INFLUENCE OF PROPERTIES OF FILTERING LIQUIDS
ON THE PERMEABILITY OF DISPERSE SYSTEMS

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A method is proposed for determining the filtration characteristics of finely dispersed systems (clayey soils) through a calculation of their adsorption and rheological properties.

Our purpose in this study was to determine the relationship between the permeability of disperse systems and their structural and adsorptive properties in the filtration of liquids of various molecular structures and to develop a basis for a method of calculating the permeability of clayey soils as a function of the processes occurring at the solid surface. As the systems for the solution of the first problem we chose natural Glukhov kaolin, Chasov-Yar monothermite clay, the Na form of Crimean kill, and several liquids: water, butyl alcohol, isopropyl alcohol, toluene, diethylamine, and carbon tetrachloride.

The specific surface areas of the particles were calculated by a method based on a determination of the density of the adsorbed water as a function of its mass and the change in the density of the disperse medium in the solid-adsorbed water-liquid system. The average dimensions of the microscopic aggregates were determined through an electron-microscopic analysis. The apparatus and procedure of the filtration experiment are essentially similar to those described in [2], except that the soil porosity was varied, not by using different contents of the liquid filling the pores, but by using different degrees of compression of the samples in a press (from 10 to 100 kg/cm²). Linear relations analogous to those found for systems of clay, water, and aqueous solutions of inorganic compounds [3] were obtained between such dimensionless parameters as the porosity coefficient and the product of the permeability and the square specific surface area per unit volume of the disperse system. Table 1 shows the specific effective porosity for various porosity coefficients for the filtration of water and organic compounds.

The next step was to determine the number of liquid layers which do not participate in the filtration. For each liquid we constructed a model for the arrangement of adsorbed molecules on the surfaces of the solid particles and calculated the projections of the length of the chemical bond on the plane perpendicular to the adsorbent surface. The masses of the "monolayers" of the adsorbed compounds, \(P_m\), and the number of layers \(L\) were determined from

\[P_m = S_dD_p\]

\[L = \frac{e_dD_p}{P_m}\]

The calculated results are shown in Table 2. Analysis of these results revealed that the relation between the permeability and the structural and adsorption characteristics of the soils during the filtration of liquids of various molecular structures is governed by an equation found previously for clays of various mineral compositions in their natural and ion-substituted forms during the filtration of water and aqueous solutions [3]. This equation is

\[K = \frac{(e - e_0)(e + 1)^2 \varphi}{d^2S_d(L - 1)^3}\]

It should be noted here that for the Na form of montmorillonite during the filtration of water, Eqs.


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Fig. 1. Number of liquid layers not participating in the filtration (L) as a function of the projection of the length of the chemical bond of the adsorbed molecule onto the plane perpendicular to the surface of the mineral (Dp, Å). 1) Glukhov kaolin; 2) Chasov-Yar clay; 3) Na form of Crimean kill.

Fig. 2. Glukhov kaolin. I: ionic forms. 1) Natural form; 2) Na form. II: structure of the filtering liquids. 3) Organic compounds; 4) water and aqueous solutions of inorganic compounds; 5) organic compounds; 6) water and aqueous solutions of inorganic compounds.

Table 1

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(1) and (3) take into account the total surface area of the particles, while in Eq. (2) the mass of a monolayer of adsorbed water which appears on the internal surfaces of the crystal lattice is used. For the filtration of organic compounds the external surface area and the mass of the monolayers of adsorbed materials formed on the external surfaces of the crystal lattice are taken into account.

Figure 1 shows the relation between the number of liquid layers not participating in the filtration and the projection of the length of the chemical bond of the adsorbed molecule in the monolayer onto the plane perpendicular to the surface of the solid phase. These results and the experimental results (Table 1) can be interpreted in the following manner: The system consisting of the natural Glukhov kaolin and a liquid is not a coagulating system, since the dimensions of the microscopic aggregates are in all cases roughly the same. The permeability of the mineral varies only due to the formation of different numbers of liquid layers not participating in the filtration. There is a decrease in the value of this number and thus in the permeability with increasing linear dimension (the "projection") of the adsorbed molecule. The system consisting of the Chasov-Yar clay and a liquid and the Na form of Crimean kill and a liquid are dispersed in water and form large microscopic aggregates in other liquids, primarily due to the interparticle interaction. This circumstance is responsible for the sharp difference between the number of layers not participating in the filtration in the case of water and this number for the filtration of organic compounds. In these systems there is a particularly marked increase in the permeability with increasing linear dimension of the adsorbed linear molecules.

On the basis of these results we can deduce the basic principles for using various structure-conditioning materials for improving the filtration properties of heavy soil:

1) The solubility in water should be good.

2) The binding energy between the surface of the soil and the molecules of the structure conditioners, particularly polyelectrolytes, should be higher than for water.

3) The material should display a good coagulating (adhesive) capability, as is usually provided for the polyelectrolytes by an extended chain of active centers.

4) Under otherwise equal conditions, it is preferable to use those structure conditioners whose molecules have a large linear dimension in the direction into the interior of the liquid from the solid surface.