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Determination of hydraulic parameters of hydro transport in pressure pipelines

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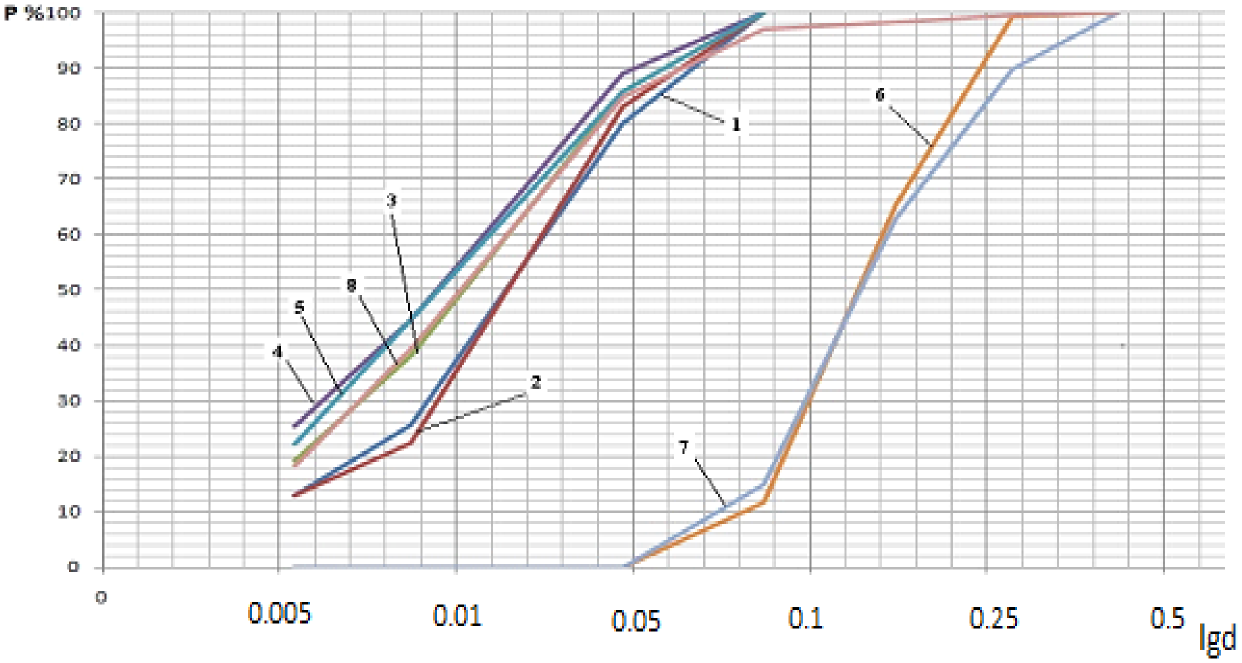
ABSTRACT: The article presents the features of the transfer of river suspended solids together with water in the pressure stations, that is, the effect on the distribution of kinematic and dynamic parameters of the flow of suspended particles of hydraulic transport..

KEY WORDS: flow, pressure, flow, pipeline, coefficient of hydraulic friction, viscosity, critical speed

Pressure suspended flows in hydro transport systems are usually characterized by high volumetric concentrations and a wide range of particle sizes and densities of solid particles that make up the mixtures. The considered flows are more complex in structure than turbulent flows of homogeneous liquids in pipes. Therefore, the methods for calculating these flows are much more complicated than the usual methods of hydraulic pressure flow of homogeneous liquids [1,2.3].

The calculation of the pressure suspended flow is, above all, the establishment of such basic parameters as specific hydraulic resistance and critical speed of hydro transport, closely related to the dynamics and kinematics of a two-phase flow [2,4]. This article discusses the transport of suspended particles of river sediment in pressure systems of irrigation pumping stations. As shown by the results of field studies at irrigation pumping stations of the Republic of Uzbekistan, a large number of river sediments are transported in the pressure pipelines along with irrigation water. Field studies conducted at pumping stations of the Karshi Main Canal [2,4]., As well as at pumping stations of the Sarikurgan pumping stations. It is shown that the composition of river sediments varies widely from 0.01 mm to 0.25 mm. However, in the existing calculation dependencies, these parameters are not always taken into account.

From the analysis of existing formulas for establishing the basic parameters of hydro transport, it follows that many researchers determine specific hydraulic resistance based on specific hydraulic resistance in a homogeneous fluid flow with allowance for corrections based on experimental data and those or other physical assumptions.



1. The granulometric composition of sediment carried by the first coastal pipe from avankamers pumping station; 2. The granulometric composition of the sediment carried by the second coastal pipe from the avankamers of the pumping station;
3. The granulometric composition of the sediment carried by the third coastal pipe from the avankamers of the pumping station;
4. The granulometric composition of the sediment carried by the fourth coastal pipe from the avankamers pump station;
5. *The* granulometric composition of sediment in the place of discharge of the pumping station into the river;
6. The granulometric composition of sediment on the outskirts of the river basin;
7. Granulometric composition of sediments in the middle part of the river basin;
8. The granulometric composition of sediment at the exit of the pipe pump station.

The calculated dependences obtained in this way are different in their structure and for the most part do not take into account the connection of hydraulic resistances with the kinematic structure of a suspended flow. As for the formulas for the critical rate of hydrotransport, they are, as a rule, empirical.[3-4]

The proposed by most researchers [1-5], calculated dependencies for determining the main parameters of hydrotransport often express the results of experiments on the basis of which they are established, and, consequently, the fields of application of these dependencies are very limited. Moreover, many formulas are not characterized by a high degree of accuracy. Analysis of the calculated dependences of critical speeds and their respective specific hydraulic resistances on the average volume concentration of the hydromixtures, made by the formulas of different authors under the same conditions of hydrotransport, shows that the calculated values of the same parameters may differ from each other by several times.

This indicates a significantly various accuracy of the formulas. The limited, and in some cases unacceptably low, degree of accuracy of the proposed formulas, the extremely large variety of hydrotransport conditions in practice, do not always allow us to choose the calculated dependence that meets the conditions of a given design object. Unreasonable application in this case of those or other formula can lead to gross errors, make the projected hydrotransport unit uneconomical or inoperative.

Thus, the practice of designing pipeline hydrotransport systems sets the task of developing a scientifically based, reliable method for calculating pressure hydrotransport. [1-5]

As is known, the second and third terms of the right side of the equation

$$\left.\begin{aligned}
&f_n\frac{\partial p}{\partial z}=\frac{\mu_n}{r}\frac{\partial}{r}\left(rf_n\frac{\partial u_n}{\partial r}\right)+\frac{\mu_n}{r^2}\frac{\partial}{\partial\varphi}\left(f_n\frac{\partial u_n}{\partial\varphi}\right)+K\left(u_{2n}-u_n\right)+\rho_n F_n\\
&f_n\frac{\partial p}{\partial r}=0\\
&f_n\frac{\partial p}{\partial\varphi}=0
\end{aligned}\right\}\quad(1)$$

where $\frac{\partial p}{\partial r}$, $\frac{\partial p}{\partial \varphi}$ and $\frac{\partial p}{\partial z}$ - is the drop pressure flow along the axes;

u_{nr}, $u_{n\varphi}$ и u_{nz} - components of the velocity vectors of the each phase;

f_n - the distribution of the concentration of each phase;

μ_n - - coefficient of viscosity of the phases;

$F_{nr}, F_{n\varphi}, F_{nz}$ - projections of mass forces;

K - the coefficient of the interaction force between the phases;

express the tangential stresses of the suspended flow, establishing a differential connection between the components of the stresses and the speeds of movement of the suspended flow.

Using the known methods of hydromechanics [2–5] and others, folding term by term equation (1) for each phase, we obtain the equation of motion of the slurry. Wherein, the concentration of the second phase is taken $f_2 = s$.

Having integrated all the terms of the equation over the cross-sectional area of the flow, for the established suspended flow in one-dimensional setting from equation (1) we have the following [1-3]:

$$\frac{dP}{dz}=\rho gi-\frac{\lambda_{см}\rho Q^2}{2d\omega^2}-\frac{s\pi d}{\omega}\tau_0 \qquad (2)$$

In deriving the equation of motion for the density and velocity of the slurry (dispersoid), the following notation was adopted:

$$\rho=(1-s)\rho_1+s\rho_2 \qquad (3)$$

$$\vartheta=\frac{(1-s)\rho_1\vartheta_1+s\rho_2\vartheta_2}{(1-s)\rho_1+s\rho_2} \qquad (4)$$

where S - is the volume concentration of the solid component; ρ_1 u ρ_2 - density of liquid and solid particles; Q - slurry consumption; ω - the cross-sectional area of the pipeline; ϑ_1 and ϑ_2 - fluid velocity and solid particle velocity averaged over the cross section of the pipeline; i - is the slope of the flow; P - hydrodynamic stress, pressure; χ - pipeline perimeter; τ_0 - the initial resistance of the mixture; $\lambda_{см}$ - coefficient of hydraulic friction.

Solving equation (2) taking into account the boundary conditions (at z = 0 P = P1 and at z = L, P = P2) we get:

$$\frac{\lambda_{\text{см}}\rho}{2d\omega^2}Q^2=\frac{P_2-P_1}{L}+\rho gi-\frac{s\pi d}{\omega}\tau_0 \qquad (5)$$

The flow rate is determined by the expression:

$$Q=\sqrt{\frac{2d\omega^2}{\lambda_{\text{см}}\rho}\left(\frac{P_1-P_2}{L}+\rho gi-\frac{s\pi d}{\omega}\tau_0\right)} \qquad (6)$$

where $P_1-P_2=\Delta P$ – is the drop pressure , created by the pumping system.
When i = 0:

$$Q=\sqrt{\frac{2d\omega^2}{\lambda_{\text{см}}\rho}\left(\frac{\Delta P}{L}-\frac{s\pi d}{\omega}\tau_0\right)} \qquad (7)$$

The condition under which the movement of the mixture begins is recorded as:

$$\frac{P_1-P_2}{L}>\frac{s}{R}\tau_0 \qquad (8)$$

Consequently, it is necessary to create a such difference of the drop pressure ΔP , that would exceed the value $\frac{s}{R}\tau_0$.

For the case under consideration, i.e. during the flow of a suspended flow in pipelines with a negative slope $i<0$, we have:

$$Q=\sqrt{\frac{2d\omega^2}{\lambda_{\text{см}}\rho}\left(\frac{P_1-P_2}{L}-\rho gi-\frac{s\pi d}{\omega}\tau_0\right)} \qquad (9)$$

Then the condition under which the movement of the mixture begins is written in the form:

$$\frac{P_1-P_2}{L}>\rho gi+\frac{s}{R}\tau_0 \qquad (10)$$

A feature of the approach is that here, in addition to the main factors characterizing the movement of a suspended flow, the influence of the slope of the pipeline is taken into account:

$$\Delta P>\rho gi+\frac{s}{R}\tau_0\,. \qquad (11)$$

Thus, the single-speed model of the mixture motion is used as a mathematical model, i.e. the slurry in its movement is identified with a fictitious one-velocity continuum of variable density. The limited, and in some cases unacceptably low, degree of accuracy of the proposed formulas, the extremely large variety of hydrotransport conditions in practice, do not always allow us to choose the calculated dependence that meets the conditions of each design object. Unreasonable use of this or that formula in this case can lead to gross errors, make the designed hydrotransport installation uneconomical or inoperative. [4-5]

The proposed by the majority of researchers calculated dependences for determining the basic parameters of hydraulic transport often Express the results of experiments on the basis of which they are established, and consequently, the scope of these dependences is very limited.

Given the insufficiency of the study of the movement of the two-phase mixture in round cylindrical pipelines with a negative slope, it is necessary to develop the design of the apparatus for removing river sediment.

On the basis of the model of Kh. A. Rakhmatullin and further developed in the works of K. sh. Latipov, A. Arifzhanov and other scientists, a model of motion of a two-phase mixture in a round cylindrical pipe taking into account the slope of the flow is proposed. That is, a one-speed model of motion of the mixture, where the slurry in its motion is identified with a fictitious one-speed continium of variable density.

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