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Abstract

Full Text

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ON DETERMINING HYDRAULIC RESISTANCES DURING THE MOTION OF CLAY SOLUTIONS IN A PIPE WITH A PERMEABLE WALL

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A number of theoretical and experimental studies have been devoted to determining hydraulic resistances during the motion of clay solutions between two coaxial circular cylinders (see, for example, ^(1,2)). The Bingham model was chosen as the mechanical model. In ⁽³⁾ M. P. Volarovich and A. M. Gutkin solved the problem of the structural regime of motion of a viscoplastic medium between two circular coaxial cylinders. To determine the radii of the rigid-core zone, a system of transcendental equations was obtained. Subsequently B. O. Sadykhov, A. A. Movsumov, and others ⁽⁴⁾ carried out numerous calculations for specific drilling conditions and proposed a rational empirical formula for determining the coefficient of hydraulic resistance. There are also experimental investigations which, however, require serious refinement.

All the works noted above relate to pipes with impermeable walls. It is known that during the motion of clay solutions in the annular space of a borehole, the walls are permeable. It is therefore of interest to estimate the influence of permeable walls on the magnitude of hydraulic resistances.

Fig. 1. Dependence of the filtered water Q_2 on the pressure drop between the pipe and the atmosphere Δp_2 . Flow rate of the clay solution Q_1 : a —2.3 l/sec; b —4.3 l/sec; v —5.2 l/sec.

In view of the variability of the core mass as the flow rate decreases, the hydraulic resistances should decrease. But approximate calculations show that, for real conditions, the decrease in flow rate has practically no effect on the magnitude of the hydraulic resistances. Thus, for example, in the experiments whose results will be given below, the greatest filtration of water is $1.6 \text{ cm}^3/\text{sec}$, whereas even the minimum flow rate is more than $1000 \text{ cm}^3/\text{sec}$. The increase in hydraulic resistances as a result of changes in the structural-mechanical properties due to water filtration is likewise of no practical interest.

In order to estimate the influence of the *wall effect* ⁽⁵⁾, experiments were carried out for the motion of a clay solution in metal-ceramic filters with a permeability of 2 darcies, located in a pipe whose internal diameter was 120 mm. A clay crust 5 mm thick was washed onto the inner surface of the filter. The length of the apparatus was 3.15 m. A clay solution was used with specific weight $\gamma = 1.26 \text{ g/cm}^3$, yield stress $\tau_0 = 1.03 \text{ kg/m}^2$, and structural viscosity $\eta = 0.01 \text{ kg/m} \cdot \text{sec}$.

Figure 1 shows the dependence of the filtered water Q_2 on the pressure drop between the pipe and the atmosphere, Δp_2 . The pressure in the pipe was taken to be the pressure in its lower cross section. Calculations were also made for the pressure in the upper and middle cross sections. Using M. Muskat's computational scheme, the permeability of the cake was found to be $6 \cdot 10^{-6}$ darcy. The cake permeability determined for other pressure values practically coincided with this value.

The experiments were carried out at three flow rates: 2.3, 4.3, and 5.2 l/sec. Pressures were measured with standard manometers. The experimental results are given below.

$Q_1,$														
l/sec	2.3	2.3	2.3	2.3	2.3	4.3	4.3	4.3	4.3	4.3	5.2	5.2	5.2	5.2
$\Delta p_1, 46$	35	27	20	17	66	44	33	26	23	81	53	39	29	26
10^{-3}														
atm														
$Q_2,$	0.00	0.03	0.08	0.12	0.14	0.00	0.06	0.10	0.14	0.15	0.00	0.08	0.12	0.15
cm^3/sec														

From the data presented it is clear that an increase in the pressure drop increases the filtration of water, which in turn leads to a decrease in hydraulic resistance—this is in full agreement with the wall-layer effect.

The experiments corresponded to the structural flow regime of the clay solution. Thus, taking water filtration into account leads to a substantial decrease in hydraulic resistance.

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