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INVESTIGATION METHODS OF PROTECTION FROM THE COMPLICATIONS DURING THE PRODUCTION IN THE FINAL STAGE OF FIELD DEVELOPMENT

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ABSTRACT
In the article, based on the data of the fields in the final stage of exploitation, the most important complications that occurred during the production period and the methods of preventing these complications in the modern period were investigated. In particular, the methods of preventing of the sand plug and flooding, which are the main problems in this type of fields, were investigated and the significance of these methods of selective control against flooding was investigated, the most successful ones among these methods were shown, the hardening of the bottom hole against sand plug and the use of sand control screen in modern times were considered, in the hardening of the bottom hole the use of resin-containing components is mentioned.

KEYWORDS:
Complications;
Sand plug;
Flooding;
Chemical hardening;
Waterproofing.

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Introduction

In this period, when the demand for oil and gas has not decreased yet, in order to provide the necessary amount of hydrocarbon, it is necessary to minimize the problems arising during the production. Statistics show that a large part of the hydrocarbon reserve is located under the seas and oceans. In these deposits, the production of wells in the later stages of the development period is very complicated and serious problems arise during these processes. Addressing these issues remains relevant and important. For this reason, researchers have tried to systematize the mentioned problems. There are many articles that confirm the importance of solving these problems not individually but as a group.

Although there are certain results of research aimed at solving these problems, research is currently being continued to obtain more advanced results with the application of new techniques and technology. The best example of this can be the measures taken against sand plug, which cause clogging of lift pipes and filter zone. Thus, the method of momentary depression used, the method of hardening the bottom hole, the methods of opening without perforation, etc. Although such methods have given positive results, they have not yet helped to solve the problem completely. Also, most of the wells in the current period are characterized by high flooding. The main source of the water problem is the approach of bottom water to the surrounding zone due to the drop in formation pressure, the approach of oil-water contact into the wells, the formation of water tongues due to the uneven injection profile, the percolate of the production casing and cement concrete. Selective isolation and other waterproofing works were carried out in the direction of combating flooding in wells. The application of complex methods is expected to be more effective in solving such problems.

The main goal of the study is to group and solve problems in order to solve them. For this, researches were conducted in the deposits located in the South Caspian Sea, problems were analyzed, and along with their solutions, a theoretical base of preventive measures against their occurrence was prepared. In particular, the effectiveness of preventive measures against sand plug and flooding, which are the main problems of the wells located in the Neft Daslari, Pirallahi, Guneshli, Bahar, Bulla, and Qum Adasi fields, was investigated.

The process that begins with oil and gas production is always accompanied by solid particles in the well product to some extent. The problem occurs in all hydrocarbon fields, regardless of the age of the reservoirs, but it is mostly produced in younger horizons (Miocene and Pliocene-aged rocks). Because these formations are consist of brittle and the poor cementing material. A possible sand plug problem depends on the interaction of chippings, their intergranular friction, stress state of rocks and in some cases, the viscosity of the formation product. Of course, there are individual solutions to each of these problems, but the main problem is that any control method applied involves additional costs and reduced production. The cost of disposal and disposal of water produced along with oil ultimately increases the cost of oil.

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Since hydrocarbons have become valuable to industry, the search for oil and gas deposits has begun, and most of them are found in sandstones or carbonates. However less common in shale, volcanic rock and basalt. If we compare the importance of sandstone and carbonate deposits, sandstones are more abundant, but limestones are more important as deposits for hydrocarbons. The problem of sand in wells is manifested in any type of deposits. The problems associated with sand and water extraction during hydrocarbon extraction are well known. These problems, which result in the formation of the formation of the productive formation, lead to bigger problems by impairing the production of the equipment in the down hole and at the wellhead.

Research method

Before looking throug complex problem solving methods, their grouping should be briefly considered. Many technologies and chemical reagents are available to prevent from flooding. Depending on the isolation mechanism and the isolation material used, all methods are divided into selective and non-selective. Non-selective methods for limiting flood are based on the simultaneous or sequential injection of several reagents into the formation, which can form an insoluble precipitate in the formation due to chemical interaction with each other or physicochemical transformation of the resulting mixtures. However, when performing waterproofing with the help of resins or cements, the entire bottom hole is technologically affected, and permeability decreases not only in the water phase, but also in the oil phase, which negatively affects the productivity of the well.

Selective isolation methods are based on the use of materials that increase the seepage resistance in the saturated part of the formation. The selective effect of chemical reagents is based on the difference in the filtration properties of the rock and the physico-chemical properties of the reservoir fluids (oil and water). Isolation of the flooding is carried out through the following mechanisms:

- cooling of the bottom hole;
- precipitation of supersaturated solutions of solid hydrocarbons;
- hydrophobization of rocks and the formation of emulsions in them;
- interaction of chemical compounds with formation water;
- physico-chemical transformation of the mixture of formation water and compounds (decreased solubility, solidification, etc.).

Selective isolation compositions are available in many formulations;

1. Technologies based on the use of dispersed systems such as polymer-dispersed systems and their modifications, fibrous-dispersed systems, systems based on carboxyl-methyl-cellulose and bentonite clay, colloidal-dispersed systems, alkaline polymer-suspension compositions, polymer suspensions, emulsion, foam systems and so on.
2. Hydroxyethylcellulose, methylcellulose solutions and their modifications, resins, gel-forming compositions, technologies used for application of polymer solutions such as visco-elastic compositions, gel-forming and visco-elastic compositions, cross-linked polymer systems and their modifications, silicate-polymer gels and so on.
3. Technologies based on microbiological impact on reservoir.
4. Among the most promising and technologically advanced methods of flooding work are technologies based on the use of sediment-forming compositions and components, including NaSi solutions, alkali, aluminum chloride compositions, etc. These compositions are stable at high pressure and temperature and are non-toxic.

The main advantage of selective technologies is that there is no need for perforation after the process in the productive zone. In this regard, preference should be given to isolation materials and methods in anti-flooding works.

In connection with the above mentioned advantages, the selective limitation of flooding in fractured-porous rocks is used as a binder in waterproofing compositions based on sodium silicate from inorganic chromium salt (III), which allows to obtain gels in the entire volume of the initial composition.

Increasing the selectivity of the effect of waterproofing compositions is possible by changing the wettability in relation to oil-saturated and water-saturated rocks. The imbue ability of the waterproofing composition is evaluated by measuring the wetting angle at the contact surface of the waterproofing composition with rock samples saturated with oil and water. Polyhydric alcohol can be added in different concentrations to the waterproofing composition to change the wettability of the rock.

The addition of alcohol to the waterproofing composition causes an increase in hydrophilicity relative to water-saturated rock and an increase in hydrophobicity relative to oil-saturated rock. The optimum concentration of polyhydric alcohol is 3% (by mass), since no change in wetting angle is observed when more alcohol is added. In addition to changing the wettability, the inclusion of polyhydric alcohol in the composition of the waterproofing mixture leads to the improvement of the technological properties of the prepared cementing material due to the increase of intermolecular forces and expands the temperature range of its application.

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Fig. 1. Sand control screens double-screen, single-screen sand control screens

As the solution enters the water-saturated interval, the fill material isolates the water-saturated section rather than the oil-saturated zone because it is in better contact with the rock.

Since sand is inevitable during the exploitation of a productive reservoir composed of brittle rocks, measures against sand must be taken. During the research, the minimization of the sand factor was considered in the use of gravel and other types of sand control screens. Sand control screens are grouped according to their materials, number of screens, and most importantly, expandability. According to the number of screens, there are single screens and double screens, hard metal sand control screens, thin sand control screens, layered sand control screens and isolated sand control screens according to their materials. Single-screen, double-screen sand control screens and layered sand control screens were used during the research from the specified sand control screens (fig. 1). At this time, the prevention of sand entering the well decreased to 67%. However, the sand still present in the well product causes problems during the initial processing of the product.

Researches continued with gravel sand control screens, and at this time sand 20% larger than the granule size of the rock that makes up the selected formation was injected into the bottom hole, creating a new artificial formation, which we call gravel sand control screens. After the flow profile was established, sloughing of sand was significantly prevented (fig. 2).

One of the sand control techniques used in world oil and gas production practice is the chemical hardening method. This method is divided into several groups, polymer (rubber) based and other organic based. Characteristics of organic-based chemicals include oil solubility, hydrophobic nature, low bioaccumulation tendencies, and high biodegradation factor. Here we will focus on polymer-based sand consolidation, which consists of injecting polymerized organic resins into the bottom hole when gravel sand control screens are also ineffective. The main idea is to bind the sand grains together without damaging the reservoir, without reducing the permeability to oil caused by the oil wetting of the pore-catchment resin. Although it is difficult to achieve both at the same time, it is necessary to combine the juicy contents properly to form a mass with better compressive strength and to keep the reservoir pores undamaged by the resin. Figure 3 shows the pore spaces and sand grains combined with resin, which increases its compressive strength.

According to their chemical composition, resins are solid, hard, soft, organic non-crystalline polymers, brittle when solid. The molecular weight distribution of the polymer network of resins is very narrow. The flammable nature of resins requires extra care when handling and researching them. In general, resins are raw mate-

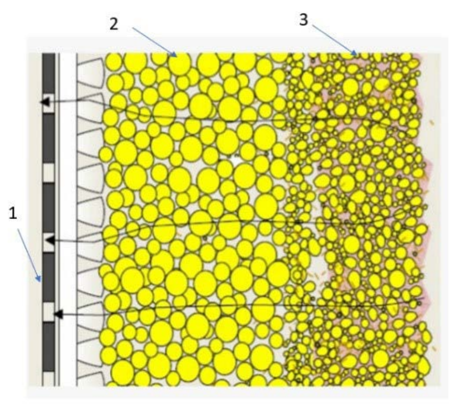

Fig. 2. Gravel sand control screen
1 – wellbore, 2 – gravel, 3 – formation

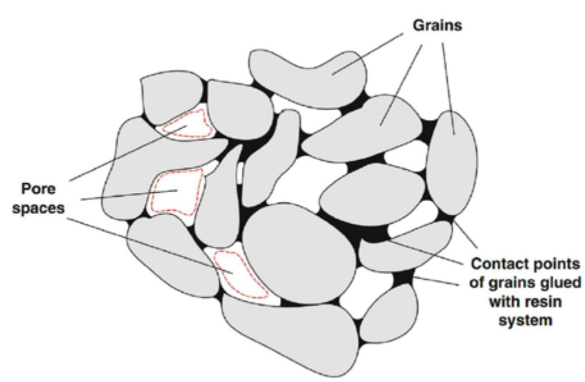

Fig. 3. Contact points of sands after the resin hardening process

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rials for adhesives and coatings used in the petroleum industry, as in many other industries. There are two types of resins: thermoset and thermoplastic resins.

When exposed to a heat source, thermoset resins irreversibly change from a melting and soluble material to a melting and insoluble material through the cross-linked polymer network. They have a very low molecular weight (<10,000). The most commonly used types of thermoset resins are: phenolic resins, furan resins, amine resins, epoxy resins, unsaturated polyester resins, urethane foams, alkyl resins.

Unlike thermoset resins, thermoplastics are reversible, that is, their physical state changes by applying different pressures and temperatures. Thermoplastic polymers consist of linked monomers of very high molecular weight (>10,000). Molecular bonds (chains) can be easily broken by heating or dissolving the substance. Thermoplastic resins include polyethylene, polypropylene, polystyrene, polyvinyl chloride, and furan resins.

There are some important requirements when applying resins:

- The dynamic viscosity of the resin should be moderate with values not exceeding 0.02 Pa·s. This will allow you to pass the resin through all the restrictions without excessive pressure loss and compress it with excessive liquid;
- The resin must have moisture-forming solids to bind them together, but must not occupy too much of the pore space at certain points;
- When placed, the polymerized resin must have good compressive strength to prevent sand movement;
- The starting moment of resin polymerization should be controlled with additives. Too short periods can result in improper consolidation or even improper placement;
- Although the polymerized resin is must be able to withstand prolonged contact with the resulting brines and not be reactive with acids.

Working with resin systems, performing the process safely and technically correctly requires the highest performance control and experience. The interval to be treated with resins should be isolated from the rest of the well to ensure effective injection into perforations, to prevent loss of process fluids and contamination of resins. Mainly, hardening works are carried out near the bottom hole up to a depth of 1.5 m. Fastening of thin layers (<6 m) is recommended. It is possible to harden a zone with a maximum thickness of 7 m in one stage.

The main purpose of the pre-cleaning operation is to remove formation fluids (especially water) that are incompatible with the resin system and can contaminate it (fig. 4. a, b). Since the resin has to stick the sand grains, this is only possible in this situation where rocs is not wet with unrecovered oil and unrecovered water, where the main problem is that the surface of the formation sands is wet with water or oil.

Therefore, the prewash fluid must be carefully selected depending on the type of resin system used. In some cases, condensate with surfactants is used. Other cleaning systems contain solvents such as isopropyl alcohol or EGMBE (Ethylene Glycol Mono-Butyl Ether) to remove water.

(a) Initially driving fluid are encountered with unrecovered water surrounding the sands;

(b) Solvents successfully displace uncovered water and maintain permeability;

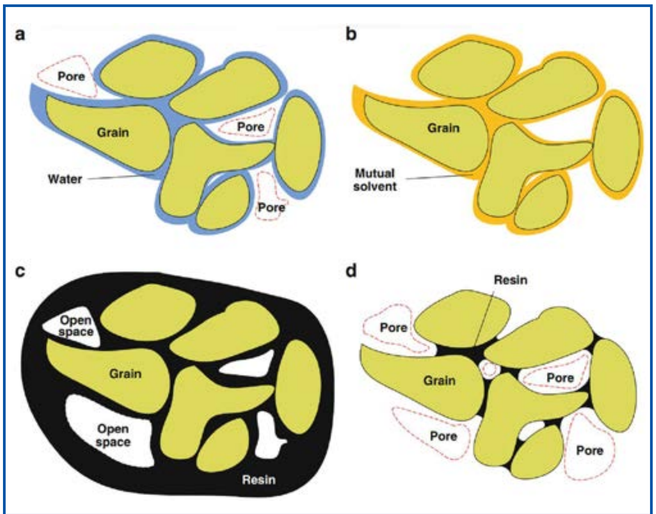
(c) The main hardener fluid is injected and enters the pores by capillary pressure;

(d) The injected fluid, other than the residual resin (which binds the sand grains together), is removed from the formation.

The final resin curing fluid to be injected usually consists of resin, solvent, hardener, activator, and accelerator (optional). Different resin systems are used depending on the cleanliness, pressure, temperature and other properties of the bottom hole.

One of the most important factors when developing a resin processing fluid is the formation temperature. This dictates the curing time of the resin and thus the necessary concentrations of certain additives such as accelerators and hardeners. In order to ensure uniform coverage of the layer to be fixed, the injection itself should be carried out at a low speed below the initial fracturing pressure (fig. 4. c).

In the phase separation process, the polymerized resin separates from the solvent as a second liquid phase after some time. Capillary forces draw the resin into the interparticle spaces to the sand grain junctions,



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where it hardens and binds the sand grains together. Conductivity is preserved by limiting the volume fraction of the individual resin phase.

At the end of the process, the unhardened resin phase remaining in the formation is extracted from it, thus connection is made between the formation and the well after that the the well is started to production. Furan and epoxy resins are mainly used. In chemical hardening, the desired fluids are rarely ready-to-use without additives, as they require proper placement, resin hardening, etc. helps to obtain the properties required for Let's take a look at some of these important supplements and their main purposes.

Activators, as very important additives, are used to extend the penetration time of the resin and minimize the hardening time. It can also be added to the second excess liquid to accelerate solidification. When excess activator is added to the fluid to be injected, excessive flushing may be required to maintain permeability. Activators require careful addition to the resin system, as the reaction time with the resin can be greatly reduced.

Accelerators are used to minimize the period used for hardening (to speed up the reaction time). Accordingly, the period used for hardening will be reduced as the injection fluid is used instead. Accelerators are included in the system when the injection and curing operations are expected to last significantly shorter than normal.

Surfactants are used to reduce the interstitial tension between two liquids or between liquids and solids. They can be very effective in removing associated water in the formation pre-wash. Basically, these are organic compounds that act as dispersants, foaming agents, wetting agents, emulsifiers or detergents.

Isopropyl alcohol (C_3H_8O) is a flammable chemical that can dissolve a wide range of compounds. That is why it is used during washing to remove water. It evaporates quickly and, unlike other solvents, is not very toxic.

EGMBE or ethylene glycol mono-butyl ether is a solvent for both aqueous and non-aqueous liquids. It effectively cleans sand and displaces mixed residual water. The end result of such an effect is a better accessibility of the resin to the intergranular spaces.

Additionally, the hardening solution may reduce permeability to some extent. In order to minimize this decrease, it has been determined based on laboratory experiments that it is possible to maintain the primary permeability of the formation when $CaCO_3$ is used up to 20-30 percent in the solution as a foaming agent.

When applied in an aggressive environment, the use of NaOH as a neutralizer will greatly increase the effectiveness.

Conclusion

- As a result of research, the methods used have shown their effectiveness. The advantages of the method of chemical hardening of the bottom hole used against sand plug are the following:
- The use of gel forming systems is more effective than others in the current waterproofing measures in fields that are in the final stage of development;
- Among the used compositions, the most successful ones are mixtures of NaSi with different compositions;
- Although the composition with many gels is effective for a certain period of time, there is a need to increase the durability of the formation.
- The application of anti-sand factor hardening systems does not require the introduction of gravel into the perforation zone, therefore, there is no significant reduction in production, as in the case of the application method of gravel sand control screen;
- No special construction equipment is required and therefore no additional funds are spent for its rental;
- Chemical consolidation can be done through existing completion or hydraulic fracturing;
- It is quite cheap compared to gravel sand control screen and hydraulic fracturing methods;
- By maintaining 60-90% of the original permeability, it prevents the increase of the Skin factor in the bottom hole, thus it is possible to maintain more than 90% of the original productivity.

As a result of the research work, all the solutions given to the problems showed their effectiveness both in terms of reducing human labor, both economically and ecologically.

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Анализ методов борьбы с осложнениями, возникающими в период эксплуатации скважин на заключительной стадии разработки

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Реферат

В статье, на основе данных месторождений, находящихся в завершающей стадии эксплуатации, исследованы важнейшие осложнения, возникшие в период добычи и методы предотвращения этих осложнений в современную эпоху. В частности, исследованы методы предотвращения песчаных пробок и обводнения, которые являются основными проблемами на месторождениях данного типа, исследованы методы выборочной борьбы с обводнением, показаны наиболее успешные среди этих методов, рассмотрены методы применения скважинного фильтра и упрочнения забоя от песчаной пробки путем применения смолосодержащих компонентов.

Ключевые слова: осложнения; песчаная пробка; обводнение; химическое затвердение; гидроизоляция.

İşlənmənin son mərhələsindəki yataqlarda quyuyuların istismarı zamanı yaranan mürəkkəbləşmələrə qarşı mübarizə üsullarının araşdırılması

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Xülasə

Məqalədə işlənmənin son mərhələsində olan yataqların məlumatlarına əsasən istismar dövründə baş verən ən vacib mürəkkəbləşmələrə və bu mürəkkəbləşmələrə qarşı müasir dövrdə aparılan mübarizə üsulları araşdırılmışdır. Xüsusilə bu tip yataqlarda başlıca problem olan qum və su təzahürü ilə mübarizə üsulları araşdırılmış və bu üsullar sulaşmaya qarşı selektiv mübarizə üsullarının əhəmiyyətliliyi araşdırılmış, bu üsullar içərisində ən uğurlu olanlar göstərilmişdir, quma qarşı quyudibi zonanın bərkidilməsi və müasir dövrdə quyudibi süzgəclərin istifadəsinə baxılmış, Quyudibi zonanın bərkidilməsində qətran tərkibli komponentlərin istifadəsi qeyd olunmuşdur.

Açar sözlər: mürəkkəbləşmələr; qum tıxacı; sulaşma; kimyəvi bərkidilmə; suizolyasiya.