Prevention of sticking during surface casing drilling in Samotlorskoye field

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Abstract. The paper considers the current problem of sidewall sticking during surface casing in Samotlorskoye field. The analysis of geological and field material was carried out and the reasons for sticking during drilling of upper unstable argillaceous deposits of Lulinorskaya, Talitskaya and Gankovskaya suites were determined. It is found that in most well construction projects, the inhibitory agents preventing clay hydration are used in drilling muds. The authors studied the mechanisms of shale inhibition. The results of experimental studies on the impact of various inhibitor additives on clay samples demonstrated the efficiency of Polysil and Osnova GS (hydrophobizated fluid) additives with sulphoacid. The results of the analysis made it possible to make proposals and recommendations to prevent sticking.

1. Relevance of the problem
Well drilling is a complex and critical technological process, which is sometimes accompanied by various complications and accidents. According to statistics, in Samotlorskoye field the largest number of accidents accounts for sticking (Figure 1). Thus, sometimes there is a situation in the interval of surface casing drilling when the drill string cannot be lifted, ran or rotated, thus causing sticking. The stuck freeing is expensive and causes complications and in many cases may end up with torpedoing of the tool and re-drilling of part of a well bore [4]. Special tools, professional technical services and special mud conditioning to release a drill pipe cause expenses, not to mention the lost time of a drilling rig. The stability of open borehole may deteriorate during time required to release the pipe and restart drilling. For this reason, the prevention of pipe sticking and accelerating of their release if such occurs is critical for well drilling.

2. Theoretical aspects of the problem
Drill pipe sticking may be caused by the following:
1. Keyseating on well walls;
2. Particles in a well;
3. Borehole with a diameter less than nominal;
4. Pressure drop in a wellbore;
5. Pipe sticking to well walls when it is left without movement;
6. Violation of well washing technology;
7. Others
Figure 1. Diagram of distribution of complications and accidents during well drilling

Figure 2 shows the diagram of reasons causing sticking of a drill bit in a well. The largest percentage of sticking cases results from the pressure drop, when a tool is left without movement and the reduction of the nominal well diameter.

Figure 2. Diagram of distribution of drill tool sticking reasons

Keyseating occurs during drilling when loads are transmitted to a bit through drill collars (DC), and as a rule a drill string is under tensile loads, which are maximum at the top of a string. When a well is vertically deviated and drilling continues this part of a bore is opposite a stretched drill pipe and tends to dig into a well wall, thereby forming a key seat where the drill string is stuck. If a well near the vertical one is drilled, the problems with keyseating on well walls are minimized.
Swellable and dispersing clay deposits, particles occurring through wellbore collapse as a result of negative differential pressure, drilling cuttings, rock debris at the formation of shoulders of the hole serve as sources of particles in a well. Clay particles trapped in a well bore are accumulated in at shrinking places and are stuck on a drilling tool forming drilling mud balls and bars leading to sidewall sticking [1–3].

Shale hydration, their volumetric increase and slide into the wellbore leads to the reduction of the nominal diameter. The diameter of a wellbore may also decrease due to abnormal pore pressure and high water content in shale under geostatic pressure. In the process of sedimentation the rock was compacted and the pore fluid was compressed in closed pores of the manifold. When such clay rocks are drilled using low density drilling fluid insufficient to balance pore pressure, pore fluids expand and shale is squeezed out to the well. This phenomenon can occur almost at any depth.

The reduction of a well nominal diameter may occur due to formation of thick clay crust on a rock surface due to high permeability, pressure drop, high filtration and prolonged impact of water-based drilling fluid on clay rocks.

Sticking due to wellbore pressure drop (differential sticking) is defined as a sidewall sticking to a permeable formation as a result of excess pressure of a drilling fluid column in a wellbore over the formation fluid pressure. Sticking due pressure drop in a wellbore can occur at any depth, but most often at large depths where high-density washing fluid is used. Special treatment of drilling fluid is carried out and special drilling tool is used to prevent differential sticking. As a preventive measure, strict filter control and addition of surfactants to water-based drilling fluids are carried out [5]. In some drilling areas drilling fluids based on hydrocarbon oil are used. Frequent movement of a drill pipe is a standard operating method to prevent sticking and maintain the nominal diameter of a well bore during deep drilling using heavy washing fluids. It is also effective to change square and spiral DC, which reduce the contact area between DC and a clay crust. The probability of differential sticking increases when a drill string is left for a long time without movement and rotation and in the absence of circulation of a drilling fluid.

3. Field geologic analysis

The analysis of field data showed that at Samotlorskoye field, sticking cases most often occur in the interval of Lulinorskaya Suite (390–560 m).

In our opinion, clays, which alternate with sand, when a clay content makes 95 % primarily cause sticking during surface casing drilling in Samotlorskoye field (Table 1). It is known that clays are characterized by high dispersion and hydrophilicity. Hydration of clay minerals leads to clay swelling, its dispersion and transition into solution, which leads to softening of rocks forming well walls, increase of clay concentration in a solution, and accordingly to the change of technological properties of solutions [1].

The analysis of drilling fluids used during surface casing drilling in Samotlorskoye field showed that in most cases polymer clay solutions mainly containing pH, viscosity and water recovery regulators, weighting agents, lubricating agents and antisealing additives are used. Only in some projects inhibitory additives “Osnova GS” and “Kolmasil” are included in the drilling mud [6].

4. Experimental analysis

Inhibition of drilling fluids is ensured by the following:

- ion exchange (chlorocalium, calcium or chlorosodium, spersene, formate or potassium solutions, Kla-Gard, Kla-Cure, Kla-Stop);
- encapsulation of particles of drilled clays and well walls by creating polymer films (Poly Plus RD, Polypac R, SP-101);
- encapsulation of drill clay particles and well walls by creating water-resistant silicate and glycol films;
- creation of waterproof barrier in pores and channels of drilled rocks with hydrophilic additives (Asphasol or Glycol);
- encapsulation of drill rock particles and well walls due to multipolymer solutions;
- hydrocarbon-based solutions both having no water in the formulation and hence being neutral to drilled clays.

Table 1. Lithological well profile during surface casing drilling

| Stratigraphic unit index | Stratigraphic unit            | Vertical interval | Short rock name       | Clay content, % | Type of complication leading to sticking |
|--------------------------|--------------------------------|-------------------|-----------------------|-----------------|------------------------------------------|
| Q                        | Quaternary deposits           | 0-125             | sand clay sand clay sand clay sand clay | 95.0            |                                          |
| P2/3                     | Zhuravskaya Suite             | 125-140           | sand clay sand clay sand clay sand clay | 95.0            | Packing, differential sticking. Loss of bore hole wall stability |
| P2/3                     | Novomikhailovskaya Suite      | 140-240           | sand clay sand clay sand clay sand clay | 95.0            |                                          |
| P1/3                     | Atlymskaya Suite              | 240-350           | clay sand clay sand sand clay sand clay | 95.0            |                                          |
| P1/3                     | Cheganskaya Suite             | 350-390           | sandstone clay sand clay sand sand clay sand clay | 95.0            |                                          |
| P2/2                     | Lyulinvorskaya Suite          | 390-560           | sandstone clay sand clay sand clay sand clay | 95.0            |                                          |
| P1                       | Talitskaya Suite              | 560-655           | siltstone clay sandstone clay sandstone clay sandstone clay sandstone | 95.0            |                                          |
| K2                       | Gankinskaya Suite             | 655-790           | siltstone clay sandstone clay sandstone clay sandstone clay sandstone | 95.0            |                                          |

To determine the best inhibitory capacity, clay samples were tested in 20 % aqueous solutions of various reagents (Figure 3). The experiments showed that the increase of clay samples in non-dispersing drilling fluids was different and ranged from 13.6 to 56.4 %.

Figure 3. Swelling of clay rock depending on chemical reagent
The obtained results confirm the advantages of solutions based on complex reagent Polysil and Osnova GS with sulfonic acid. The final swelling over 12 hours of this solution makes 13.6%. A good indicator is that the clay rock samples remained solid after being exposed to the solution.

Osnova GS additive hydrophibizes clay surface of drilled rock and well walls. It prevents the dispersion of slurry, stabilizes unstable rocks prone to collapse and landslide, prevents tool packing. Besides, Osnova GS stabilizes rheological and filtration parameters of the drilling fluid, including under conditions of salt aggression.

According to TU U 26.8-34656408-002:2010, POLISIL is a complex reagent containing sodium or potassium silicate; modified bitumen; nitrogen-containing polymer. The synergetic effect of three reagents ensures high inhibitory capacity of drilling fluid with POLISIL.

Modified bitumen blocks cracks of a bore well, prevents collapse and landslide, as well as hydration of clay shales.

The main components of bitumen: asphaltenes – crystalline solids, resins – amorphous solids and oils, which may contain dissolved waxes. Using the above components the chemical agent blocks microcracks in sloughing argillites. Sodium silicate is used to suppress hydration and swelling of clay materials. Silicate molecules are adsorbed in active areas of a clay surface. By shielding these areas, the hydration and swelling processes of clay materials are suppressed.

Nitrogen-containing polymer increases viscosity of washing liquid filtrate thus affecting the reduction of water yield index. As a result, the penetration of a filtrate into fractured clay rocks is reduced. Besides, nitrogen-containing polymers have low inhibitory capacity.

5. Conclusions and recommendations

Thus, geological-field material and analysis of design documents for well construction showed that despite high content of clay minerals in rocks during surface casing drilling the inhibitory additives are not designed in drilling mud solutions in most well construction projects.

This analysis allows recommending the following:

- To prevent washing of unstable sands, maintain the relative viscosity to a depth of 350-400 meters (up to Lyulinovskaya Suite) shall be maintained not less than 70 sec.
- During drilling of clay deposits POLISIL and Osnova GS inhibitory reagents shall be introduced.
- Talitskaya Suite shall be uncovered using bulk density drilling mud.
- In order to limit the drilling mud impact on clay deposits and reduce the probability of well wall washing, the interval of surface casing drilling shall be drilled at the maximum possible speed.

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