Development of detergent for drilling muds while directional drilling

R.R. Gizatullin

Postgraduate student, Saint-Petersburg Mining University, Saint-Petersburg, Russia

M.E. Budovskaya

Postgraduate student, Saint-Petersburg Mining University, Saint-Petersburg, Russia

M.V. Dvoynikov

Doctor of technical sciences, Saint-Petersburg Mining University, Saint-Petersburg, Russia

ABSTRACT: Research is devoted to the development of formulations detergent for drilling muds in order to reduce the adhesion of clay particles to drill pipes while deepening complex sections of the trajectory of a directional well in the intervals composed of clay rocks. Three types of glycerol-based additive composition with the addition of emulsifiers and water repellents were investigated in various concentrations in the range of 0.5 - 2%. As a result of complex studies which including measurements of the rheological parameters of drilling fluids and bench tests on the model according to the methodology presented in the report, the optimal formulation of detergent was determined. The best results were determined for the additive at a concentration of 1% for all test samples of the presented drilling fluids. The effectiveness of the detergent is estimated in the mass reduction degree of oil seal which formed on the simulator. It amounted to 65-71% in the experiments.

1 INTRODUCTION

The main part of graphic log in Russia (especially Western Siberia) is made up of plastic rocks, in the total mass of which prevail clays. Drilling rocks of this kind with water-based muds is often accompanied by various complications, such as bit balling leads, column tacking. Oil seal formation is the process of sticking of soft sticky rocks (usually clays) on the cutting edges of the bit, which leads to their temporary inefficiencies on the elements of the drill string in the places of transition from a large diameter to a smaller one (Guseynova et al. 2016). This process leads to a decrease in the rate of penetration, an increase in the forces of resistance to movement of the tool in the well, the occurrence of talus and rockfall due to the effect of pistoning at lifting the drill string with the oil seal (Nikolaev et al. 2014; Idress et al. 2020). The cause of oil seal formation is insufficient breed inhibition, in particular hydration and drilling of granular highly permeable formations.

Resistance forces to tool movement in wells largely depend on the quality of the drilling fluid and, above all, on the level of its antifriction and adhesive properties (Durkin et al. 2013; Petrov et al. 2015). It should be noted that the worsening of the structure, thixotropic and rheological properties of the drilling mud causes the bit balling. In this case, the bit balling leads to an increase in uncontrolled hydrodynamic pressures in the wellbore and possibility of oil and gas shows and hydraulic fracturing (Morenov et al. 2017; Petrov et al. 2015). In this regard, relevant is the development of formulations detergent and lubricant additives to reduce friction between the borehole walls and the drill string and to reduce bit and elements of the bottom hole assembly balling (BHA) (Alsaba et al. 2017; Nikolaev et al. 2016).

Currently, research is underway in the field of lubricating and anti-oil additives. There are Russian and foreign production. For example, SONBUR manufactured by CJSC “PETROCHEM EXPERIMENTAL PLANT” (Russia), K-LUBE (KEM-TRON INC, USA), TORQ-TRIM II (Halliburton), OPTIBUR (“BURINTEKH”, Ltd, Russia). All of these anti-oil additives are successfully used in production, but they all have approximately the same component composition. A distinctive feature of the developed detergent is the replacement of an water base with glycerin (anhydrous), which currently has no analogues in the production of additives for drilling fluids.

Three types of additive compositions (COMPOSITION 1, COMPOSITION 2, COMPOSITION 3), each of which consists of glycerol (glycerol) $C_3H_5(OH)_3$, monoalkyl ether of polyethylene glycol based on fatty acid with the addition of oxyethylene and monoalkylamine in different volume fraction, were studied in order to solve the task of developing formulations of detergent additives for drilling muds. To determine the effectiveness of the fight against bit balling, these COMPOSITIONS (1-3) in concentrations of 0.5-2.0% were added to the basic drilling muds. Further measurements of rheological parameters and comparison of bench tests on the model were made. It was carried out to find the best additive composition in the muds at which the mass reduction degree of oil seal will be noticed.

2 MATERIALS AND METHODS

Together with the company “Service Center SBM” for the experiment, a technique was developed that simulates the process of the bit balling leads. A laboratory stirrer was used as the basis for an experimental setup in which the standard polished rod with blades for mixing the solution was replaced with an unpolished steel rod of equal diameter (the layout and appearance of the stirrer are shown in Figure 1 a, b).

This was done in order to bring the experimental conditions closer to real ones, since drill pipes and BHA elements have a higher roughness than polished metal parts of laboratory devices (Bulatov 1977; Ganjumyan et al. 2000; Kalinin 2008). The rod is wetted with the solution while it is in it for 5 minutes before the start of the experiment. The rod rotates in a solution with a frequency close to standard conditions of rotation of a drilling tool with rotary drilling - 50 rpm.

Installation elements simulate a well with a diameter D , a drill string with a diameter d_1 , a calibrator with a diameter d_2 . In this case, these values will accordingly have values $D = 40$ mm, $d_1 = 20$ mm, $d_2 = 30$ mm, taking into account the proportional reduction of the actual dimensions.

Figure 1. Scheme and type of experimental setup.

The choice of the calibrator as the bottom element of the BHA is due to a small difference in its diameter with the bit and a large role in the danger of the formation of an oil seal in the transition zone from the calibrator in the drill string. The cavernosity coefficient is 1.3 (Idress et al. 2020).

The application of this technique makes it possible to see the process of the bit balling leads during the rotation of a metal rod in the test drilling mud. Researches were carried out using a polymer solution.

3 RESULTS AND DISCUSSION

The grade of clay powder for COMPOSITION 1 was selected after a comparative analysis of the ability of clay powders of various grades to form an oil seal in a polymer solution, as well as taking into account the availability of material (Litvinenko 2007; Chubik 1999; Leusheva et al. 2017). We also recommend the use of dried clay sludge obtained from the interval in which intensive an oil seal is observed.

For example, consider research conducting with COMPOSITION 2. Pour 350 grammes a polymer solution into a 500 ml glass, then use a paddle stirrer with a stirring speed of 100-150 rpm and add the detergent reagent gradually to the solution. Mixing is carried out until the component is completely dissolved. Then 42 grammes of clay powder is gradually dispersed into a glass at a stirring speed of 400-500 rpm. It is necessary to ensure that the minimum amount of clay is dispersed on the mixer blades when dispersing. Dispersion is carried out within 10-12 seconds. Next, pour the suspension into metal cups into which the rods are lowered for subsequent rotation at a speed of 50 rpm. An oil seal is formed within 20 minutes then the rod is washed in distilled water for 20 minutes. Weigh the rods, calculate the average weight of the oil seal in 3 parallel experiments. The effectiveness of the reagent is determined by reducing the weight of the oil seal in comparison with a dummy experiment (without additives).

The optimal formulation of the detergent additive was determined as a result of comprehensive researches which included measurements of the rheological parameters of drilling fluids and bench tests on the model according to the presented methodology. The best results were determined for the additive COMPOSITION 2 with a concentration of 1%.

The graphs (Figures 2-5) show the correlation between two values: the degree of decrease in plastic viscosity and mass reduction degree of oil seal for: gypsum-lime drilling mud, clay drilling mud, biopolymer saline inhibited mud, non-clay mud. Detergent additive COMPOSITION 2 was introduced into all samples at concentrations of 0.5–2%.

Figure 2. The effect of additives on the reduction the bit balling leads and changes in the viscosity of gypsum-lime mud.

Figure 3. The effect of additives on the reduction the bit balling leads and changes in the viscosity of biopolymer saline inhibited mud.

Figure 4. The effect of additives on the reduction the bit balling leads and changes in the viscosity of clay mud.

Figure 5. The effect of additives on the reduction the bit balling leads and changes in the viscosity of non-clay mud.

The criterion for the success of detergent additives is the achievement of an effect in which mass reduction degree of oil seal is reduced by more than 50%. An increase in the content of introduced additives of more than 1% does not have a noticeable effect on the elimination of oil seals on BHA elements. The zones of dependence of the change in mass of oil seal with the introduction of additives for each solution are highlighted in green in Figures 2–5. Researches have shown a mass reduction degree of oil seal with the introduction of additives by 67-71% and a decrease in plastic viscosity - up to 15%.

4 CONCLUSION

The use of a new detergent additive leads to a decrease in oil seal formation on the elements (BHA) and bit due to a decrease in the adhesion of clay particles to metal surfaces. This detergent additive improves the rheological properties of the drilling fluid and increases the lubricating properties. A regulation has been developed for regulating the technological properties of the system on the basis of the studies as well as a draft instruction for the use of detergent additives.

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