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ACID-PERFORATION FRACTURE

Abstract. In the course of developing wells their daily production rate begins decreasing overtime, and subsoil users need to carry out measures to increase oil recovery of productive layers. In oilfield practice there are well-known methods of intensifying oil recovery, such as deep penetrating perforation with the use of thermo-gas-cumulative effect (perforation with forming cracks up to 4 meters), and methods of chemical treatment of the formation that permit increasing the productivity factor by dissolving a part of the formation skeleton and forming oil drainage channels. These methods have recently proved well and have been widelyused in the primary and secondary opening of reservoirs and in increasing oil recovery of oil reservoirs. However, these methods of layer intensification have certain drawbacks. In this regard in this article, there are considered factors affecting the reduction of oil recovery from the layers. There are analyzed advantages and disadvantages of present-day methods of chemical treatment of a layer and the method of perforation with the use of the thermo-gas-cumulative effect. There has been revealed and justified the need for the joint use of these methods. The authors propose to combine the two technological processes and present a new technological process that will combine the advantages of both technologies, as a result of which their effectiveness will increase. The essence of the process is to carry out deep penetrating perforation with simultaneous injection of chemical reagents into the formation, in order to study and to fix the formed cracks in the formation which leads to a significant increase in the inflow of formation fluid into the well.

Keywords: perforation, enhanced oil recovery, acid treatment, secondary opening of layers, swabbing, near-well region, cumulative charge.

After drilling and opening productive oil layers there begins thewell development process, that is the complex of operations to call the inflow of formation fluid from productive horizons. Over time the layers are depleted, the daily production rate drops, and the first place for the subsoil user is the issue of oil recoveryintensification.

It is advisable to carry out measures to increase oil recovery after determining the coefficient of their residual oil saturation by such methods as pulse neutron-neutron logging (PNNL), pulse neutron-gamma spectrometriclogging (PNGSL), broadband acoustic logging (BBAL). There are the following factors that reduce oil recovery:

- reduction porosity in formation and collapse of cracks due to forming compressive stresses in the well walls after drilling and perforating casing;
- the blocking effect of water that is caused by surface and capillary phenomena occurring in the pore space under the action of mutual displacement of immiscible liquids, since the phase permeability of oil is less the more is water saturation;
- forming hydrophobic areas in bitumen reservoirs if the drilling mud penetrates into the formation to the depth of about 0.2-3 m;
- forming a mud cake on the well walls in the perforation interval;
- swelling the reservoir rock (clay rocks are especially prone to this);
- swelling clay particles contained in the pores of the reservoir;
- forming stablewater-oil emulsions in the reservoir, as well as insoluble precipitation as a result of interaction of formation fluids and filtrates;

- phase transformations occurring in the formation fluid (for example, the evolution of gases from oil and their dissolution in filtrates, etc.);

- clogging pores of the formation with solid particles (colmatation) penetrating into the collector together with the filtrate;

- changing the properties of the rock surface in the filtration channels (hydrophilization) due to increased water saturation of the rock pore space;

- changing pH of the medium [1].

In oilfield practice methods for intensifying deeply penetrating perforation with the use of thermal-gas-cumulative impact (perforation with forming cracks up to 4 meters) are well known. These methods have recently proved well and have been widely used in the primary and secondary opening of reservoirs. However, this method of intensification has certain drawbacks. When forming a depression of more than 30 MPa there takes place a microcracks collapse due to the impact of rock pressure and displacement of rock particles which leads to decreasing rock permeability [2].

Another way to increase wells productivity is the methods of chemical treatment of the formation that permits to increase the productivity factor by dissolving a part of the formation skeleton and forming oil drainage channels. The methods of chemical treatment of the formation also have certain drawbacks. When chemical reagents are injected into the reservoir, the most permeable interlayers are first processed, and thus less permeable interlayers are not involved in the process of operation which in turn leads to the incomplete production of the reservoir [3].

In practice it is worthwhile to use a comprehensive approach to solving the above-mentioned problems, combining the two technological processes and presenting a new technological process that permits to increase significantly the capabilities of both technologies. The essence is to carry out deep penetrating perforation with simultaneous injection of chemical reagents into the formation with the purpose of working out and fixing the formed cracks in the formation which leads to a significant increase in the inflow of formation fluid into the well.

Acid-perforation fracture of the formation consists of 3 stages:

1. *Perforation-reperforation of the productive interval.* In the well on the pump-tubing string (PTS), depending on the thickness of the layer being treated, there is lowered the apparatus of the complex action of the required length. The internal filling of the apparatus presents a frame equipped with cumulative and gas-generating charges. The outer part of the perforator housing, depending on the results of the software simulation of the processing design, can also be equipped with a gas-generating shell (figure 1).

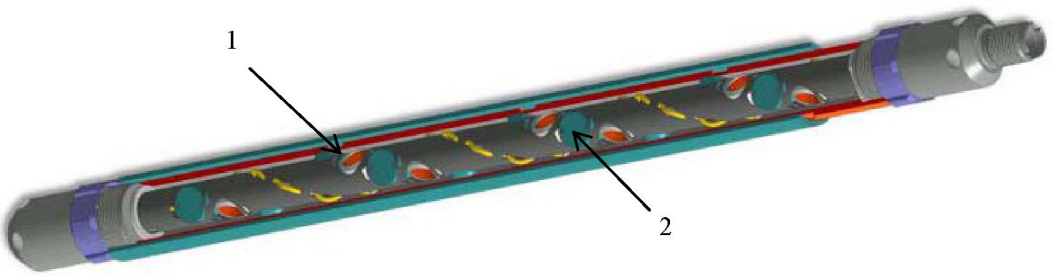

Figure 1 – Perforator body:
1 (red) – cumulative charges; 2 (green) – gas charges

The apparatus is activated by means of a hydro-mechanical initiating head by raising thepressure in the PTS tubing string to a predetermined value, or by dropping the impact rod from the wellhead [4]. The depth of penetration, depending on the power and weight of the explosive of the shaped charge, can reach 1600 mm (figure 2).

2. *Thermal-gas impact.* After opening the formation by cumulative perforation that in turntriggersgas generating internal and external charges, the collector loading is immediately formed by the burst pressure directly into the perforation channels.

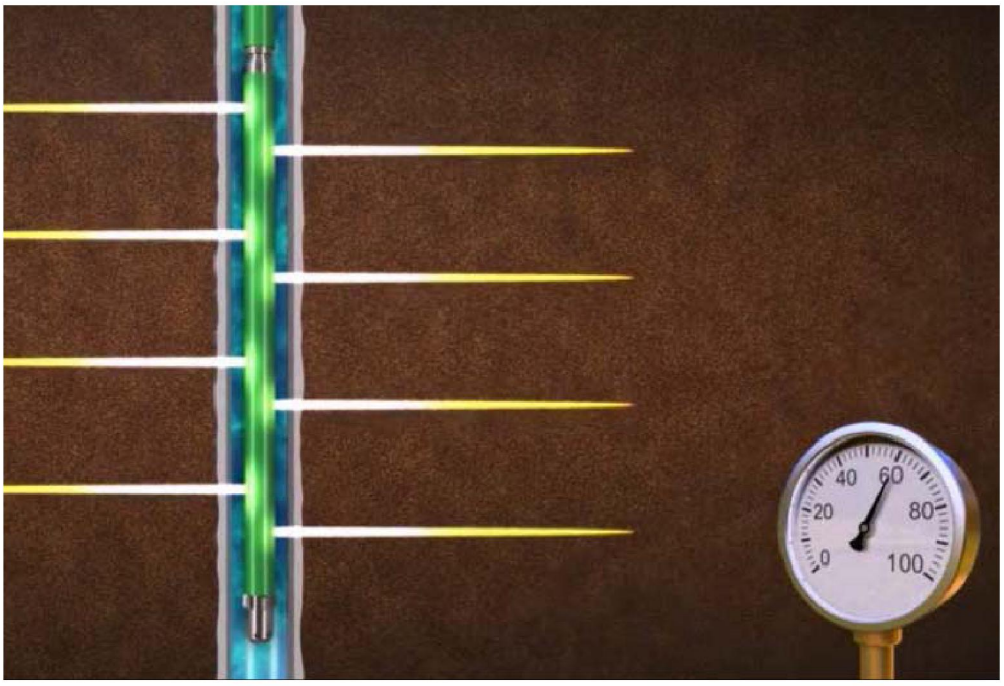

Figure 2 –Perforation of productive layers

Pressure raises the column of fluid in the well. After arriving the reflected pulse from the surface of the borehole fluid, the pressure in the treatment zone becomes less than hydrostatic pressure and the reaction products with sandy-argillaceous particles are removed from the reservoir cracks. The duration of such "depression-repression" cycles is approximately 101-102 s. which facilitates the cleaning of the near-well zone of the formation with the simultaneous forming of extended channels in the reservoir, and effectively improves the hydrodynamic connection of the well with the formation over a wide range of porosity and permeability values (figure 3).

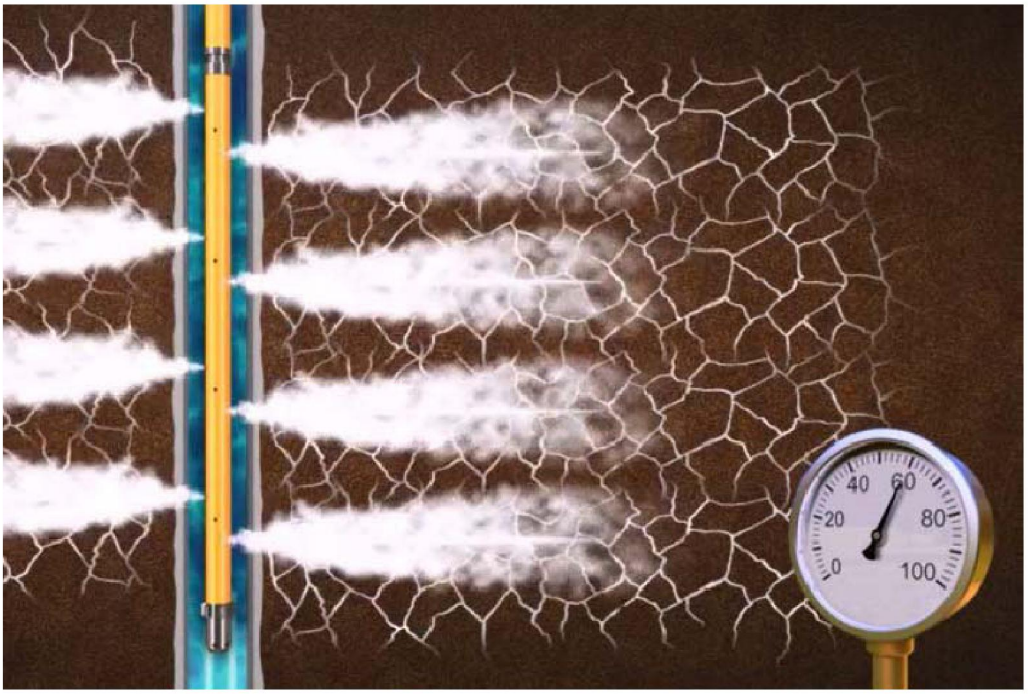

Figure 3 – Thermal-gasimpactonthelayer

3. *Acid treatment followed by recovery of reaction products.* After dropping the fracture pressure, there takes place pressure drop in the PTS tubing string that is filled with an active reagent. The reagent starts entering the formation and filling the formed cracks. At the same time, the pumping unit is put into operation at the wellhead pushing the calculated volume of the prepared composition. After filling the volume of cracks there takes place the further injection of the reagent to affect the remote zone of the formation [5].

The reaction occurs within 6-12 hours depending on the concentration of the active substance, acceleration and injection rate (figure 4).

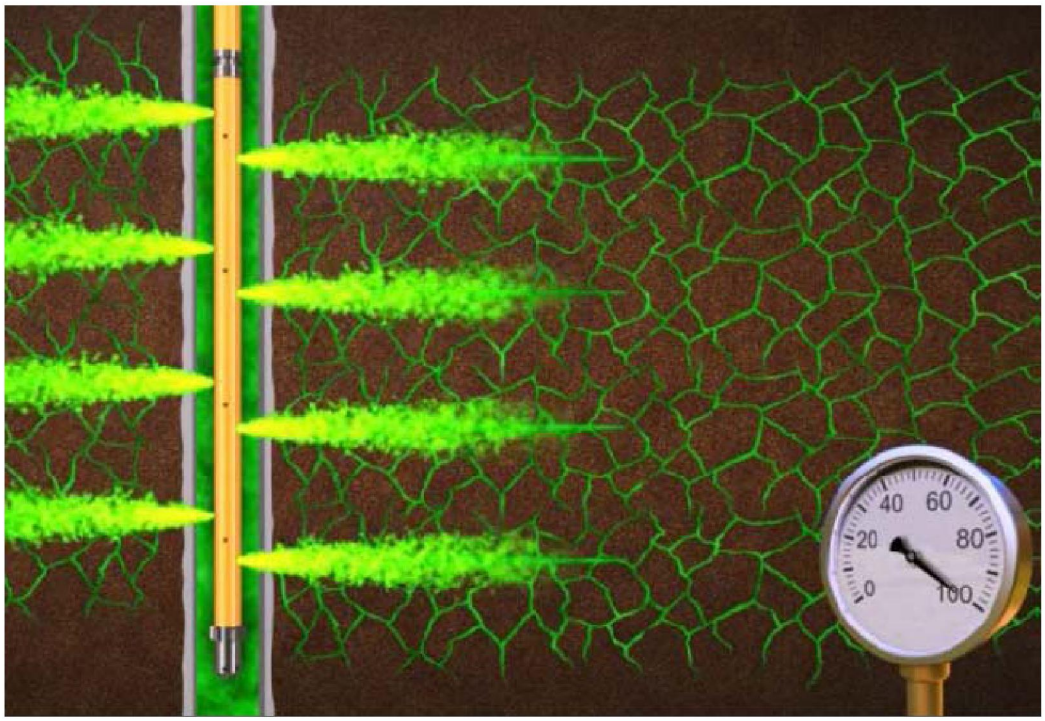

Figure 4 – Acidimpactonthelayer

Upon termination of this time, the reaction products are removed from the formation. This operation is mandatory. It permits to clean the cracks formed from the secondary precipitation and to clean the filtration channels.

The success of the acid-perforation fracture depends on the following factors:

1) compatibility of acid composition with formation fluids;

2) coverage by the impact of low permeability zones of the productive part of the deposit;

3) low interfacial tension at the interface between oil phases and acid composition in the course of pumping, as well as waste solution in the course of development;

4) absence of precipitation in the course of reaction of acid with minerals of the reservoir and at all stages of acid movement within the operation;

5) lowcorrosivity of acid composition;

6) using acid compositions that react with the rock within prolonged time at high formation temperatures [6].

Another favorable condition is apresence in the reservoir of thin clay interlayers to form a more stable system of cracks.

The developed method was used in the wells of the Kok-Arna deposit of Western Kazakhstan. As the acid composition there was used the following mixture: 60% of hydrochloric acid (15%concentration); 15% of hydrofluoric acid (35%concentration), 25% of solvent, kerosene. Comparing the changes in the well production rate (table) and studying the schedule of changes in production rates in wells (figure 5), it can be stated that the use of the method increased oil recovery by 50-70%.

Comparing daily production rate of wells before and after acid perforation fracture

Well No.	Daily production rate before using the method, m^3/day	Daily production rate after using the method, m^3/day
62	25.8	39.5
53	19	32.2
30	12.1	20.3

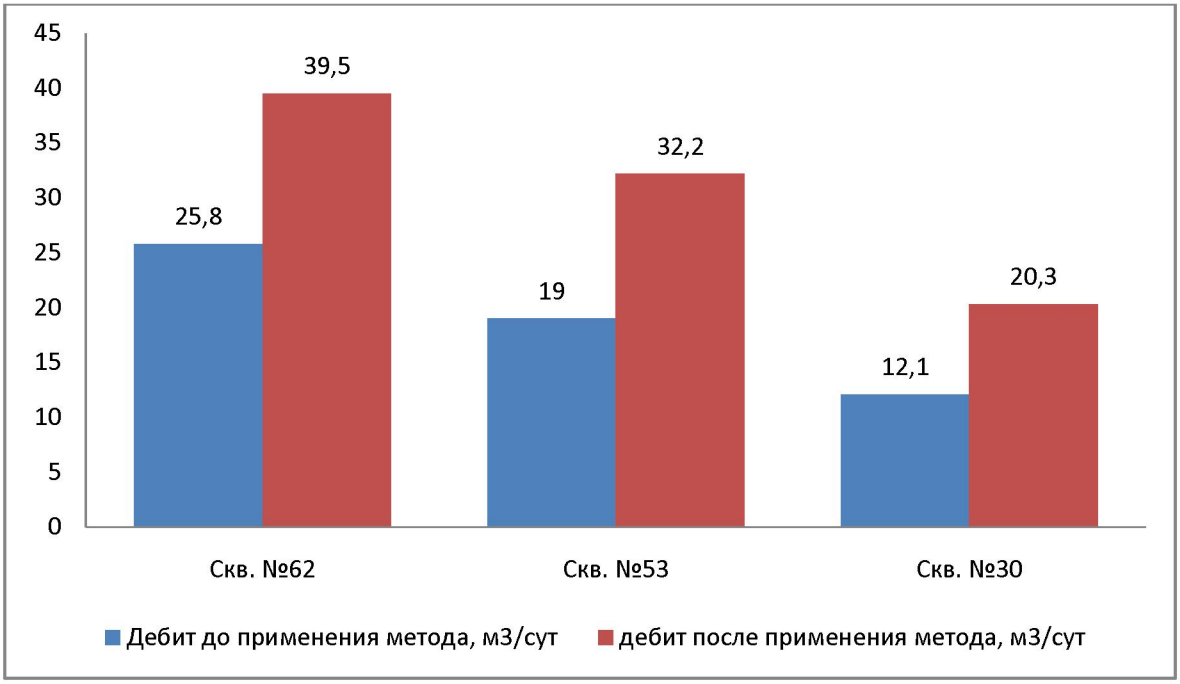

Figure 5 – Schedule of changing the production rate in the wells of the Kok-Arnafield

Having analyzed the data from the wells of the Kok-Arna field the method was used in Matin (7 wells), S. Nurzhanov (10 wells), and Sazan-Kurak (10 wells) fields. The efficiency of the method at these deposits was from 35% to 60%. On the basis of the data provided, it can be concluded that combining the perforation method with the thermal-gas-cumulative effect and methods of chemical treatment of the formation can eliminate the shortcomings of both methods and enhance the possibilities and efficiency of these methods.

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ҚЫШҚЫЛДЫҚ-ПЕРФОРАЦИЯНДЫҚАБАТТЫҢЖЫРТЫЛУЫ

Аннотация. Ұңғымаларды игеру кезінде олардың тәулік дебиті азаяды, сондықтан жер қойнауын пайдаланушыларда, өнімділік қабаттардың мұнай беруін жоғарлату қажеттілігі туады. Мұнайкәсіпшілік тәжірибеде, термогазкумулятивті әсерді қолданым терең енетін перфорация (4 метрге дейінгі жарықшақтарды жасау перфорациясы) және қабат қаңқасын ерітіп және мұнайды сорғытатын каналдарды жасау арқылы өнімділік коэффицентін жоғарлату үшін қабатты химиялық өндеу әдістері мұнайөнімділік қарқындығын жоғарлату үшін кең таралған. Соңғы кездері берілген әдістер, мұнайлы қабаттардың мұнай өнімділігін жоғарлату үшін қабаттарды екінші және бірінші ашу кездерінде өздерін жақсы көрсеткен. Бірақ қабаттардың қарқындылығын жоғарлату кезінде бұл әдістердің белгілі бір кемістіктері бар. Осыған байланыты берілген мақалада қаббатың мұнай өнімділігін азайтатын факторлар қарастырылған. Қабатты химиялық өндеудің қазырғы заманғы әдістері және термогазкумулятивті әсерін қолданумен перфорация әдістерінің анализі өткізілді. Осы әдістерді бірлесе қолданылуының қажеттілігі анықталып негізделді. Авторлар осы екі технологиялық процестерді қосып, екі технологияның жетістіктерін қосып, ссоның салдарынан олардың тиімділігін жоғарлататын жаңа технологиялық процесті ұсынды. Процестің маңызы, ол ұңғымаға қабат флюидінің ағуын жоғарлату үшін, пайда болған жарықшаларды бекіту және өндеу үшін бір уақытта терең ену перфорациясымен қабатқа химиялық реагенттерді сығындау.

Түйін сөздері: перфорация, мұнай өнімділікті жоғарлату, қышқылды өндеу, қабаттарды екінші рет ашу, свабтау, ұңғыма жанындағы аймақ, кумулятивті заряд.

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КИСЛОТНО-ПЕРФОРАЦИОННЫЙ РАЗРЫВ ПЛАСТА

Аннотация. В процессе освоения скважин их суточный дебит с течением времени начинает уменьшаться, и у недропользователей возникает необходимость в проведении мероприятий по увеличению нефтеотдачи продуктивных пластов. В нефтепромысловой практике хорошо известны методы интенсификации нефтеотдачи такие, как глубоко проникающая перфорация с применением термогазокумулятивного воздействия (перфорация с созданием трещин до 4 метров), и методы химической обработки пласта, позволяющие увеличить коэффициент продуктивности за счет растворения части скелета пласта и образования каналов дренирования нефти. Данные методы в последнее время хорошо зарекомендовали себя и нашли широкое применение при первичном и вторичном вскрытии пластов и в увеличении нефтеотдачи нефтяных пластов. Однако у этих методов интенсификации пластов имеются определенные недостатки. В связи с этим в данной статье рассмотрены факторы, влияющие на уменьшение нефтеотдачи пластов. Проанализированы преимущества и недостатки современных методов химической обработки пласта и метода перфорации с применением термогазокумулятивного воздействия. Выявлена и обоснована необходимость совместного использования этих методов. Авторами предлагается объединить два технологических процесса и представить новый технологический процесс, который позволит объединить преимущества обеих технологий, вследствие чего увеличится их эффективность. Сущность процесса заключается в проведении глубоко проникающей перфорации с одновременной закачкой химических реагентов в пласт, с целью проработки и закрепления создавшихся трещин в пласте, что приводит к значительному увеличению притока пластового флюида в скважину.

Ключевые слова: перфорация, увеличение нефтеотдачи, кислотная обработка, вторичное вскрытие пластов, свабирование, прискважинная зона, кумулятивный заряд.