PRODUCTIVE RESERVOIR PENETRATION AND DEVELOPMENT OF WELLS BY DUAL COMPLETION METHOD*

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Abstract

Selection and use of rational method of drilling-in productive formations is one of the most important and complex tasks of modern technology of drilling and production of oil and gas. High-quality drilling-in of productive formations is the reason for an increase in the flow rate from productive low-permeable oil and gas formations. This situation ultimately leads to an increase in oil and gas recovery of reservoirs.

Keywords: formation, selective, paraffin, portland cement, lyophil, diesel, water, phase, hydraulic fracturing, inhibitor.

Within the frame of penetrating productive horizons (formations), the same technology and drilling fluid are usually applied as for drilling the rest of wellbore sections. Productive horizons (formations) are usually penetrated using water-based drilling fluids. In case of the use of such drilling fluids, water with fine fractions of barite is filtered into the formation. This process ultimately leads to the collimation and deterioration of the reservoir properties of productive formations, as well as low oil and gas recovery.

The importance of the study is the choice of types of drilling fluids in order to preserve the natural reservoir properties of productive horizons.

The purpose of the work. Development of more efficient methods of drilling-in and development at the lowest cost and their introduction into production to increase oil and gas production.

In connection with the above, the main purpose of the presented scientific research consists of the following:

a) proving the effectiveness of the method of drilling-in productive reservoirs in increasing oil and gas production;

b) reasonably choosing the types of drilling, grouting solutions in the application of drilling-in and fixing productive horizons;

c) conducting geological and technical analyses in choosing the right types of drilling fluids for drilling wells during drilling-in and development to increase oil and gas production and their justification;

d) making scientific and practical proposals on the improvements in this area, based on the results of scientific, theoretical and practical research using the method of drilling-in and development of reservoirs in increasing oil and gas production.

Main part. In respect of studied wells No. 147 Northern Goturdepe, formations from depth of 600 to 3800 meters, No. 37 Northern Goturdepe from depth of 800 to 4900 meters, No. 156 Northern Goturdepe from depth from 400 to 4100 meters and No. 200 Northern Goturdepe from depth from 600

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to 4900 meters were penetrated using ALKAR-3M drilling fluid developed at «Nebitgazylmytaslama» Institute of the State Concern «Turkmennebit». All productive formations for wells No. 37 and 200 Northern Goturdepe were penetrated using drilling fluid of ALKAR-3M type. With a view to increase the stability of wellbore walls and prevent complications, «Nebitgazylmytaslama» institut developed and put into production the formulation of inhibited aluminocalcium fluid system ALKAR-3M. The system is stabilized by lignosulfonates. Alkaline and acidic hydrolysates of portland cement are used as an inhibitor containing both anions (chromato-aluminates, ferrates) and cations (calcium, potassium, magnesium). A class of polyoxyalkylenes in selective solvents, performing the functions of a defoamer and lubricating additive, has been proposed as a hydrophobizing surfactant (hereinafter referred to as surfactant).

The industrial surfactant product provides an inhibitor of paraffin deposits in XT-48 oil.

The ALKAR-3M system properties suppresses the lyophilicity of clays due to its inhibiting;

1. Allows trouble-free passage of colloidal clays (dangerous packs of black clays of Apsheron formation),

2. Leads to significant savings in chemical reagents by reducing number of treatments, since fluid retains optimal viscosity and structural-mechanical properties for a long time during the drilling process.

Difference between the inhibiting fluids of the system and ALKAR is that they have increased clay capacity, but ALKAR-3M also has the fastening properties of FC, thereby increasing stability of wellbore zone. In this regard, fluids transferred to inhibited ALKAR-3M system can withstand high fluid loss values of 1,5–2,0 times higher in comparison with required values laid down in geological and enginerring ITC and, at the same time are able to maintain stability of wellbore for long time.

One of properties of ALKAR-3M is the increase in structure strength over time. Therefore, after long stops (for the period of geophysical surveys and others), restoration of fluid circulation is carried out at intervals after lowering the drilling tool into the cased part of wellbore (casing shoe). This determines sedimentation stability of solution for long time and reduces likelihood of sticking of drill string due to retention of barite particles and drill cuttings.

Productive deposits of fields at Southwestern Turkmenistan are characterized by complex and ambiguous composition of rocks, water, drilling fluid and oil. Each of components, interacting with the drilling fluid filtrate, predetermines the deterioration of reservoir properties and decrease in flow rates of hydrocarbon fluids.

Subject deterioration is mainly caused by two processes such as swelling of clays and formation of emulsions. Weakening of these processes is carried out through the use of drilling fluids, filtrates of which have a combination of inhibitory and surface-active properties. Depending on specific features, in particular, degree of shaleness of reservoirs, muds containing mineral inhibitors and surfactant XT-48, in comparison with other types of clay drilling muds, have the best (minimum filtration of water into the formation) properties, both when drilling a well and drilling-in productive deposits.

Oil-based fluids are used to penetrate productive horizons while maintaining natural permeability, as well as for drilling in particularly unstable clayey, salt-bearing deposits. In such fluids, dispersion medium is represented by diesel fuel, and the dispersed phase is finely ground oxidized bitumen.

At wells No. 147 and 156 Northern Goturdepe, all productive formations were discovered using hydrocarbon drilling fluid, at well No. 147 Northern Goturdepe from a depth of 3800 meters to a design depth of 4400 meters, and at well No. 156 Northern Goturdepe from a depth of 4100 meters to a design depth of 4300 meters, using an ALKAR-3M type system, where a transition to HC based mud was ensured, leading to successful completion of well construction to design depths.

Construction of wells No. 147, 156 Northern Goturdepe and penetration of productive formation with HC based fluid was carried out. In well No. 147 Northern Goturdepe, when drilling a Ø295.3 mm wellbore, replacement to HC fluid Versadril type from a depth of 3800 m was carried out. Further, Ø 295.3 mm wellbore from a depth of 3800 meters to a depth of 4206 meters along the wellbore was drilled directionally at inclination angle of 42 degrees and azimuth of 264 degrees with HC based fluid of Versadril type. Versadryl is one of the most appropriate systems for drilling active clays, where hole stability is the main issue. In addition, this system operates at high temperatures up to 180-190 degrees and has improved rheological properties of fluid and inhibition. The Versadryl system has very low water loss. Fluid loss can be reduced, if necessary, by adding Versatrol (fluid loss reducer) and VG-69 (crust clay). Subject system will prevent hydration of clays and, subject to appropriate density conditions, trunk instability and even prevent the process of cavities and oil seal formation, due to its high inhibitory abilities, and also has good lubrication characteristics (Deryaýew, 2015).

Schlumberger equipment was used to drill this interval to set the angle and reach the direction, which requires special control of the rheological parameters of the drilling fluid. The choice of hydrocarbon system was based on composition of this system, which is a direct emulsion, where the aqueous phase is a dispersed medium, which eliminates the chemical reaction of the solution with the rocks in the well. Calcium carbonate (Safe Carb) was added to this solution to prevent filtrate penetration and minor absorption. Addition of calcium carbonate made it possible to stop penetration of filtrate into microcracks and prevent instability of the wellbore. Type, parameters and components of the HC based drilling fluid used to penetrate productive horizons under the II intermediate and production casing at well No. 147 Northern Goturdepe are presented in Table 1.

Table 1

Parameters and components of HC based drilling fluid used for penetrating productive formations under the II intermediate and production casing at well No. 147 Northern Goturdepe

Parameters of drilling fluid	II intermediate casing (3800 m–4206 m MD)	Production casing (4206 m–4555 m MD)
Casing diameter, mm	295,3	215,9
Density, g/sm^3	1,40	1,46
Conditional viscosity (sec/q)	45–60	45–60
Plastic viscosity	<35	<35
Dynamic Shear Stress (lb/100 ft2)	15–25	15–25
Water loss ml/30 min	3–4	3–4
Solid phase (%)	<5,0	<5,0
Electrical stability	800–1500	800-1500
Salt content, % by weight	26	26
Lime, kg/m^3	18–25	18–25
Additional lime, kg/m^3	8–12	8–12
Diesel/water ratio (%)	70/30 (75/25)	70/30 (75/25)
Static shear stress	10–20	10–20
Type of fluid	Versadrill	Versadrill
Interval Components	Lime	Lime
	VG-69	VG-69
	Versamul	Versamul

Continuation of table 1

	Versacoat HF	Versacoat HF
	Versatrol	Versatrol
	$CaCl_2$	$CaCl_2$
	Diesel	Diesel
	Water	Water
	Barite	Barite

At well No. 147 Northern Goturdepe, drilling of Ø215.9 mm wellbore from 4206 meters to 4555 along wellbore was performed directionally at an inclination angle of 42 degrees and an azimuth of 264 degrees, with an offset of 298 meters with HC based fluid of «Versadril» type.

Versadril system has high emulsion stability and a diesel/water ratio of 70/30 with electrical stability maintained at 800–1500 Volts to create an emulsion and maintain the required solution parameters for a given range. Considering that this interval is with productive formations, fluid loss readings were kept within 3 ml/30 minutes. This fluid yield minimized the likelihood of reservoir damage and sticking of the drilling tool (Deryayew, 2017) right up to the wellhead.

Thus, for the case of technological need to use drilling fluids with a solid phase, the mechanical rate of penetration per bit sharply decreases due to the deterioration of the operating conditions of the drill bit. It is required to eliminate or significantly reduce the impact of solid phase in the drilling fluid. In order not to damage productive reservoirs, the solid phase content at well No. 147 Northern Goturdepe was reduced to a minimum of less than 5%.

Well No. 156 Northern Goturdepe, in contrast to No. 147 Northern Goturdepe, was drilled vertically to a design depth of 4300 meters with a drilling fluid density of 1.40 g/cm3. When penetrating productive formations, all parameters (electrical stability, water loss, emulsion creation, solid phase) were maintained stably at the required level (Deryayew, 2021).

Hydrocyclones, sieve hydrocyclones and double centrifuges were used to regenerate barite and remove solids. Centrifuges were constantly used to avoid solids in solution. Before cementing the casing strings Ø244,5 and 139,7 mm, the readings of the dynamic shear stress in the solution were reduced.

Thus, in order to maintain natural permeability during the initial penetration of productive formation, it is necessary to minimize the repression on formation (before drilling at «equilibrium»). When implementing such technology, the likelihood of oil and gas inflow and the danger of well blowout increases. In this regard, in order to manage the productive formation and reduce the risk of blowout, it is advisable to develop technical means for detecting oil and gas inflows in productive formation at the initial stage, that is, recording the moment of formation fluid appearance in the annular space in the productive formation zone. The drilling-in of productive formations is mainly carried out with a bit of the same diameter as the drilling of the overlying interval. The production string is lowered to the bottom of the well, and the cement slurry behind the string rises to a great height.

In the meanwhile, high hydrodynamic pressure is created on the productive formation during cementing, which ensures the penetration of the cement solution into the pores and cracks of the productive formation and often leads to hydraulic fracturing of the formation with the subsequent release of significant volumes of cement solution into it, as indicated by cases of insufficient rise of the cement solution to the design level. This is why a very important task when cementing a production casing is to reduce the hydrodynamic pressure of the cement solution on the productive formation and, if possible, completely eliminate contact of the cement solution with the productive formation.

During the cementing process of studied wells, Safety Rules in Oil and Gas Development Industry were strictly complied with. During cementing, high hydrodynamic pressure was not

created on the productive formation, and no absorption of cement slurry into the productive formations was observed. In all cementing processes, the level of rise of the cement slurry is obtained to the design level.

At wells No. 147, 37, 156 and 200 Northern Goturdepe, perforation of productive formations was carried out using cumulative casing perforators of PKO-89, PKO-102 types and Schlumberger perforator of Enerjet type. Data on perforations and research indications during the development process are reflected in Table 2.

Table 2

Perforation data and research indications during well development

№	Object designation, perforator type, number of holes	Distance of the tested object, (m)	Age, artificial depth, (m)	Development results
Well No. 147 Northern Goturdepe				
1	I Hollow-carrier jet perforator – 102 504	4008–4030 4040–4050	Sand IX	I-tubing, oil inflow; Cd=10mm, Pw=108 atm; Qf=321,3 m^3/day; Qoil=234,33 m^3/day
	Specialized filter	4150–4193 4238–4248	Lower Red-Sands-1	II-tubing, oil inflow; Cd=30mm, Pw=24 atm; Qf=557,1 m^3/day; Qoil=426,1 m^3/day.
Well No. 37 Northern Goturdepe				
2	I Hollow-carrier jet perforator -102 733	4448–4454 4612–4618 4626–4629	Lower Red-Sands -7 Lower Red-Sands -8	Oil inflow; Cd=25mm, Pw=35 atm; Qoil=730,33 m^3/day
Well No. 156 Northern Goturdepe				
3	I Hollow-carrier jet perforator -102 240	4000–4012	Sand IX	I-tubing, oil inflow; Cd=10 mm, Pw=84 atm; Qoil=241,0 m^3/day
	Specialized filter	4170–4300	Lower Red-Sands-1, 2	II-tubing, oil inflow; Cd=8 mm, Pw=77 atm; Qoil=241,6 m^3/day
Well No. 200 Northern Goturdepe				
4	I Hollow-carrier jet perforator -102 800	4046–4052 4057–4067 4071–4077 4079–4085 4086–4092 4094–4104 4122–4128 4134–4140	Sand IX	I-tubing, oil inflow; Cd=22mm, Pw=38 atm; Qoil=157,3 m^3/day
	Hollow-carrier jet perforator -89 545 Enerjet-43 273	4192–4198 4204–4216 4288–4292	Lower Red-Sands-1, 2	II-tubing, oil inflow; Cd=15mm, Pw=38 atm; Qoil=127,4 m^3/day

During the dual completion and developenmt of two – three formations, they are isolated from each other and the corresponding number of tubing strings are lowered into the well. As a result, separate development of formation is achieved. Thus, operation of each formation does not affect the development of other formations. It is also feasible to carry out necessary research and maintain given operating mode in each formation.

In all four studied wells, dual assembly was arranged in order to ensure dual completion and development of formations, and with the simultaneous operation of each formation not to impact nature of the operation of other formations. At wells No. 147, 156, the lower part, due to arrangement of specialized filters to productive section was performed without perforation. All conducted studies are patented.

For high-quality fastening of wells, a «System of hydrocarbon buffer fluid oil-based spacer fluid (OBSF)» for displacing hydrocarbon-based drilling mud during well cementing was developed and a limited patent No. 605 for the invention was registered in the state register dated 06/16/2014.

Development at all studied wells was carried out by replacing the hydrocarbon and clay fluid with water and supplying gas to a short lift of the pump-compressor pipes using the gas-lift operating method. Upon replacement of fluid with water, long elevator was mastered using free-flow production method. In connection with successful development of science and invention of new technologies in the field of high-quality penetration of productive formations, extensive experience has been accumulated, application of which promotes significant progress in foreign companies.

Currently, following types of materials and equipment are used for high-quality primary and secondary penetration of productive formations:

– liquid barite in order to reduce the solid phase in composition of the drilling fluid.

– drilling fluids without solid phase: calcium bromide, magnesium bromide, zinc bromide and cesium formate.

– drilling and development of wells with liquid nitrogen.

– drilling in balance.

CONCLUSIONS

1. In order to improve the quality of cementing, the buffer liquid «UBSS» has been specially developed using this technology.

2. A patented inhibited drilling mud of the PACS (potassium alumocalcium solution) type has been developed in order to open layers at a great depths with high-temperature complex mining and geological conditions.

3. Hydrocarbon-based drilling fluids provide the possibility of drilling unstable, swelling or expanding rocks in the aquatic environment, and prevent oil seal formation and tool grabs due to the pressure drop between the well and the formation. They have the best lubricating properties, protect the tool from corrosion.

4. The resulting large inflow of oil from four wells proves the correct selection of drilling mud types, parameters of the grouting solution when drilling-in and fixing productive formations.

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