Investigation of the influence of physico-chemical properties of drilling fluid on friction gear in the “metal-filter cake”

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Исследование влияния физико-химических свойств буровых растворов на механизм трения в системе «металл-фильтрационная корка»

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***Abstract**: direction of resistance forces in system "metal – filter cake" is possible by the variation of the adhesion, autohesion and friction factor values. It is established, that the best antifrictional properties have the monodispersed filter cake.*
***Аннотация:** приводится пример управления силами сопротивления в системе «металл-фильтрационная корка», возможного путем варьирования величинами адгезии, аутогезии и коэффициента трения. Установлено, что лучшими антифрикционными свойствами обладают монодисперсные корки.*

***Keywords**: sticking of drill string, metal – filter cake, utohesion.*
***Ключевые слова**: прихват бурового инструмента, металл-фильтрационная корка, аутогезия.*

In the given work the system “metal - filter cake” in application to well drilling is investigated on the basis of B.V. Derjaguin conception about the binomial law of friction. The appropriate method for study of antifriction properties of filter cake is offered. The influence of solid phase dispersion ability of a clay drilling fluid on its frictional properties is investigated either.

There are different perspectives on the nature of occurrence of resistance forces to movement of drill strings in wells caused by quality of a drilling fluid. However majority of the researchers always mark the presence of molecular forces playing a significant role at the drags on and sticking of drill string [1,2,3] alongside with frictional forces.

With the purpose of studying of the friction mechanism at phases contact interaction, eliciting some basic physico-chemical factors and definition of their quantitative estimation, in the given work a new approach studying of this process is considered, which is based on B.V. Derjaguin, A.D. Zimon and E.I. Andrianov works[4,5].

As is known, one of the laws of friction is the Amonton law according to which the resistance to shear force is directly proportional to normal loading on a friction pair and does not depend on the area of contact.

The force between two adjacent layers that move relatively to each other at a certain speed depends on the type of fluid, the contact area between the friction layers and a share rate:

$$F = \mu S\gamma ,$$

where F – the frictional force between two adjacent layers of fluid; μ - dynamic viscosity which depends on the nature of the liquid; S – the area of contact of layers; γ - shear rate.

We divide both sides of equation by S:

$$F / S = \mu\gamma,$$

where $F / S = \tau$ is shearing stress, causing a shift of layer.

$$[\tau] = F / S = H/m2 = Pa.$$

Then in the final form the Amonton law is written as follows

$$\tau = \mu N, \qquad (1)$$

where τ – resistance to shear force, N – normal load to a shear plane, μ –proportionality factor named in friction factor.

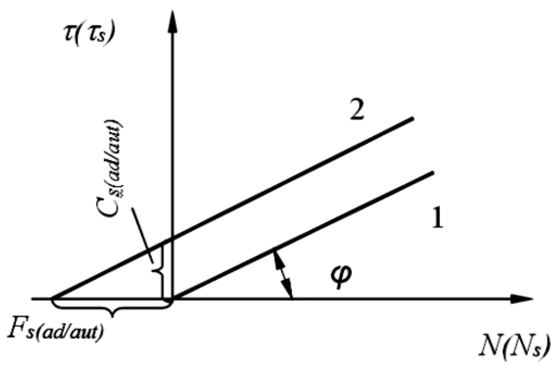

Fig.1. Graph of representing the relationship of resistance to shear force against load according

to the Amonton law of friction (1) and B.V.Derjaguin binomial law of friction (2)

According to the equation (1) the relationship between τ and N represents a straight line 1, which passes through the origin (fig. 1).

However Amonton law is truth for systems, in which both contacting phases are represented by homogeneous continuous mediums. A filter cake of a drilling fluid is a high-concentrated dispersing system with thixotropy properties, structurally non-uniform on thickness, the filter cake density increases from the top layers to the bottom.

The numerous experimental researches at study of friction arising in pair "metal – filter cake" show, that the similar law is not observed. Actually the relationship of resistance to shear of force against normal load in the considered system essentially depends on the area of contact, therefore it is expedient to consider the relationship between specific forces τ_s and N_s (forces are referred to unit of the contact area). The relationship τ_s against N_s is not characterized by the straight line 1, and a straight line 2, which passes above the straight line 1 and is described by B.V. Derjaguin binomial law of friction [4]: $\tau_s=\mu(N_s+F_s)$.

In the given equation the value F_s is a resultant force of intermolecular interactions. In a case if the shear takes place directly on the contact boundary "metal – filter cake", the force F_s is a consequence of adhesion $F_{s(ad)}$, if there is the direct shear inside filter cake, F_s is a consequence of autohesion $F_{s(aut)}$.

The friction factor μ is equal to the tangent of an inclination angle φ of a straight line to the abscissa axis and characterizes the frictional force interfering movement of filter cake particles on the surface of metal (at adhesion) or relative movement of particles inside of filter cake (at autohesion).

It is obvious that the direction of resistance forces in system "metal – filter cake" is possible by the variation of the adhesion, autohesion and friction factor values.

From a fig. 1 it is visible, that the straight line 2 cuts off some segments on coordinate axes. The segment on the abscissa axis $F_{s(ad/aut)}$ characterizes breaking strength of contact and the segment on the ordinate axis $C_{s(ad/aut)}$ - shear strength of contact. The values $F_{s/aut)}$ and $C_{s/aut)}$ are the consequence of autohesion, if the shear plane is in the filter cake, and $F_{s(ad)}$ and $C_{s(ad)}$ – the consequence of adhesion, if the shear takes place directly on the contact boundary "metal – filter cake".

In the contact of two bodies distinguished by strength, the shear doesn't on their contact boundary, but inside of more plastic body. If the shear is direct inside of a filter cake, in the absence of load (N_s = 0), the frictional factor is determined by shear specific strength to breaking specific strength ratio for a filter cake: $\mu = C_{s(aut)}/F_{s(aut)}$.

The executed researches have allowed to appraisal influence of the dispersion ability degree of the solid phase of the clay drilling fluids on frictional properties of the filter cakes. It is established, that the best antifrictional properties have the monodispersed filter cake. Hence, the perspective methods are some methods of homogenization of the dispersed phases of well drilling fluids, alongside with some hardening cakes methods and improvement of their properties in the direction of decrease of resistance to shear forces. Realized with our participation a hardening filter cakes method by some chrome content substances for drilling deep wells in Turkmenistan has given positive results for the prevention of sticking.

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