Application of Natural Polymer Drilling Fluid System in J7 Well Area

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Abstract. The natural polymer drilling fluid mainly includes four kinds of additives: natural polymer inhibitive coating agent IND30, filtrate reducer NAT20, non-fluorescence "white asphalt" NFA-25 and polyol PGCS-1. This system has been successfully applied in many wells of the J7 well area by Xinjiang oilfield Company. The in-situ application show that the drilling fluid system possesses excellent features: particular theological property, strong inhibition, strong anti-collapse ability, oil/gas reservoir protection and environment protection.

1. Introduction

The J7 well area of Xinjiang Oilfield is close to the farmland area and has high environmental protection requirements. In addition, the formation from Paleogene to Toutunhe in this well area is easy to be hydrated, dispersed and mud-making. The well walls of the Wutonggou formation are easily exfoliated and collapsed. In response to these problems, Xinjiang Oilfield Company decided to apply a natural polymer drilling fluid system that protected the environment, protected the oil and gas layers. It had good technical performance in the J7 well area. The natural polymer drilling fluid system is aimed at protecting the environment and protecting the oil and gas layer. It rejects the chemical synthesis method to produce drilling fluid treatment agent, and replaces it with natural materials to prepare drilling fluid treatment agent, which develops a new drilling fluid system. The system mainly consists of four kinds of additives: natural polymer inhibitive coating agent IND30, filtrate reducer NAT20, non-fluorescence "white asphalt" NFA-25 and polyol PGCS-1. IND30 has strong ability to inhibit drilling cuttings dispersion and clay swelling, and NAT20 can significantly reduce filtration; NFA-25 has strong anti-collapse ability and no fluorescence; PGCS-1 can help the coating agent to inhibit the hydration dispersion and expansion of clay particles, and can form a lubricating film on the surface of the rock and the surface of the metal drilling tool to reduce friction and torque. Each additive has no biological toxicity.
2. Formulation and Properties of the System

2.1. Lab research results
After a series of indoor research and evaluations for the J7 well area, the following formula is preferred [2]: Water +2-4% bentonite +0.3% Na₂CO₃ + 0.5-2% NAT20 + 0.2-0.5% IND30 + 1-3% NFA-25 + 0.5-1.5% PGCS-1.

2.2. Performance parameters

| Performance | FV (S) | AV (mPa.S) | PV (mPa.S) | YP (Pa) | Gel (Pa/Pa) | API.FL (mL) | HTHP.FL (mL) | Kf |
|-------------|--------|------------|------------|---------|-------------|-------------|-------------|----|
| Data        | 32-65  | 8-35       | 5-25       | 3-10    | 0.5-2.5/1-6 | ≤5          | ≤12         | ≤0.1 |

The system can resist high temperature of 120 °C. The recovery rate of the cuttings of the Wutonggou formation in the J7 well area is over 90%. It can resist 5% bentonite pollution, resist salt to saturation, and resist calcium to 5000ppm. After the interaction with the core layer of the Wutonggou formation in the J7 well area, the permeability recovery value of the system was measured and found to be more than 80%. The system has been tested and its biotoxicity index EC50 value is more than 30000mg/L, which is non-toxic. It can be seen that its inhibition, rheological property, wall-building property of filtration and reservoir protection are good, and it has no pollution to the environment.

3. Field Application

3.1. General situation of test wells in J7 well area (taking well J1020 as an example)
(1) Basic data: actual well depth 1995 m; borehole size Ø311.2 mm borehole × 105 m + Ø215.9 mm borehole × 1995 m; well structure Ø244.5 mm surface casing × 104.2 m + Ø139.7 mm oil casing × 1949.92 m.
(2) Geological stratification: J1020 well in J7 well area is Quaternary Q, neogene N, paleogene E, Shishugou group J₂sh, Toutunhe formation J₂t, Xishanyao group J₂x formation before 1500m deep; The deep 1995m is the J₁s of the Sangonghe formation, the J₁b of the Badaowan formation, and the P₃wt₂ formation of the Wutonggou formation.
(3) Difficulties in drilling technology: red-brown mudstone, reddish-brown smudged mudstone, white scum mudstone, reddish-brown mudstone hydrated and dispersed pulp, reddish brown smudged mudstone, white smudged mudstone in the Palaeogene strata to the Toutunhe formation. Reddish-brown smudged mudstone and white scum mudstone are easy to cause calcium pollution to drilling fluid, resulting in a significant increase in viscous shear of drilling fluid, poor rheological property and increased filtration loss. Coal seams of Xishanyao formation and Badaowan formation are prone to collapse and block falling [3].

The Wutonggou formation is a thick layer of grey mudstone (including a large number of easily hydrated illite-montmorillonite mixed-layer), fine sandstone and glutenite interbed, which is easy to hydrate and expand, and the borehole wall is easy to peel off and collapse [4].

3.2. Field application
After the second drilling, the performance of the drilling fluid is very stable. The strong coating inhibiting ability of natural polymer drilling fluid effectively inhibits the dispersion, mud making and expansion of mudstone, cuttings and clay particles (especially effectively inhibits the hydration, dispersion and mud making of reddish brown mudstone). It ensures the stability of viscous shear (in the past, in the reddish brown mudstone section, the drilling fluid has a high viscosity, the funnel viscosity is above 80S, and the fluidity is poor) [5]. Sectional drilling fluid formula (Table 2).
Table 2. Natural polymer drilling fluid formula of J1020 well

| Well section | Formula |
|--------------|---------|
| 105m         | 4% bentonite slurry +0.3%Na₂CO₃+0.8~1.0%NAT20+0.2~0.3%IND30 |
| ~900m        | 4% bentonite slurry +0.3%Na₂CO₃+0.8~1.0%NAT20+0.2~0.3%IND30+0.5~1.0%PGCS-1 |
| ~1300m       | 4% bentonite slurry +0.3%Na₂CO₃+0.8~1.0%NAT20+0.2~0.3%IND30+1~2%NFA-25+0.5~1.0%PGCS-1 |
| ~1800m       | 4% bentonite slurry +0.3%Na₂CO₃+0.8~1.2%NAT20+0.2~0.3%IND30+2~3%NFA-25+1~1.5%PGCS-1 |

Natural polymer drilling fluids have strong anti-calcium contamination ability. The viscous shear and filtration of drilling fluids are relatively stable (in the past, in this well section, the dynamic and static forces become larger, and the filtration volume increases greatly) [6]. Natural polymer drilling fluid performance of J1020 well is shown in Table 3.

Table 3. Natural polymer drilling fluid performance of J1020 well

| Bentonite content (g/L) | Well depth (m) | Density (g/cm³) | FV (S) | Static shear stress 10s | Static shear stress 10min | API-FL (mL) | Filter cake (mm) | pH value | AV (mPa.s) | PV (mPa.s) | YP (Pa) |
|-------------------------|----------------|-----------------|--------|-------------------------|--------------------------|------------|-----------------|----------|------------|------------|--------|
| 32                      | 757            | 1.12            | 40     | 0.5                     | 1                        | 3.6        | 0.3             | 8        | 26         | 20         | 6      |
| 35                      | 940            | 1.18            | 42     | 0.5                     | 1                        | 4.2        | 0.3             | 8        | 27         | 21         | 6      |
| 38                      | 1320           | 1.2             | 43     | 0.5                     | 1                        | 4.2        | 0.3             | 8        | 27         | 22         | 5      |
| 42                      | 1510           | 1.25            | 43     | 1                       | 2                        | 3.8        | 0.3             | 8        | 26         | 21         | 5      |
| 44                      | 1650           | 1.3             | 43     | 1                       | 2.5                      | 3.2        | 0.3             | 8        | 28         | 22         | 6      |
| 45                      | 1820           | 1.32            | 44     | 1                       | 3                        | 3.2        | 0.3             | 8        | 29         | 23         | 6      |
| 45                      | 1995           | 1.33            | 45     | 1                       | 3.5                      | 3.2        | 0.3             | 8        | 28         | 22         | 6      |

The natural polymer drilling fluid has strong ability of plugging, anti-collapse and improving mud cake [7]. It can form compact, thin and tough, lubricious compressible mud cake, effectively prevent the coal seams of Xisanyao and Badaowan formations, especially the formation wall of Wutonggou formation from peeling and collapsing. It also can achieve the stability of the well wall (in this well section, the wall peeling and collapsing are serious in the past), and the mechanical drilling speed is faster. From the whole second drilling stage to the completion stage, the drilling fluid has stable performance, good rheology, stable borehole wall, no obstruction in pulling up and dropping bit, and the electric logging is successful once. The whole well construction is smooth without complications and accidents.

4. Conclusion and Understanding

(1) The main additives of the natural polymer drilling fluid system are all modified from natural materials and have no biological toxicity. J1020 well completion drilling fluid is taken to test its biological toxicity. Its EC50 value is more than 30 000 mg/L, which is non-toxic.

(2) Various additives of natural polymer drilling fluid system can be biodegraded without blocking oil and gas reservoirs.

(3) The drilling fluid system has strong coating inhibition. It effectively inhibits the dispersion of drilling cuttings and clay particles, and ensures the stability of bentonite content (stable at about 40 g/L).

(4) The drilling fluid system has strong filtration reduction ability. The non-fluorescent white asphalt NFA-25 in the system has strong ability to improve mud cake and wall protection, effectively prevent collapse of easily collapsed formation (such as Wutonggou formation) and achieve wellbore stability.

(5) Non-fluorescent white asphalt NFA-25 has excellent plugging ability and cloud point effect of polyol PGCS-1 (it can form lipophilic colloidal particles), which can temporarily block oil and gas reservoirs. NFA-25 and PGCS-1 have good surface activity, which can reduce the interfacial tension between oil and gas, reduce the water locking effect in the process of oil and gas production, improve oil and gas recovery, and effectively protect oil and gas layers.
(6) The system is light color and no fluorescence, which is conducive to the discovery of oil and gas reservoirs.

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