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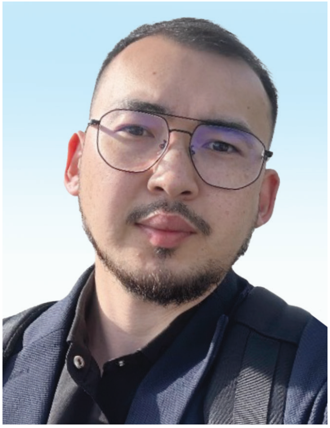
COMPARATIVE ANALYSIS OF PERCUSSION-HYDRAULIC SYSTEM FOR OPTIMIZATION OF MULTILATERAL DRILLING PROCESS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This paper presents a comparative analysis of percussion-hydraulic systems aimed at optimizing the multilateral drilling process. The research focuses on evaluating the effectiveness of hydraulic pulse interaction systems in horizontal and directional well drilling, addressing the inherent limitations of traditional drilling techniques where the absence of sufficient static load reduces penetration rates. The study investigates the potential of hydraulic percussion tools to improve drilling speed, enhance borehole stability, and mitigate operational issues typically encountered in low-permeability and vertically fractured reservoirs.

Key design parameters of hydraulic pulse systems, including curvature radius, axial loads, and wellbore trajectory profiles, are examined to ensure precise directional control and efficient rock destruction. Advanced mathematical models are employed to optimize parameters such as pulse frequency, impact energy, and crown rotation speed. The integration of rotary-impact techniques alongside traditional methods is explored to address challenges in drilling complex geologic formations.

Furthermore, the paper proposes novel improvements to existing hydraulic systems, including enhanced spring configurations that ensure tool operation even in cases of partial spring failure.

Comparative analyses with technologies such as Baker Hughes' AutoTrak and Sperry-Sun's Geo-Pilot illustrate the advantages and limitations of percussion-hydraulic systems in practical applications.

The research concludes that the adoption of these systems significantly improves drilling efficiency, reduces costs, and enables effective multilateral well construction under challenging conditions. This study's outcomes are expected to contribute to the further development of drilling technologies in Kazakhstan and other oil-producing regions, offering promising prospects for commercialization and practical implementation.

KEYWORDS: *hydraulic percussion systems, multilateral drilling, deflector, rock strength, directional drilling, drilling speed, reservoir development efficiency.*

СРАВНИТЕЛЬНЫЙ АНАЛИЗ УДАРНО-ГИДРАВЛИЧЕСКОЙ СИСТЕМЫ ДЛЯ ОПТИМИЗАЦИИ ПРОЦЕССА МНОГОЗАБОЙНОГО БУРЕНИЯ

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В данной работе представлен сравнительный анализ ударно-гидравлических систем, направленный на оптимизацию процесса многоствольного бурения. Исследование посвящено оценке эффективности гидравлических систем импульсного взаимодействия при бурении горизонтальных и наклонно-направленных скважин, что позволяет устранить ограничения, присущие традиционным методам бурения, когда отсутствие достаточной статической нагрузки снижает скорость проходки. В исследовании изучается потенциал гидравлических ударных инструментов для увеличения скорости бурения, повышения устойчивости ствола и смягчения эксплуатационных проблем, обычно возникающих в низкопроницаемых и вертикально трещиноватых коллекторах.

Рассматриваются ключевые параметры конструкции гидроимпульсных систем, включая радиус кривизны, осевые нагрузки и профили траектории ствола скважины, для обеспечения точного управления направлением и эффективного разрушения породы. Для оптимизации таких параметров, как частота импульсов, энергия удара и скорость вращения коронки, используются современные математические модели. Интеграция роторно-ударных технологий с традиционными методами рассматривается для решения проблем при бурении сложных геологических формаций.

Кроме того, в статье предлагаются новые усовершенствования существующих гидравлических систем, включая улучшенные конфигурации пружин, которые обеспечивают работу инструмента даже в случае частичного разрушения пружин. Сравнительный анализ с такими технологиями, как AutoTrak компании Baker Hughes и Geo-Pilot компании Sperry-Sun, иллюстрирует преимущества и ограничения ударно-гидравлических систем в практическом применении.

В исследовании делается вывод, что внедрение этих систем значительно повышает эффективность бурения, снижает затраты и позволяет эффективно строить много-

ствольные скважины в сложных условиях. Ожидается, что результаты данного исследования будут способствовать дальнейшему развитию технологий бурения в Казахстане и других нефтедобывающих регионах, открывая многообещающие перспективы для коммерциализации и практического применения.

КЛЮЧЕВЫЕ СЛОВА: *гидравлические ударные системы, многозабойное бурение, отклонитель, крепость пород, наклонно-направленное бурение, скорость бурения, эффективность разработки.*

КӨП КЕНЖАРЛЫ БҰРҒЫЛАУ ПРОЦЕСІН ОҢТАЙЛАНДЫРУ ҮШІН ГИДРАВЛИКАЛЫҚ СОҚҚЫЛЫ ЖҮЙЕСІН САЛЫСТЫРМАЛЫ ТАЛДАУ

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Бұл жұмыста көп кенжарлы бұрғылау процесін оңтайландыруға бағытталған соққылы-гидравликалық жүйелердің салыстырмалы талдауы ұсынылған. Зерттеу горизонталды және көлбеу-бағытталған ұңғымаларды бұрғылау кезінде гидроимпульстік өзара әрекеттесу жүйелерінің тиімділігін бағалауға арналған. Бұл дәстүрлі әдістерге тән статикалық жүктеменің жеткіліксіздігінен бұрғылау жылдамдығының төмендеу мәселесін шешуге мүмкіндік береді.

Зерттеу барысында гидравликалық соққылы құралдардың бұрғылау жылдамдығын арттырудағы, ұңғыма оқпанының тұрақтылығын күшейтудегі және әдетте төмен өтімділікті әрі вертикалды жарықшақтары бар коллекторларда туындайтын өндірістік мәселелерді жұмсартудағы әлеуеті зерттелді.

Гидроимпульстік жүйелердің құрылымдық негізгі параметрлері, соның ішінде қисықтық радиусы, осьтік жүктемелер және ұңғыма траекториясының профилдері қарастырылды. Бұл параметрлер бағытты дәл бақылау мен тау жынысын тиімді бұзуды қамтамасыз ету үшін маңызды. Импульс жиілігі, соққы энергиясы және коронканың айналу жылдамдығы сияқты параметрлерді оңтайландыру үшін заманауи математикалық модельдер қолданылды. Күрделі геологиялық формациялардағы бұрғылау мәселелерін шешу мақсатында роторлы-соққылы технологияларды дәстүрлі әдістермен біріктіру мүмкіндіктері қарастырылды.

Сонымен қатар, мақалада қолданыстағы гидравликалық жүйелерге жаңа жетілдірулер ұсынылады. Олардың ішінде серіппелердің жетілдірілген конфигурациялары бар, бұл серіппелердің жартылай істен шығуы жағдайында құралдың жұмысын жалғастыруды қамтамасыз етеді. Baker Hughes компаниясының AutoTrak және Sperry-Sun компаниясының Geo-Pilot технологияларымен салыстырмалы талдау гидроимпульстік жүйелердің практикалық қолданудағы артықшылықтары мен шектеулерін көрсетеді.

Зерттеу нәтижесінде бұл жүйелерді енгізу бұрғылау тиімділігін едәуір арттырып, шығындарды азайтып, күрделі жағдайларда көпсайлы ұңғымаларды тиімді құруға мүмкіндік беретіні анықталды. Бұл зерттеудің нәтижелері Қазақстан және басқа да мұнай өндіруші *өңірлердегі бұрғылау технологияларын одан әрі дамытуға ықпал етеді деп күтілуде, сонымен қатар коммерцияландыру мен практикалық қолдануға кең перспективалар ашады.*

ТҮЙІН СӨЗДЕР: *гидравликалық соққылы жүйелер, көп кенжарлы бұрғылау, ауытқытқыш, тау жынысының беріктігі, көлбеу бағытталған бұрғылау, бұрғылау жылдамдығы, резервуарды игеру тиімділігі.*

Introduction. The development of many fields involves an abundance of oil reservoirs located at relative distances from each other. To achieve the maximum level of optimization of the production process, it is necessary to implement an optimal development system. The methods of drilling oil and gas fields by inclined as well as horizontal methods used nowadays can be rightly classified as an effective approach to solving the issue of well distribution. The result of using the above methods when opening the productive strata is the exclusion of water inflow in the process of utilization, increase in filtration parameters.

Horizontal drilling has a lot of positive characteristics, but the rate of drilling using the traditional method is much inferior to vertical drilling. The reason for this is the lack of pressure on the bit by weighted drill pipes. In the absence of static load, the optimal solution to this problem can be the introduction of hydraulic pulse interaction systems, which in turn will increase the drilling speed by replacing static load with dynamic load.

The introduction of percussion-hydraulic generators in the technology of oil and gas-bearing horizons development contributes to enhanced oil recovery and significantly increases the drilling speed relative to the traditional method.

In connection with the above, a number of promising tasks at the moment include further research in the field of development and creation of improved rotary-impact drilling systems, which in turn will be a significant factor affecting the productivity of drilling, and as a result of increasing oil recovery in the oil and gas sector of the economy of our country.

The purpose of this paper is to determine the effectiveness of water hammer systems in horizontal and directional drilling by comparing current systems and innovative industry approaches. Determination of the optimal method will increase oil recovery, especially effective for penetrating low-permeability reservoirs and reservoirs with vertical fracturing. Research in the field of drilling multilateral deviated and horizontal wells has significant prospects in many fields of Kazakhstan and can form a sustainable basis for the future development of the energy sector of the country.

Materials and methods. In order to identify the optimal approach to drilling horizontal and directional wells, a comparative analysis was made between the innovative drilling technology using a hydraulic pulse generator and analogs that are currently available for use by field operators in the global technology market. A number of measurements of design parameters were made on the basis of technological data on the considered technology, parameters of deviation profile calculation, calculation of deviation radius, determination of axial loads during operation, as well as analysis of bit penetration rate during drilling were analyzed.

To make a successful start for the drilling process of horizontal and directional wells, it is necessary to make a highly accurate preliminary calculation of the trajectory elements of directional wells. To determine the well profile, the required value of the maximum zenith angle is determined by the formula:

$$\cos\ \alpha = \frac{\left[R(R-A) + H * \sqrt{H_2} + A_2 - 2AR\right]}{(R-A) * 2 + H_2}, \qquad (1)$$

where R is the radius of curvature of the second section of the wellbore, m; A is the deviation value of the bottom hole from the vertical, m; H is the vertical depth interval of the second and third sections of the wellbore, m.

When calculating the profile of the second type, the length of the fifth vertical section is first established. If an oil or gas well is designed for a multilayer deposit, the length of this section of the wellbore should be not less than the total thickness of the deposit plus 5%-10% of it. [1] The required zenith angle of the third barrel section is determined from the following formula:

$$\sin\ \alpha = \frac{[R_o H * (R_0 - A) * \{(H_2)2 - A(2R_0 - A)\}]}{[H_2 - (R_2)2] - A(2R_0 - A)}, \qquad (2)$$

where: $R_o = R_1 + R_2,\ H = H_0 - H_в - H_з$.

When calculating the third type of profile (Figure 1), when the well depth, the length of the first vertical section and the bottomhole deviation from the vertical are known, the radius of curvature of the second section is determined. In addition, the angle with the pay zone (the angle between the wellbore axis and the bedding plane) can be specified. [2] Then the zenith angle at the point of entry into the formation is determined by the formula:

$$\alpha = 90 - \gamma - \beta \qquad (3)$$

where: γ - angle of encounter between the well and the formation; β – is the dip angle of the formation.

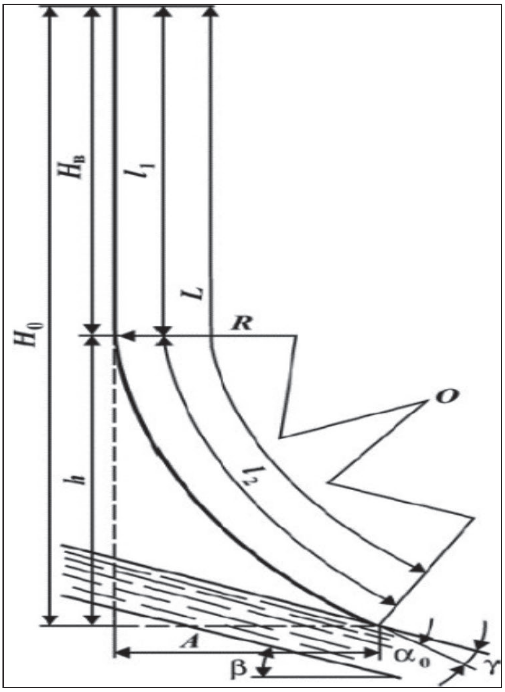

Figure 1 – **J-type directional well (third type), vertical projection**

In some production conditions it may be necessary to change the length of the vertical part of the wellbore, this can be achieved by changing the entry angle of the well into the formation. [3]

One of the most important factors affecting the success of directional drilling is the correct determination of a number of deviation parameters, including radius, when dialing in the borehole curvature. The need to operate deviation tools and navigation aids while dialing in the curvature of the well creates production challenges that complicate the directional drilling process. The radius of curvature of the directional well should be minimized as much as possible to reduce to the limit the interval in which the interaction with the aforementioned tools will be reduced. [4]

However, during the attempts to reduce the interval, it is necessary to use some rules, in order to increase the life of the equipment, as well as all holistic industrial safety:

1) The intensity of curvature in normal case should not exceed 1.5°/10 m of penetration;

2) Sufficient axial load on the bit should be provided in any drilling interval;

3) The formation of troughs in curved intervals of the wellbore should be excluded. This condition can be quantitatively evaluated by the lock pressure on the borehole walls:

$$R > 12 * \frac{P}{Q}, \tag{4}$$

where P - axial force acting on the drill pipes; Q - permissible normal force from the side of the drill lock on the borehole wall; 12 - average length of half of the drill candle. For sections composed of soft rocks, Q value can be taken as 10 kN, for sections composed of medium-hard rocks - 20-30 kN, for hard and strong rocks - 40-50 kN.

Pneumatic rotary percussion drilling of wells with pneumatic percussion drills MP-3, M-48 and P-105P (up to 71% of wells) is carried out in rocks with a coefficient of hardness from 6 to 20 on the scale of Professor M.M. Protodyakonov with a depth of up to 50 meters. [14]

In recent years, the use of underbalanced drilling technology in the well-bore-plate system has become more and more widespread in foreign well construction practices. [6]

4) Drill string during any work in the borehole shall not experience stresses exceeding the yield strength of the drill pipe material σ:

$$R > \frac{d * E}{2 * \sigma}, \tag{5}$$

where *d* - outer diameter of drill pipe; E is Young's modulus.

5) When running the downhole motor through curved sections of the wellbore, the stresses generated in the downhole motor housing must not exceed the yield strength of its material:

$$R > 0{,}25 * L_j^2[0{,}74(D - d_i) - K], \tag{6}$$

where L_j, d_i - length and outer diameter of downhole motor respectively; D - bit diameter; K - clearance selected on the basis of geological conditions (K = 0 for hard rocks, K = 0.003 ÷ 0.006 m for soft and medium rocks). [10]

The practice of recent years has confirmed high efficiency of percussive rotary drilling of wells and expediency of its application in combination with other known modern methods. [7]

6) Downhole instruments, submersible equipment and devices for workover and well operation must be freely lowered into the production casing and positioned without deformations.

To ensure this requirement, the following condition must be observed:

$$R > \frac{L^2}{[8 * (d_i - d_H - k)]} \tag{7}$$

where L is the length of the downhole submersible; d_i is the inner diameter of the production casing; d_H is the diameter of the downhole submersible; k is the gap between the inner wall of the casing and the casing of the downhole submersible (in most cases k = 0.0015 ÷ 0.003 m).

The wellbore curvature radius selected based on the above constraints is increased by 5% to 10% to account for anticipated deviations in project implementation. The curvature radius value is adjusted by comparing the axial load generated during the tripping of the drill string from the curved wellbore with the permissible load for the given drill string and drilling rig. To solve this problem, it is necessary to replace static loading (application of UBT) with dynamic loading through the use of hydro-pulse generators. [8]

At the moment in the world practice of application of hydro pulse signal generators, there are systems used in drilling directional systems, but many of them are considered ineffective in a number of aspects. The main objective of the invention is to increase the lifetime of the water hammer in the well to increase the technical speed of rotary-impact drilling. After careful analysis and study of the systems presented in the industrial market, it was decided to research in this industry, and attempts were made to improve existing technologies, or to develop a unique tool.

Non-oriented BHAs for SBO and GS drilling. With increasing volume of directional drilling, non-oriented bottomhole assemblies are more and more widely used in practice, with the help of which the intervals of set, stabilization and decrease of zenith angle of the design profile of directional wells are realized. [13]

According to the results of the work, an innovative patent RK № 29033 dated 15.10.2014, bulletin № 10 was obtained for the created samples of high-pulse hydraulic percussion system.

The invention is explained in *Figure 2*, which shows a longitudinal section of the proposed percussion device.

The percussion device consists of a tubular body 1, inside which the valve-piston 2 with return springs 3 and the percussion device 4 with return springs 5, resting with their lower ends in the anvil 6, installed with the possibility of longitudinal movement together with the bit adapter 7 relative to the body 1 are sequentially located. At the upper end of the body 1 there is an adapter 8 to the drill string (not shown in the figure) having a replaceable cylinder 9. The valve-piston 2 at the lower end has a stroke limiter 10, and at the upper end - piston part 11, under which there is a ring 12 to compress the springs

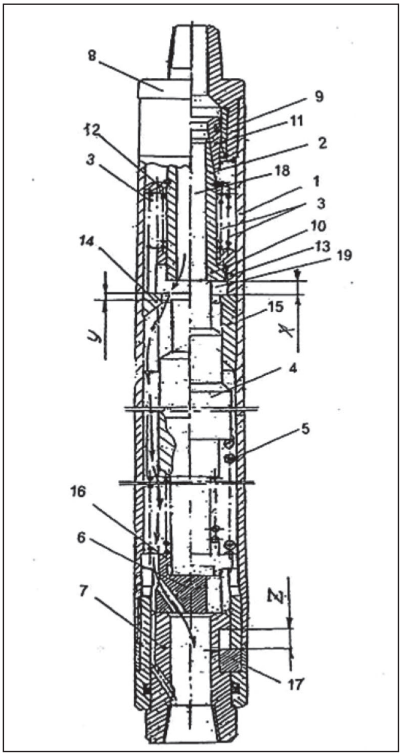

Figure 2 – **Longitudinal section of the proposed percussion device**

3 relative to the support sleeve 13, resting in the annular protrusion 14 of the body 1. To center the striker 4 in the body 1 there are slotted projections 16 in the anvil 6. Bushing adapter 7 is installed with the possibility of longitudinal movement relative to the keys 17, mounted stationary in the sockets of the body 1. When the water hammer operates, a cavity 18 of high pressure (see the right side of the figure) and a cavity 19 of low pressure of the fluid medium are formed.

In the figure, on the left side, the striker 4 is shown in the lower position, and on the right side - in the upper position. The left side of the figure shows the axial position of return springs 3 and 5, and the right side of the figure shows the concentric position of the return springs.

The Latin letters in the figure indicate:

X - valve-piston stroke;

U - free stroke of the striker;

Z is the amount of compression of the firing pin return springs.

To construct a horizontal projection, first draw a point marking the wellhead, then, using a protractor, draw a ray from this point in the direction of the design azimuth and lay off on it a segment equal to the length of deviation of the bottom hole from the vertical through the wellhead. From the end of this segment, marking the design bottom of the well, on the same scale draw a circle limiting the tolerance of deviation of the bottom hole from the design target. From the wellhead point draw two tangents to the constructed circle (limits of possible deviation of the actual borehole trajectory from the design trajectory). [12]

When interacting with weak to medium hard rock (from V-VII category) using rotary percussion drilling techniques, we will not see a meaningful difference if we were to use rotary drilling. [11] In order to get a tangible progress in efficiency, we can use more depth of cutters by applying percussion pulses. This condition will help to seal the contact of the cutters with the drilled rock surface, when interacting with hard species. Controlling the optimal operation of the hydraulic pulse generator is one of the most important goals, as excessive load will result in increased wear of the cutters, which in turn incurs third-party repair and replacement costs. This results in optimum conditions for shock pulse transmission and tool stability.

The crown speed determines the distance that each cutter travels between two adjacent impacts, as well as the total friction path of the impact pulses on the rock and the degree of wear. The optimum value of this parameter (in rpm) is calculated using the following formula:

$$N = \frac{m_p * \delta}{\pi * D_{av}}, \tag{8}$$

where m_p - frequency of impact pulses per minute (taken from the technical characteristics of the water hammer), δ - the optimal length of the cutter run between adjacent impacts, mm; D_{av} - average diameter of the crown, mm.

The value of δ depends on the hardness and abrasiveness of rocks, as well as on the diameter of the drill bit. For low abrasive rocks of VI-VII categories δ is 16-30 mm, for hard and highly abrasive rocks of IX-X categories δ is equal to 4-5 mm. The axial load on the bottom hole depends on rock properties and borehole diameter, varying within 4-10 kN, with increasing hardness and abrasiveness of rocks and decreasing borehole diameter the load approaches the lower limit of the specified range.

Each subsequent layer of rock is fractured using the effect of partial unloading, i.e. weakening of the rock during the fracture of the previous layer. Approximately drilling speed, m/s, at rotary-impact method can be calculated by the formula:

$$\vartheta_\beta = \frac{1{,}27A_p * n * tg\left(\frac{\alpha}{2}\right)}{d^2\sigma_c\left[tg\left(\frac{\alpha}{2}\right) + f_t\right]}, \tag{9}$$

where A_p - energy of a single blow, J; n - frequency of blows; α - angle of crown blade sharpening, deg; d - diameter of crown, m; σ_c - compressive strength of rock, Pa; f_t - coefficient of friction of steel on rock.

At rotary-impact drilling, as well as at rotary-impact drilling, the rock-destroying tool deepens into the rock only under dynamic impact, i.e. at the moment of impact. Drilling tool rotation is carried out continuously from an independent motor operating independently of the impact mechanism. At the same time, the tool remains pressed against the bottom hole by static force of 0.5-1.0 kN per 1 cm of the tool blade length.

The theory of the working process can be presented in the form of optimization of the ratio between energy and frequency of blows, at which the drilling speed will be maximum.

It is known that the impact power during drilling is equal to the product of the unit impact energy Ap by the impact frequency Z1, and for a given impact power the ratio between them can be different.

Drilling speed is related to the drill rotational speed and the drilling mud rate by the equation:

$$\vartheta = (\vartheta_r + \vartheta_p)n \tag{10}$$

where ϑ_r is the feed rate per one bit rotation during rotary drilling without impacts, mm/rev; ϑ_p is the feed rate per one bit rotation due to impacts, mm/rev; n is the drill rotation speed, rpm.

For strong rocks ϑ_r>0 even with a large axial force, taking into account the fact that there is a shock load, the value of ${}_r$ is different from 0. When drilling strong rocks, the feed rate for one turn is practically provided by the impact destruction, so:

$$\vartheta = \vartheta_p * n. \tag{11}$$

If the full depth of penetration of the drill blade into the rock h_p be used, then:

$$\vartheta_p = h_p * Z_1 \tag{12}$$

When developing well construction strategies in old fields, oil producers are primarily driven by the need for drilling efficiency combined with geologic uncertainty. [9]

In *figure 3* you can see some dependencies of drilling speed obtained as a result of calculations by the above formulas and studies. Two graphs are presented below. The

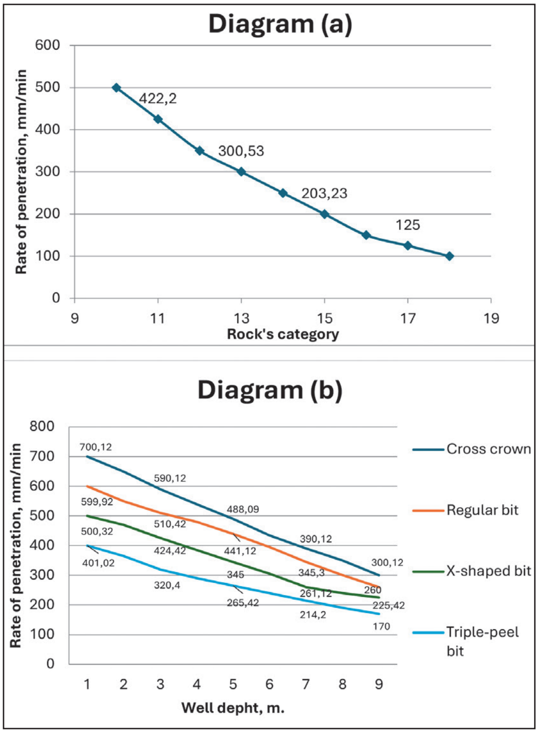

Figure 3 – **Graphs of drilling speed dependencies**

first graph (a) shows the dependence of drilling speed (y-axis) on rock strength (x-axis). The obvious assumption is that as the hardness category of the rock increases, the rate of penetration of the drill bit will decrease, from the graph we see that when the rock class 10-12, the average drilling speed is about 435-450 mm/min, but when we encounter rocks of category 16-18 (rock hard to break), the average rate of penetration decreases to 75-90 mm/min.

The second graph (b) shows the dependence of drilling speed on borehole depth, for different types of drill bit bits. On the right are subcategories A, which includes rocks of strength 10-12. The lines on the graph are marked with numerical designation, each digit is linked to the type of drill bit crown: 1-bit, 2-triple-peel, 3-X-shaped, 4-cross crown.

The use of a hydraulic percussion system for drilling through casing cutouts is a promising solution for multilateral drilling. The use of the shock-hydraulic system makes it possible to create cutouts in casing strings, providing drilling of additional wellbores at considerable depth without the need for multiple tripping operations. This is especially relevant for wells located in difficult geologic conditions, where traditional drilling methods often prove to be insufficiently effective. As part of the project, various shock-hydraulic system and deflector designs will be investigated and tested to select the most effective for use in Kazakhstan's oil industry.

Results and discussion. This combination of innovative solutions, including new shock-hydraulic system and deflector designs, will improve drilling efficiency and increase recoverable oil reserves in low-permeability reservoirs. The project is expected to make a significant contribution to the development of drilling technology in Kazakhstan and internationally.

There are many advanced technologies being utilized in the directional drilling process today, some successful examples of innovation in this area are Baker Hughes and their AutoTrack rotary directional drilling system, Sperry-Sun who developed the Geo-Pilot rotary directional drilling system. Each company offers a different way to solve today's field challenges, with its own unique advantages.

Directional drilling is the process of drilling a well along a predetermined trajectory where maintaining precise directional control is critical. This process relies on various technologies designed to develop and monitor wellbore trajectories based on the complexity of the well. Specialized tools and instruments are employed to ensure maximum alignment between the actual and planned well paths.

In 1997, when the revolutionary Auto Track system was introduced to the world market, Baker Hughes introduced an innovative approach to drill string assembly design. A system of sensors, downhole computer and deflector allows the assembly to control itself while drilling. Accurately reaching a specific reservoir zone is accomplished through formation analysis and evaluation, as well as continuous monitoring of geologic conditions. This system has already shown its effectiveness worldwide, with this technology helping companies in more than 15 countries around the world to optimize their field development plan.

Principle scheme of the Auto Track system shown ant the *figure 4*. The layout sensor system allows vibration measurements to be taken, and once azimuth is determined, the data is transmitted via the downhole computer to the deflector. The downhole computer plays the role of the main manipulator of processes in this scheme. When receiving data

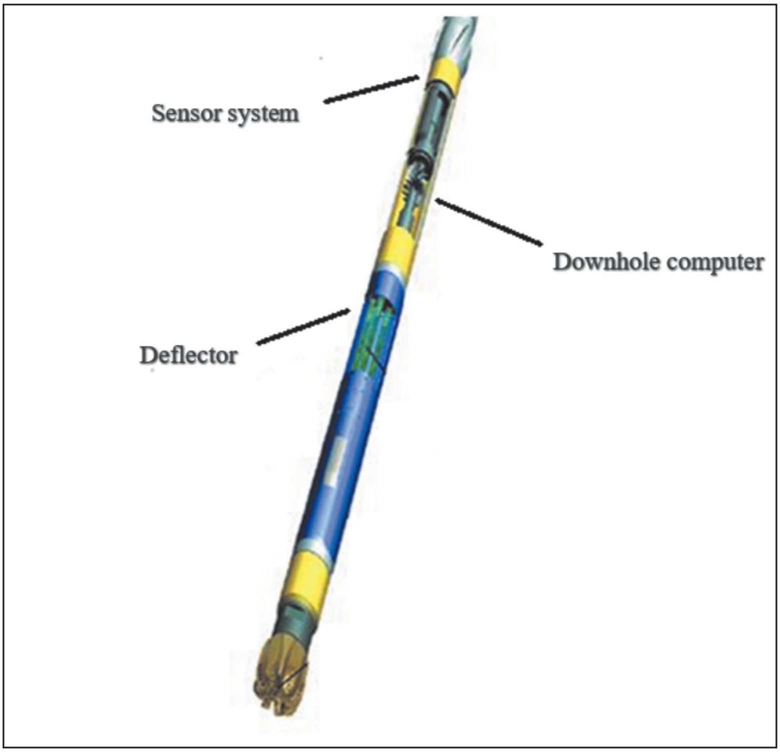

Figure 4 – **AutoTrack system scheme**

on the change, the comparison and subsequent control of the drilling direction, this model is able to maintain contact with the operator from the production in real time, as well as perform all necessary commands.

Sperry-Sun is actively developing efficient drilling and production methods to meet the challenges of the rig. The Geo-Pilot guided rotary drilling system now makes it possible to develop targets that were previously considered logistically and economically infeasible. Sperry-Sun has developed a controlled bit deflection technology for rotary drilling that allows the steering of the well course to be controlled at the same time as the drill string is rotated. This system is fully integrated with logging sensors during drilling. The Geo-Pilot system makes it possible to drill more complex directional wells and extended-reach wells, targets that were considered impossible to drill with conventional steerable layouts a few years ago. The shaft is hollow for unobstructed mud passage and there are no hinge joints to fail. [15] Geo-Pilot continuously delivers valuable real-time directional data to the surface for engineers, geologists, directional drillers and logging operators during the drilling process. This automated drilling system provides all the levers of control, resulting in significant time and cost savings.

To adjust the inclination and azimuth during drilling, both steerable and non-steerable BHA (Bottom Hole Assemblies) are used. Steerable BHAs can include bent subs with fixed or adjustable angles or eccentric components, as well as self-orienting deflection devices. Non-steerable configurations may feature components mounted on downhole

Table 1 – **Comparative analysis of technologies**

Technology	Advantages	Disatvantages
Hydraulic - percussion device	1. Highest economic benefit due to inexpensive equipment, and high uptime. 2. The use of a combination of technologies (cutting + rotation) allows high drilling speed results. 3. Extended range of technology applications using deflectors.	1.The technology is at the research stage, the experience of practical application is not so high
Auto Track	1. Improved borehole quality over traditional methods, i.e., smoothness and straightness because the AutoTrak tool has no bend. 2. AutoTrak allows you to drill with less torque and bit force, but at a slower bit rate.	1. A typical Auto Track hydraulic system includes a paired series of springs on the pistons, and a return valve, which leads to the pulse generator going out of service if one of them breaks.
Geo-Pilot	1. This system is integrated with logging sensors, enabling real-time monitoring of geologic parameter data	1. This technology is based on rotary drilling, which causes certain difficulties when encountering high-strength rocks 2. Drillstring slip steer is accompanied by significant tightening, which can limit the ability to transfer loads to the bit.

motors or drill collars, such as stabilizers of varying diameters, articulated joints, and combinations of joints with stabilizing elements.

With the introduction of hydraulic percussion systems already well-established in technology, a persistent issue remained: the valve piston and percussion valve are single cylindrical springs, so if one of the springs fails, the hydraulic percussion valve is disconnected and must be removed from the well. Additionally, when single springs are used, their length needs to be increased, which necessitates a corresponding extension of the hydraulic striker.

In the hydraulic impact device, which includes a valve-piston and an impactor, both spring-loaded and arranged sequentially in a tubular housing, the springs are designed as axially or concentrically arranged springs made from wires of smaller diameter.

The impactor is installed to allow longitudinal movement by a specified amount to precompression the spring. With this design, even if one or two of the impactor springs fail, the hydraulic impact device will generate impact pulses with a slightly reduced frequency but with higher energy per pulse. In the event of failure of some of the valve-piston springs, the frequency of impacts will increase, though the energy per individual impact will decrease due to a reduction in the valve-piston stroke, caused by the more vigorous upward movement of the impactor.

The use of a hydraulic percussion system for drilling through casing cutouts is a promising solution for multilateral drilling. The use of the shock-hydraulic system makes it possible to create cutouts in casing strings, providing drilling of additional wellbores at considerable depth without the need for multiple tripping operations. This is especially relevant for wells located in difficult geologic conditions, where traditional drilling methods often prove to be insufficiently effective. As part of the project, various shock-hydraulic system and deviator designs will be investigated and tested to select the most effective for use in Kazakhstan's oil industry.

Directional deviation of wells based on the use of artificial deviators: curved adapters, eccentric nipples, deviation wedges and special devices. The listed deviating devices are used depending on specific field conditions and technical and technological conditions.

This system has potential to grow into well performing production tool, as the project. So, this project at the present moment of time includes several key phases. First, the existing technologies for drilling additional shafts will be analyzed and different types of shock-hydraulic system and deflectors will be studied. This stage involves collecting data on the application of similar technologies in the world practice, as well as identifying the shortcomings of existing methods. Secondly, a new method of drilling with the use of the shock-hydraulic system will be developed, focused on reducing operating costs and improving the penetration of productive formations. An important part of the project will be to conduct laboratory tests of the new methods to verify their effectiveness under real conditions. It is expected that the laboratory tests will confirm the possibility of applying the developed solution in practice. Thirdly, based on the data obtained, recommendations will be prepared for implementation of the new technology at oil and gas enterprises.

The expected results of the project include the creation of a new drilling technology using a shock-hydraulic system, which will significantly improve the drilling process in difficult geological formations. This will increase well productivity and reduce equipment operation costs. Implementation of the developed solutions in the practice of oil and gas companies of the Republic of Kazakhstan will lead to an increase in their competitiveness in the international arena, as well as improve the economic performance of the industry. In addition, the project will contribute to the development of scientific and technical potential of Kazakhstan in the field of drilling and creation of new tools to improve well productivity. The project results have a high degree of readiness for commercialization.

Conclusion. Thus, in this paper we have obtained new scientific and practical results to substantiate the technology of enhanced oil recovery based on the use of hydro-pulse generators, the use of which provides a solution to a major applied problem that significantly increases the efficiency of production and drilling of horizontal wells.

The analysis of domestic and foreign scientists' researches shows that life extension and recovery of depleted fields is a priority task, covering many different technologies, the main of which is considered to be horizontal drilling, which allows to recover unrecovered reserves by improving the coverage of the formation drainage zone. It is in horizontal wells it is necessary to carry out works related to methods of oil recovery enhancement - application of physical-chemical, gas-hydrodynamic and other methods of influence on the bottomhole zone.

This project definitely has prospects for further development of hydro-pulse impact generators associated with large-scale use of rotary-impact drilling (including underbalanced drilling) of horizontal wells in low-permeability formations with subsequent application of hydraulic fracturing to increase the depth of already formed fractures.

The project also outperforms existing similar designs by emphasizing the combination of a percussive-hydraulic system with new types of deviators, which significantly expands the technology's applications. The expected results of the project will reduce drilling costs, increase well productivity, and improve multilateral drilling through casing cutouts.

This combination of innovative solutions, including highest economic benefits due to inexpensive equipment, and high uptime, the use of a combination of technologies (cutting + rotation) allows high drilling speed results, extended range of technology applications through the use of deflectors, all of which will improve drilling efficiency and increase recoverable oil reserves in low-permeability reservoirs. The project is expected to make a significant contribution to the development of drilling technology in Kazakhstan and internationally.

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