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Satbayev University

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ИЗВЕСТИЯ

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ANALYSIS OF COMPLICATIONS ASSOCIATED WITH THE PARAFFINIZATION OF BOREHOLE EQUIPMENT AND MEASURES TO PREVENT THEM

Abstract. Oil production from wells is accompanied by a decrease in temperature, pressure and degassing of the produced oil. As a result, asphaltene-resin-paraffin deposits (ARPS) are separated from oil and deposited in the wellbore region and on oilfield equipment. These deposits significantly impair the filtration characteristics of the wellbore, reduce the throughput of equipment, and also reduce their operation period.

From the analysis carried out, the problem of protecting field equipment from ARPS is the most common method in the fields, the thermal method of dewaxing wells using hot water.

The analysis of the effectiveness of the work carried out on the injection of the emulsion of a complex effect on the formation is carried out. When evaluating the effectiveness of the complex impact emulsion, additional oil production was determined, calculated as the difference between the actual and base production for this well. The article discusses the issue that a whole range of scrapers of various designs has been developed to remove the already formed deposits of ARPS on the tubing.

The use of pipes with a polyamide coating (high mechanical, chemical and thermal resistance) is also used, which open up great prospects for their implementation in some fields of Kazakhstan.

It should be noted that the thermal effect on the flow of well production, in which the temperature of the liquid remains above the temperature of the onset of wax crystallization throughout the depth of the well, is an effective solution to the problem of preventing the formation of ARPS. Such an effect is executed using a heating cable.

Key words: asphaltene-resin-paraffin deposits, thermal method, hot water, complex action emulsion, plastic scrapers.

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ЖЕРАСТЫ ЖАБДЫҚТАРЫНЫҢ ПАРАФИНИЗАЦИЛАНУЫНА БАЙЛАНЫСТЫ АСҚЫНУЫ ЖӘНЕ ОЛАРДЫҢ АЛДЫН АЛУ ЖӨНІНДЕГІ ІС-ШАРАЛАРДЫ ТАЛДАУ

Аннотация. Ұңғымалардан мұнай өндіру кезінде температура қысымның төмендеуімен және өндірілген мұнайдың газдануымен бірге жүреді. Осының салдарынан мұнайдан кенжар аймағында және мұнай өндіретін жабдықтарға асфальтты-шайырлыпарафинді шөгінділер бөлініп тұнады. Бұл шөгінділер ұңғымалардың төменгі шұңқыр аймағының сүзу сипаттамаларын едәуір нашарлатып, жабдықтың өткізу қабілетін төмендетеді, сондықтан, олардың жөндеудің аралық кезеңі де қысқара түседі.

Жүргізілген талдау кезінде кәсіптік жабдықты асфальтты-шайырлыпарафинді шөгінділерден қорғау үшін кен орындарында ең көп таралған әдіс ыстық суды пайдаланып ұңғымалардағы парафиндерді жылыту әдісі қолданылды. Қабатқа кешенді әсер ететін эмульсияны айдау бойынша жүргізілген жұмыстардың тиімділігіне талдау жүргізілді. Кешенді әсер ететін эмульсияны қолдану тиімділігін бағалау кезінде осы ұңғыма бойынша нақты және базалық өндіру арасындағы айырмашылық ретінде есептелген қосымша мұнай өндіру болып табылады. Сорғы-компрессорлық құбырда пайда болған асфальтты-шайырлыпарафинді шөгінділерді жою үшін әртүрлі конструкциядағы қырғыштардың тұтас гаммасы жасалғанын атап өткен жөн.

Сондай-ақ полиамидті жабыны бар (жоғары механикалық, химиялық

және термиялық төзімділігі) құбырларды қолдану Қазақстанның кейбір кен орындарында пайдаланып, оларды енгізудің үлкен қолдаулар керек екені айтылады. Сұйықтықтың температурасы ұңғыманың бүкіл тереңдігі бойынша парафиннің кристалдануының бастапқы температурасынан жоғары болатын ұңғымалық өнім ағынына жылу әсері асфальтты-шайырлыпарафинді шөгінділер түзілуінің алдын алу мәселесін тиімді шешуге ықпал етеді. Бұл әсер жылыту кабелінің көмегімен жүзеге асырылады.

Түйін сөздер: асфальт-шайырлыпарафинді шөгінділер, жылу әдісі, ыстық су, кешенді эмульсиялар, пластикалық қырғыштар.

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АНАЛИЗ ОСЛОЖНЕНИЙ СВЯЗАННЫХ С ПАРАФИНИЗАЦИЕЙ ПОДЗЕМНОГО ОБОРУДОВАНИЯ И МЕРОПРИЯТИЙ ПО ИХ ПРЕДУПРЕЖДЕНИЮ

Аннотация. Добыча нефти из скважин сопровождается понижением температуры, давления и разгазированием добываемой нефти. В результате этого из нефти выделяются и осаждаются в призабойной зоне и на нефтепромысловом оборудовании асфальтено-смолопарафиновые отложения (АСПО). Эти отложения значительно ухудшают фильтрационные характеристики призабойной зоны скважин, снижают пропускную способность оборудования, а также уменьшают их межремонтный период.

Из проведенного анализа, проблема защиты промыслового оборудования от АСПО является самым распространенным методом на месторождениях тепловой метод депарафинизации скважин с использованием горячей воды.

Проведен анализ эффективности проведенных работ по закачке эмульсии комплексного воздействия на пласт. При оценке эффективности применения эмульсии комплексного воздействия определялась дополнительная добыча нефти, рассчитанная как разница между фактической и

базовой добычей по данной скважине. В статье рассмотрен вопрос, что для удаление уже образовавшихся отложений АСПО на насосно - компрессорной трубе разработана целая гамма скребков различной конструкции.

Также используется применение труб с полиамидным покрытием (высокая механическая, химическая и термическая стойкость) открывают большие перспективы их внедрения и на некоторых месторождениях Казахстана.

Следует отметить, что тепловое воздействие на поток скважинной продукции, при котором температура жидкости остается выше температуры начала кристаллизации парафина по всей глубине скважины, является эффективным решением вопроса предупреждения образования АСПО. Такое воздействие осуществляют с помощью нагревательного кабеля.

Ключевые слова: асфальтено-смолопарафиновые отложения, тепловой метод, горячая вода, эмульсией комплексного воздействия, пластиковые скребки.

Introduction. Formation of asphalt-resin-paraffin deposits (ARPS) on the surfaces of downhole equipment is the most common type of complications during well operation. The factors determining this process are the high content of colloidal particles of asphaltenes, dissolved resins and solid hydrocarbons - paraffins, temperature and pressure in reservoir oil. Deposition of paraffins on the walls of the tubing string is caused by oil supersaturation due to a decrease in oil temperature and gas release as the fluid flow moves from the bottomhole to the wellhead. [1,2,3]

The presence of paraffin, regardless of its amount in oil, poses many technological and technical challenges for the production workers associated with the elimination of complications caused by ARPS.

Taking into account the technological parameters of the wells, the depth of formation of asphaltene-resin-paraffin deposits is calculated. The calculation of the beginning of the depth of asphalt-resin-paraffin deposits has been carried out. The results of calculating the interval of paraffinization of the tubing column by wells are presented in Table 1.

Table 1 - Results of calculating the depth of deposition of ARPS

№	№ well.	Horizon	Wellbore, m	Q_{fluid}, t/day	Water cut, %	Temperature paraffin crystallization, ºC	Depth of ARPS deposition from the wellhead, m
1	2	3	4	5	6	7	8
1	1076	7	2050	34,65	55	54,3	269,1

2	2227	5c 6ab	1975	16,59	21	50,8	468,1
3	2253	3	1821	13,46	12	51,7	510,9
4	2279	5abc	1935	19,91	12	50,8	419,9
5	1252	8	2154	26,24	71	52,1	109,4
6	1038	8	2140	9,92	79	52,1	85,4
7	498	9	2203	5,87	29	52,9	624
8	2067	5abc	1920	29,73	35	50,8	298,7
9	2124	5bc	1948	20,96	24	50,8	401,4
10	2594	8	2150	10,95	35	52,1	555,7
11	2606	9	2178	11,07	65	52,9	411,7
12	1323	8	2136	11,86	45	52,1	512,2
13	3362	12	2380	12,46	48	54,7	550,9
14	3390	5bc	1935	11,75	29	50,8	512,9
15	1282	8	2160	14,8	55	52,1	440,5
16	396	12	2387	10,12	65	54,7	476,6
17	2989	11	2326	23,29	60	53,9	295,4
18	929	5c	1943	21,34	35	50,8	388
19	1363	8	2139	7,11	18	52,1	628,9

It has been established that wax deposits occur at a depth of about 90 meters to 829 meters.

Prevention of complications, removal of various deposits, destruction of oil emulsions require significant material and labor costs.

According to the analysis of the field material, the fund of wells complicated by ARPS – 427 wells was determined, including small deposits where measures were taken to combat asphaltene-resin-paraffin deposits (ARPS), including: hot water treatment with the addition of surfactants of the Rauan type (HWT) - 4976, and an emulsion of complex action ECA- well №46.-oper.

From the analysis carried out, the problem of protecting field equipment from ARPS continues to be relevant - the fund of wells subject to paraffinization has increased by 1.3 times. In conditions of intensive deposition of ARPS, normal operation of wells is impossible without systematic work on the dewaxing of equipment. Thermal methods are used to eliminate deposits: hot water treatment (HWT).

Theory and methods of research. The most common method in the fields is the thermal method of dewaxing wells using hot water. The process of melting, dissolving and removing the ARPS by a flow of moving hot liquid from the inner surface of the tubing is carried out by circulation of the coolant through the channels of the borehole when it is directly injected into the tubing or through the annulus. The object of application of the technology is producing wells with reduced productivity.

Measures have been taken at the field to restore productivity, as well as to remove asphaltene-resin-paraffin deposits (ARPS), to determine the effectiveness of these methods, the period of workover for wells has been determined. The wells were divided into groups according to the flow rate and water content.

As follows from the presented data, a total of 116 wells were analyzed, which is 27% of the fund of wells complicated by paraffin deposits.

As the analysis showed, all groups of wells are subject to paraffinization, the frequency of treatments on wells with a flow rate of up to 60 t/day and a water cut of up to 60% is less than that of wells with a flow rate of more than 60 t/day and with the same water cut. The lowest workover period (12.5 days) is observed for a group of low-flow wells (with a Qf of up to 10 t/day) and a water content of 30% to 60%. The highest workover period (23 days) is observed for a group of wells (with a Qf of up to 60 t/day) and a water content of more than 90%.

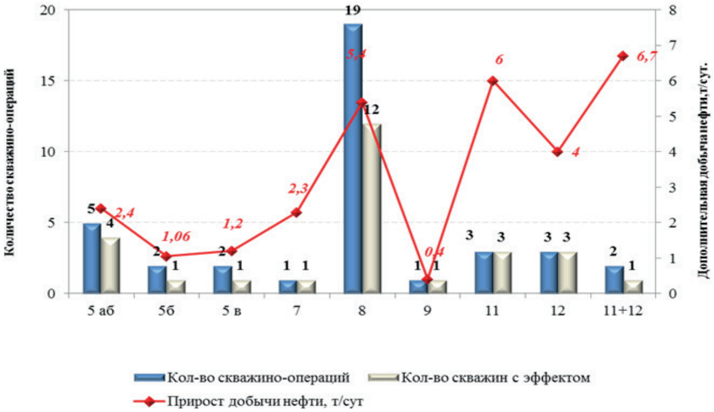
A statistical analysis of the efficiency of the injection of hot water treatment was carried out. The efficiency of the injection of HWT was also determined by the change in the daily oil flow rate for a group of wells. As follows from the presented data, 51 well operations were analyzed, of which 38 gave a positive result: the increase in oil per well operation averaged 2.0 t/day. In 6 wells, the parameters of well operation remained unchanged. At 13 wells, the treatments did not give positive results. For example, the dynamics of technological parameters of wells operation before and after thermal treatments is presented. The change in the oil flow rate was taken into account only from the influence of the HWT during the period when no other measures were carried out at the well.

The emulsion of complex action (ECA) carried out 46 well operations in order to restore the productivity of wells. The composition of the injected composition is presented in Table 2.

Table 2-Composition of the complex action emulsion

Product Code	Name	The content of components in 1m3 of emulsion, % by weight
1	2	3
HM	Hydrocarbon mixture	50-60
Surfactant	Surfactant type "Neonol"	1,5-2,5
BK	Potassium (sodium) bichromate	0,4-0,6
HCl	Hydrochloric acid	10-15
H2O	Technical water	Other

When evaluating the effectiveness of the use of ECA, additional oil production was determined, calculated as the difference between the actual and base production for this well, the productivity coefficient and displacement characteristics for a group of wells of different horizons were used to determine the oil reserves involved in the development.



Drawing.1- Changing the technological parameters of the wells along the horizons before and after the emulsion complex exposure.

In the course of the study, it was found that there was an ECA injection at well 2077; the average oil flow rate before the work was 6.7 t/day, water content of 60%. After the work, the oil flow rate was 8.6 t/day, the water content was 60%. As a result of the work carried out, additional oil production of 1.9 t/day was obtained. with a success rate of 104 days.

It should be noted that the injection of the composition was carried out during the workover due to the change of the pump. After the repair work, the pump operation parameters remained unchanged.

Well operation analysis: out of 21 analyzed wells, an increase in the productivity coefficient was obtained in 10 wells on average:

in well 431 (11+12 horizon) - the productivity coefficient increased by 1.1 times (from 15 to 17.1);

3 wells (8 horizon) - the productivity coefficient increased on average by 1.6 times (from 4.3 to 7.3);

in the well 826 (10 horizon) – by 1.7 times (from 7.1 to 12.1);

in the well 871 (11 horizon) - by 1.3 times (from 8.6 to 11.4) 4;

in the well 2153 (6 horizon) – by 1.6 times (from 2.9 to 4.65);

in the well 2077 (5 abcd horizon) – by 1.1 times (from 2.3 to 1.5);

in 2 wells 1402,2981 (12 horizon) – by 2.5 times (from 2.0 to 2.9);

in 6 wells (334,1369,1196,2067,3311, 308b) - the productivity coefficient remained unchanged;

in 5 wells (501, 1076, 1248, 1307,1315) – the productivity coefficient decreased.

As the analysis showed, an increase in the productivity coefficient confirms the effectiveness of ECA.

For a group of wells of different horizons, when determining the efficiency of the ECA, displacement characteristics were used to determine the oil reserves involved in the development after the emulsion complex exposure.

During the data analysis, in general, the volume of involved reserves due to the ECA amounted to 85.5 thousand tons.

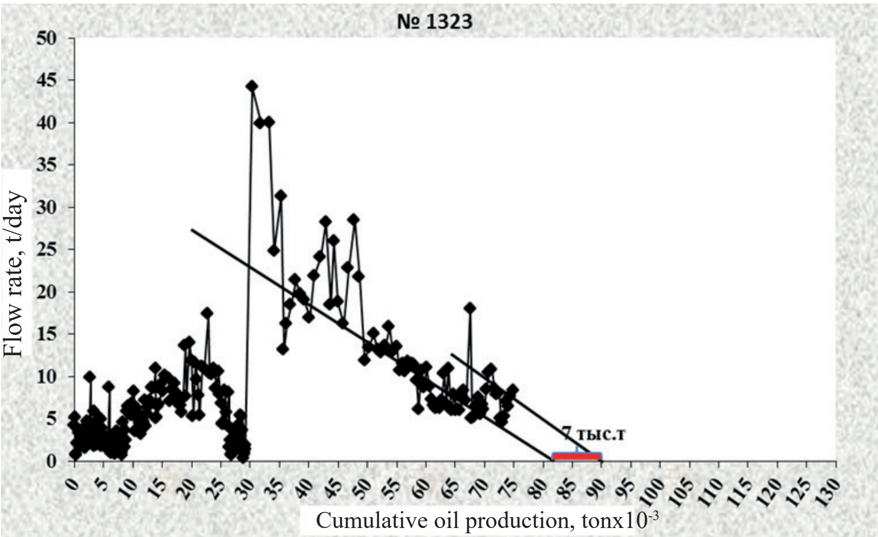


Figure 2 - Change in the involved oil reserves before and after the ECA on the borehole 13323

As follows from the presented data, the volume of involved reserves due to the ECA was 7 thousand tons.

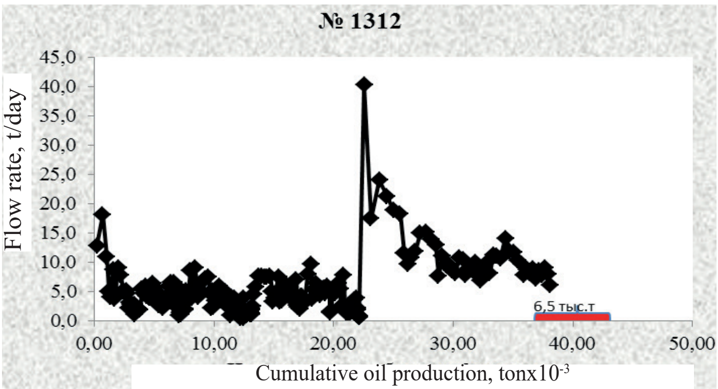


Figure 3 - Change in the involved oil reserves before and after the ECA on well 1312

As follows from the presented data, the volume of involved reserves due to the ECA amounted to 6.5 thousand tons.

The use of an acid-based emulsion with a hydrocarbon solvent gives the best effect of cleaning the wellbore zone due to the simultaneous action of the solvent on ARPS and acid on the formation rock cleaned from ARPS, as well as as a result of deeper treatment of the formation due to the stability of the emulsion.

It should be noted that not all wells received technological efficiency from the use of ECA. The analysis of wells operation with a negative result of ECA processing was carried out.

It should be noted that not all wells have obtained technological efficiency from the use of ECA. The analysis of wells operation with a negative result of ECA processing was carried out.

As follows from the data presented, in 16 wells the injection of the ECA composition did not give positive results - the oil production rate decreased by an average of 1.9 times, the water cut increased by 16.4%.

It should be noted possible reasons for poor-quality injection at wells violation of injection technology;

non-compliance with recipes when preparing the solution;

unpreparedness for the operation of the well according to the technical condition.

It is necessary to improve acid compositions in order to improve its effectiveness. For example, to adapt the technology of using an emulsion based on liquefied petroleum gas (LPG) and solutions of nitrate compounds in order to restore the productivity of wells. The composition of this emulsion is shown in Table 3.

Table 3 - Composition of the emulsion

Product Code	Name
UGS	Gas condensate
Surfactant	Surfactant type "Neonol"
BK	Sodium Nitrite
HCl	Hydrochloric acid
NH4 Cl	Ammonium chloride
H2O	Technical water

Field experience gives reason to recommend the use of solvents that accelerate the dissolution of ARPS (LPG, hexane and pentane hexane fractions), as well as the use of a small amount of scale inhibitor and surfactant with a solvent. The effectiveness of a particular reagent should be determined in laboratory conditions with subsequent experimental field tests.

Table 4 - Recommended reagents for protection against ARPS

Reagent	Component composition	Reagent consum-ption per 1 m effective thickness, m3	Success, %	Developer	Deposits where technologies were used
SNPH-8903-B	1.Acid composition (hydrochloric acid, amino acid composition); 2.Alkaline composition - sodium salts of mono- and dicarboxylic acids and mutual solvent	0,5-3	89-95	"NIPINeftep-romchem" OJSC	Tatarstan, Eastern and Western Siberia, Komi
Netrol	1.Nitric acid; 2.Active additives; 3.Anti-corrosion additives	0,5-1,0	70	"RosTechnocom" LLC	Lukoil, Slavneft
KSPEO-4	Acid composition of complex action	1,2-1,5	90-93	"PermNIPIneft" LLC	Lukoil, Permneft
INTAT	Nonionic block copolymer, ethylene and propylene oxides		90	"Tatneft-Chemservice" LLC	«Tatneft» OJSC

Field practice shows that the intensity of paraffinization often increases with increasing well productivity (with equal large diameters of tubes and oil viscosity, the Reynolds number is proportional to the productivity of the well), but this increase in paraffinization is not unlimited. With an increase in flow, the tangential stresses of the liquid on the tubing wall also increase, which removes paraffin deposits.

Research results and conclusion. As you know, the problem of cleaning tubing and pumping rods is solved easier and more efficiently by periodic treatment of wells with hot water (HWT). Thermal flushing is preventive in nature and stabilizes production for a period of up to 15-20 days.

It should be noted that a whole range of scrapers of various designs has been developed to remove already formed deposits of ARPS on tubing. By design and principle of operation, scrapers are subdivided into: plate scrapers with a rod rotator, having two cutting plates capable of cleaning the ARPS only when rotating. For this, rod rotators are used, suspended from the horsehead of the pumping unit. Rotation of the rod string, and therefore of the scrapers, occurs only when moving downward. In this way, the scraper cuts off the ARPS from the tubing surface. Type of scrapers are: spiral, reciprocating action; "flying", equipped with knife-wings, which open when moving upward, which provides them with lifting force. They are used, as a rule, in deviated wells. However, the use of such a method for combating ARPS is complicated by the fact that its application often requires shutdown of the well and preliminary preparation of the tubing surface (for some types of scrapes). In addition, the scrapers may stuck, break their attachment and some other complications.

In recent years, plastic scrapers have been deposited on rods instead of metal plate scrapers. Their appearance is shown in Figure 4.

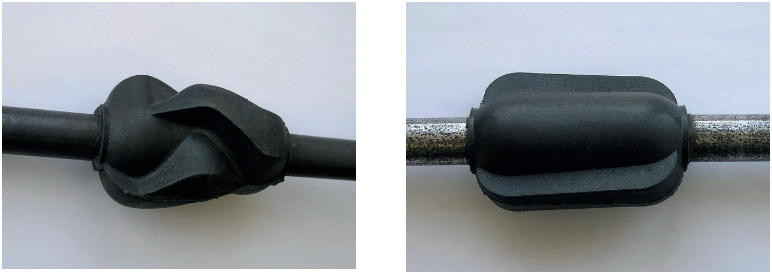


Figure 4 - Rods with fused centralizer scrapers

The use of tubing with an internal polyamide coating, a coating of lacquers, enamel is also used. The use of such methods in the OJSC "Tatneft" fields allowed to increase the operation period of wells up to 3 years. The use of tubing with polyamide coating (high mechanical, chemical and thermal resistance) opens up great prospects for their implementation at the Uzen field. To do this, it is necessary to open a pipe plant in Kazakhstan using modern equipment, advanced technologies that will allow for dynamic development and solve complex technical and technological tasks. Their appearance is shown in Figure 5.

Figure 5 - Tubing with polymer coating PEP-585.

Conclusions. It should be noted that the thermal effect on the flow of well production, in which the temperature of the liquid remains above the temperature of the onset of wax crystallization throughout the depth of the well, is an effective solution to the issue of preventing the formation of ARPS. This effect is carried out using a heating cable. An application was filed for a patent for a combined method of heating a well, operated by rod pump installations and an electric centrifugal pump installation.

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