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Research Article

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Technology of Creation of Cracks in Well-Borehole Zone of Formation

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Abstract
The development of energy-saving technologies requires a new approach to intensifying oil production. The decline in well production rates in almost all oil and gas producing countries, as well as the commissioning of new oil fields with a complex geological structure, require new technological solutions to increase the permeability of the well bore zone of the oil reservoir. To penetrate low-permeability reservoirs, it is necessary to break the rock mass, creating a volumetric dense network of cracks. The existing technologies of mechanical action on the bottomhole zone either increase the pressure too slowly, which, when very high pressure is applied, leads to the formation of one crack, or with a rapid increase in pressure, they contribute to brittle crushing of the rock, but without developing cracks in the depth of the formation. It is desirable to use technology that can create cracks on the surface of the rock, and then fill them and develop them along the formation column in all directions. In addition, it is important that the proposed technologies are economical and have minimal damage to the environment.

There are two types of Rock Destruction: Brittle And Plastic

Plastic Fracture

Plastic fracture is a classic fracking where tensile forces act on the rock. Fracking is the most effective method, but it is complicated, expensive, dangerous, unpredictable, requires the use of chemical reagents, creates one long crack that must be fixed with proppant. It has limitations in the number of applications, since during reprocessing the same crack is opened, new cracks are not formed.

Brittle Rock Fracture

Brittle rock fracture occurs, for example, when explosives are used. Sharp stress differences and, as a result, cracks form on the rock surface. Therefore, it is more efficient to use hydraulic shocks than constant pressure to create a network of divergent cracks. But periodic impacts should have a given duration and a certain rate of pressure change for optimal deformation and cracking of the rock. With a very rapid increase in pressure, the rock and cement stone are broken into small fragments. With a very slow pressure build-up, conventional fracturing will occur with one fracture. To develop cracks, it is necessary to fill them with liquid and expand, preferably with periodic repetition of expansion and compression processes.

The best option is to combine brittle and plastic rock fracture methods that complement each other. To form and develop a network of fractures, the brittle fracture process should be repeated periodically to form microcracks and then maintain a high fluid velocity to fill and develop existing and formed fractures. Tensile forces act on the rock, the rock breaks with the confluence of pores. As the fracture network develops, it is possible to change the pressure and duration of fluid injection in order to maximize the volume permeability of the wellbore zone [1].

The duration of increased pressure in the crack should be at least 0.5 seconds, so that under the influence of pressure the cracks have time to expand, and then, with a decrease in pressure, close. The optimal duration of periodic pressure pulses in the bottomhole zone of the well can be considered units of seconds during which fractures regularly deform and develop intensively. An important factor in the development of fractures in the formation is their regular deformation.

A column of fluid in the well can be represented as a long compression spring. If a pressure pulse is applied to the upper end of the spring, it is compressed and stores energy. When the energy of the fluid movement moves through the elastic medium and reaches the lower end of the spring, a sharp pressure drop occurs to promote brittle fracture of the rock, then the formation pressure is maintained by the accumulated inertia of the fluid movement.

The front of the pressure pulse acts on the walls of the crack as a wedge moving at a high speed. Pressure pulse energy is used to open the fracture and repack the rock grains of the formation. In deep wells, the pressure pulse fades to a greater extent, and the leading edge of the wave is less steep. The moving liquid loses the ability to repack the grains of the rock skeleton, but if its pressure exceeds the mountain pressure, then cracks are opened, deformed and developed. Practice shows that it is not necessary to bring to fracking, with regular impulse exposure, cracks develop due to systematic deformation. The pressure shall be sufficient for periodic crack expansion leading to strength weakening and subsequent rock fracture [2]. Computer modeling of the process is shown in Figure 1.

The oil reservoir is a porous fractured structure, between the grains of which there is a liquid. Impulse pressure is transmitted by liquid in the gaps between the grains, pushes them apart, breaks the skeleton of the formation and develops cracks. By filling cracks with liquid and maintaining high pressure in them for several seconds, the network develops by plastic destruction. In addition, regular counter-parallel movement of the fluid contributes to the erosion of the formation rock in the bottomhole zone.

As the technology was developed, well tests were performed. The first experiments were conducted at injection well 1157 of NGDU Tuymazaneft. After forty minutes of treatment, permeability increased from 26 to 80 m^3/day and decreased very little within 10 months. For a long time, the injectivity of the well was higher than the passport data since additional fractures were formed in the wellbore zone of the formation or existing fractures increased permeability after deformation.

In 2020, the technology was tested at 10 injection wells of NGDU Almetyevneft and Aznakaevneft. The impact on the well bore zone was carried out by formation water with a density of 1.07 t/m3, the ambient temperature during the tests was – 2 ·/· +5°C. According to tests on injection wells, the technology made it possible to increase injectivity to values from 130 to 400 m^3/day, which is significantly higher than the passport injectivity.

Taking into account the positive experience of using the technology, it was decided to continue work in 2021-2022. In December 2021, 20 wells of NGDU Almetyevneft were processed. The near-well zone was affected by formation water with a density of 1.060-1.184 t/m^3, the ambient temperature during the tests was -16 + -2 ° C. During the work, the results were similar to those obtained in March 2020. It should be noted that record results were achieved when the injectivity of the well was raised from 0 to 800 m^3/day for an hour.

Pulsed processing methods have been used for a long time, methods of pumping a column of well fluid are known, but when applied, the energy of the moving fluid is insufficient to create a network of cracks. The proposed technology is applicable in low permeability reservoirs, as well as for the restoration of old wells, where other methods are ineffective. It can be combined with chemical treatment of the bottomhole zone with simultaneous pulsating erosion of rock. To verify the operability of the technology, experience was conducted at well 571 of NGDU Tuymazaneft at the Ardatovskoye field. After performing 32 hydraulic pulses during acid composition injection, the efficiency almost doubled compared to conventional injection [3]. The technology of using this method in the production of viscous oil has been developed and patented. In addition, in 2015, Kuzbass conducted experience in pulse hydraulic fracturing of a coal seam to remove methane. The method was successfully used in a horizontal degassing well.

Compared to classical fracking, this technology has undeniable advantages. For example, a minimum amount of equipment is used, energy consumption is minimal, a small amount of liquid is injected into the formation [4]. In many cases, the work is carried out without lifting operations, which is much more economical than most technologies close to obtaining a similar result and practically does not harm the environment. The proposed technology allows the development of a network of divergent fractures, increases the permeability of the wellbore zone of the formation and is intended for use in low-permeability reservoirs.

Conclusion

It can replace expensive technologies of hydraulic fracturing, torpedoing, chemical treatment, as well as all versions of hydraulic shock vibration, pulsation and other processing methods [5].

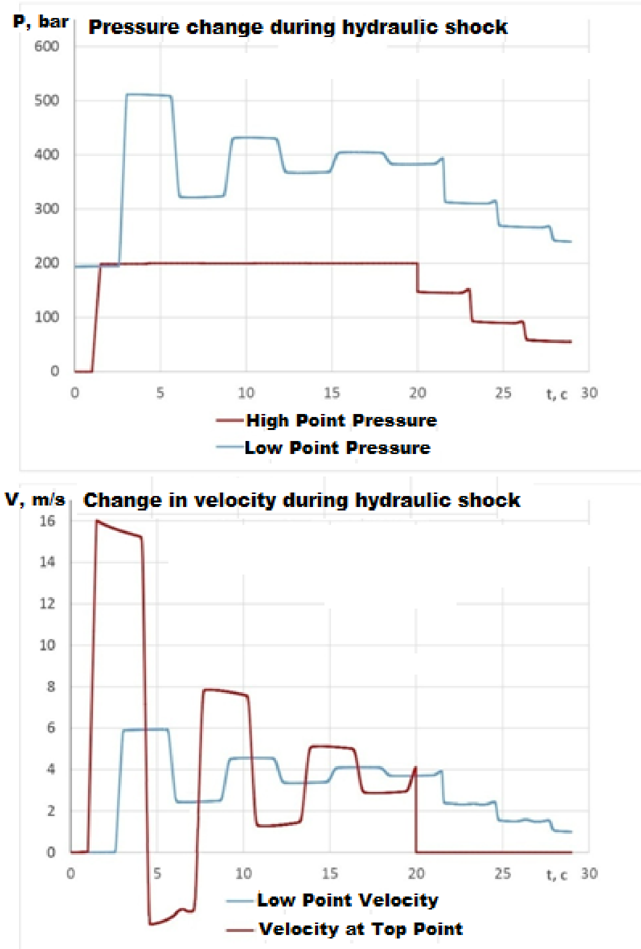

Figure 1: Computer simulation of the process

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