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APPLICATION OF HYDRO-SAND JET PERFORATOR IN OIL INDUSTRY

Анотація - Переваги сполучення свердловини з нафтогазоносним пластом проведенням гідро піскоструминної перфорації за допомогою модернізованого апарату з регулюванням потужності процесу утворення каналів

Аннотация - Преимущества сообщения скважины с нефтегазоносным пластом проведением гидро-пескоструйной перфорации посредством модернизированного аппарата с регулировкой мощности процесса образования каналов

Annotation - Advantages of establishing good flow communication between the well bore and the reservoir by the modernized hydro-sand jet perforator with regulation of the channels' creation power

Ключові слова - нафтова свердловина, гідро-пісоко-струминна перфорація, насадок, сопло, інжекція

An oil well is a layman's term for any perforation through the Earth's surface designed to find and release both petroleum oil and gas hydrocarbons.

The well is created by drilling a hole (5 to 30 inches wide) into the earth with an oil rig. Drilling rig is a machine, which creates holes in the ground. After the hole is drilled, a metal pipe called 'casing' is cemented into the hole. In order to get access to the hydrocarbon producing interval, the casing and cement are either perforated ('cased hole completion') or additional section of earth is drilled below the casing ('open hole completion'). In most cases several casings are set in the well, starting with large shallow casing, and then deeper casings are set in smaller holes drilled through the upper casings. Cementing and pumping operations may be performed by specialized pumping services or in conjunction with well servicing operations (such as, casing, squeezing, and zone isolations). The hazards involved will vary with mode of dry cement delivery and mixing as well as the primary designed function of the pumping equipment.

Perforation is the way to establish good flow communication between the well bore and the reservoir. It helps create a hole in the casing through the cement and into the formation to form a channel for the oil and gas to flow from the producing formation into the wellbore.

There are several types of perforation: between them are Shaped-charge (or "jet") perforating, cumulative, hydro-sandblasting.

One of the perforation pioneers was bullet perforation patented in the USA in 1926.

Holes in production casing were punched by amour-piercing bullets, receiving an electrical pulse from the surface, charges explode. Bullets get high speed and penetrating power. It causes destraction of the metal, cement sheath. Number of holes in the tube and their places in the reservoir are calculated in advance. Pressure of burning gases in trunk may reach 0.6 ... 0.8 thousand MPa. It affords to reach perforation holes with the diameter up to 20 mm, and with the length between 145.. 350 mm. The balls are made of alloy steel and to reduce friction during movement they are covered with the copper or lead.

Comparing the existing methods of disclosure, the least in depth and drainage channels area is bullet method of perforation: 80 mm and 0.03 m2 accordingly and 10 holes for the running meter of tubing. Besides this method has two considerable disadvantages: sticking of bullets in the casing

walls and inadequate penetration into formation. Bullet perforation has become obsolete in our days.

Shaped charges accomplish penetration by creating a jet of high-pressure, high-velocity gas. The charges are arranged in a tool called a gun that is lowered into the well opposite the producing zone. Usually the gun is lowered in on wireline. When the gun is in position, the charges are fired by electronic means from the surface. After the perforations are made, the tool is retrieved. Perforating is usually performed by a service company that specializes in this technique.

A typical shaped charge consists of a high explosive into which a cone shaped cavity is pressed. The cavity is fitted with a metal conical liner, often made from copper or copper alloys. The entire assembly fits in a metal housing, usually steel or aluminum. When the high explosive is detonated, the metal liner is compressed and squeezed forward, forming a jet of metal particles with a tip velocity in excess of 20,000 feet per second. The lined shaped charge was originally developed for warfare, but ironically they are now used extensively to disarm landmines in war torn countries around the world. But the biggest use of lined shaped charges is in the oil and gas industry as perforators. Interestingly, when the liner is pressed into the high explosive, there are occasional accidental detonations; while these episodes are hard on the presses, special press construction and the use of blast shields makes the press operator's job a safe one.

Perforation has been used in world practice for more than 60 years. In spite of it jet perforation has some considerable disadvantages:

- It exerts destroying influence on the cement sheath.
- Lack of steering system (balancing system) brings to unsatisfactory holes.
- There is an opportunity that not all jet charges will be activated;
- Glass is formed because of the cumulative perforation flow action in the terrigenous rock. This results in the mudding of nearwellbore zone.
- The hole pattern in the production casing is not capable of including the maximum number of fluid conductive channels & well-drainage areas.

Hydro-sand-jet perforation is the way of creation channels, going through the well bore, cement casing pipe and the reservoir using kinetic energy of the jet. It is developed in the nozzles by the flow of the liquid with sand. Channels could be horizontal, sloping, cracking. They go deep down to the rock from 100 mm up to 300 mm. The length and profile of each channel depends on the cutting regime.

As an abrasive is used silica sand, barite, hematite. Choosing a fluid for the HSJP is necessary to pay attention to the fact that the liquid is must not decrease productivity and permeability of the reservoir, it should facilitate and improve the filtration properties of bottomhole zone and contribute to extraction of debris punched material. Mostly fresh, technical water with the touch of active substances is used.

Due to reach better destruction characteristics the sand must be contained in the flow, that goes through the orifice. While the pressure difference is 20…40 MPa creation of the hole is possible only providing abrasive in the liquid. The results of channel creation are demonstrated on the graph 1. At the time period from 0 till 75 min – the water was pumped without the sand and later, from 75 till 150 min with it. On a definite distance from the orifice the velocity of the jet drops as a result of being captured turbulent boarding layer of the medium parts during interaction with the jet that turns from the channel. As a result of velocity reduction deepening of the channel almost stops.

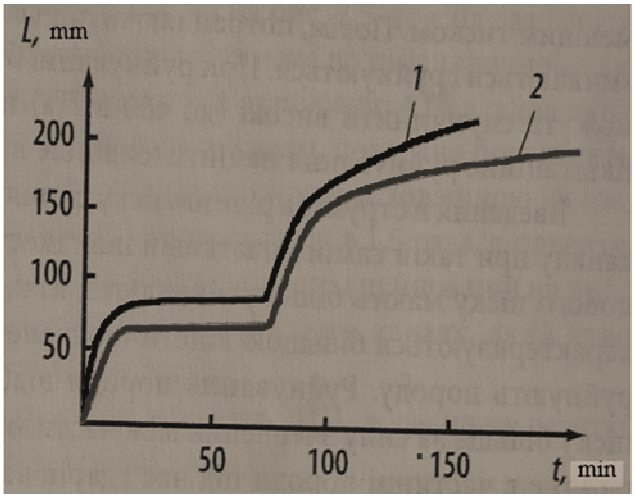

Figure 1- Hydro-jet and hydro-sand-jet destruction of the cement sheath

1. *1 - Compressing strength is 40 MPa*
2. *2 - Compressing strength is 20 MPa*

HSJP advantages over other methods of perforation (bullet, torpedo, cumulative) are:

- The length and angle of the hole punched can be adjusted;

cement ring is not destroyed and retains its strength;
edges of holes formed in the tubing are smooth;
devices used in the HSJP are simple and reliable in operation and can be used practically in wells of any diameter

- Any method of intensification can be performed after HSJP without picking up the instrument on the surface;
- Punched channel length is much greater than with other types of perforation and can reach up to 500-700 mm with more channels of filtering area of 20-30 times;

there is no seals in the end of perforation channel in the end of perforation channel after the.
The actual position of the hole in the reservoir is determined using radioactive territory logging. Radioactive logging is complex of nuclear-physical methods of studying the composition and structure of rocks that make up the walls a well.

The hardware is intended to record volumetric water content in rocks with the help of compensated neutron-neutron logging and neutron gamma logging by means of simultaneous recording of data in order to:
improve accuracy of identification of gas-saturation factor and filtration-capacitive properties of rocks;
use in lithologically heterogeneous drill cores.

The hardware RK5-73-150/90 is designed for development surveys in uncased boreholes with 150...300 mm diameter, in cased wells equipped with casing pipes with 141...245 mm diameter, as well as for operations through drilling tool with boom drift diameter not less than 90 mm by means of simultaneous recording of parameters.

During perforation the following procedures take place: cementing aggregates CA-320 serves water (mud) into the machine for sand mixturing, for example 4PA, where the mixture of water and sand is prepared. It goes to the pump units 4AN-700. From water injection units sand mixture under pressure through the manifold block BM-700 filter, ball valve comes in the column tubing. Bottom of tubing is equipped with hydro-sand-jet perforator. Through its orifices jet is pushed with great speed and by the abrasive action and hydro-motor effects the column and reservoir are destructed. Hard particles of the water-sand mixture sink into the bottom of the well, while other part of it rises to the surface, mouth hermetic prevents overflow of mud. Through the pulse valves 4, that are mounted at the end of the perforator, the sand gets into the vacuum chamber.

When the stream with a portion of abrasive from the tubing 7 (fig.2) enters the orifices 3, another portion of sand is injected into them from the vacuum chamber 2. Work of orifices is based on the principle of jet apparatus. The perforator has two diametrical orifices 3, which are directed to the well wall. At the bottom of the perforator pulse valves 4, are held with a cover 6. A muff 5 connects the tubing string 7 with the perforator.

Jet apparatus is a device for pumping or suction of liquid (gas) materials, based on the exchange of mechanical energy of the two flows of substances in the process of mixing. Flow with higher pressure is called the worker (or the flow of the working environment). It consists of a nozzle, receiving and mixing chamber, diffuser. The flow of the working environment comes from the nozzle into the receiving chamber with a great speed and drags the environment of low pressure. In the mixing chamber velocity (pressure) of flow is equalized. Then the flow is directed into the diffuser, where the conversion of kinetic energy into potential energy of compressed stream. Efficiency of jet apparatus does not exceed 30%, but due to the possibility of increasing the pressure drain flow, simple structure, reliable operation contributed to their wide application.

In the newly modernized perforator injection process is controlled from the surface by the altering of the supply of the pumping unit. This ensures efficient use of energy to destroy a pump casing, a cement ring formation and filtration area in the layer of rock.

The processes, which take place during cutting slot-shaped seats by hydro-abrasive method. The perforator 3 is put into well 4 on PCS 2. The working perforator travels along the casing pipe at a speed determined by parameters of hydro-brake 8, but not exceeding 0.5 m/sec, without rotation of tubing.

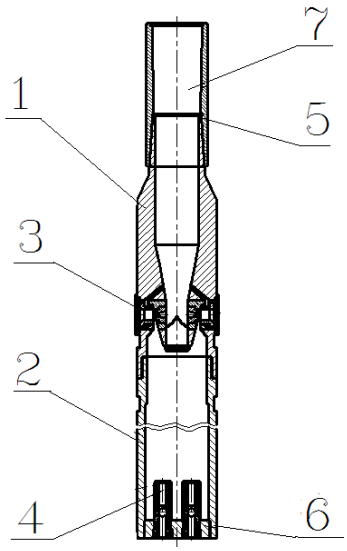

Figure 2 – Structure of hydro-sand-jet perforator

It is important to note that controlling the speed of perforator 3 movement in the process of cutting is technologically impossible. To get information about the end of travel, special signaling devices are applied. It can look like an upward pin mounted under the ball valve. The pin opens the ball valve (i.e. it pushes the small ball out of the pulse valve 7 when the perforator 3 travel is completed. This will cause abrupt pressure drop in the tube space (it will open from below) thus informing of the travel completion.

The disadvantage of such perforator is difficulty of the construction as a result its sell cost increases. Deep penetrating perforation increases the effective wellbore radius and reduces the need for additional perforating operations, acid washes or other perforation cleanup techniques. One of the key factors in improving of the process of the hydro-sand-jet perforation is increasing of the length of the drained channels.