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ABSTRACT

of the dissertation for the degree of Doctor of Philosophy

DEVELOPMENT OF TECHNOLOGICAL SOLUTIONS AND IMPROVEMENT OF PROPERTIES OF DRILLING FLUIDS FOR DRILLING HORIZONTAL WELLS

Specialty: 2523.01– “Well Drilling Technology”
Field of science: Engineering

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The dissertation work was performed in the problem laboratory "Technique and technology for drilling deviated and horizontal wells" of the Research Institute "Geotechnological problems of oil, gas and chemistry"

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MAIN CHARACTERISTIC OF THE WORK

The urgency of the problem. The current state of the world practice of drilling wells reveals that with the design and creation of new models of equipment and principles of development technology for oil and gas fields, the technology of drilling horizontal wells for production purposes took an important place.

The prospects of this technology can be explained by the fact that the technology allows not only to increase the flow rate of wells, but also to increase their service life.

The greatest efficiency in the construction of horizontal wells is observed in reservoirs with a small productive thickness of 10 to 100 meters, a large strike from 500 meters to more than 1000 meters.

In such conditions, even with the same production rates, if compared with vertically directed or directional wells, a horizontally drilled well will create a much lower load per unit area of the reservoir.

Considering the decent production experience in drilling directional wells of the Caspian shelf and on the land of the Absheron Peninsula, SOCAR, based on the geological conditions of the construction of oil and gas wells and high economic indicators, focuses on the further development of horizontal drilling in Azerbaijan.

Based on the information provided, the stated and solved tasks of this dissertation are urgent, modern, have scientific novelty and practical value.

The purpose of the work and objectives of the study. The purpose of the thesis presented is to improve the quality of horizontal drilling by improving technological measures and compositions of drilling fluids and creating the latest technical tools.

In the presented dissertation, the following main objectives of the study to be developed have been identified:

- the optimal profile of horizontal wells;
- technical means for the implementation of the project profile;
- a number of measures to increase the values of the mechanical speed of drilling;

- the composition of the drilling fluid for flushing horizontal sections of wells;

- the design of a dispersant for influencing the rheological properties of drilling fluids;

- a device for preparing a quick setting mixture in horizontal wells.

Research methods. In the work well-known statistical methods and programs for data processing and information analysis, correlation analysis and decision making have been used for solving the problems.

Points to be defended:

- principles of designing the optimal profile of horizontal wells;
- stabilizer designs for implementing horizontal well sections;
- dispersant design to change the rheological properties of the drilling fluid.
- design of technical equipment that can be used in the cementing process of horizontal wells

Scientific novelty:

- technique for calculating the optimal profile of horizontal wells has been proposed.
- a number of technical tools for the implementation of the project profile have been developed;
- additives to drilling fluids, as well as the percentage of additives for drilling horizontal intervals of wells have been proposed.
- a dispersant design has been developed and proposed for influencing the rheological properties of drilling fluids.
- the designs of technical means for effective cementing of horizontal wells have been developed.

Theoretical and practical significance of the research. As a result of the use of the proposed developments in design organizations and production associations, the efficiency and quality of the design and drilling of horizontal wells on the shelf and land of Azerbaijan will increase.

Approbation of work and publication. The main provisions of the thesis have been reported at five international conferences.

- II International Scientific and Practical Conference Readings of A.I. Bulatov, Krasnodar - March 31, 2018.
- XXI International scientific-practical conference "World Science: Problems And Innovations", Penza - May 30, 2018.
- International conference dedicated to the 90th anniversary of Academician A.Kh. Mirzadzhanzade "Modern problems of innovative technologies in oil and gas products and applied mathematics", Baku - December 13-14, 2018.
- III International Scientific and Practical Conference Readings of A.I. Bulatov, Krasnodar - March 31, 2019.

The main content of the dissertation has been presented in 18 scientific papers, of which 12 articles (4 of them have been published abroad (RSCI), 1 - in Web of Science) and 6 - in materials of international scientific and technical conferences (3 thesis have been published abroad).

Application of researches. As a result of the implementation of the proposed developments, in particular software for designing the profile and layouts for its implementation at the Guneshli field, an economic effect of 467,083.54 AZN has been obtained.

The volume and structure of the work. The dissertation consists of an introduction, four chapters, conclusions and recommendations, as well as a list of used references. The work contains 175 pages, including 5 tables and 37 figures. The bibliography contains 120 items.

The author expresses deep gratitude to the team of the problematic laboratory “Technique and technology for drilling deviated and horizontal wells” and personally to the scientific leader, Doctor of Technical Sciences, Professor N.E. Zeynalov for valuable advice and assistance in preparing the dissertation.

MAIN CONTENT OF THE WORK

The introduction substantiates the relevance of the topic of the dissertation, formulates the goals and objectives of the study, and shows the scientific novelty and practical value of the work.

The first chapter of the dissertation is devoted to the analysis of scientific and technical literature, materials of companies and publications.

The application of horizontal well technology in Azerbaijan has been justified. In different years, certain regions of Azerbaijan were explored by a large number of exploration wells, however, due to the complexity of the geological structure of the regions and the incorrect location of the design vertical exploration wells, many oil and gas facilities were not discovered.

It was found that it is not advisable to conduct the development of promising fields with traditional directional or vertical wells due to the low capacity of the productive formations. From there the only correct conclusion came - to design the construction of production horizontal wells in these fields.

The section shows that world oil companies apply horizontal well technology, realizing the prospects and economic benefits that can be obtained from long-term field exploitation.

Recent decades are characterized by a significant increase in the number of wells with a large deviation from the vertical. There were already samples of successful practical construction of such wells - in Azerbaijan, Western Siberia, Bashkiria, Sakhalin, Kazakhstan and Vietnam.

A number of studies have been devoted to the development and improvement of the design and construction technology of such wells. The following conclusion has been made that the most important technological aspect of the construction of horizontal wells is the degree of provision of high-tech tools, such as borehole curvature mechanisms (rotary system RS) and modern means of controlling downhole parameters (i.e. zenith angle, azimuthally direction angle), and also the possibility of using a special solution to reduce the friction and adhesion forces and special equipment for regulating the rheological properties of the drilling fluid.

The second chapter is devoted to the development of technical devices and technological principles for drilling wells with a horizontal section.

The optimization task of constructing the profile is paramount and formulated as minimizing the functional dependence of the parametric curve, with the elements connecting the wellhead and producing formation.

The solution to this problem is a predetermined combination of geometric parameters that can provide unimpeded descent of the productive column into a given area. At the same time, a number of specified technological limitations are taken into account.

The method of numerical optimization of the well profile has been used in the work. Its structural diagram has been shown in Fig. 1.

Two models are used to optimize and determine the intensity of well curvature: a model of the dependence of the length of the horizontal interval on the values of the curvature intensity and a model of the influence of the well curvature radius on the length of the vertical section.

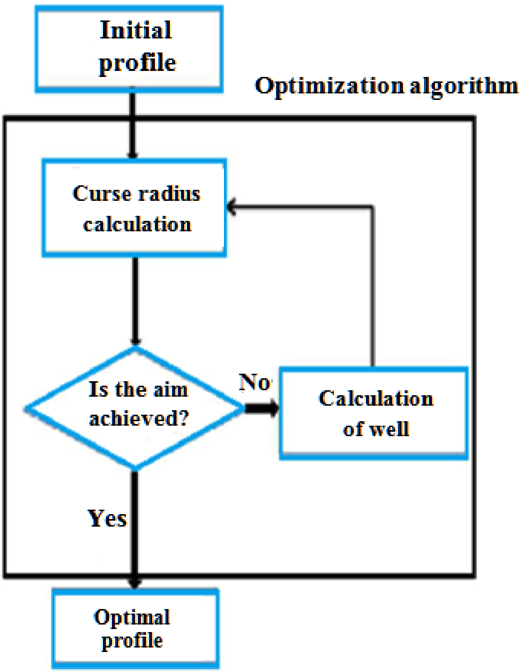


Figure 1. The direct method of numerical optimization

Considering that the direct method requires the calculation of individual sections characterizing the profile, then with the preference for the methods of their calculation, the advantage should be given to the method in which all properties of the transitions of the profile sections are taken into account for small, medium and large values of the curvature radii of the curved sections. Along with this, the method itself, as well as the calculation algorithm, must be substantiated by efficiency and profitability. The most common model is profile calculation, which solves all the tasks necessary when analyzing horizontal well profiles. First, the parameters of the vertical section are calculated. To do this, the relationship between the length of the vertical section and the length of the horizontal section has been studied.

To identify the intensity of the curvature of the well, the dependence of the horizontal interval length on the values of the curvature intensity is used. The effect of the curvature radius of the well on the length of the vertical section is also taken into account.

Analytical and polynomial functions used to parameterize the profile during optimization.

The essence of this procedure is to the description of the curved section of the profile by a function that takes the following form:

$$y = y_{\text{base}} + \sum_{j=1}^{N} \left(a_j f_j\ (x) \right)$$

Where

$f_j\ (x)$ -is a parametric function,

N -is the number of variables,

a_j- is a variable,

y_{base}- the ordinate of the plot with curvature.

As an optimization algorithm, the so-called genetic algorithm has been used. This algorithm relates to numerical optimization using the stochastic method. When constructing new profile geometry, the followings are used in it: possible changes in design parameters, selection of profiles with the best indicators of objective functions, possible emergence of new significant variables that have arisen based on existing in practice linear combinations of constructing a well profile.

The dissertation provides examples of profile optimization using the method described above. To optimize the source profiles, common profiles calculated using established direct optimization methods have been applied. Optimization is achieved by choosing a variety of optimization criteria, possibly one or more.

The second important step is to solve the horizontal-type well curvature problem using a stabilizer with a varying diameter and freely rotating around its own axis. The stabilizer is presented in fig. 2.

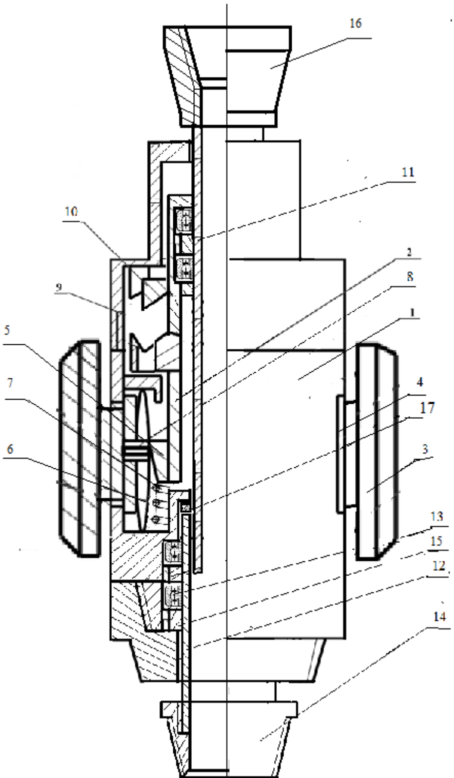


Figure 2. Stabilizer

A distinctive feature of the proposed stabilizer is that the centering slats have the ability to move with the help of a pusher connected with a rod and a coil spring of a spiral shape, acting on the return spring, rigidly connected to the holder of the centering strips. The stabilizer body rotates freely on bearings it for use in rotary drilling.

A stabilizer with a varying diameter and free rotation around its own axis, contains a housing 1 with a rod 2 inside, four centering strip 3, each installed in the connector of the housing 4, the node for moving the centering stripes, contains pusher 5, rigidly connected to rod 2, coil spring 6, rigidly connected to the truncated part of the pusher 5, return spring 8, rigidly connected to the holder of the centering stripes 7, resting on the base of the pusher, the hollow first shaft for rotation of the stabilizer 11, the second hollow shaft for rotation 12, sliding bearings 13, clutch lock for connecting to drill pipes 14, retaining rings for longitudinal movement 15, clutch lock for connecting to drill pipes or bit 16, stuffing box for sealing between shaft movements 17, pusher moving mechanism 9, installed on the upper part of the stabilizer integrated in the retention mechanism 10.

Change of the diameter of the developed stabilizer during drilling is carried out in this way. An axial load affecting the control mechanism of the stabilizer is created on the bit, as a result of which the spring mounted on the rod inside the housing is compressed, while the position fixing mechanism located in the upper part of the proposed stabilizer is retracted from the fixed position. And with the help of a mechanism for changing the position due to the guides, it transfers the control mechanism to a new place where, with the help of conical pushers, the return spring is released and the centering stripes fixed on it move inside the developed stabilizer and fix its changed and reduced diameter size.

With further drilling at the required load of about 8-12 kN, the fixation mechanism remains in a new position and reliably fixes the diameter of the developed stabilizer until the next technological curvature of the horizontal well section.

Operational management of the wellbore trajectory is an important task in the drilling process. Proposed stabilizer with a varying diameter and rotating freely around its own axis allows controlling the zenith angle during drilling by creating a deflecting force when implementing a horizontal well profile.

Studies on the movement trajectory of bits and BHA taking into account the anisotropy of the rock have also been carried out in the dissertation. When drilling a well, the bit and the downhole motor move along a certain path under the influence of various factors. Depending on the geological conditions of drilling, the trajectory of the well axis has a planar and spatial shape. In order to calculate the trajectory of a bit with a downhole motor at different times, a number of studies have been conducted. However, it turned out that there is a need for analytical studies of calculating the path of the bit in space, taking into account anisotropic properties.

This problem has been studied in the thesis and the mathematical equation of the spatial trajectory has been obtained.

Some conclusions have been drawn. If the ability to destroy rocks with a bit in the axial and radial directions is the same, then drilling in isotropic rocks occurs in the direction of the force acting on the bit. If the bit is not able to destroy the rock in the radial direction, then drilling in isotropic rocks will occur in the direction of rotation of the bit axis. If the formation angle and the zenith angle are equal, the azimuth of the wells drilled in the direction of the formation rise remains constant, in all other cases, the azimuth increases. If the angle of bedding exceeds the zenith angle, the azimuth of wells drilled in the direction of left and right bedding of the formation reduces, in other cases, and in the case of drilling in the well descent direction, the azimuth increases.

For the rational development of bits, tests have been carried out that made it possible to determine the influence of the main operating parameters (load on the bit, speed, fluid flow) on tool wear.

After the tests, it has been found that drilling with average performance parameters is the most rational and has less impact on the drilling tool wear.

The results of laboratory tests have been used to identify the influence of the main operating parameters (load on the bit, speed, fluid flow) on tool wear. For each operating parameter, analytical expressions have been derived to determine tool wear.

Taking into account the influence of the amount of flushing fluid on cleaning the bottom and on the mechanical drilling speed, as well as using experimental data and taking into account the dependence of the decrease in mechanical speed on the differential pressure, more accurate analytical dependencies were derived.

In the third chapter, the properties of drilling fluids at horizontal intervals have been investigated and a technical device for controlling the density of drilling fluids has been developed.

As you know, horizontal wellbores can consist of the following intervals: upper vertical, middle directional and lower horizontal.

The upper vertical and middle directional intervals of the horizontal wellbore are drilled in the usual way (using the rotary method or the downhole motor). The drilling of the third horizontal interval of the well is carried out taking into account some additional requirements, both to the drilling technology and the rheological properties of the solutions that are used to drill the well. When drilling the horizontal part of a horizontal well drilling fluids are used, are classified as solutions predetermined for drilling wells in difficult geological and physical conditions.

The construction of horizontal wells has a distinctive feature from vertical and weak shallow wells in that when drilling rock, the sludge carried to the surface of the day settles on horizontal or transitional sections of the horizontal wellbore and creates a blockage that turns into a plug blocking the progress of the drilling fluid and contributes to the sticking of the drill tool. A solution to this problem may be a reasonable choice of parameters for the optimal drilling mode for a particular curved section, the horizontal wellbore. It should take into account the rheological parameters of the drilling fluid, the axial load on the bit, the pressure value of the pumps injecting the flushing fluid and, of course, the geology of the drilling formation.

Literary sources describe in detail the principle of lowering or raising the density of the drilling fluid by foaming. There is also a device for forming bubbles in a drilling fluid using a special-purpose electric motor that changes the density of the flushing fluid. The main disadvantage of this device is that it is necessary to supply electricity to the motor through a cable considering the depth of the well, which will ultimately lead to certain problems, the depth of the well.

An analytical review of references and patent sources made it possible to establish the disadvantages and advantages of known devices intended for the preparation of multiphase drilling fluids. According to the comparative results of the analysis of the studied devices operability, a new design of the dispersant has been proposed.

The thesis presents a developed device that forms a turbulent flow, which promotes foaming in the drilling fluid itself, changing its density due to the pressure of the pumps and the values of the fluid velocity.

The dispersant developed for changing and controlling the rheological properties of the drilling fluid during drilling at horizontal intervals is shown in Fig. 3.

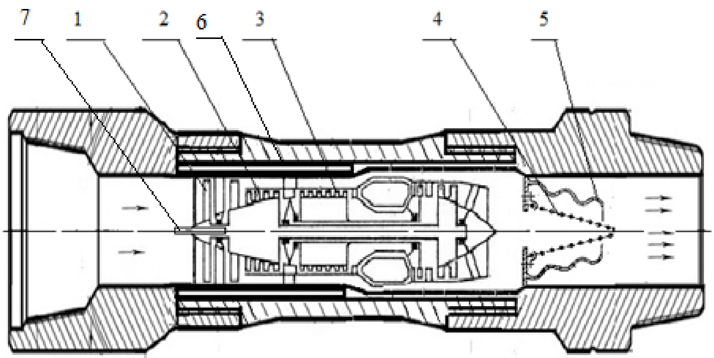


Figure 3. Dispersant for changing and controlling mud parameters

1-fluid primary circuit compressor; 2- compressor with low pressure turbines; 3-compressor with high-pressure turbines, 4- vibrators, 5- activator, 6-cylinder battery, 7- pressure sensor

Structurally, the dispersant consists of two sections. The first section is turbine, where, under the action of the injected drilling fluid, the rotor rotates, which increases the turbulence of the drilling fluid flow. The second section is the activator, in it the turbulent flow passes into the laminar flow forming a large number of bubbles in the drilling fluid; the latter involves a decrease in its density.

This is due to the fact that under the action of the obtained high-speed turbulent flow, the drilling fluid is pumped into the second section, where, using the elastic elements of the vibrator and activator, the entire flow is divided into many small ones, thereby reducing its intensity and leveling the velocity field with the formation of many bubbles. The elastic elements are made in the form of vibrators and activators and mounted directly at the outlet of the dispersant body.

The dispersant body is in the form of a drill pipe. Dimensions - diameter, length of the device depend on the drilling interval of the horizontal section, where there is a need to use this device to maintain the desired density of the drilling fluid.

The design features of the developed dispersant create conditions leading to the formation of bubbles in a turbulent moving drilling fluid, which often leads to an intense effect on its density during the drilling of horizontal wells.

The principle of operation of dispersants is laid depending on the functional purpose, but their main task is to change the properties of the liquid in the process of acting on its structure.

The novelty of the device is that a section is installed inside the casing to increase the speed of the turbulent flow, providing complete passage of the solutions to the second section to switch to a new quality laminar flow using vibrators and activators that form bubbles and lead to foaming.

The proposed device is located directly near the site with difficult geological conditions, where there is a need for operational modification of the drilling fluid density.

The third chapter also presents studies of the effect of the addition of hydroxyethyl cellulose (HEC) on the height of the sludge layer in a horizontal well. Knowing the amount of drill cuttings in a horizontal wellbore is necessary to control the pressure in the wellbore, prevent jamming of the pipe and minimize circulation time to clean the wellbore. Therefore, it is very important to improve the prediction of the slurry layer, which will help in the decision-making process during drilling and minimize the number of problems that arise. Experimental studies were conducted with drilling fluids of various viscosities and flow rates to study the height of the slurry "bed". An experimental setup has been developed in which the test section is supported in a horizontal position or slightly inclined at a certain angle. The test section of 6 m long with an outer diameter of 0.06 m and an inner diameter of 0.0545 m is designed so that the inclination angle can be changed. The channel is made of a transparent PVC pipe, which is connected at both ends to removable steel joints 1.75 m and 3.25 m long, respectively, i.e. PVC pipe itself has a length of 1.0 m.

The unit is equipped with a flow meter is connected to a computer for online display of values and recording. A viscometer and a mixer have been used.

The main objective of the experiment was to observe and record the height of the sludge layer. The main task was to determine the time required to form a stable height of the sludge layer and then to measure the height of the layer. The temperature of the solution was kept within room temperature.

The solid-liquid mixture has been pumped through the horizontal section of the pipe and the parameters have been controlled: flow frequency (Hz), sludge “bed” height (m) and circulation time (t).

In the experiment, the addition of hydroxyethyl cellulose (HEC) has been used at various concentrations (0; 0.5; 1.0; 2.0 g/l). The solution has been mixed with the HEC with a mixer to the desired consistency. The solution with sludge has been pumped into the test tube. The fluid has been pumped with different rate the sludge settling on the pipe wall formed a “bed”. The time required for its formation and height have been measured. The obtained result has recorded, analyzed and compared with the result obtained from theoretical assumptions.

When comparing the experimental values of the height of sludge "bed" with the results obtained from theory, we have obtained a consistency of results.

The experimental results are presented in Fig. 4.

At a concentration of 0.0 g / 1l, the highest value of the height of the sludge bed was obtained, the lowest - at a concentration of 2.0 g / 1l. However, the height of the sludge "bed" with a low flow rate is greater than with a high flow rate. This is characteristic of all experiments. Moreover, the optimal flow rate is in the range of 30-40 l / min for all concentrations, except for 0.0 g / 1l.

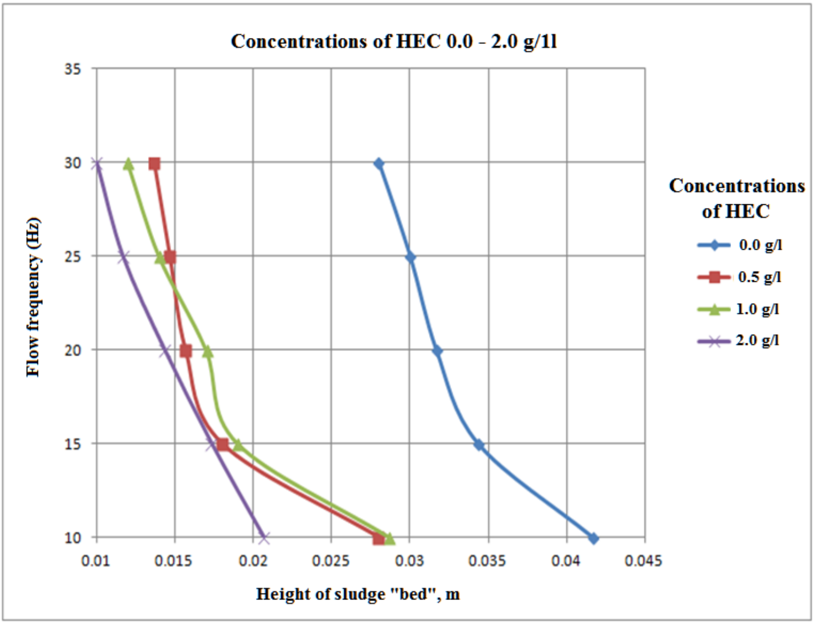


Figure 4. Comparative chart for various concentrations of HEC

Inadequate cleaning of the wellbore can cause several problems, such as jamming of pipes, loss of circulation, high torque and resistance, loss of density control, poor cement handling, etc.

Researches on the sludge transport of have been carried out since the 1940s. Initial researches have focused on studying the marginal velocity for single-phase drilling fluids, since for most wells; the marginal velocity was a sufficient parameter to solve problems.

As interest in deviated and horizontal wells increased, the studies were transferred to experimental approaches and mechanistic models trying to explain the transfer phenomenon for all angles of the wellbore inclination.

Important fundamental factors in the transport of solid particles (sludge) are the resistance force that the liquid exerts on the particles, and the ability of liquids to lift such particles, which is called the lifting force. Both factors are complex functions of flow rate, particle shape, degree of turbulence, and interaction between particles and the pipe.

Resistance force is a force that acts parallel and opposite to the translational motion of an object, while the lifting force exerts a force normal to the movement of particles.

It was decided to conduct an experiment and analyze its results for determining the coefficient of resistance depending on the Reynolds's number.

For example, this is important for estimating the particle deposition rate, which is a parameter necessary to avoid the various effects of the transport of sediment particles and deposits in pipelines.

A large number of studies report about the existing difficulties of theoretical modeling depending on the resistance coefficient.

This problem is that the drag coefficient cannot be expressed analytically in the turbulent flow mode, since the flow conditions during the process are too complicated.

This ratio can be obtained experimentally in the form of diagrams and tables by observing the deposition rate in stationary liquids or by measuring the resistance of particles in liquids.

Due to the rapid and successful growth of computer and software application development, numerical data from diagrams and tables representing the relationship will not be practical for quick calculation. Several attempts have been made to empirically express this relationship in order to expand the forecasting range for accurately estimating the drag coefficient versus the Reynolds's number.

So far, most empirical expressions have not been satisfactory. Only a few empirical attempts, although valid for limited ranges of Reynolds's numbers, provide acceptable resistance coefficient results.

This research paper focused on the coefficient of resistance with respect to the Reynolds's number. The resistance coefficient and Reynolds's number were reproduced experimentally. The experimental results were compared with theoretical values in order to understand whether their results coincide.

For the experiment, four different sludge particles of various size ranges were used. Water was used as a Newtonian fluid during the experiment. Four different power law fluids representing non-Newtonian fluids were also prepared in advance. These fluids were obtained by adding hydroxyethyl cellulose (HEC) additives to the drilling fluid in different proportions in order to change the rheology of the fluid, making it power-law fluid particles.

Particles of the same size were selected using a sieve analysis of dry sludge.

Four solutions with HEC were prepared in advance. To create power fluids, HECs were added to a vessel already filled with the proper amount of drilling fluid and allowing the solution to mix freely. Stirring was carried out for about one hour after addition, and the mixture was left for 24 hours to completely hydrate it. Before the test, the mixture was again stirred within 10 minutes, a sample was taken for rheological measurements and the test was started.

The fourth chapter has been devoted to cementing the horizontal section of horizontal wells. An important thing in the construction of horizontal production wells is the completion process, at this time it can be represented by an open wellbore, a deflated perforated liner or a deflated production casing.

The paper considers the definition of the allowable gap in the annular space to completely fill it with cement mortar, and also reveals the need to install special combined centralizers along the entire length of the production string on the lock joints.

Each of the above well completion schemes has positive and negative factors affecting both the flow rate and the life of horizontal wells.

Let us dwell on the well completion scheme using production string cementing. Considering that the cementing process of the production string will take place on a horizontal section, the following measures must be taken. One of the main measures is the need to install special combined centralizers on the lock joints along the entire length of the production string, since the well-known traditional elastic centralizers are ineffective under these conditions.

For efficient cementing of a horizontal section, it is necessary to create a centralizer that provides reliable centering and eliminates emergency situations.

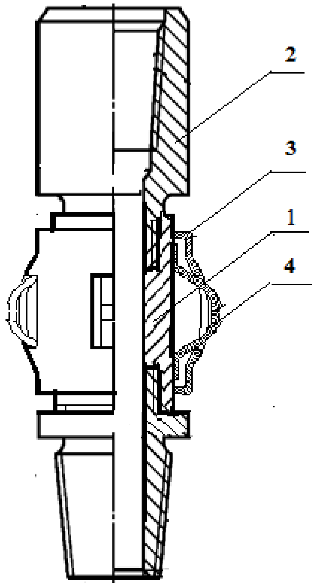


Figure 5. Centralizer for production casing while cementing

The problem is solved, by a centralizer developed which consists of a hollow convex-shaped body with slotted windows. In the inner part of the housing there is a pipe with two sub adapters installed for its fixation from longitudinal displacements on both end sides from above and below. Support strips are inserted into the cut-out openings of the case; they are made of carbon fiber and can freely move along the cut-out windows of the centralizer case, while the pipe with adapters and the case are made of steel.

The novelty of the developed centralizer: support strips are inserted into the slotted windows of the case. These strips are made of carbon fiber and move freely in the inner part of the centralizer body. The case itself, pipe, adapters are made of steel. The use of such a constructive solution allows us to solve the problem.

Figure 5 shows the developed centralizer, comprising a housing 3 with slotted windows, inside of which there are mounted carbon fiber support strips - 4, a pipe - 1, with adapters - 2. The latter are located on both sides of the pipe.

The centralizer works according to this scheme. On the pipe - 1, the adapter - 2 is served and the pipe is turned over with the other end up. Then, carbon fiber support strips - 4 are inserted into the cut-out windows of the centralizer case, and the assembled structure is mounted on the free end of the pipe - 1 until the sub - 2 touched or locked. Then, a second sub is wrapped from above for complete fixation, which fixes the entire structure.

The centralizer assembled in this way with the straps is screwed onto the production pipe, which will be located on a horizontal section, and all together they are lowered into the casing located in the well. After passing through a large diameter casing, the centralizer will exit into the open horizontal wellbore, and the carbon fiber support strips will occupy the position on the lower wall of the horizontal well, thereby centering the production string inside the well relative by to its axis for high-quality cementing of the horizontal well.

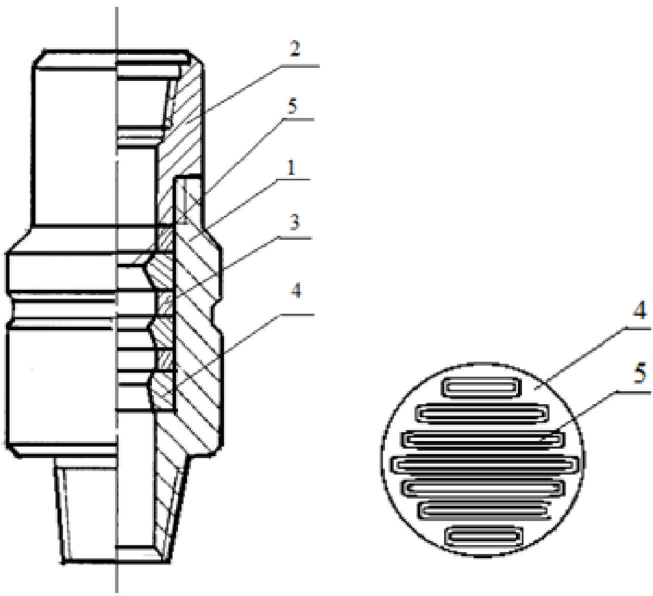
Another important problem is the preparation of cement fast setting mixture with increased requirements in a horizontal section of a horizontal well.

Another important problem is the preparing of quick-setting cement mixtures having increased requirements in horizontal area of horizontal well.

The most well-known devices that prepare quick-setting mixtures in a well are the devices, consisting of a housing in which a pipe is concentrically mounted, forming an annular chamber with housing. The chamber is filled with a setting accelerator. A piston is located in the chamber with a nozzle for introducing a working agent and a nozzle for withdrawing it. A mixer is installed inside the case, and a packer is installed on the outer surface. However, field practice of cementing horizontal sections of wells showed that these devices have a number of rather significant drawbacks. It can be attributed that in the process preparation of the working agent in most cases there is uneven dosage and mixing of reagents. This adversely affects cementing quality.

The highest quality production string cementing can be created using an ultrasonic treatment device. The device used to obtain emulsions and suspensions, grouting mixtures, contains a cylindrical body with a cover inside of which there is a central axial nozzle made in the form of a Laval nozzle with a supercritical expanding convex part. It is known that the Laval nozzle is a channel having a narrowing in the middle. Along with the great advantages of using ultrasonic processing device, the disadvantages inherent in its design do not allow to use it in horizontal wells. This can be explained by the fact that in deviated wells it is very difficult to intensify the preparation process of highly viscous, high dispersion grouting systems due to the presence of a single Laval nozzle with a critically expanding convex part, and in horizontal wells practical us of this device is impossible. The task was to develop a device to increase the dispersion of grouting systems, when completing horizontal wells. The solution to the problem was achieved by the fact that we developed a device that allows us to prepare quick-setting mixtures for its installation in a horizontal section.

Figure 6 presents this device.



a) **b)**

Figure 6. Device preparing quick setting mixtures in horizontal wells:

a) assembly device, b) disks with slots

The device includes a cylindrical case 1 with a sub 2, inside of which there are disks 4 having slots installed on them with an expanding part 5, while the disks forming the chambers are mounted on supporting rings 3 adjacent to the inner surface of the case.

The dimensions of the developed device are regulated by the inner diameter of the column. The outer diameter of the device casing is equal to or less than the diameter of the column coupling, and its length does not exceed one meter.

The novelty of the developed device - in the case we installed horizontal disks having slots with an expanding part. Due to slots on horizontal disks, at the moment of the impact of liquid jets on disks with slits, conditions for intensive destruction of hydrated shells of minerals of grouting systems arise.

The device works on this principle. A support ring 3 is installed on the inner base of the housing 1, and a disk 4 with slots with an expanding part 5 is mounted on it in a horizontal position.

All disks are installed similarly. In the final part of the assembly of the design of the device for preparing a quick setting mixture, sub 2 is installed.

The assembled design of the device for preparing a quick setting mixture in the well is screwed onto the end of the tubing and lowered into the horizontal section of the well. During pumping of the grouting system through slots with an expanding part 5 located on the disks 4, the process of impact of high-speed jets of liquid on the perpendicular plane of horizontal plates with slots occurs. This creates obstacles to the free flow of the grouting system and it is repeated many times, which contributes to the intensive destruction of hydrated shells of mineral particles of the grouting system and to obtain highly viscous and high dispersion solutions that cement the horizontal section of the well.

The proposed centralizer and device will allow reliable and high-quality cementing of horizontal sections and create conditions for the subsequent development of an oil and gas field with large volumes of hydrocarbon production and long service life. At the end of the work, conclusions and recommendations are presented.

CONCLUSIONS

1. A method for calculating the optimal profile of horizontal wells is proposed.

2. A number of technical tools have been developed to implement the optimal design profile;

3. Additives to drilling fluids have been investigated and recommended during the drilling of horizontal wells.

4. The design of a dispersant has been developed and proposed for regulating and controlling the rheological properties of the drilling fluid.

5. Technical means have been developed for effective cementing of horizontal wells.

6. As a result of the implementation of the proposed developments, in particular software for profile design and line-ups for its implementation at the Gunashli field, an economic effect of 467,083.54 AZN was obtained.

The main content of the dissertation have been reflected in the following works:

1. Kuznetsov V.A., Veliyev R.H., Ismayilov F.N. Improvement of technical equipment for preparation of multi-phase drilling mud in the drilling wells process // Machine Science, № 1, Baku, 2017, pp. 25-27.

2. Ismayilov F.N. Improvement of technical devices when drilling horizontal wells. Readings of A.I. Bulatov: Materials of II International scientific and practical conference (On March 31, 2018): in 7 v.: Conference bulletin / Under the general editor, Doctor of Technical Sciences, Professor O.V. Savenok. – Krasnodar: Publishing House – South. V. 3: Drilling of oil and gas wells. – 2018. – pp. 138-139.

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13. Shmoncheva Y.Y., Bogopolsky V.O., Ismayilov F.N. Effect Hydroxyethylcellulose on the Size of the Chips' Layer in a Horizontal Well // "Modern problems of innovative technologies in oil and gas production and applied mathematics" proceedings of the international conference dedicated to the 90th anniversary of academician Azad Khalil oglu Mirzajanzade. 13-14 December, 2018, Baku, Azerbaijan, p. 556-557.

14. Shmoncheva Y.Y., Ismayilov F.N. Equipment for cementing the production casing in a horizontal section. Readings of A.I. Bulatov: Materials of III International scientific and practical conference (On March 31, 2019): in 5 v.: Conference bulletin / Under the general editor, Doctor of Technical Sciences, Professor O.V. Savenok. – Krasnodar: Publishing House – South. V. 3: Drilling of oil and gas wells. – 2019. – pp. 129-131.

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Personal contribution of the applicant:

Works [2, 3, 6, 8] - performed independently

Works [1, 4, 5, 9, 11-18] - research, analysis, modeling, processing of results.

Work [10] - development of the structure, preparation of tasks.

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