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ANALYSIS OF THE MEASURES TO PREVENT AND ELIMINATION TROUBLES DURING OPERATION OF GAS AND GAS-CONDENSATE WELLS WITH WATER IN THEIR PRODUCTION STREAM IN THE EAST-TARKOSALINSKOE FIELD

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АНАЛИЗ МЕРОПРИЯТИЙ ПО ПРЕДУПРЕЖДЕНИЮ И БОРЬБЕ С ОСЛОЖНЕНИЯМИ ПРИ ЭКСПЛУАТАЦИИ ГАЗОВЫХ И ГАЗОКОНДЕНСАТНЫХ СКВАЖИН ВОСТОЧНО-ТАРКОСАЛИНСКОГО МЕСТОРОЖДЕНИЯ С НАЛИЧИЕМ ВОДЫ В ПРОДУКЦИИ

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Abstract. The article reviews the issue of waterflooding of gas and gas–condensate wells in the East–Tarkosalinskoe Field. The article lists currently applied methods to prevent and elimination the troubles in question. Recommendations are given regarding the application of the new technologies and technical means.

Аннотация. В статье рассмотрена проблема обводнения газовых и газоконденсатных скважин Восточно–Таркосалинского месторождения. Перечислены методы предупреждения и борьбы с осложнениями, применяющиеся в текущий момент. Даны рекомендации по использованию новых технологий и технических средств.

Keywords: liquid plugs, well waterflooding, water influx isolation, gas well, gas-condensate well.

Ключевые слова: жидкостные пробки, обводнение скважин, изоляция водопритоков, газовая скважина, газоконденсатная скважина.

The main problems when operating the gas wells in the East–Tarkosalinskoe Field are the presence of bottom liquid plugs consisting of condensed and service water, casing gas showings, and the startling rise of the gas–water surface.

At this stage of the East–Tarkosalinskoe Field development during the period of reduced reservoir pressures, the main factors complicating the operation of the gas–condensate wells are accumulation of liquid (water, hydrocarbon condensate) at the bottom of the wells, an increase in mechanical impurities in the production stream, as well as hydrates depositing in the well and pipelines.

At the time of the available data, the total stock of the gas wells is 95, including 73 operating ones, 4 wells belong to the inactive well stock, there are 10 observation wells, and 8 wells have been abandoned.

In the wells where the tubing string is lowered to the bottom (vertical and directional) or to the remote (sub–horizontal and horizontal) perforation holes and below, the conditions are ensured for the removal of liquid and sand from the bottom of the wells. However, if the gas flow rate decreases failing to ensure their removal, it is possible for the liquid to accumulate at the bottom and for sand and clay plugs (SCPs) and liquid plugs to form, which will subsequently have an adverse effect on the production rate of the well. Should PCPs accumulate at the bottom of a well, sticking of the tubing string is possible and its breakage when being removed from the well during good workover?

Gas–condensate pools in the East–Tarkosalinskoe Field have been developed since 2001. The total stock at the gas–condensate facility comprises 34 wells. There are 24 wells in the operating well stock.

The source of the waterflooding of gas and gas–condensate wells is the breakthrough of the bottom and edge (formation) water. Wells are being flooded with the bottom water as the field is being developed, as the water surface (the gas–water surface) rises and the water surface rises locally (coming below the bottom of the well) [1–2].

In some cases, water emergence is associated with damage to the integrity of the design of wells and breakthrough of foreign water (the water from overlying aquifers).

The breakthrough of water and its accumulation at the bottom affect the operation of wells, namely, they lead to decreased gas production rates. Formation water causes sedimentation of mineral salts in the tubing and intensive corrosion of pipes and equipment [3].

In order to remove liquid from the bottoms of vertical and directional watering-out gas wells in the East–Tarkosalinskoe Field, one can continue to apply the proven intermittent borehole blowing, releasing gas into the atmosphere, treatment of the bottom–hole with solid surfactants, injection of the gas fed from the booster compressor station to the annulus of the well, installation of a plunger lift as well as concentric tubing.

In order to remove liquid from sub–horizontal and horizontal wells, one can recommend pumping liquid surfactants to the bottom, to lower U–pipes, and also carry out intermittent borehole blowing with gas release into the atmosphere and to pump the gas fed from the booster compressor station to the annulus of the well.

In order to eliminate the formation of water influx into wells, it is necessary to carry out well workover for water shutoff.

Borehole *blowing* is the simplest measure in terms of the equipment, machinery, and materials used. The disadvantages of the blowing include:

– a rapid increase in the pressure drawdown, which leads to destruction of the sand reservoir and emergence of cavities in the area of perforation channels, formation of PCPs at the bottoms of wells;

– non-recoverable losses of gas as the most valuable crude hydrocarbon;

– no lasting effect.

Application of *solid surfactants* in the horizontal sidetrack wells in the East–Tarkosalinskoe Field did not yield favorable results, the wells functioned for two or three days, after which the effect of the surfactants ended and the wells started to carry up water.

When feeding *the gas to the annulus* supplied from the booster compressor station, the flow rate in the tubing increases and liquid removal from the borehole is ensured. In general, the amount of the gas that must be fed into the annulus does not exceed 20–50% of the amount of the produced gas. In addition, the flow rate of the gas fed to the annulus can be further reduced if it is intermittently shut off while the well operates at a sufficiently high flow rate.

The main application of a *plunger lift* is to maintain the specific process conditions in operation of the well by removing liquid from the tubing from the pipes on a regular basis. Due to the intermittent (ranging from once every seven minutes to once per hour) removal of the liquid from the well, the pressure loss in the tubing and the bottom–hole zone is reduced. It ensures that the well operates with the absolute open gas flow rate in accordance with the process conditions at the current wellhead and flowline pressures. The minimum gas production rate required for reliable operation of the plunger lift is 43 000 m^3/day.

In order to apply the *concentric tubing* technology, a smaller diameter string is lowered into the well and a special Christmas tree is installed at the wellhead. The installation operates in such a way that, at a gas flow speed below the critical one in the string, it is partially overlapped, and the flow rushes through the inner tubing at a speed higher than the critical one, and the accumulated liquid is removed from the bottom of the well. Automation equipment maintains the optimal well operation conditions.

Lowering of U–pipes to remove the liquid. When a U–pipe is lowered, the ascending gas flow velocity rises above the critical value, and removal of the liquid with the gas flow begins.

In the wells in which difficulties arise during operation with U–pipes (the fluid flows through U–pipes at a rate higher than the critical one, but excessive frictional pressure losses occur in this case), production can be increased by switching to the operation in the annular space (between the tubing and the U–pipe) where friction is low until the fluid starts to accumulate in the well. After that, the well is switched to the operation with a U–pipe in order to remove the liquid.

The flow in the U–pipe is controlled by controlling the annular pressure in such a way that the U–pipe receives the amount of gas that is minimally required to maintain the flow speed above the critical one, and the rest of the gas is drawn through the annular space. The gas flow is controlled by a choke on the flowline from the annular space, which controls the separation of the gas flow between the U–pipe and the annular space so that the gas flow speed through the U–pipe is not below the critical one, and the bottomhole flowing pressure is minimal.

Gas–withdrawal from the annular space and the U–pipe is monitored and optimized but not suspended. The well operates continuously without interruptions. The flow in the U–pipe can be controlled automatically by automatically selecting such position of the choke on the flowline from the annular space, in which the flow in the U–pipe becomes optimal, which results in the ability to minimize the bottomhole flowing pressure and maximize the total production (through the U–pipe and the annular space).

The layout of the wellhead and underground equipment of such well equipped with an automatic system for positioning of the choke on the flowline is shown in Figure.

In order to prevent the formation of and to eliminate sedimentation of hydrates, a hydrate growth inhibitor (methanol) must be supplied into the well as needed, and intermittent blowing of wells must be carried out.

Formation water influx must be isolated in those wells where the perforated interval is significantly blocked by the liquid column, constant water removal is observed, application of surfactants to remove the liquid from the bottom of the well does not yield a positive result, formation water intrusion is observed into the well due to a leakage of the production string [4].

When conducting operations to isolate the bottom water influx with the help of a switch valve station to prevent clogging and reduce the permeability and porosity of the overlying productive regions of the reservoir, a technology is recommended to reduce the capacity of the water–flooded parts of the reservoir and subsequent selective isolation with the help of a packer lowered with the tubing string to prevent contamination of the overlying productive part of the reservoir.

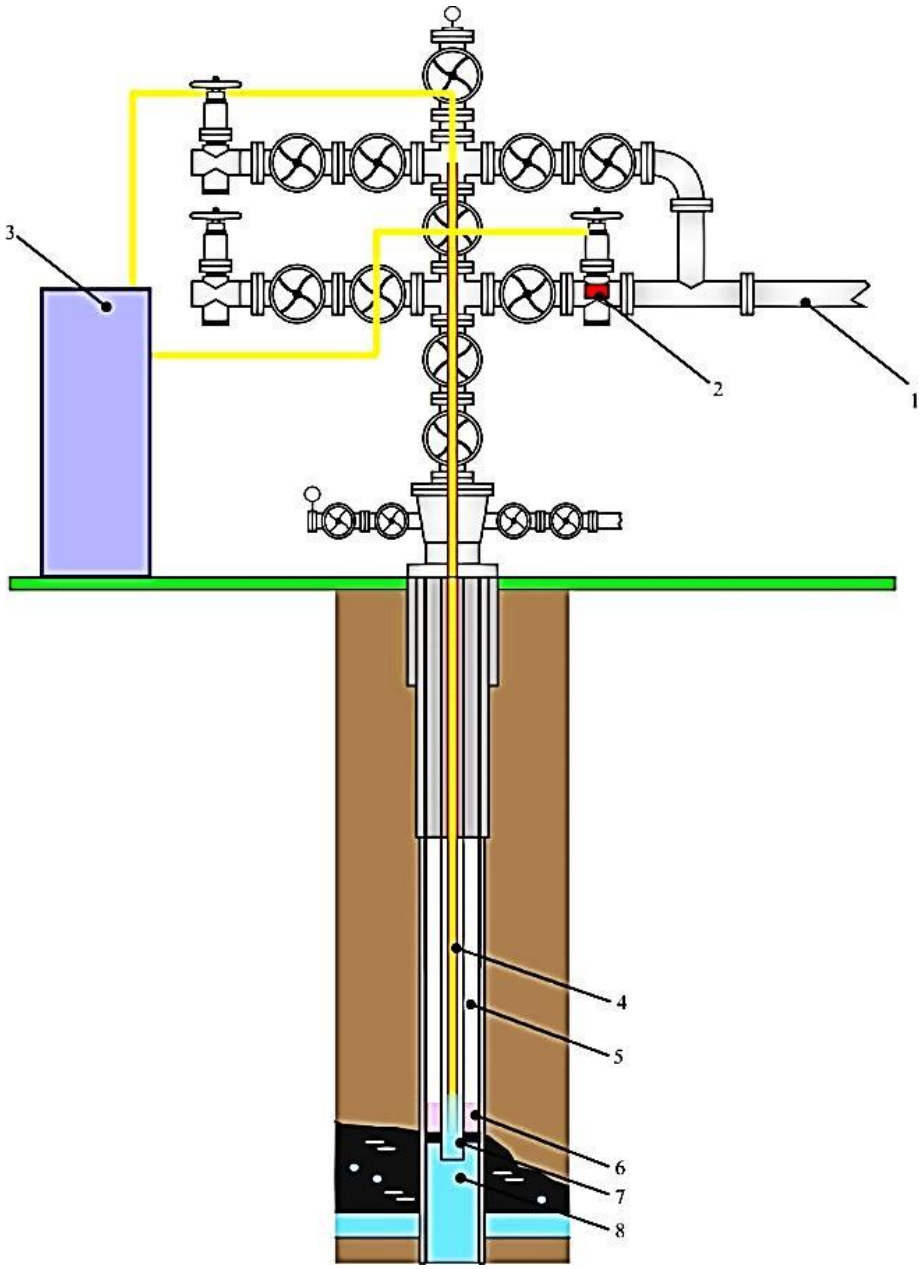

Figure. Layout of the well equipped with the automatic system: 1 — flowline; 2 — adjustable choke; 3 — telemetry system; 4 — U–pipe; 5 — tubing; 6 — packer; 7 — downhole sensors; 8 — liquid at the bottom.

Water shutoff operations are recommended to be carried out in two stages (polymer + oil–well portland cement):

Stage 1. Injection of insulating polymeric compound which hardens in reservoir conditions;

Stage 2. Following a technical interruption (36–48 hours), injection of the portland cement solution that has chemical additives to reinforce the water shutoff barrier.

It is recommended to apply the technology of interval water shutoff using the AKOR BN-102 water shutoff compound in order to isolate the formation water inflow into a gas well.

In the conditions of abnormal low reservoir pressure, it is recommended to isolate the formation water influx with the help of coiled tubing units.

Flushing of sand plugs must be carried out only in conjunction with the operations to reinforce the circumwell zone of the formation. Flushing will have no effect in other cases because of the destruction of the circumwell zone of the formation; plugs will form again. If the well

operates with a sand plug and the production rate does not decrease, it is not recommended to remove the sand plug from the bottom of the well; the plug will be used as a water shutoff barrier.

There are technologies and technical means, which are known, being developed, and improved, to operate wells in difficult conditions [5].

1. In addition to switching to a smaller diameter of the tubing, it is recommended to test the technology of shuttle fluid lift (flying valves, plunger lift, combined gas lift, etc.), the technology of VNIIGAZ.

2. It is recommended to use various surfactant–based foam systems in order to remove the liquid from the bottom of a well. The following agents are recommended as surfactants:

– sulphonol, DS–RAS (for low-mineralized water, up to 10 g/l);

– OP-7, OP-10, Universal (for mineralized water);

– neonol, water– and oil–insoluble surfactants (in the presence of gas condensate at the bottom of the well).

3. Moreover, it is recommended to use the technology of continuous flexible lift in order to remove liquids, solids and sand from the bottom of a well, as well as clean the tubing from the deposits of paraffins and hydrates. Continuous flexible lift is a standalone, easily transportable hydraulically–driven unit that lowers and lifts the continuous flexible tubing into the production tubing or into the well casing. This technology is widely used as a pipeline for circulation and injection of liquids to a set depth and to remove deposits in oil and gas wells. The main advantage of this flexible lift technology compared to the conventional fabricated pipe is a higher speed of trips, as well as the ability to use it in a well under pressure, which enables to conduct operations without interrupting the production of oil and gas.

4. Preventive measures must be provided to conduct repairs to isolate the formation water influx and reinforce the bottom–hole zone in order to prevent waterflooding of wells and abrasive equipment wear associated with eventual emergence of water and sand in the production stream from wells.

It is recommended to use various selective insulating materials, for example, a compound made of acetone, stiromal and AKOR–B_{100} organosilicon fluid, in order to isolate the formation water.

In order to improve the reliability of water influx isolation, it is recommended to install water shutoff barriers in wells by pumping selective insulating compound based on a modifier with waterproofing organosilicon fluid or based on ethyl silicates with waterproofing organosilicon fluid into the reservoir.

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