RGNZ/MGPB

Selection of the optimal technology to prevent sand production, taking into account rock deconsolidation in the bottomhole formation zone

Rudarsko-geološko-naftni zbornik
(The Mining-Geology-Petroleum Engineering Bulletin)
UDC: 622.276.67:553.98
DOI: 10.17794/rgn.2024.4.9

Preliminary communication

Larisa Churikova[1]; Samal Akhmetzhan[2]; Gali Gumarov[3]; Ainash Mukambetkaliyeva[4]; Kumiskali Gubaidullin[5]

[1] *West Kazakhstan Innovation and Technological University, 44 Ihsanov Street, Uralsk, 090001, Republic of Kazakhstan. ORCID https://orcid.org/0009-0000-1262-5794*

[2] *West Kazakhstan Innovation and Technological University, 44 Ihsanov Street, Uralsk, 090001, Republic of Kazakhstan. ORCID https://orcid.org/0009-0009-7119-271X*

[3] *M. Utemisov West Kazakhstan University, 162 N. Nazarbayev Avenue, Uralsk, 090000, Republic of Kazakhstan. ORCID https://orcid.org/0009-0006-1600-6193*

[4] *West Kazakhstan Innovation and Technological University, 44 Ihsanov Street, Uralsk, 090001, Republic of Kazakhstan. ORCID https://orcid.org/0009-0001-1422-1555*

[5] *West Kazakhstan Innovation and Technological University, 44 Ihsanov Street, Uralsk, 090001, Republic of Kazakhstan. ORCID https://orcid.org/0009-0008-7462-3282*

Abstract

This article presents studies on the selection of the best sand control option, technologically based on the application of the method of fixing the bottomhole part of the well system with polymerized proppant, which will prevent the destruction of the formation zone of the wells and facilitate the development of the Kumkol field in the future. During the development of the Kumkol field, the main and most complicating factor in the operation of wells is sand production, leading to long downtime and repairs. The aim of the study is to scientifically substantiate and improve the technological methods of fixing the bottomhole zone of the well system to exclude or limit sand production with the well production of the Kumkol field, taking into account the current state of the reservoir rocks. The work applied a set of research methods, including: analysis of the experience of combating sand ingress at the Kumkol field; the use of the theoretical foundations of the relationship between the methods of anti-sand filtration and the properties of reservoir rocks; mathematical experiments on the constructed geological and mathematical model of the current state of the rocks of the decompacted zone. The scientific novelty of the work lies in the establishment of patterns that relate the impact of the destruction of reservoir rocks with a weakly cemented property in a production well on the degree of formation of deconsolidation zones at the bottom of wells that reveal a weakly cemented rock formation.

Keywords:
productive reservoir; weakly consolidated formation; sanding; proppant; fracturing

1. Introduction

One of the major oil fields that contributes to the nation's oil output is the Kumkol field, which is situated in the Republic of Kazakhstan. It is administratively a part of the Kyzylorda region and is located 150 kilometres northeast of Kyzylorda. The Kumkol field has 23,143 hectares in total. Hundreds of producers and injectors are actively involved in enhanced oil recovery (EOR) and oil extraction operations across the field's large number of wells. The distribution of the wells is determined by a number of completion techniques, including multilateral, horizontal, and vertical completions, which are selected in accordance with the production needs and geological features of distinct field segments. PetroKazakhstan Kumkol Resources and Turgai-Petroleum are two of the largest firms operating in the Kumkol field. As of January 1, 2016, 314 wells in the active production fund are managed by PetroKazakhstan Kumkol Resources, and 143 wells are under the management of Turgai-Petroleum. These businesses are essential to the growth and continuous productivity of the industry because they use their resources and experience to maximise oil recovery and efficiently manage field activities. The Kumkol field's development and eventual rise to prominence as a crucial part of Kazakhstan's oil sector began in 1984 with the drilling of the field's first well (**Aydarbekov, 2020**).

Sand production is one of the main issues facing the Kumkol field. Sand control is a recurring problem that can have a big impact on the wells' longevity and operat-

Corresponding author: Larisa Churikova
e-mail address: larisachurikova277@gmail.com

ing effectiveness. Although the amount of sand produced varies throughout the area, it might be significant enough to require regular management and intervention. The Kumkol field has a wide variety of sand particle sizes, from fine particles that may be passed through regular screens to bigger granules that need more stringent filtering and control procedures. The reservoirs at the Kumkol field contain a significant amount of sand (up to 20%) in production wells; therefore, sanding will be the maximum expected. During the operation this was confirmed. The removal of sand from a production well at the Kumkol field is reflecting the formation of sand plugs at certain intervals at the bottomhole, such a state is possible in any operating mode of well systems: pumping, gas lift, and flowing (**Gershtansky, 2016; Zotov et al., 1987**). The problem of combating sand ingress in the bottomhole formation zone is discussed in the works of many international scientists (**Khamehchi et al., 2015; Bondarenko et al., 2013; Service oil company, 2022**). Sand control is always one of the main tasks of process engineers (**Perera et al., 2017; Ranjith et al., 2013; Nouri et al., 2006; Isehunwa and Olanrewaju, 2010**). Thus, scientists from the Amirkabir University of Technology (Iran) conducted scientific research on the choice of several different methods to prevent sand formation. The choice of prevention method depends on various parameters of the productive reservoir as well as on technological and environmental factors in the production of oil fluid (**Khamehchi et al., 2015; Kunytska et al., 2024**). In their opinion, before choosing a method to prevent sand production and deposition, it is necessary to know the value of the filtration resistance of the oil fluid in the formation zone near the well, the clogging of which leads to a decrease in well productivity. According to scientists, knowing the skin factor of the method, it is possible to estimate the production of a well and the cost-effective use of a screen to protect against sand intrusion during a certain period. In search of a highly effective method for sand control (SC), several options for using proppant in the bottomhole zone (BHZ) casing were considered (**Dolgov and Zhikhor, 2015; Deryaev, 2024**).

Specialists of the "RN-Krasnodarneftegaz" private limited company proposed a new technology for fixing the wellbore formation zone using ceramic proppant coated with special resins (**Bondarenko et al., 2013; Service oil company, 2022**). Testing of this technology began in 2006, with subsequent implementation the following year. Another project, implemented by the same company "RN-Krasnodarneftegaz," allows for a reduction in the sand production rate by about 20%, thereby doubling the turnaround time of production wells: "Chemical bonding of weakly cemented rock," which considered the following technologies:

1. LINK – the technology is designed for the chemical bonding of weakly cemented rocks by pumping a water-based chemical composition into the formation zone of the wellbore as a plugging agent.

2. SECURE 2020 – the technology is designed to bind weakly cemented rock particles using an organosilicon compound soluble in oil fluid (**Service oil company, 2022**). LINK is formulated with a water-soluble synthetic resin, hardener-gasifier and water.

In the work **Perera et al. (2017)**, the authors conducted experiments on a model of a weakly consolidated reservoir containing sand. The purpose of these experiments was to simulate oil-bearing formations with the presence of sand at the stage of production of a productive formation, considering the process of producing oil fluid under various conditions. The conditions of fixing in the area of the bottomhole formation zone were considered, which affect the oil production rate and reduce the drainage of sand from the productive formation. In a high-pressure reservoir, there is a high probability of sand drainage during fluid movement to the bottomhole formation zone, as well as the presence of formation stress in the formation, which together affect the oil recovery efficiency factor. Thus, the percentage of sand drainage can be estimated from the content of resistance in the form of the presence of clayey rock, and accordingly, appropriate measures can be taken to prevent sanding. This implies the need for a better understanding of the mechanism of sand production, especially from poorly consolidated rocks, through detailed and accurate analysis of quantitative measurements.

In general, studies by **Perera et al. (2017)** showed that the dominant factors of protection against sand ingress into the wellbore are the properties of the cement screen, that is, the resisting ability of the screen material (**Ranjith et al., 2013; Nouri et al., 2006**). In their work, scientists **Ranjith et al. (2013)** found that the rate of sand drainage increases with an increase in drag force and decreases with an increase in clay content or during the period of consolidation of the bottomhole formation zone. In the work of **Isehunwa and Olanrewaju (2010)** scientists performed mathematical modelling of such a system, linking additional factors, including oil production rate, oil viscosity, reservoir grain size and density, sand drainage control. They found that under such conditions, there is an increase in sand production.

The aim of this study is to scientifically substantiate and improve the technological methods of fixing the bottomhole zone of the well system to exclude or limit sand production with the well production of the Kumkol field, taking into account the current state of the reservoir rocks. The main objectives of this study include the following: analysis of the causes and mechanisms of decompaction of rocks in the bottomhole zone, the problematic process of sand removal from productive horizons, including the parameters of reservoir conditions of the Kumkol field; the study of a model of the real situation of the bottomhole zone during well operation and methods for assessing its state; the use of an effective developed method to strengthen the bottomhole zone, taking into account the new proposed model of the reservoir system in the existing operating conditions of the field.

2. Research methods for analysing the sand production problem

The work applied a set of research methods. Analysing the experience of combating sand ingress at the Kumkol field, Republic of Kazakhstan, the authors examined information and approaches previously applied to address issues with sand production in this specific field. In order to comprehend the prior tactics used, this required examining the field's history, production data, and workover records. In the use of the theoretical foundations of the relationship between the methods of anti-sand filtration and the properties of reservoir rocks, researchers employed well-established theoretical concepts and correlations to link the characteristics of the reservoir rock (permeability, clay content, grain size distribution) to the efficacy of various sand control strategies. Mathematical experiments on the constructed geological and mathematical model of the current state of the rocks in the decompacted zone made it possible to evaluate the dynamics of its change in the bottomhole formation zone during the injection of compacting and strengthening agents. Considering the same productive reservoirs, it is noticed that the most problems due to sanding occur in wells equipped with suction rod pumps. Pumping liquid containing sand through the suction pump leads to the rapid wear of plungers, liners, valves and other pumping units, blockage of plungers in the pump cylinders and disruption of the fluid supply sand than gushing.

The reason for the destruction of the reservoir system is the stress in the rock as a result of fluid seepage. With a decrease in the filtration rate as a result of a decrease in the drawdown in the reservoir, the stress decreases. Therefore, in principle, damage to the zone of the well can be avoided by maintaining the flow rate at an acceptable level. The destruction of the bottomhole formation zone occurs in weakly cemented loose rocks, the flow of destruction products from such rocks to the bottomhole leads to complications and complex damage to downhole equipment. During the well development, when the inflow is induced, there is a detachment of rock particles from the walls of the perforation channel and the walls of the wells, due to high drawdowns. Also, a high percentage of water cut in the reservoir fluid contributes to an increase in the intensity of sand manifestations. The active agent (water) breaks down the clay cement when grain contact occurs, helps to reduce the cohesion of the sand grains, and adversely affects the possibility of sand grain arching.

To achieve the best result from BHZ well system anchorage, it is necessary to calculate such parameters as critical pressure and the required volume of sealing and proppant injection into the well. Thus, it is possible to use the model of compaction of unconsolidated rocks in the bottomhole zone of wells. Several fractions were sequentially pumped into the well: the rock consolidation process began with a proppant with a fine fraction of 16/20 and ended with a larger fraction of 12/18. This pumping process provided a more uniform proppant filling of the bottomhole zone and increased the size of the fixed part of the bottomhole formation zone, while reducing the risk of injection stopping due to blockage of proppant perforations at the beginning of injection. A proppant was used with a pre-applied polymer that bound the rock into a hardened structure under reservoir conditions. This prevented proppant backflow.

The incorporation of data covering diverse time intervals yields a thorough comprehension of workover activities and their progression over the course of the Kumkol field's existence. The ability to analyse long-term trends, spot possible operating condition transition points, and facilitate comparison studies between various operational phases is all made possible by this multi-period data presentation. In the end, adopting such a comprehensive perspective enhances the capacity to create workover strategies that are optimised and customised to the unique demands of the field's present and future development stages.

3. Results and Discussion

Based on the field data for the analysed period, 2347 workovers were carried out in production wells, of which 1934 are current and 413 are overhaul workovers of wells. Out of 1934 current workovers, 4 workovers were carried out on flowing wells, 1510 workovers were carried out on wells equipped with an installation of an electric centrifugal pump (IECP), 185 – on wells equipped with a screw rod pump unit (SRPU), and 235 – on wells equipped with a downhole rod pumping unit (DRPU). The distribution of current well workovers (CWW) by types and methods of operation at the production wells of the Kumkol field is presented in **Table 1**. CWW are routine, repetitive maintenance type operations on the producing wells, while overhaul well workovers (OWW) are major repair/remedial operations.

Table 1 reflects the use of the following types of repairs at the Kumkol field, which were carried out frequently:

- pump revision (861 repairs), pump revision and replacement (545 repairs) and removal of IECP pumps (210);
- revision and replacement of PCP were performed in 46 cases;
- to change the mode of operation, 106 repairs were made (5-11 points of **Table 1**);
- 26 workovers on wells equipped with IECP for the purpose of optimisation.

With 861 cases of just pump revision and 545 cases of both revision and replacement, a significant percentage

Table 1: Distribution of CWW by types and methods of operation at producing wells

No. p.p.	Types of repairs	Number of wells				Total
		IECP	SRPU	DRPU	The fountain	
1	Pump revision	820	2	39		861
2	Revision and replacement of the pump	301	136	108		545
3	IECP extraction	210				210
4	Revision and replacement of PCP	44	1	1		46
5	Replacing of IECP with DRPU	42				42
6	Replacing of IECP with SRPU	10	2			12
7	Replacing of SRPU with IECP	3	19			22
8	Replacing of SRPU with DRPU		5	1		6
9	Replacing of DRPU with IECP			19		19
10	Replacing of DRPU with SRPU			4		4
11	Transfer from IECP to fountain	1				1
12	Optimization. Change of IECP	26				26
13	Dismantling of the pump	3	4	19		26
14	Replacing the polished stem		2	15		17
15	Wellhead equipment repair		1			1
16	Pump installation	8		7		15
17	DPE extraction			11		11
18	DPE extraction. Transfer to the monitoring fund	10				10
19	Well evaluation. Pump replacement	7	12	11		30
20	Well evaluation				4	4
21	Bottomhole cleaning, PCP replacement	1				1
22	Paraffin plug cleaning of PCP		1			1
23	Suspension tube replacement	20				20
24	Cable revision. IECP replacement	2				2
25	Revision and replacement of the IECP cable	1				1
26	Revision and replacement of the pump in the water well	1				1
	Total:	1510	185	235	4	1934

Note: PCP – progressing cavity pump; DPE – downhole pumping equipment.

of workovers are devoted to pump revisions and replacements. Sand output increases downhole equipment wear and tear, requiring regular pump maintenance to address sand particle abrasion and clogging. It is important to control sand accumulation and preserve equipment performance, as demonstrated by certain workover tasks, including IECP extraction, revision, and pump replacement in the water well. The range of pump types and completion techniques (such as PCP and DRPU) that are employed emphasises even more how specialised strategies are needed to address sand-related problems. **Table 2** shows the OWW carried out at the production wells of the Kumkol field. The total number of repairs is 413.

Frequent geological and technical measures (GTM) were associated with perforating and blasting and repair and isolation works, which are aimed at improving well performance (**Bondarenko and Savenok, 2014; Suman et al., 1986**). Well logging, perforation of new intervals, reperforation and completion of existing intervals, and isolation of flooded intervals were frequently carried out using geological and technical measures. In order to recover well productivity, sand management concerns frequently necessitate re-perforation and pump replacements. OWWs were also often carried out, related to the commissioning of wells from drilling (50 repair works), the commissioning of wells into the production fund from other categories of the fund (36 repair works), a change in the production facility (19 repair work) and the treatment of the bottomhole zone (28 repair work). Analysing the types of current and major repairs carried out, the following conclusions can be drawn: the reason for the repairs is PCP leakage, wear of the cables of the electric centrifugal pump; repairs to optimise well performance; integrity of underground equipment, decrease or absence of flow rate, jamming of working parts of pumping units and leakage of underground equipment. The above reasons were caused by high-viscosity heavy oil, with the presence of sand in the production and with high water cut, the action of these factors occurs simultaneously (**Karmansky, 2010; Churikova and Nizamov, 2021; Zhikhor et al., 2014**).

Table 2: Distribution of OWW by types at production wells

No. p.p.	Types of repairs	Number of wells, units
1	Perforating new zones. Reperforation. Pump replacement	54
2	Input from drilling	50
3	Isolation of watered intervals (RIW). GIS. Pump descent	51
4	Commissioning of wells from other categories	36
5	Optimization. Ensuring slaughter. Pump change	32
6	Reperforation, well completion, communion	24
7	Operational facility change	48
8	BHT by Himeko-Service technology	15
9	Development (Redevelopment)	16
10	Ensuring slaughter. MAC	12
11	BHT by Orient-Terra technology. GIS	12
12	Input from the observational fund. Descent of the IECP	8
13	RIW ex. column leakage. Descent of the pump.	4
14	PD EOR by microbiological method	3
15	Input from the observation to the injection fund	2
16	Testing. GIS	3
17	Preparation for GIS. GIS	7
18	ACM record. Well testing	8
19	Well evaluation	6
20	Perforating new zones. Well evaluation.	4
21	Selective limitation of water inflows	2
22	APP liquidation	3
23	Swabbing	2
24	HF	1
25	Perforation. GIS	1
26	Enter from idle	1
27	PD RIW AC using Syntec technology. GIS. Descent of the IECP	2
28	RIW. HMSP. BHT	2
29	Bottomhole recovery. Shot Yu-2. GIS. Descent of the IECP	1
30	Bottomhole sealing with cement bridge installation	1
31	Further development with BHT (MAC-2) GIS-k. Descent of the IECP	1
32	Elimination of accidents (b/f)	1
	Total:	413

Note: RIW – repair and insulation work; GIS – geophysical investigation of site; BHT – bottomhole treatment; MAC – multicomponent acid composition; PD – pilot development; ACM – acoustic cement meter; APP – annular pressure problem; HF – hydraulic fracturing; AC – behind-the-casing, or annulus, circulation; HMSP –hydromechanical slotted perforator.

Table 3: Distribution of repairs at injection wells by types of repairs for 2013-2016

No. p.p.	Types of repairs	Number of repairs
CWW		
1	Bottomhole cleaning	137
2	Bottomhole cleaning, BHZ. Replacement of underground equipment	62
3	Revision of the ESI layout, bottom hole cleaning	22
4	PCP revision, bottomhole cleaning	7
5	Cleaning the bottomhole and bottomhole formation zone. Revision of underground equipment.	5
6	Downhole cleaning for IPA	3
7	Inspection and change of wellhead equipment	1
8	Bottomhole cleaning. Acceptance definition. Running PCP and packer	1
	Total:	238
OWW		
9	IPA	86
10	Translation to RPM	60
11	Bottomhole cleaning. perforating and blasting works	38
12	Bottomhole cleaning. Bottom hole treatment from MAC -1	34
13	BHT by Himeko-Service technology	9
14	Incorporation of horizons under ESI	7
15	RIW. HMSP. BHT	7
16	AS liquidation. Revision and change of PCP	6
17	Installation of equipment for separate injection	5
18	Commissioning of wells from other categories	4
19	Operational facility change	4
20	Redevelopment	3
21	Cement bridge drilling	3
22	RIW. GIS. Pump descent	3
23	Well completion	3
24	PD EOR by microbiological method (iREX reagent)	3
25	Bottomhole cleaning. BHT	2
26	Bottomhole sealing with cement bridge installation	2
27	Fishing work	1
	Total:	280
	Total:	518

Note: IPA – injectivity profile alignment; RPM – reservoir pressure maintenance; AS – annular space.

OWW, GTM and underground well workovers (UWW) were carried out at the field, aimed at protecting against complications and their consequences. For capital and underground repair work on injection wells for the period 2013-2016, a total of 518 repairs were carried out on injection wells. Of these, 238 are current and 280 are major repairs. All types of repair work carried out on injection wells are reflected in the summary **Table 3**. The values in the table show that the main number of current repairs was mainly associated with the bottomhole cleaning (137 repairs) and the bottomhole cleaning with the replacement of underground equipment (62 repairs). Also, 22 repairs were made to the wells of simultaneous-separate injection to revise the layout of equipment for separate injection (ESI) and clean the bottom hole.

The production of sand causes a need for regular bottomhole cleaning and underground, equipment repair. The need for both PCP and ESI layout revisions is indicative of ongoing efforts to preserve injection efficiency and avoid blockages caused by sand. Advanced treatments, like bottom hole treatment from MAC -1 and BHT by Himeko-Service technology, are used to handle more serious sand management difficulties and assure the longevity of injection wells. From **Tables 1-3**, it can be seen that the wells were put into operation after the repair, due to sand control measures carried out through repair work to clean and flush the bottomhole zone with a DPE revision and replacement of the downhole pump (**Gasumov and Kukulinskaya, 2016; Stavland et al., 2011**). The main complicating factors in the field are still sand production, resulting in the mechanical wear of the downhole equipment, which leads to frequent breaks or backlashes of rods, pump jams, and sand plugs. It can be concluded that the influence of these factors leads to a decrease in the efficiency of pumping units. The main reason that adversely affects the operation of downhole equipment is sanding. An analysis of the dynamics of average reservoir and bottomhole pressures in the Kumkol field (the first production facility) (see **Figure 1**) reflects the picture that the initial reservoir pressure in the field at this facility (at the level of horizons M1 and M2) was 11.5 MPa, the saturation pressure of the oil fluid is relevant gas – 1.77 MPa, while the initial saturation pressure was 4.7 MPa, which is overestimated.

The graph reflects the overall picture of the pressure drop in the reservoir below saturation pressure (P_{sat}), resulting in the degassing of the oil fluid, but not in full. The watering of the reservoir system contributed to a decrease in the gas content of the oil fluid, which, in turn, caused the dissolution of a certain proportion of light hydrocarbons in the injected water agent (**Gasumov et al., 1997**). At the field, there was a weakening of the hydrodynamic connection between the production zone and the injection zone. This phenomenon was observed due to a drop in bottomhole pressure in production wells and an increase in bottomhole pressure in injection well systems. Analysing the high-water production well stock, it was found that out of 374 well systems, about 86% are wells with a water cut of 90% or more (329 wells). At the Kumkol field, a number of geological

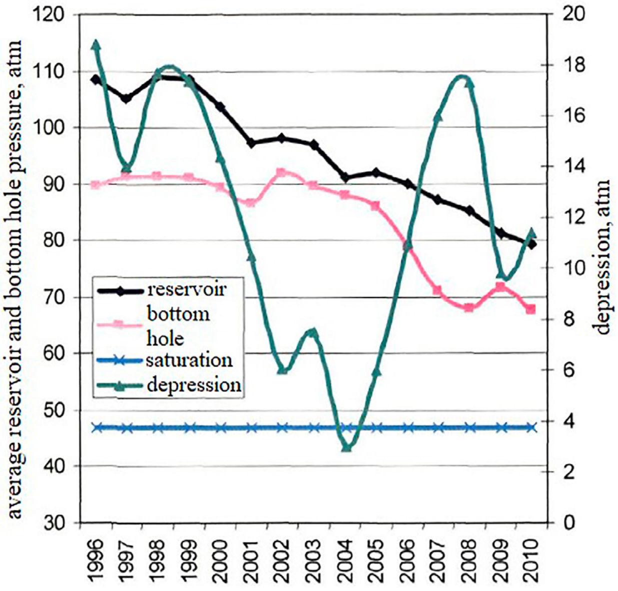

Figure 1: Graph of changes in the average pressure indicators at the first production facility of the Kumkol field

and technical measures, as well as UWW, including OWW and CWW, were carried out, aimed at preventing complications and their consequences during the operation of well systems. Repair work on the injection well stock was carried out, such as the bottom hole and BHT in order to increase injectivity and achieve the necessary compensation for withdrawals (see **Figure 2**).

In order to improve the efficiency of production wells in the field, HF was performed using a proppant drive. Such measures made it possible to establish a hydrodynamic connection between the well and the remote zone of the oil-saturated reservoir. Considering work to strengthen the bottomhole zone, aimed at preventing the production of sand with oil fluid, it is possible to inject a proppant into the formation reservoir. The HF technique is used to determine the parameters of well system bottomhole stabilisation, more precisely, the volumes of sand-carrying fluid, squeezing agent, proppant, and injection pressure. The consequence of this is the inefficiency and instability of the results of the bottom hole repair operation (**Pereima and Kukulinskaya, 2014**). Representing the model of such a BHZ formation system as deconsolidated, the representation of the sequence of operations will look like this (1 – reservoir system; 2 – agent in the form of a gel; 3 – decompaction zone; 4 – oil fluid; 5 – sand particles; 6 – compacted rock; ρ1 – soil density in the "fluid" area, ρ2 – soil density in the compacted part of the face, ρ3 – the density of the soil in the region of decompaction) (see **Figure 3**).

An acceptable combination of strength characteristics and permeability BHZ provides a method of fixing sand using a urethane prepolymer implemented by IPNG-Plast2 technology (**Kaushansky et al., 2015**). Using this technology, a polymer filter is created inside the reservoir. The strength index of such a filter reaches 6 MPa,

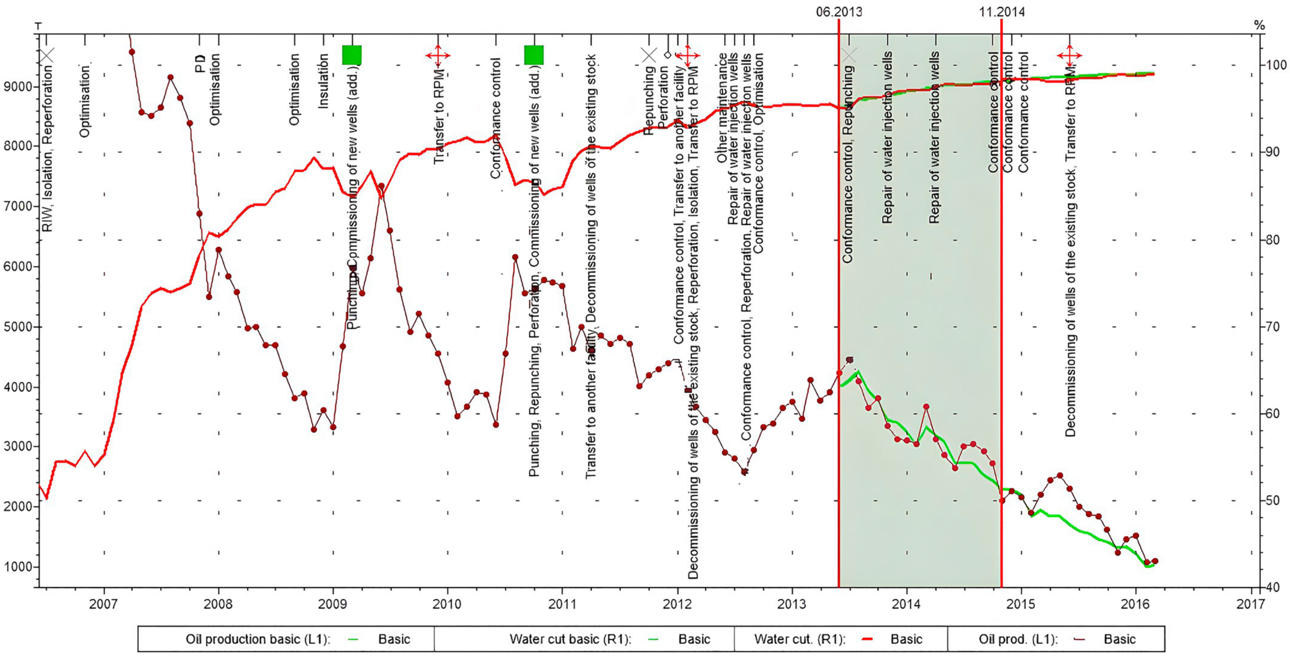

Figure 2: Graph of oil production indicators

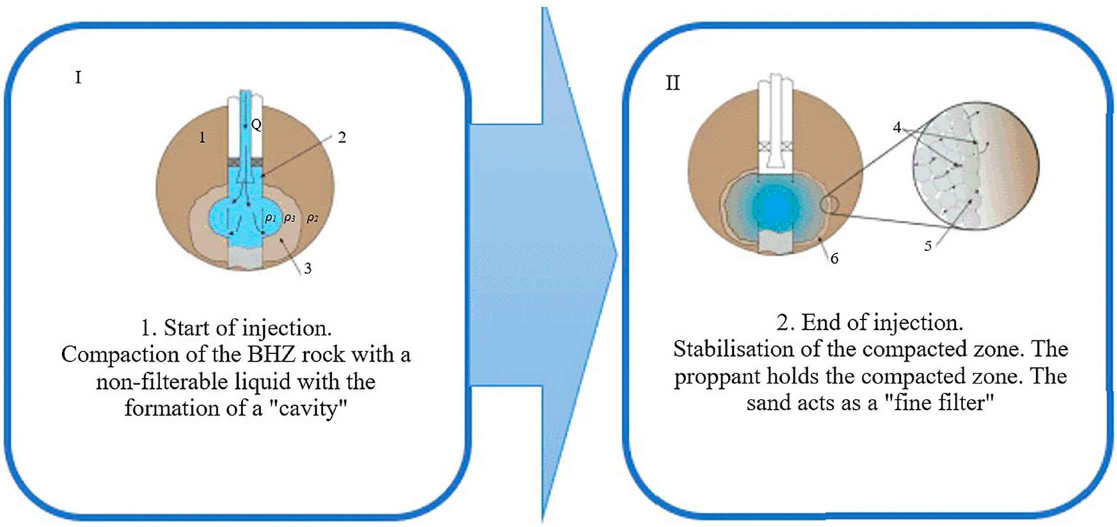

Figure 3: Schematic diagram of bottom hole compaction in the area of deconsolidation

while the minimum decrease in the permeability of the reservoir rock is less than 20%. To study the structural characteristics of such a polymer filter, a scanning technique based on the use of electron microscopy was used. The study revealed areas in which sand particles are bound by a urethane prepolymer. The image shows the presence of free spaces between the grains of sand, which provides a significant value for the permeability of such a filter inside the reservoir (see **Figure 4**).

Improving the efficiency of fixing the sandy structure in the area of the bottomhole zone of the well depends on the resistance of rocks to destruction under the action of external forces. To estimate this indicator, the method of determining the coefficient of ultimate strength depending on volumetric compression was used. Using the

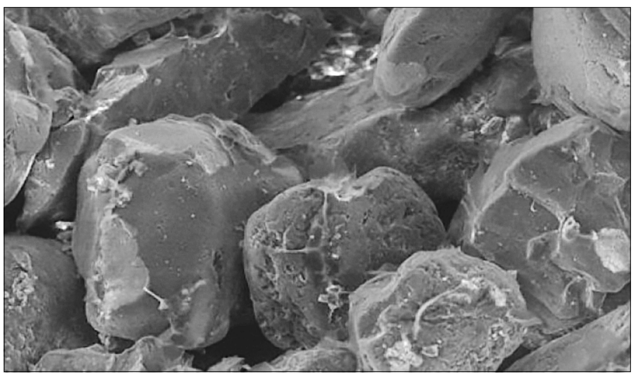

Figure 4: A sample of a quartz sand structure bonded using the IPNG-Plast2 technology. Obtained by scanning electron microscopy

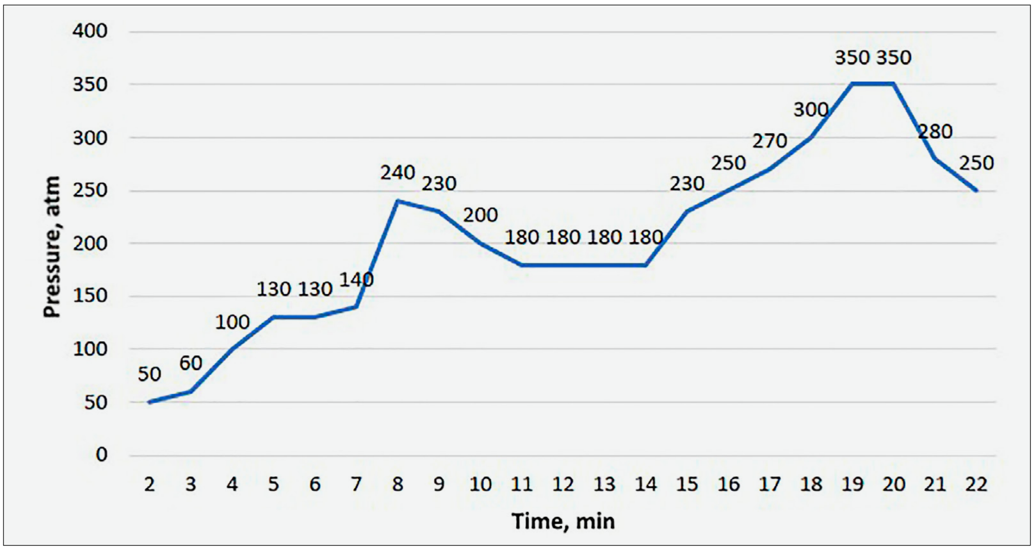

Figure 5: Change in proppant pressure values during SBHZ operation

chemical composition of the prepolymer-solvent, it is possible to achieve a high mechanical strength of the polymer filter – about 6 MPa. It is formed in the bottom-hole formation zone, which binds sand; the oil permeability of such a polymer filter is about 85% of the initial one. By changing the pump flow rate, the proppant and sealing fluid discharge pressures are controlled. The volume of proppant injection is determined depending on the parameters of the well design and the area of the decompacted part of the rock in the bottomhole zone.

Determination of the optimal values of indicators that affect the effectiveness of rock fixation in the BHZ area was carried out according to the Sausier diagram. Thus, the result is the following: for agent 16/18, the parameter values are D_0prop/D_0sand=4.1÷5.8. Provided that the well has the following parameters: depth – 1502 m, production string diameter – 140 mm, formation permeability 1.280 μm^2, fluid viscosity 3.935 mPa*s (water-saturated formation), formation pressure was 118 atm, it is necessary to pump 6.45 m^3 of sealant at a pressure of not more than 261 atm, which makes it possible to restore the compacted layer in the bottomhole area to its original state and prevent its destruction. The whole process of carrying out the stabilisation of the bottomhole zone (SBHZ) technology takes place in the following order: improving the quality of conductivity in the bottomhole formation zone, forming a cavity for the BHZ seal, pumping proppant for fixing the BHZ, taking into account, the operation of pushing the polymerized proppant residues. The cyclical nature of this technological operation should be noted. The graph of pressure values during the technological operation (see **Figure 5**) shows such two phases, where the sequence of compaction-destruction occurs, the first phase lasts 11 minutes, the second – 9 minutes.

Thus, in the first phase of the compaction of the first SBHZ operation, the fracture pressure of the cavity destruction surface in the BHZ is 240 atm, the proppant pumping time at the same values of the pump unit operation parameters is 6.55 min. This means that at the 8^{th} minute of agent injection, the BHZ well compacted to its original state. By filling the bottom-hole zone with polymerized proppant and stopping this operation at 8 minutes, it is possible to bring the rock in the bottom-hole zone into a compacted state and minimise the removal of formation soil into the wellbore.

4. Conclusions

The analysis of methods for combating sand intrusion shows that the study of the causes of the destruction of the collector system and the removal of sand has been studied in sufficient fragments and is contradictory. The creation of a well formation stabilisation model to prevent or reduce sand production from the wells of the Kumkol field, taking into account the current state of the reservoir rocks, is currently the most relevant. Sand clogging of the bottomhole zone of wells during operation is accompanied by the formation of a cavity. Small suspended particles of sand clog the pores adjacent to the walls of the wells in the zone of the oil-saturated reservoir; this is a negative consequence of the removal of sand from the wells.

Gravitational settling of sand particles on the elements of equipment and the bottomhole part of the well is observed at the lowest rate of oil lifting along the PCP. Such a situation, when sand plugs are formed and, as a result, downhole equipment fails, leads to a state of complexity in repair work and a rise in price. Complications with paraffin within 12% are observed at the Kumkol field, in such conditions, the operation of oil wells can be accompanied by corrosive activity, sanding, and salt deposits. At the present stage of field development, geological and geomechanical conditions have changed sig-

 pp. 115-124, DOI: 10.17794/rgn.2024.4.9

nificantly compared to the initial ones, so the results of using modern methods of protection associated with sand production are unstable. Solving problems of this nature at the Kumkol field requires a scientific approach, and from an economic point of view, it is necessary to take into account the current state of the commercial reservoir of this field. To maintain the integrity of the oil column in conditions of low reservoir saturation, the volume of proppant injected should be minimal. To refine and optimise the parameters of sealing and propping materials injection, the proposed system of loose rock compaction model in the bottomhole zone provides a fairly accurate representation of them. Thus, optimising the effective result when fixing the bottomhole zone will allow for accurately determining the required volume and maximum pressure of the injected sealing and propping materials.

5. References

Aydarbekov, K.D. (2020): History of discovery and development of the Kumkol field. Oil and Gas, 117-118, 3-4, 180-186.

Bondarenko, V.A. and Savenok, O.V. (2014): Analysis of modern methods and technologies for managing sand production processes during well operation. Collection of Scientific Articles Based on the Results of the International Correspondence Scientific and Practical Conference, 988, 3, 042046.

Bondarenko, V.A., Klimovets, V.N., Schetnikov, V.I., Sukhlyaev, A.O., Dolgov, S.V. and Shostak, A.V. (2013): Some experience of sand control while operating wells of Anastasievsky-Troitsky field in Krasnodar region. Construction of Oil and Gas Wells on Land and Sea, 6, 17-21.

Churikova, L.A. and Nizamov, R.R. (2021): Substantiation of the choice of methods for preventing sand production, taking into account the decompaction of rocks in weakly consolidated formations. Universum: Technical Sciences, 84, 3, 48-52. https://doi.org/10.32743/UniTech.2021.84.3-2.48-52

Deryaev, A. (2024): Engineering aspects and improvement of well drilling technologies at the Altyguyi field. Machinery & Energetics, 15(2), 9-20. https://doi.org/10.31548/machinery/2.2024.09

Dolgov, S.V. and Zhikhor, P.S. (2015): Russian Federation patent No. 2558080. Way of fastening of slightly cemented layer. Rospatent, Moscow.

Gasumov, R.A. and Kukulinskaya, E.Yu. (2016): Technological solutions to limit sand production from producting gas wells. Science. Innovations. Technologies, 3, 165-176.

Gasumov, R.A., Mosienko, V.G. and Nersesov, S.V. (1997): On the question of the method of testing the insulating ability of special process fluids and grouting slurries. VNIIGAZ, Moscow.

Gershtansky, O.S. (Ed.). (2016): Topical issues of the oil and gas industry. Research and Design Institute of Oil and Gas, Aktau.

Isehunwa, S.O. and Olanrewaju, O. (2010): A simple analytical model for predicting sand production in a Niger Delta oil field. International Journal of Engineering Science and Technology, 2, 9, 4379-4387.

Karmansky, A.T. (2010): Experimental substantiation of strength and destruction of saturated sedimentary rocks. Mining University, Saint Petersburg.

Kaushansky, D.A., Tsitsorin, A.I., Dmitrievsky, A.N. and Demianovsky, V.B. (2015): Physicochemical and rheological properties of IPNG-PLAST 2 composition for limiting the mechanical impurities washing over in the oil wells. Oil Industry, 4, 84-87.

Khamehchi, E., Omid, A. and Alizadeh, A. (2015): Choosing an optimum sand control method. Egyptian Journal of Petroleum, 24, 2, 193-202. https://doi.org/10.1016/j.ejpe.2015.05.009

Kunytska, M., Piskun, I., Kotenko, V. and Kryvoruchko, A. (2024): Digital modelling technologies in the mining industry: Effectiveness and prospects of digitalisation of open-pit mining enterprises. Bulletin of Cherkasy State Technological University, 29(1), 52-61. https://doi.org/10.62660/bcstu/1.2024.52

Nouri, A., Vaziri, H., Kuru, E. and Islam, R. (2006): A comparison of two sanding criteria in physical and numerical modelling of sand production. Journal of Petroleum Science and Engineering, 50, 1, 55-70. https://doi.org/10.1016/j.petrol.2005.10.003

Pereima, A.A. and Kukulinskaya, E.Yu. (2014): Analysis of causes leading to damage of a formation bottom-hole area in oil and gas wells and methods, providing the damage prevention. Construction of Oil and Gas Wells on Land and Sea, 2, 35-41.

Perera, M.S.A., Ranjith, P.G., Rathnaweera, T.D., De Silva, G.P.D. and Liu, T. (2017): An experimental study to quantify sand production during oil recovery from unconsolidated quicksand formations. Petroleum Exploration and Development, 44, 5, 860-865. https://doi.org/10.1016/S1876-3804(17)30097-6

Ranjith, P.G., Perera, M.S.A., Perera, W.K.G., Wu, B. and Choi, S.K. (2013): Effective parameters for sand production in unconsolidated formations: An experimental study. Journal of Petroleum Science and Engineering, 105, 34-42. https://doi.org/10.1016/j.petrol.2013.03.023

Service oil company LLC "SNK". (2022): URL: http://snkoil.com/torgovye-brendy/remont-skvazhin/link/ (accessed 2nd May 2024)

Stavland, A., Vilcane, O. and Skrettingland, K. (2011): In-depth water diversion using sodium silicate on snorre-factors controlling in-depth placement. https://doi.org/10.2118/143836-MS

Suman, G.O., Ellis, R.C. and Snyder, R.E. (1986): Sand Control Handbook. Nedra Publishers, Moscow.

Zhikhor, P.S., Dolgov, S.V., Shostak, A.V., and Bondarenko, V.A. (2014): Application of some methods of factor analysis to improve the technology of casing the bottomhole zone of wells of the IV horizon of the Anastasievsky-Troitsky field. Science and Technology in the Gas Industry, 1, 57, 86-91.

Zotov, G.A., Dinkov, A.V. and Chernykh, V.A. (1987): Operation of wells in unstable reservoirs. Nedra Publishers, Moscow.

SAŽETAK

Odabir optimalne tehnologije za sprječavanje proizvodnje pijeska s obzirom na dekonsolidaciju formacije na dnu bušotine

U ovome je radu dan prikaz provedenih istraživanja o izboru najbolje metode kontrole pijeska tehnološki utemeljene na primjeni metode stabilizacije dna bušotine polimeriziranim propantom koji će spriječiti urušavanje formacijske zone i olakšati razradu polja Kumkol u budućnosti. Tijekom razrade polja Kumkol najveći i najsloženiji izazov prilikom proizvodnje jest proizvodnja pijeska, što dovodi do dugih zastoja rada bušotine i popravaka. Cilj je ovoga istraživanja znanstveno potkrijepiti i poboljšati tehnološke metode stabilizacije dna bušotine kako bi se isključila ili ograničila proizvodnja pijeska na polju Kumkol uzimajući u obzir trenutačno stanje ležišnih stijena. U radu su primijenjene različite istraživačke metode, uključujući analizu iskustva s dosadašnjom proizvodnjom pijeska na polju Kumkol, korištenje teoretskih osnova odnosa metode protupješčane filtracije i svojstava ležišnih stijena te pokusi na izgrađenome geološkom i matematičkom modelu postojećega stanja stijena u dekonsolidacijskoj zoni. Znanstveni je doprinos rada definiranje obrazaca koji povezuju utjecaj razrušavanja slabo vezanih ležišnih stijena u proizvodnoj bušotini sa stupnjem stvaranja dekonsolidacijskih zona na dnu bušotine kojima se otkrivaju slabo vezane stijene formacije.

Ključne riječi:
proizvodno ležište, slabo konsolidirana formacija, abrazija pijeskom, propant, frakturiranje

Author's contribution

Larisa Churikova (1) (PhD, Associate Professor) conceived of the presented idea. **Samal Akhmetzhan (2)** (Researcher) wrote the manuscript with support from **Ainash Mukambetkaliyeva (4)** (Researcher). **Gali Gumarov (3)** (Researcher) collected the data and prepared figures. **Kumiskali Gubaidullin (5)** (Researcher) conceived and designed the analysis. All authors discussed the results and contributed to the final manuscript.