18 mm and height of 2 mm. A sample was placed into a measurement chamber evacuated by a diffusion pump with a speed of 10^{-3} m^3/sec to a pressure of about 10^{-3} Pa. In the course of the experiment the sample warmed up at the rate of 1 degree in 20 seconds. A mass-spectrometer analyzer was connected with the measurement chamber through a leak, and at the beginning of the experiment the analyzer was evacuated with an ion pump to a pressure of about 10^{-7} Pa, thereby allowing the analysis of the gas composition admitted into the analyzer ot the mass-spectrometer up to a pressure of about 10^{-5} Pa.

The procedure for conducting the experiment consisted of a linear heating of the sample with constant vacuum pumping with simultaneous measurement of its electrical resistivity and of the pressure in the experimental chamber with continuous mass-spectrometry of the gases desorbed from the surface of the sample.

The experimentally obtained dependences of the pressure in the experimental chamber and of the electrical resistivity of the sample upon temperature are presented in Figs. 1 and 2. Gas emissions from the surface of the samples from electrolytic nickel powders with different average particle dimensions are identical in pressure and in mass spectra. For all types of samples there were partial pressures from the mass components 2, 18, 28, 40, and 44 atomic mass units (amu).

A mass spectrometric analysis of the gases desorbed from the heated sample surfaces showed that the first pressure peak was due to thermally desorbed water (18 amu). In the case of samples from electrolytic nickel the vapor pressure of water in the temperature range 315 to 525 K increased by about a factor of 1000, for samples from carbonyl nickel to 570 K this variation was about a factor of ten. From 525 to 675 K the pressure of water for the samples from electrolytic nickel powder decreases by approximately a factor of ten, which is connected with an improvement of the vacuum in the measurement chamber. For samples from nickel carbonyl this improvement was a factor of 7 at 595 K.

The second peak of pressure is connected with thermally desorbed CO_2 (44 amu). The pressure for samples from electrolytic nickel increased from 575 to 740 K by almost a factor of 100, for samples from nickel carbonyl this increase was nearly a factor of seven in the temperature range 595 to 685 K. The subsequent decrease of pressure in the measurement chamber is connected with the decrease of the pressure of the CO_2 component of the gas mixture.

The electrical resistance of the sample varied irreversibly in the course of an experiment. It was not restored when the sample was placed in air.

The variation of electrical resistance of a dispersed medium during heating may be a consequence of a competition of the following mechanisms [4]:

1) a temperature variation of the metallic conductivity;

2) adsorbed gases on the surface of metallic particles may increase or decrease the electron emission potential barrier from the metal, and their decay in the process of heating the corresponding sample may well affect the volume resistance of the dispersed medium;

3) the gradual reduction of an oxide layer on the surface of the particles may lead to a significant increase of the electrical conductivity of the sample (complete removal or elimination of the oxides on a nickel particle may induce an increase of the specific electrical conductivity by a factor of 10^{11} [5]);

4) thermoelectronic emission;

5) change in the location of components of the dispersed medium of particles in relation to the elemental location of nodes of the matrix which contains these particles, which may be accomplished as a consequence of a separation of the particles due to pressure of the desorbed gas mixture, and a drawing together of the particles as a result of contraction of the sample, connected with the removal of structural defects on the surface of the particles.

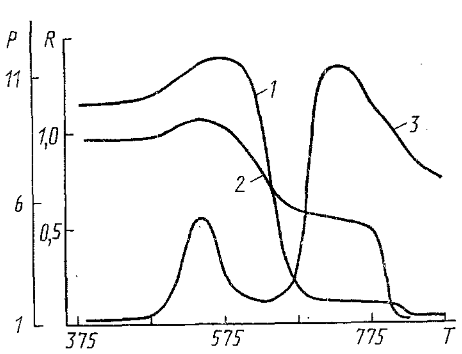

Fig. 1

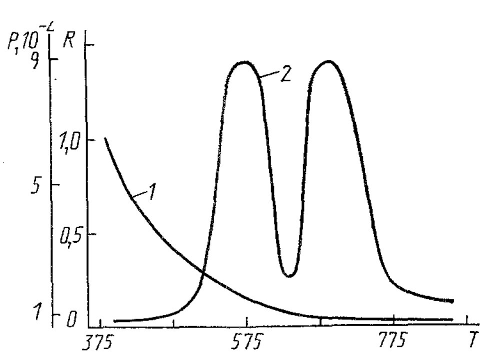

Fig. 2

Fig. 1. Experimental dependence for samples from electrolytic nickel powder. Curves 1 and 2 are electrical resistance of the samples with average particle size of 0.9 and 0.45 μm, respectively. Curve 3 is the presence of gases desorbed from the sample's surface. P is in Pa, R is in kΩ, T is in K.

Fig. 2. Experimental dependence for samples from nickel carbonyl powder. Curve 1 is the electrical resistance of the sample. Curve 2 is the pressure of gases desorbed from the sample's surface. R is in Ω.

Obviously, it would be logical to propose that the differences in the behavior of the electrical resistance of the samples from electrolytic and carbonyl nickel are connected with different volume evolutions of gas from these samples, which in turn may be a consequence of the difference in the sorption capacity of the surfaces of the constituent particles. It is known that particles obtained by electrolytic means have a dendritic shape and a more developed surface than that obtained with carbonyl process particles, which have a rounded shape, close to equilibrium [6]. The hypothesis of a large thickness of the adsorption layers on the particles' surfaces from electrolytic nickel powder is subject also to the fact that a sample prepared by slight heating from carbonyl powder has significantly less resistance despite a large porosity (82% against–47% for a sample from electrolytic nickel), which indicates a better interparticle contact, the quality of which depends upon the presence of adsorbing layers on the particle's surface.

In the author's opinion, the elevation of the electrical resistance of a sample from electrolytic nickel powder at the initial portion of the temperature dependence (see Fig. 1), attaining 7 to 30% of the elemental value, is due to the release of the sample desorbed from the surface of particles (the basic pressure here is created by water). Somewhat delayed in relation to the initial decrease of pressure in the measurement chamber (which may be a consequence of resistance of the interstitial medium to the gas flux), there begins an abrupt drop of electrical resistance (the result of the particles beginning to draw together), which was much more significant for samples with average particle dimension 0.9 μm (reaching 99% of the elemental value). For samples with an average particle dimension of 0.45 μm, this drop was near 50%. The subsequent growth of the pressure, due this time to thermal desorption of CO_2 produces a new motion of particles of the dispersed medium, which leads to a decrease in the rate of the drop of the electrical resistance. The commencement of a decrease in the pressure, as in the previous case, precedes a new sharp drop of the electrical resistance. Toward the temperature 875 K the electrical resistance reaches a value of almost 10^{-1} Ω and no longer changes perceptibly. A significant lightening of the sample after heating indicates partial reduction of oxides on the surface of the particles. Complete reduction did not occur at the temperature of the experiment.

Jumps of the electrical resistance, observed in [7], also may be a result of the motion of the particles of the resulting medium under the action of the pressure of desorbed gases.

The pressure of desorbed gases does not significantly affect the behavior of the electrical resistance of the samples from nickel carbonyl powder, since the quantity (thickness) of the adsorbed layer on the electrolytic particles is much smaller than the quantity (thickness) of the adsorbed layers on the electrolytic particles. The temperature dependence of the electrical resistance of the sample from nickel carbonyl is typical for isolated metallic layers [4].

In this way, a comparative analysis of the given experiment for samples from electrolytic and carbonyl nickel powders shows that adsorption layers on the surface of particles of the resulting dispersed layer not only determine the potential barrier of electron emission from the metal [4, 7] but also while passing to the gas phase (desorbing) may by their own pressure separate particles, thereby increasing the same gaps which are barriers for electrons tunneling in the direction of the field.

The results obtained must, obviously, refine the concepts about interparticle contacts and will serve to further the development of the physicomathematical model of transport in a dispersed medium, in particular the one proposed in [8].

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IMPROVING THE EFFICIENCY OF ACOUSTIC FOAM SUPPRESSION

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UDC 532.501.34:541.182:622.765.066

The loss of efficiency of acoustic foam suppression at higher sound frequencies can be attributed to stabilization of the liquid foam films by high-frequency vibrations.

Tests on the ultrasonic breakdown of flotation foam on copper concentrate have been described previously [1]. We have used the results of these tests to map isographs of the efficiency (degree) of foam suppression by ultrasound at various amplitudes and frequencies (see Fig. 1). The figure indicates that the frequency of ultrasound at a fixed amplitude must be lowered in order to increase the degree of foam suppression. An increase in the frequency, on the other hand, tends to lower the degree of acoustic foam suppression. It seems to us that this effect is attributable to stabilization of the foam by the vibration input.

We now seek to demonstrate this fact. We model the foam by a viscous incompressible fluid layer of infinite extent with free boundaries [2], which corresponds to the case of a coarsely disperse foam, where the characteristic dimensions of the foam films are much greater than their thicknesses. We model the process of acoustic foam suppression as an instability of the plane surfaces of an infinite viscous fluid film of thickness h, which is surrounded by a gas (inviscid fluid) and executes small vibrations along the vertical axis (z-axis) with a frequency ω and an amplitude a ($a \ll 1$) according to the law $a \cos \omega t$.

State Scientific-Research and Design Institute of the Petroleum Industry, Perm. Translated from Inzhenerno-fizicheskii Zhurnal, Vol. 61, No. 3, pp. 373-377, September, 1991. Original article submitted January 3, 1990.