Analysis of the current issue of well bore and well bottom cleaning

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Abstract. The paper considers the problem of insufficient cleaning of oil and gas wells from drill cuttings. The formation of slurry dunes is the main cause of complications and accidents in horizontal well dr illing. The task related to the development of high-efficiency equipment for well bottomhole cleaning from drill cuttings is quite relevant. The existing techniques and technologies for borehole bottom cleaning from drill cuttings caused by rotary drilling were analyzed to find a way of improving the efficiency of borehole bottom cleaning. A new technical solution for cleaning vertical, directional and horizontal wells from drill cuttings was developed. The process functional diagram of at-bit sludge chopper during turbine drilling is presented to increase the cleaning efficiency of bottomhole and wellbore of vertical, directional and horizontal wells from drill cuttings during roller boring.

1. Introduction

Russia’s energy strategy implies the annual increase of oil production. The increase of oil and gas production is inextricably connected with the increase of technical and economic indicators of well drilling. It is possible to reduce well construction time by increasing the drilling speed due to new types of rock-cutting tools, new types of washing fluids, mud circulating equipment: drill pumps, equipment for preparation and cleaning of washing fluids, as well as due to reasonable improvement of equipment operation. An essential reserve in improving the efficiency of drilling operations is the improvement of drilling techniques and technologies based on the introduction of efficient equipment for borehole bottom cleaning from drill cuttings. The degree of perfection of well circulation and the equipment for its implementation greatly affects successful, accident-free well drilling. The quality of borehole bottom cleaning from drill cuttings affects the cutting rate, well bore quality, penetration and resistance of a drill bit, a turbodrill, drilling equipment elements [7].

The bottomholes of oil and gas wells during drilling are usually contaminated with coarse cuttings thus deteriorating rock destruction and reducing bit operation parameters [1]. With the increase of the drilling depth at the bottomhole there remains an increasing amount of sediment consisting mainly of large-sized drill cuttings [3]. Cutting transport is complicated by the drilling of deep vertical, directional and horizontal wells, as well as by the drilling shallow wells – when rinsing fluid circulation does not create sufficient upward flow for cutting transport. The most pressing problem is the cleaning of the horizontal borehole from drill cuttings. At present, horizontal drilling during
construction and reconstruction of wells is the most promising in oil and gas development industry [2, 5]. The development of oil and gas fields with the use of horizontal wells is a priority in the oil and gas production industry that involves hard-to-recover oil reserves (low-permeable heterogeneous formations and reservoirs, confined to water and gas-oil zones, oil basins of oil and gas deposits; deposits with high-viscosity oil, blind, peripheral and stagnant zones, with lens interlayers of different configuration, etc.) [4].

Insufficient cleaning from drill cuttings is the main cause of complications and accidents during horizontal well drilling, more than 80% of seizures occur due to well bore constraint during cuttings sinking. Due to complications and accidents caused by inefficient cleaning of wells with high slope angle, additional costs can reach up to 60% of the total costs of well construction [6]. Poor cleaning of wells from drill cuttings leads to such complications as the reduction of bit load, uncontrolled change of bore trajectory, difficulty with drilling tool orientation, change of the bottom-hole assembly operation mode, absorption of washing fluid, hydrodynamic seizure [9].

Compared to vertical wells the cleaning of horizontal bottomhole and well bore from drill cuttings is difficult due to radial orientation of gravity forces affecting mud particles and eccentric arrangement of a drill string in a well bore.

The effect of flooding increases due to complication of mud particles removal by washing fluid during drilling of direcitonal and horizontal wells, and the majority of technological and structural solutions connected with the transportation of drill cuttings to day surface is inefficient.

2. Materials and Methods

The existing techniques and technologies for borehole bottom cleaning from drill cuttings caused by rotary drilling were analyzed to find a way of improving the efficiency of borehole bottom cleaning.

F.A. Agzamov, T.O. Akbulatov, K.A.Kh. Alvan, T.E. Becker, A.I. Bulatov, M.S. Gabdrakhimov, N.A. Gukasov, B.I. Esman, G.P. Zozulya, V.I. Isaev, A.G. Kalinin, V.V. Kretsul, V.I. Krylov, E.G. Leonov, A.Kh. Mirzadzhanzade, J.J. Ozara, S. Okraji, G.A. Panfilov, A.N. Popov, V.I. Ryabchenko, B.Z. Sultanov, V.A. Fisher, R.I. Shishchenko, etc. made a great contribution to solving theoretical and practical issues of carrying out drill cuttings from wells with high slope angle and horizontal wells.

There are various techniques and technologies for improving the quality of well bore cleaning: improved quality composition of the drilling mud; increased flow rate of washing fluid; backflow; washing fluid flow separation devices; borehole washing with periodic lifting of a drill string by several stands and repeated drilling; introduction of devices with better hydrodynamic properties.

In order to increase the efficiency of bottomhole and borehole cleaning from drill cuttings, various devices built into a bit are used: ball, balance, acoustic vibrators. The quality of horizontal bores cleaning can be improved through radial oscillations of a drill string [8]. The use of vibration technologies also reduces the friction forces of a drill string against the well walls [2]. The disadvantage of vibrators in a drilling equipment is that in an extended horizontal section of a wellbore, there is a need for two or more vibration generators in a drill string to provide cleaning conditions and ensure self-synchronizing conditions in order to increase the efficiency of the hydraulic power of drill pumps consumed by the generators.

Various at-bit devices are used to improve the bottomhole cleaning: a drilling tool substitute equipped with a screw; screw helical finning drill pipes; jet pumps of different design. These devices improve the bottomhole cleaning to a certain extent, but do not remove coarse, solid mud particles, allow mud re-crushing, formation of mud dunes during horizontal drilling.

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3. Results and Discussion
In horizontal drilling, all rock cuttings tend to fall on the bottom wall of a well. In order to prevent cuttings sinking and deposition, it is necessary that the rock cuttings are in a suspended state rather than in a transported state. However, increasing the supply and density of the drilling fluid results in the colmatation of well walls. According to literary data, rock cuttings with the size of not more than 1-2 mm can be transported in suspended state [10].

In order to increase the efficiency of well cleaning from drill cuttings, an at-bit device was developed, passing through which coarse rock cuttings are crushed to a size of 2 mm and less. The drum (grid) is mounted on a turbodrill shaft and is connected to a rotary shaft by means of springs. The rotary shaft of the turbodrill and the drum connected by springs form the oscillating system. The rotation of the turbodrill shaft creates torsional vibration of the drum due to the presence of springs, which provides grinding and screening of drill cuttings.

The device is installed during rotary drilling (rotary method, downhole motors) above the bit. The figure shows the process functional diagram of the at-bit sludge chopper during turbine drilling.

The main parts of the device include a housing 2, which is equipped with a screw 3 and a rotor 8, and a drum 5. The screw and the rotor are installed inside the drum, which has inlet and outlet channels 4, 9, holes 6, a baffle 7. At the top, the drum has a ribbed surface 12, which is integrated with the rotor end face. The device is equipped with a screw, which sucks the mud and sends it to the rotor, which, in turn, pushes the mud to the drum baffle 7. Thus, the mud is crushed, its fine particles are sieved through the drum, coarse particles are repeatedly crushed by the rotor end face.

**Figure 1.** Process functional diagram of at-bit sludge chopper during turbine drilling

1 – drill bit; 2 – case; 3 – screw; 4 – inlet holes; 5 – drum; 6 – drum holes; 7 – baffle; 8 – rotor; 9 – outlet; 10 – turbodrill shaft; 11 – turbodrill; 12 – ribbed surface of the drum; 13 – torsion spring

4. Conclusion
The at-bit device ensuring crushing, sifting and withdrawal of drill cuttings from the bottomhole during drilling of vertical, directional and horizontal wells is developed. Fluid with drill cuttings is sent by the screw in axial and radial directions, at the same time drill cuttings are partially crushed due to shocks, fine particles are sifted through the grid (grid holes of 2-3 mm), coarse particles get into the
rotor and are radially pushed onto the reflector, then drill cuttings are further crushed. Final grinding takes place when coarse particles get into the channels and are crushed by the rotor end face. Torsional vibrations of a drum (grid) under the drum inertia force, fluid thrown by the rotor onto eccentric reflector and spring forces contribute to drilling mud cleaning.

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