ISSN: 2639-7536

Review Article

Petroleum and Chemical Industry International

Technology of Crack Formation in Wellbore Zone

A.V. Shipulin

OJSC "RAINES", Saint-Petersburg, Russia

***Corresponding author**
A.V. Shipulin, OJSC "RAINES", Saint-Petersburg, Russia

Submitted: 08 June 2021; **Accepted:** 14 June 2021; **Published:** 21 June 2021

Citation: *A.V. Shipulin. (2021). Technology of Crack Formation in Wellbore Zone. Petro Chem Indus Intern, 4(2), 40-42.*

The most effective methods of well treatment, such as hydraulic fracturing, torpedoing and chemical treatment, are complicated, expensive, unsafe and unsustainable and, most importantly, insufficiently effective. We have proposed a new cost-effective, environmentally friendly and efficient well treatment technology, which has been developed over 20 years and patented many times.

There are two types of rock destruction - brittle and ductile.
An example of ductile fracturing is classic hydraulic fracturing, where tensile forces are applied to the rock and develop a fracture. Hydraulic fracturing is the most efficient method, but is complicated, expensive, dangerous, unpredictable, requires the use of chemicals, and creates one long crack that must be fixed with a proppant. It has a limited number of applications, as the same crack is opened during reprocessing, no new fractures are formed.

An example of brittle fracture is the use of explosives or plasma-pulse technology, where a powerful pulse with a duration of about 53 microseconds is applied to the formation rock. The effect of the pulse can be compared to an explosion, which creates a high-pressure region of about 10 t/cm2. At the same time the formation is crushed, and cracks are developed in all directions.

Here is a figurative comparison to assess the properties of brittle fracture. Suppose you have a nail and a wall. You could try pushing that nail into the wall or hammering it into the wall. In the first case, the process seems complicated, long and illogical. And if you use a hammer, you will get results quickly and efficiently. In practice, an extremely high pressure is required for fracturing, and the pressure is much less during hydraulic impact. Consequently, the impact is much more effective in creating a network of diverging cracks. But intermittent impacts must be of a given duration and with a certain rate of pressure change for optimum deformation and fracturing of the rock. If the pressure build-ups very quickly, the rock and cement stone will break into small fragments. A very slow increase of pressure results in normal hydraulic fracturing with a single crack.

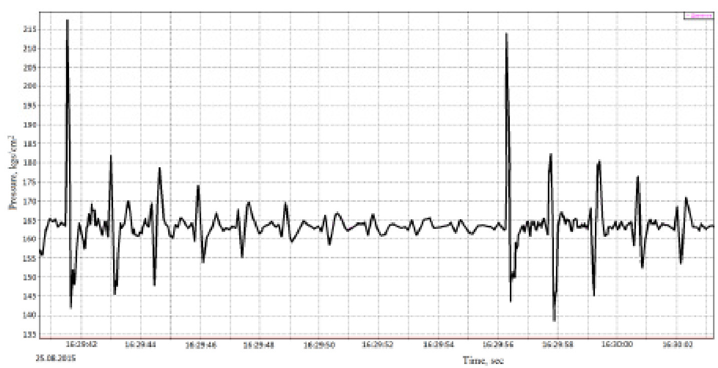

Figure 1: The example of a pressure chart in the bottomhole of the well when performing pulse fracturing [1].

The disadvantages of brittle fracture are cracking of the formation only in the near zone, further on, a seal is formed by impact, which reduces permeability. In order to develop cracks through the seal zone, it is necessary to fill them with fluid and expand them, preferably with periodic repetition of the expansion and contraction processes. The best option is to combine the methods of brittle and ductile rock fracture, which complement each other. Brittle fracture creates a network of cracks, which further develop due to ductile fracture. The cracking process can be repeated many times.

Rock is irreversibly deformed at high loading rates when stresses in the formation have no time to redistribute. In hydraulic fracturing, the loading rate is on the order of 1 MPa/s, and for fractures to open from a pressure pulse, the loading rate must be more than 100 MPa/s. Such velocities are provided only by submersible pressure generators or fluid flow shapers from the wellhead. The duration of increased pressure in the fracture must be at least 0.5 sec, so that under the influence of pressure the fractures have time to expand, and then, when the pressure decreases, to close. The optimal duration of periodic pressure pulses in the bottom hole zone can be considered as units of seconds, during which the fractures are regularly intensively deformed and develop. An important factor in reservoir fracture development is their regular deformation. The liquid column in the well can be thought of as a long compression spring. If a pressure pulse is applied to the upper end of the spring, it compresses and accumulates energy. When the energy of fluid movement through the elastic medium reaches the lower end of the spring, a sharp pressure drop occurs, contributing to brittle failure of the rock and creation of divergent cracks, then the pressure in the formation is maintained by the accumulated inertia of fluid movement. An energy accumulator is installed at the surface, which carries out periodic pressure discharges into the well. Increase of pressure in bottom hole zone during technological works by 150-180 atm above hydrostatic pressure does not have destructive effect on column and cement stone [2].

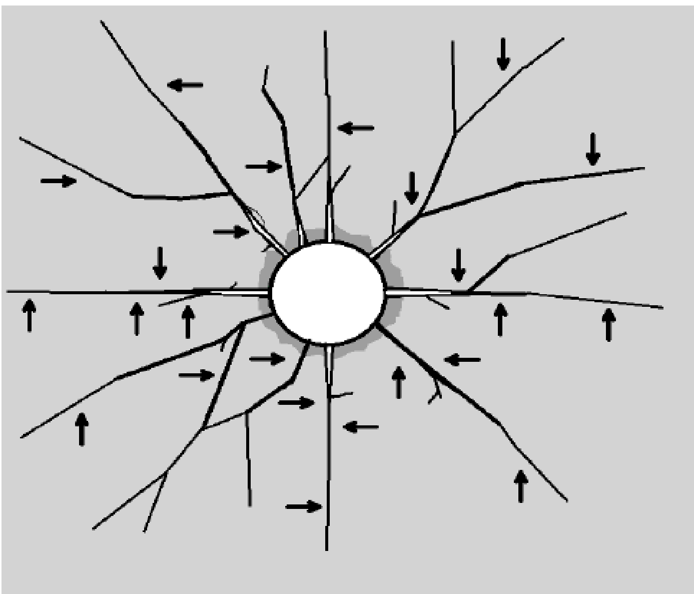

Figure 2: The network of divergent cracks.

To develop a network of cracks, it is necessary to periodically repeat the brittle fracture process to form micro cracks and then, as the fluid is pumped, to convert brittle fracture to ductile. It is important not to maximize the expansion of large cracks and the closure of small fractures, and to limit the duration of fluid injection. An oil reservoir is a porous-fractured structure with fluid between the grains. Impulse pressure is transmitted by the fluid into the gaps between the grains, pushing them apart, fracturing the formation skeleton and developing cracks. The transition to ductile fracture promotes network development by filling cracks with fluid. In 2020 the technology was tested on oil wells in Tatarstan. The effectiveness of the technology was confirmed by pilot well treatment. The permeability of well bottom hole zone increased on average by 150-400 m3/day.

The technology has the following advantages [3]:

1. The technology is an alternative to classical hydraulic fracturing, torpedoing and all variants of hydraulic shock, vibration, pulsation and other methods.
2. The high impulse pressure is created in the perforation zone, which is formed of hydrostatic pressure, the pressure at the wellhead and water hammer, which depends on fluid density and speed of its movement through the pipes.
3. The small amount of injected fluid is used.
4. The network of cracks is created, so that fluid can flow evenly from all sides of the reservoir.
5. The technology is used in low permeability reservoirs and for rehabilitation of old wells where other methods are ineffective.
6. The regular countercurrent fluid flow assists in erosion of bedrock in the buttonhole area.
7. The regular deformation of reservoir rock causes its fatigue destruction.
8. If repeated deformation occurs, the formation fractures do not completely close, proppant is not used in many cases.
9. No chemicals are used.
10. The technology of using this method for production of viscous oil has been developed and patented.
11. The proposed technology is economic and ecological as it does not require any lowering and is two times cheaper than hydraulic fracturing technology.
12. The energy costs are minimal for the technology.
13. The repetitive water hammer has an additional wave effect on reservoir with the following effects:
    - reduction of capillary resistance to oil;
    - reduction of surface tension forces at media boundaries;
    - increase of porous medium oscillations;
    - relieving of small tectonic stresses;
    - change of pore space structure;
    - change of direction and nature of filtration flows;
    - change of rock wettability;
    - change of rheological properties of fluids;
    - redistribution of formation pressures;
    - destruction of emulsions and clay aggregates;
    - reduction of the skin effect.

A high permeability enhancement effect in the near-wellbore zone can be obtained by combining pulse injection and chemical well treatment technologies. The experience has shown a satisfactory result, which indicates the success of the chosen direction of work. High-flow Slickwater fracturing, in which fluid is injected at a rate of 8-15 m3/min, is often recommended for shale oil production. First, the technology is very costly. It requires many pumping units with a total capacity of at least 22,000 hp. In addition, turbulence in a fracture on the order of a few millimeters wide creates little transverse fluid oscillation and is insufficient to form a network of cracks.

In our opinion, it is more economical and efficient to use pulse fracturing rather than high-flow fracturing, which saves pumping power and accumulates energy for each subsequent pulse in wellhead accumulators. According to the technological scheme, tribalization occurs due to flow discontinuity, pulse fluid motion does not allow proppant to settle and contributes to its pushing into the depth of cracks.

In 2014, an experiment on pulse hydro fracturing of a coal seam for methane extraction was carried out in Kuzbass. The method was successfully applied in a horizontal degassing well. The proposed technology allows the creation of a divergent network of cracks, increases the permeability of the near-wellbore formation zone and is intended for use in low-permeability reservoirs, including the rehabilitation of blind wells, shale oil recovery, viscous oil production, as variable pressure affects the rheology of oil, and for the extraction of methane from coal seams and in many cases can replace costly fracturing, torpedoing, chemical treatment and all variants of hydro-shock, pulsation and other processing methods. Pulsed treatment methods have been used for a long time and rocking the borehole fluid column is well known, but with these methods the energy of the moving fluid is not sufficient to create a network of cracks [1, 3].

References

1. A.V.Shipulin, K.S.Kupavih, A.S.Kupavih. Increasing the energy efficiency of a pump unit under pulse hydraulic fracturing breakdown. St. Petersburg Polytechnic University Journal. 2016. №4 (254). p.39-44. DOI 10.5862/JEST.254.5.
2. Russian Federation patent No. 2586693. Method of implementation of pulse hydraulic fracturing. A.V. Shipulin 10.06.2016.
3. A.V. Shipulin. Development of pulse hydro-fracturing procedure. Neft. Gaz. Novacii. 2018. №4. p.23-25.