ASSESSMENT OF THE ROLE OF VISCOSITY AND LIQUIDITY OF HIGH-VISCOUS OILS BY PIPELINE

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Abstract: *it is known that most of the oils produced in the Republic of Uzbekistan, due to the high content of paraffin resins, sulfur and other compounds, have a high viscosity and low fluidity through pipelines. Therefore, to improve the process of transporting high-viscosity oils through a pipeline, it is necessary to study their composition and properties, taking into account local factors. The rheological properties of oil primarily depend on its chemical composition and are different for different fields. Therefore, when developing new oil fields, it becomes necessary to study its rheological properties in order to issue initial data for calculating pipelines using the formulas of applied hydromechanics. In this case, it is convenient to use the models developed for each type of oil, which can be used to compile a program for calculating the hydrodynamic parameters of oil on a computer for determining the average speed, flow rate, plasticity coefficient of oil, drag coefficient, pressure drop in the pipeline, and others. All these data will help to establish the regularities of the process of transporting viscous oil through pipes of various cross-sections with minimal energy costs.*

Keywords: *oil, paraffin, resin, sulfur, viscosity, reagent, transportation, Newtonian and non-Newtonian fluids, pseudoplastic and dilatant fluids, rheogram.*

ОЦЕНКА РОЛИ ВЯЗКОСТИ И ТЕКУЧЕСТИ ВЫСОКОВЯЗКИХ НЕФТЕЙ ПО ТРУБОПРОВОДУ

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Аннотация: *известно, что большинство нефтей, добываемых в Республике Узбекистан, из-за высокого содержания парафина смол, серы и других соединений имеет высокую вязкость и низкую текучесть по трубопроводам. Следовательно, для совершенствования процесса транспортировки высоковязких нефтей по трубопроводу требуется исследование их состава и свойств с учетом местных факторов. Реологические свойства нефти, в первую очередь, зависят от её химического состава и различны для разных месторождений. Поэтому при разработке новых месторождений нефти возникает необходимость исследования её реологических свойств для выдачи исходных данных к расчёту трубопроводов по формулам прикладной гидромеханики. В этом случае удобно пользоваться разработанными для каждого вида нефти моделями, по которым можно составить программу расчёта гидродинамических параметров нефти на ЭВМ определения средней скорости, расхода, коэффициента пластичности нефти, коэффициента сопротивления, перепада давления в трубопроводе и других. Все эти данные помогут установить закономерности процесса транспортировки вязкой нефти по трубам различного сечения с минимальными энергетическими затратами.*
Ключевые слова: *нефть, парафин, смола, сера, вязкость, реагент, транспортировка, ньютоновские и неньютоновские жидкости, псевдопластичные и дилатантные жидкости, реограмма.*

It is known that most of the oils produced in the Republic, due to the high content of wax, resins, sulfur and other compounds, have high viscosity and low fluidity through pipelines.

The issues of oil transportation by pipeline are dealt with in many countries of the world, incl. and here in Uzbekistan in order to reduce the cost of expensive reagents, energy, etc.

Therefore, improving the process of transporting high-viscosity oils through a pipeline requires studying their composition and properties, taking into account local factors.

Oil belongs to a class of real fluids that are compressible, have thermal expansion, resist tensile and shear forces, and are viscous. The last or internal friction is the property of fluid bodies to resist the movement of one part of them relative to another.

In turn, real liquids, depending on the nature of the change in viscosity with a change in the magnitude of the shear stress, are subdivided into Newtonian and non-Newtonian [1, 2, 3]. For Newtonian fluids, the viscosity is constant at constant temperature and pressure. They obey Newton's basic law of internal friction [1]:

$$\tau = -\mu \frac{d\vartheta}{dy} = \mu\gamma \qquad (1)$$

where τ - is the stress of internal friction Pa:

μ - dynamic viscosity. Pa·s:

ϑ - shear (flow) rate of liquid, m/s;

y - coordinate on an axis perpendicular to the direction of flow (shift), m;

$\gamma = \frac{d\vartheta}{dy}$ - speed gradient, s^{-1}.

The quantity $\varphi = 1/\mu$ is called the fluidity of the liquid under study. The minus sign in equation (1) is explained by the fact that the normal is directed in the direction of decreasing the speed of movement.

Non-Newtonian or abnormal, are called liquids (for example oil) that do not obey Newton's fundamental law of internal friction [1]. The structure of non-Newtonian fluids is determined by the nature of the interaction of their particles. When these fluids deviate from equilibrium, the structure of such fluids is disturbed, and their properties depend on the applied forces and the rate of deformation. The laws of deformation and motion of non-Newtonian fluids constitute the subject and tasks of science, which is called rheology. Usually, the rheological properties of non-Newtonian fluids are determined experimentally. The main characteristic of non-Newtonian fluids are the so-called flow curves or rheological curves (diagrams), depicting a graphical relationship between the gradient of the fluid flow rate γ and the shear stress or shear stress τ arising in it. The flow curves can be constructed based on the processing of data obtained as a result of special studies. Rotational viscometers are usually used for these purposes. There are various methods for conducting such research. But they all have much in common and are as follows: one of the cylinders of the viscometer is set in rotation and causes (due to viscosity) a relative movement (shear) of a viscous fluid located in an annular intercylindrical space. As a result, on the surface of both cylinders, as well as in the liquid (between its individual layers), shear stresses arise, leading to the appearance of a torque received by the second cylinder.

The flow curves of pseudoplastic and dilatant fluids are well described by the following power dependence:

$$\tau = K * \gamma^n \qquad (2)$$

where k and n are constants;

k - is a measure of the consistency of the liquid (the higher the viscosity, the greater the value of k);

n - characteristic of the degree of non-Newtonian behavior of the fluid.

The more the value of n differs from unity (Newtonian fluid), the more its non-Newtonian properties are manifested; for pseudoplastic fluid n <1, for dilatant fluid n <1.

To characterize the rheological properties of non-Newtonian fluids, the concept of effective apparent viscosity is often introduced [4, 5]. This is a certain conditional characteristic used when performing calculations using the usual formulas for the hydraulics of Newtonian fluids. It is not a constant value even for a given liquid. Its values depend on the velocity gradient γ, shear stress τ and are determined on rheograms by the slope angles β of the straight lines connecting the origin of coordinates with the points of the flow curve [5]:

$$\mu_э = ctg\ \beta = \frac{\tau}{\gamma} \qquad (3)$$

For pseudoplastic fluids, the effective viscosity μ decreases with increasing τ or γ. These liquids seem to expand as they flow. In dilatant fluids, on the other hand, fluids thicken during flow. In this case, the viscosity values are determined here only by the instantaneous shear state.

Analysis of the rheological properties of high-viscosity oils shows that they should be classified as non-Newtonian fluids, which have specific features during transportation through pipelines. First of all, this must be taken into account when developing and operating in-process technological schemes for the transportation of high-viscosity oils [6].

When developing schemes for the in-house transportation of oil through pipelines, it becomes necessary to study its regularities, linking the characteristics of the process of fluid flow [7, 8, 9, 10].

It is known that when an ideal fluid flows through a pipeline, the process parameters are related by the following relationship:

$$V = A\vartheta\ t \qquad (4)$$

where V - is the volume of the leaked liquid, m^2;

t - is the time during which a given volume of liquid flows, s:

A - is the cross-flow area of the pipe, m^2;

ϑ - fluid flow rate, m/s (for viscous fluid media - average velocity);

The rheological properties of oil primarily depend on its chemical composition and are different for different fields. Therefore, when developing new oil fields, it becomes necessary to study its rheological properties in order to provide the initial data for calculating pipelines using the formulas of applied hydromechanics.

In this case, it is convenient to use the models developed for each type of oil, which can be used to compile a program for calculating the hydrodynamic parameters of oil on a computer for determining the average speed, flow rate, plasticity coefficient of oil, drag coefficient, pressure drop in the pipeline, and others. All these data will help to establish the regularities of the process of transporting viscous oil through pipes of various cross-sections with minimal energy costs.

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