Abstract

A mathematical model of two-phase systems, such as clay suspensions, consists of a set of partial differential equations which reflect both the general laws of mechanics and the relations connecting the involved characteristics of the particular system under consideration. The latter equations are known as constitutive relations.

The aim of this study was to find the constitutive relations for kaolin suspensions that are necessary when solving forward problems of fine sludge thickening processes. The task was to design and carry out experimental research of the given suspension and to find a convenient method of utilizing the results for the sake of getting the sought relationships. It follows from the applied mathematical theory of two-phase systems that the sought relationships are hydraulic conductivity of the suspension as a function of the solid-phase concentration and the dependence of the solid-phase concentration on the solid-phase stress.

The first part of this study describes the experimental research. Since both the characteristics are difficult to measure, it was necessary to analyze the suspension's characteristics and their measurability. Subsequently, the process of the suspension preparation and the method of laboratory measurements were determined. The following sections present the way of utilizing the obtained data and getting the sought constitutive relations. The problem of the hydraulic conductivity determination is solved in two steps. In the first one, the general theory is utilized in order to get a correspondence between the measured height of the column of the suspension column and hydraulic conductivity. Making use of these results and applying an optimization method the sought functional dependence is then derived.

Solving the problem of finding the dependence of the solid-phase stress on the suspension concentration, the general theory makes it possible to find a relationship between the initial data, height of the suspension column and the total mass of solid phase, and the final solid-phase stress at a specially chosen point. Making use of the entire series of performed experiments, the sought constitutive equation is determined. In this case, two different solutions have been found; their comparison shows that, quantitatively, both solutions almost identically match within the entirety of their domain.

Keywords

Kaolin suspension, suspension thickening, solid-phase concentration, monotonous process, theory of two-phase systems, gel point, hydraulic conductivity, compressibility.