TECHNOLOGY OF HYDROFRACTURING

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Hydraulic fracturing (fracturing) is an effective means of intensifying the inflow of formation fluid to the well and increasing the oil yield of the formation, as well as increasing the throughput of injection wells. The formation of an artificial crack in the formation of a large length and permeability, connecting layers with different filtration-capacitive properties by a single channel, significantly changes the drainage regime of both individual layers and the formation as a whole [1].

The essence of the method consists in the artificial formation and expansion of cracks in the rocks of the outcrop zone by creating increased pressures of the liquid injected into the well. To prevent cracks from closing, quartz sand or proppant is pumped into the formation along with the fluid after the pressure is removed. As research shows, in the process of hydraulic fracturing, cracks with a width of 1-2 mm appear in the most unpredictable direction. Their radius can reach several tens of meters. Cracks filled with coarse-grained sand or proppant have significant permeability, as a result of which the productivity of the well increases several times after hydraulic fracturing. In some cases, well flow rates increase tenfold after fracturing. This indicates that the formed cracks have connected with other previously existing cracks and the inflow to the well comes from separate highly productive zones [2].

Making changes to the structure of the reservoir and the rocks containing it leads to the need to adjust the approaches to the application of traditional methods of influencing the near-cut and remote zone of the formation, as well as the need to create new technologies aimed at changing the cracks created in the fracturing process [3].

In most inclined wells, with a high probability, the plane of the formed fracture does not coincide with the trajectory of the well in the reservoir, so the interval of good hydrodynamic connection between the well and the fracture can vary widely from the maximum, when the line of the well lies in the plane of the fracture, to the minimum, when the vertical is perpendicular to the crack. During the transition of the flow of the injected agent from the well to the fracture during the fracturing process, the vector and velocity of the proppant-gel mixture change dramatically, which provokes the fallout of the proppant and the formation of plugs, the probability of complications increases with the decrease in the interval of active hydrodynamic connection between the wellbore and the fracture, i.e. in the formation.

During fracturing of the formation, shale rocks are formed, individual particles of the skeleton of the formation and the clay screen are disaggregated and included in the composition of the proppant that fills the crack. Fracturing crack formation occurs in the mode of mechanical instability of the walls, when the crack is filled with proppant, the surface of the crack is destroyed, which is an additional source of solid particles entering the crack. As a result, inclusions of various sizes appear in the volume of the proppant-fixed crack, which reduce porosity and permeability and negatively affect the filtration mode, which complicates the operation of well equipment. The volume of inclusions and the degree of their influence on the filtration properties of the crack are determined by the mode of crack formation and the composition of the process fluid, as well as the mechanical strength of the skeleton, the size of the particles that make it up, and their wettability. The mobility of these inclusions in the space between the proppant grains is fundamentally important, which is primarily determined by their size and features of interaction with the fluids that saturate the crack: pellet particles with a size smaller than the characteristic size of the cavities of the proppant bag are able to accumulate in it and block the filter [4, 5].

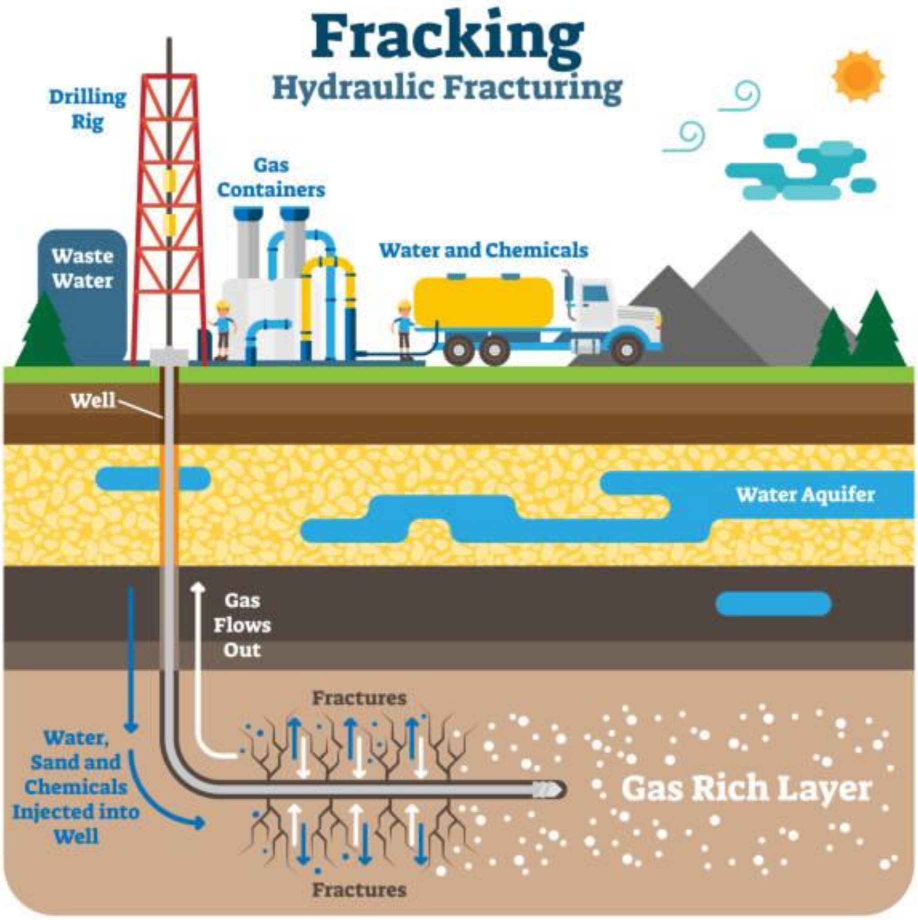

Fig.1 Hydrofracturing technology

The formation of long cracks and their filling with proppant is possible when using special rheological fluids, the filtrate of which into the formation through the crack wall and the film on the surface of the proppant negatively affect the conductivity of the crack and the permeability of the fractured zone and significantly reduce the efficiency of fracturing [6].

There are several types of hydraulic fracturing, which differ in technology and the purpose of the process: one-time, multiple, massed, directional (interval), two-fraction, fracturing with gases, oils, explosives. Conventional one-time hydraulic fracturing with Newtonian fluids involves fixing cracks (5-10 tons of sand at a concentration of 50-600 kg/m^3); deep-penetrating hydraulic fracturing and massive hydraulic fracturing involve a large amount of wedging material, the use of non-Newtonian fluids, large volumes of fluids, and a large number of equipment [7].

Thus, from the moment the well is put into operation after fracturing, processes occur that lead to a decrease in fracture conductivity and a decrease in fracturing efficiency. These features must be taken into account during the planning of fracturing technology and further work on the rehabilitation of fracture conductivity. For a correct forecast of the degree of influence of these factors on the operating mode of the well, along with traditional studies of the mechanical and filtration-capacitive properties of the formation and proppant, it is necessary to study the strength properties of the rocks in the area of the formation of the crack and, on this basis, to select the fracturing modes, the optimal dimensions of the proppant, and the properties of the process fluid.

Forecasting the removal of particles and the accumulation of pollution is necessary for the prevention of pump equipment failures during the development of wells and their bringing into operation, optimization of measures for cleaning cracks and rehabilitating the productivity of wells.

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