OIL AND GAS EXTRACTION

The effectiveness of modern technologies of secondary opening of productive horizons and the ways of its improvement

UDC 622.245.142

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The technologies of secondary penetration of productive formations are considered. Main factors affecting the efficiency of technologies in well completion and operation are shown.

The success of geological exploration (GE) of oil and gas is defined from the technology that is used at the main stages of exploration: seismic exploration, drilling and wells completion. In the field of drilling technology and well completion the most important factors that influence the ultimate effectiveness of the opening of the productive horizons and evaluation of the reliability are the values of repression in the reservoir during the primary and secondary opening, physicochemical properties of process fluids that are used during drilling and secondary opening layers, as well as some technological parameters: perforation depth, quantity, phasing angle holes, hole diameter [1-5].

The purpose of the work is to assess the effectiveness of modern methods of secondary opening of oil and gas reservoirs and to determine ways of its improvement.

The analysis of professional literature [2] shows that secondary opening of productive layers with repression in brine solution (CaCl2, KCl) leads to lower productivity of wells by 40-50 %, oil by 20-40 %.

According to data [1-3] of assessment of the initial opening of drilling productive horizons in the fields of Ukraine following features can be identified:

unacceptably high values of repression during the initial opening of productive horizons, especially in the intervals of abnormally low reservoir pressure (ALRP) at the depths exceeding 2,500 m, this leads to the need to use special activities to trigger off the influx of reservoir fluid [1];

drilling solutions and water-based fluids of well jamming (FWJ), including salt solutions, lead to deterioration of reservoir properties of reservoir granular rocks and permeability reduction by 20-50 % depending on the initial permeability; according to the date, particularly [2], the use of emulsions "water in oil" or petroleum based drilling solutions (or FWJ) enables to obtain specific well efficiency 4-20 times greater than the flushing of bottom hole with water or water-based drilling solution;

special drilling solutions are used outside Ukraine (in some cases in Ukraine) that pollute the area around the hole less; foreign drilling and service companies are using technology to balance the initial opening and pressure drawdown.

International experience [2-5], as well as author studies conducted for several dozen fields of Dnieper-Donetsk Basin (DDB), Carpathian and Transcarpathian basins showed that it's very important for ultimate effectiveness of the opening of productive horizons the technologies of secondary opening: in case of drawdown, on the equal balance or overburden on formation. For drilling technologies with the use of clay, polymer-salt, polymer-humate solutions [1], or even petroleum-based solutions [2], which is used in Ukraine and neighboring countries, the general rule is a completion of the hole with cumulative perforation for drawdown, on the equal balance or minimal overburden on formation, rarely with hydroperforation or filter. According to our research in the fields of DDB and Sarmatian deposits of Prikarpatsky basin and due to the perforation technology for pressure drawdown with small perforators on the cable the increase of well flow rate in gas and condensate reaches up to 1.2-1.5, sometimes twice or thrice in comparison with perforation the same objects in the overburden with more powerful charges. According to [2], perforation of drawdown with perforators PR-43, PR-54 causes the increase of well flow rate twice or thrice in comparison with perforation charges PCB-80 even after additional intensifying pressure inflow of generator of type PHD.BK-100/150.

Under the conditions of deep drawdown during perforation in a gaseous medium the effect is enhanced so that the performance of the well is increased a lot [6, 7]. In the Russian Federation, the technology of opening of massive gas fields are used in two stages:

Under the conditions of deep drawdown the first few meters of productive horizon are opened with following purification on the torch of open area for a few days;

The opening of the reservoir main body is carried out in a gaseous medium that provides the increased depth of perforation hole of well performance a lot and reduces the cost of development and maintenance, as well as the impact on the environment [6, 7].

Hollow-carrier perforators on the cable and charges of extremely deep invasion, that are creating channels in the rock reservoir in 1.5-1.6 times deeper than their counterparts, are well established in the fields of oil wells in Western Siberia, where they are used for reperforation and overperforation of order to level the profile inflow, the intensification of fluid reservoir influx into active, including in low-wells [8].

Positive results in the case of perforation on overburden on formation of gas condensate wells even with charges of super deep invasion can be achieved only if the following conditions are met:

opening of a minimum of overburden;

injection of a special liquid into project material that does not pollute the rock-collector;

carrying out perforation in the shortest time;

carrying out work on the well development immediately after perforation.

It should be noted that during the overburden on the formation a rock-collector is in a state close to the compression, but in terms of drawdown, especially deep, with perforation in a gaseous medium rock-collector which increases porosity, opening cracks, that means deconsolidation of the rock and the increase of the channel depth. Some formations are deconsolidated by the known mechanism of zonal disintegration of concentric circular cracks around the unloaded well.

During the design work on the secondary openings often the real depth of the channel in the rock reservoir in situ is not considered, which should be commensurate with radius of clogging zone or exceed it for successful object opening. On the Fig. 1 the dependence of the coefficient of hydrodynamic perfection of well from length [2] of the perforation channel is shown. Hence the following result: if the area around the hole is reduced by 10 times of the permeability with the size (radially) of 100 mm, then a channel length l_k = 90 mm gives φ = 0.4, and l_k = 150 mm – φ about 0.9, more than twice. For most of the wells drilled in clay mud with overburden of formation, an area of contamination is 0.4-0.6 m, and in some cases up to several meters [2]. So for quality opening it is necessary to have charge of the depth channel exceeding the size of the filtrate invaded zone, that should be no less than 600-700 mm. The majority of Ukrainian and foreign perforations of mass application have just the same channel parameters or even more, obtained by the method of target shooting of API RP-19B. However, they usually do not provide the well connection with unpolluted area of the reservoir.

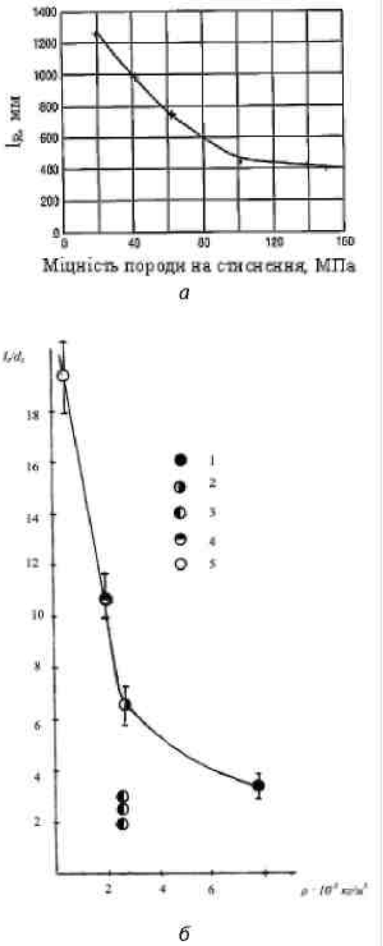

Fig. 2. The dependence: a - channel depth from strength [2]: concrete (20 MPa); soft sandstone Berea (41 MPa), solid sandstone Berea (63 MPa), hard rock Nugget (104 MPa), Granite (140 MPa) Blue Thor (154 MPa), b - relative channel depth from the density of the target material (1 - steel, 2 - aluminum alloy, 3 - granite, 4 - concrete, 5 - foam)

The perforation depth in the rock reservoir is usually different from the depth obtained in the channel depth l_c from the resistance of rocks [2], in Fig. 2b - from the density of the target material. The curve in Fig. 2b the authors obtained in the tests of the cumulative airtight charge ZKM-38D on aerocrete, concrete, granite, aluminum and steel targets (d_c – diameter of charge cartridge). The porosity of aerocrete, concrete and granite in the experiments was respectively 80-82, 20-22 and 1.7-1.9 %. Considering that with increasing of rock density usually increases strength [9], we can predict that the solid rocks of the sedimentary cover and rock foundation the channel depth will be lower, and in the rocks of medium and high porosity, fractured rocks will be more. But it will always be less than the channel depth obtained on the targets of artificial geomaterials or a core material which are promoted by manufacturing and service companies. The graph on the Fig. 2b illustrates the known experimental result of a sharp decrease in the channel depth in brittle materials and rocks (granite channel depth is lower than steel). This means that for dense sedimentary rocks and foundation rocks it is necessary to use a more powerful system perforation.

The analysis of the work results from the secondary opening of productive horizons with increasing depth indicates that at depths more than 4-4.5 km the efficiency of all perforation is reduced because of the decrease in porosity and increase the rock resistance. So often the well did not reach the design productivity [10]. With depth increasing it is necessary to increase the depth and a number of holes, i.e. the power of perforation charges and to accompany the opening operation with the intensification of the reservoir inflow [2].

In reservoirs with low porosity, particularly at the border rate ($k_п \leq 5–8$ %), the perforation efficiency also falls down sharply. For this type of collector a technology of well completion is required with the inflow intensification or construction of aimed and inclined horizontal wells with completion of their deep invasion perforation, and in some cases the inflow intensification, as it is done during the extraction of shale gas and gas of central basin type type. An alternative may be a special technology of initial opening with limitation of mud filtrate invasion into the reservoir [11].

The reducing of the channel depth in dense hard rock reservoir to some extent is compensated by the crack formation around the hole, which can found in experiments [2]. During overperforation of before perforated intervals these cracks increase in size under the influence of shock waves and hydraulic flows, especially from the charges of cumulative perforators without casing and torpedoes. In the interaction areas of the blast waves from the neighboring charges dilatancy areas can be formed [2, 9]. Cumulative ray penetrates the rock, saturated with filtrate of drilling solution that enhances the intensity of the shock and cracking process.

These physical and mechanical effects explain the positive intensification impact of reperforation at the wells performance, which is further enhanced in the case of perforation in physically and chemically active fluids. It should be noted that there is a class of collectors who have held the opposite: the walls seal of the perforation hole. These are mainly clay and highly porous sedimentary rocks.

It is known that a non-zero angle of charge phasing in the perforator (60°, 90°) increases the well productivity by 10-15% [4]. This fact is explained by the spatial diversity of the holes, which are located in a spiral rather than along the generatrix at zero phasing angle. This arrangement allows the holes to prevent a further thickening of the plastic reservoir in case of high density perforation and increases the volume of drainage area in brittle rocks and quasi-brittle reservoir, reduces hydraulic resistance of fluid movement near the well.

Due to the examples of Yuliyivskyy, Skvortsivskyy and some other fields it was found that the high reservoir pressure in the gas fields and moderate values of overburdern on the foundation during the initial opening reservoir of average porosity, good results are obtained even in the case of perforation during overburden and drawdown in older systems perforation PKSUL-80, DFP-89 , PR-43 and more.

If there is no result after the second opening of low porosity reservoirs, in reservoirs with ALRP, represented with pure quartz sandstones, and in collectors represented by foundation rock (granite, granodiorite), it is recommended to use explosive-pulse method of intensification (section torpedoes , oil-oxidizing mixture etc.), and for rocks with small impurities of the plastic component (clay sandstones, siltstones, including calcareous cement) use pulse-chemical methods of intensification (small section torpedoes, powder generators pressure in combination with chemical and physical chemical reagents in the absence of nearby aquifers).

Finally, it should be noted the main ways to improve opening efficiency of productive horizons:

technology of filtering limitations of the liquid phase of drilling fluids in the reservoir;

technological improvements and technology of secondary opening of productive layers.

From all described above the following conclusions can be made.

Based on the professional literature and research of the authors on the effectiveness of second opening of productive horizons it was found that the conditions of successful opening of object search and extraction of traditional hydrocarbons are controlled moderate values of overburden on a foundation during the primary and secondary opening, the predominant use of secondary opening in deep drawdown layer or at equal balance, the increase of the number and depth of the holes with depth of the reservoir, the minimum period of work, the use of intensification liquids during the second opening in terms of overburden on foundation. In case of non-compliance with specified conditions intensification treatment should be applied to the working space area of the reservoir, including overperforation and reperforation of perforated intervals in the first stage, the physical, chemical and integrated methods of intensification in the second stage.

In reservoirs with maximum porosity a well completion should include intensified inflow with formation of new drainage channels in the layer in vertical,inclined-aimed and horizontal wells.

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