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Nalivaiko O., PhD, Associate Professor
Nalivaiko L., senior lecturer
Reznichenko A., student
Poltava National Technical Yuri Kondratyuk University
Chyhyriov V., permanent representative
Scientific and production firm «Ukrpromtechnology-K» (Kyiv, Ukraine) in Canada

THE REASONS OF DIFFERENTIAL WALL STICKING IN DRILLING OIL AND GAS WELLS

Of the article raised the question of occurrence the causes of differential wall sticking. An attempt to analyze the mechanism of differential wall sticking in drilling oil and gas wells was made. Operations in liquidation of wall sticking and casing pipe that occur in drilling are the most difficult and time-consuming. One of the ways to improve the requirements ofcasing string cementing is the use of different chemical additives in cement that change the structure of well cement. One of them is hydrophobic additive «Silpan-P», which effectiveness is described in the article. Own view on the issue of process occurrence of differential wall sticking that is different from the existing ones was offered.

Keywords: *drill string, differential sticking, osmosis, hydrophobic additive «Silpan-P», well, pressure.*

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Наливайко О.І., к.т.н., доцент
Наливайко Л.Г., ст. викладач
Резниченко А.О., студентка.
Полтавський національний технічний університет імені Ю. Кондратюка
Чигирьов В.В., постійний представник
науково-виробничої фірми «Укрпромтехнологія-К» (м. Київ, Україна) в Канаді

ПРИЧИНИ ДИФЕРЕНЦІАЛЬНИХ ПРИХОПЛЕНЬ БУРИЛЬНОЇ КОЛОНИ ПРИ БУРІННІ НАФТОВИХ І ГАЗОВИХ СВЕРДЛОВИН

Піднято питання виникнення причин диференціалних прихоплень бурильних колон. Зроблено спробу аналізу механізму диференціалних прихоплень бурильної колони при бурінні нафтових та газових свердловин. Роботи з ліквідації прихоплень бурильних і обсадних труб, що виникають при аваріях у процесі буріння свердловин, є найбільш складними та трудомісткими, Одним з напрямів щодо підвищення вимог до цементування експлуатаційних колон є застосування різноманітних хімічних домішок до цементу. Однією з них є гідрофобна добавка «Silpan-P», ефективність застосування якої розглянуто у даній статті. Запропоновано свій погляд на питання виникнення процесу прихоплень бурильних колон, що відрізняється від існуючих.

Ключові слова: *бурильна колона, диференціалні прихопленя, осмос, гідрофобна домішока «Silpan-P», свердловина, тиск.*

Statement of the problem. Under current conditions one of the most common types of complications or accidents that occur during the drilling of deep wells for oil or gas is wall sticking incidents that occur during the so-called pressure drop action, or they are called the differential sticking.

Operations in liquidation of wall sticking and casing pipe that occur in drilling are the most difficult and time-consuming.

This type of accident that is called «sticking» concern drillers from the beginning of deep wells drilling. But the mechanism of sticking, which was described by Heydorfom (USA) in 1937 still exists in literature [1]. Research of the causes of wall sticking in drilling wells of Hrestyschenskiy GCF (gas-condensate field) made us believe that perhaps the current view on the sticking mechanism is obsolete, so it makes it impossible to find the effective means of preventing and combating the "sticking" in practice.

Defining parts of the general problem unsolved before. This article deals with the causes of differential wall sticking in drilling of oil and gas wells. In the oil and gas industry, this problem is an urgent and top-priority. There is an opinion as in the literature and in practice that with increasing the pressure drawdown, especially as the depletion of layers due to field development, the possibility of sticking is increasing as the difference between the hydrostatic and formation pressure is increasing.

There is a significant amount of researches which are devoted to the theoretical and practical aspects of the causes of differential wall sticking in drilling of oil and gas wells. Great contribution to the theoretical and practical issues such scientists as V.S. Boyko, Yu.A. Balakyrov, G.R. Galustyan, John R. Gray, G.S. Darla, Yu. V. Zaitsev, I.Y Rybchych, K.H. Orkyn, M. Svitlytskyy, A.V. Suleymanov, R.M. Kondrat, A.M. Yurchuk, M.A. Myslyuk, R.S. Yaremiychuk, S.I. Yahodovskyy made in their works.

In their works these scientists describe sticking under the effect of well-layer as «sticking» of drill string to the walls of the well (which is right in some way), but in our opinion the physical nature of this phenomenon is not explained sufficient ly. Judge by the existing explanation of this phenomenon in scientific and technical literature we are always doomed to sticking, as to the rules of regulation of drilling operations, for the purpose of well-kill security it is necessary to ensure the excess of hydrostatic pressure on formation pressure.

And what do we get if to pressing force from the differential pressure add force of the weight of the drill string in directional and horizontal wells? Based on the above mentioned explanation of "sticking" if it is possible to drill directional or horizontal wells but it is too problematic. But in practice, drilling of such wells is successfully carried out.

It is known that at present restraining force (force stuck) is calculated by the formula:

$$F = (m \cdot b_n \cdot D_p + t_a \cdot b_1) \cdot l_n + m \cdot G_n \ , \qquad (1)$$

where b_1 and b_n – correspondingly weighted mean width of sticking in an arc;

D_p - weighted mean pressure difference, which presses the pipe to the wall;

m – pipe friction coefficient of crust;

t_a – shearing strength of adhesion;

l_n – sticking length zone;

G_n – normal weight component of tool in the stuck zone.

Almost all measures included in the formula, from the beginning of pressing the tube to wall are growing in time, that leads to an inevitable increase in F [1]. Initial pipe contact with the wall takes place in further increase of crust formed under conditions of dynamic filtration in free borehole section and around the pressed pipe in the so-called no flow area and pipe due to deformation of the crust is pressed into it. It seals the crust and reduces dynamic pressure under the pipe in the stuck area, that leads to increasing of p according to the formula:

$$p = p_c - p_g \ , \tag{2}$$

where p_c – the pressure in the well at a stuck depth;

p_g – weighted mean of dynamic pressure under the pipe, pressed to the wall.

A similar explanation of stuck mechanism due to pressure difference are found in foreign literature. For example (John R. Gray, G.S. Darly «Composition and properties of drilling chemicals (flush liquid)» [2, 3].

There is no difference from the explanation of stuck occurrence mechanism, which are set out in the reference guide «Well drilling» [4].

This guide sets out a lot of useful information, but the authors of this articledo not give answers to the mechanism of their formation.

The fact that existing in literature mechanism description of so-called differential sticking, does not meet the requirements of time, the evidenced of this is in the practice of drilling wells of Hrestyschanskiy GCF.

Analyze of the causes of sidewall sticking when drilling wells Hrestyschanskiy GCF made in the article let us to suggest that existing mechanism of differential sticking in the scientific and technical literature is not exactly correct in practice, but currently existing formula of sticking calculation are almost impossible to use during practical work.

To avoid the possibility of creating conditions for mechanism of differential sidewall sticking it is necessary to prevent the showing of osmotic process, so there is a dielectric layer between the drill string and the wellbore wall that lead to the slipping the line.

The aim of the work is to analyze the reasons of preventing the formation of differential sidewall sticking in drilling of oil and gas wells, determination of sticking mechanism and provide guidelines for controlling methods of sticking.

Basic material. From a scientific point of view, in our opinion, very interesting and sufficient at preventing the mechanism of the sidewall sticking is the process of osmosis.

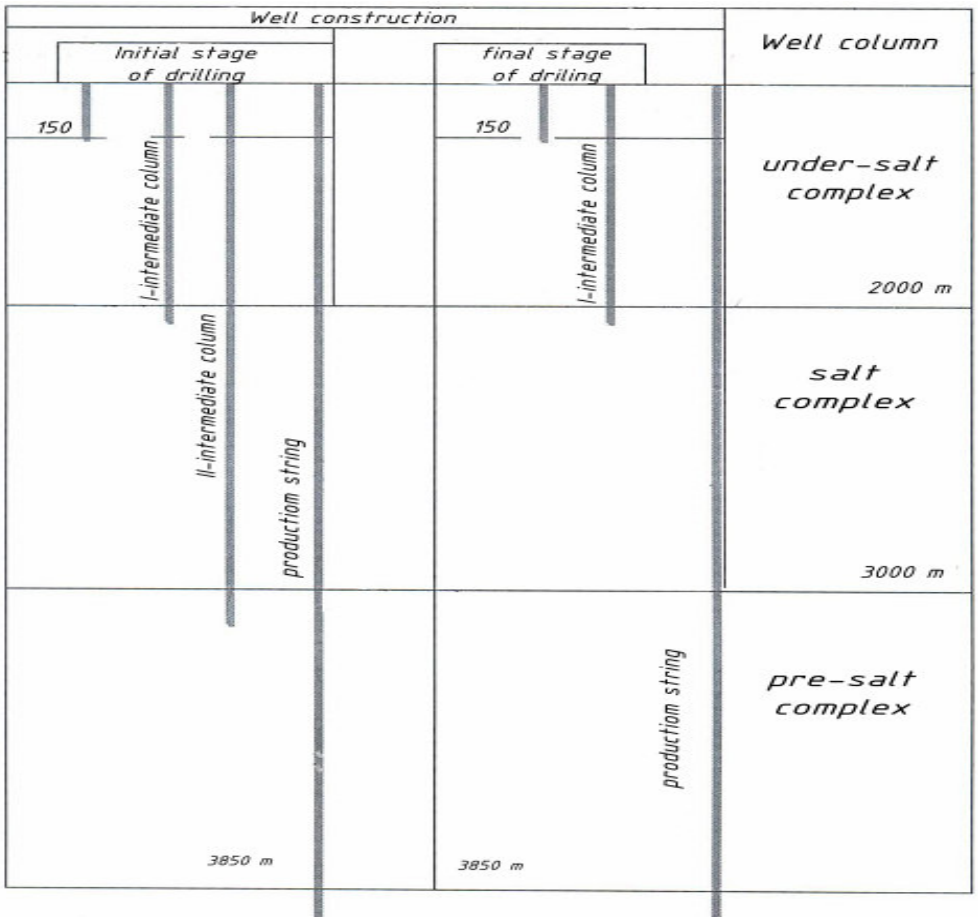
Examples of Khrestyschanske GCF well drilling suggest to this opinion from 1973 to the present.

When drilling a unique Khrestyschanske GCF in Ukraine at the beginning of drilling, when repression was less than 5 – 6% of the formation pressure (R_{fr} = 410 at), that was about 20 – 30 at, sticking were quite frequent. At that time, it was not allowed to leave drill string without movement even for a short time of 1 – 2 minutes, because stopping of drilling for more than 5 minutes led to sticking.

At the end of drilling when there was an intensive exploitation and formation pressure dropped to 160 – 180 at., and specific gravity of drilling mud retained within 1,30 – 1,387 sm3 and it created hydrostatic pressure on the producing layer at a depth of ~ 3800 m within 450 – 480 at, so overburden on formation reached 300 atm, such sticking have not been observed, even at extremely long, for a few hours, leaving the drill string without moving.

To explain these phenomena we should closely examine the geological section of Khrestyschanske GCF and the process of its drilling.

Khrestyshchanske GCF is presented by three powerful geological complexes: post-salt 0 ~ 2000 m, salt (chemogenic deposits) ~ 2000 – 3000 m and pre-salt 3000 – 3850 m. At the initial stage of drilling out the construction of well was tripled-column when there were two intermediate columns and one production casing. Intermediate column insert down to divide post-salt from salt complex, salt from pre-salt complex. After inserting the second intermediate column in drilling for production casing fresh drilling mud or distilled mud were used. In this period «sticking» of drill string were quite frequent.



Picture 1 – Scheme of Khrestyshchanske field with the construction of wells

After the formation pressure dropped they switched to double-casing structure. One intermediate column was run in the hole to overlap post-salt deposits. Drilling of salt deposits and productive layers was carried out on fully saturated NaCl drilling fluids. Specific gravity of drilling fluid retained within 1,30 – 1,38, based on the presence of intermediate column under the shoe layers of kartamyshska formation with an initial formation pressure. This created a repression on pay bed located at a depth of 3800 m about 300 atm.

But «sticking» was not observed because the composition of the drill mud changed from fresh to saturated NaCl. The result of NaCl drilling mud usage we will consider later.

For example, let's consider the common case. Sidewall sticking has happened IN the well at a depth of 4700. By geophysical methods it is determined that the tool is free to a depth of 4500 m, from a depth of 4500 m to the bottom hole there are drill collar (DC). At the depth of 4550 m there is pay top in which P_{for} = 450 atm.

Well drilling was carried out by the drilling fluid density of 1,40 g/cm^3, which was chosen on the basis of the conditions of the upper bed. To release the tool an oil bath is set at the rate of oil recovery to a height of 100 m above head of DC. After setting the oil bath the tool is released in some time.

When drilling these wells was found out that the sticking mechanism, related to pressure difference is not fully explained, so there are no effective means of struggle and methods to prevent this phenomenon. If you use a medical term, the wrong diagnosis leads to incorrect treatment.

Analyzing an example given in the article the question arises: what mechanism worked against «sticking» in these cases?

The examples from practice suggests that the sticking mechanism , related to pressure difference, is not fully explained, so there is no effective means of struggle and methods to prevent this phenomenon,

Analyzing the above mentioned examples and practical experience we reached the conclusion that neither differential pressure between hydrostatic or formation pressure nor any other factors referred to the literature as the cause of sticking have no fundamental importance.

So naturally there is a question, what is the valid mechanism of sticking in the well? In this case, we paid attention to such process as osmosis.

Taking into account that the phenomenon of osmosis is described in detail in relation to different events that take place in the well, and specialists know about its influence on the destruction of mudstone, clays swelling, etc., we reached the conclusion that taking into account the actions of osmosis during well drilling sticking can be prevented. It really works if the pressure on the permeable layer will be expressed as follows:

$$p_{sv} = p_{hidrost} + p_{hidrodynam} + p_{osm}\,. \tag{3}$$

It is known that drilling fluids are colloidal suspended mixture that can be prepared both as fresh and on mineralized water.

The rock bed which the well log consists of are saturated by different fluids and salt solutions of different concentrations. As it is known formation of sediments occurred in the marine environment. So the remains of seawater occur in oil and gas layers.

As you know the process of osmosis is a movement of solvent towards greater concentration. Based on this definition, we can make the following assumptions:

– when there is the osmotic process between the well and the layer in the well, so occurring electric potential is the main reason of sticking.

– the greater the difference is in concentration between the formation fluid and drilling fluid in the well, the higher is the osmotic pressure from the well fluid, the greater is potential difference, and the occurrence of sticking is more probably.

If to provide a scheme of sticking under the influence of pressure difference, it is possible to explain their mechanism and practical approach of solving problems in the prevention and elimination of sticking. Let’s come back to above mentioned examples.

One of the ways to improve the requirements ofcasing string cementing is the use of different chemical additives in cement that change the structure of well cement. One of them is hydrophobic additive «Silpan-P», modification «Ramsinks-2M» [6].

In Hrestyschanskiy GCF at low overburden of formation sticking have happened, and at significant ones have not happened.

Perhaps that at the beginning of pre-salt pay zone drilling was conducted on fresh drilling mud and there was great concentration of salt in the pay formation.

At measuring the concentrations between the well and the layer and there occurs intensive osmatic process, which was the cause of sticking.

Later, during the switch to two-column construction when opening of salt and pre-salt pay zones was carried out together, i.e. there was the solution with a concentration of salts in the well, equilibrium of concentrations or liquid mud concentration was greater than in layers. The phenomenon of osmosis did not appear.

In another example why the installation of oil bath release the stuck instrument, despite the fact that the installation of bath slightly reduce the overburden on formation? Perhaps when installing the oil bath there is the moving of drilling mud from stuck area, osmotic process stops as a result, a dielectric layer is created between the drill string and the wellbore wall, that leads to slipping the line.

Theoretical studies suggest the following general conclusions. Based on the made assumptions we can offer following three solutions of prevention the sidewall sticking:

1. To keep in the flush liquid the solution of salts of higher concentration or equal to the concentration of salt solution reservoir fluid.

2. To carry out the chemical treatment with the drilling fluid so as much as possible to bound water (solvent) not to have free water.

3. To provide the washing liquid as much as possible higher dielectric properties.

These conditions are not difficult to perform, especially when you understand clearly that it is necessary to prevent accidents during well drilling.

Today, in our opinion, in addition to the decisions mentioned above to prevent the sidewall sticking, you need to create modern polymer-based drilling mud.

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