Research on a New Oil Based Drilling Fluid System

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Abstract. Nowadays, the oil-based drilling fluid has become more and more popular because of the limitation of the type of the exploited oil and gas wells. In this paper, a new type of oil-based drilling fluid formulation is developed through the study of organic clay, emulsifier, wetting agent and so on. It is proved by the experiment that the recovery rate of drilling fluid slurry reaches more than 80%, the demulsification voltage is more than or equal to 2000V, the ability of anti high temperature is very strong, and the pollution to the oil layer is very small.

1. Introduction
Nowadays, with the continuous exploitation of the oil and gas reservoirs, the conditions of the new mined geology have become more and more complex, so the requirements for drilling fluid are becoming higher and higher. The new oil-based drilling fluids have better anti-pollution ability, lubricity and thermal stability and stronger inhibition compared with past drilling fluids [1]. The probability of occurrence of some complex situations such as borehole collapse and shrinkage is greatly reduced. It can be well applied to drilling of special technology wells, such as deep well with resistance to high temperature and high density, ultra deep well, directional well and extended reach well, and can effectively prevent shaft wall instability. Based on the development of bentonite and optimization of emulsifier, wetting agent and filtrate reducing agent, a new oil-based drilling fluid system is developed in this paper.

2. Preparation of organic clay
Organic clay has a direct influence on the rheology and filtration of drilling fluid. There are three methods of preparation of organic clay: wet method, pregel method and dry method [2].

2.1. Preparation steps
The preparation steps of organic clay are shown in Figure 1.
The organic clay used for oil based drilling fluid is developed through the above experimental steps.

2.2. Performance evaluation of organic clay
The prepared organic soil was heated by 24h at the room temperature, 150°C, 200°C and 220°C, observed the properties of the soil, as shown in Table 1.

| Temperature(°C) | Colloid rate (%) | AV (mPa·s) | YP (Pa) | Φ6 | Φ3 |
|----------------|------------------|------------|--------|----|----|
| Room Temperature | 97               | 13.6       | 2.6    | 3.0 | 2.6|
| 150            | 100              | 14.4       | 2.4    | 7.5 | 7.0|
| 200            | 100              | 13.0       | 3.0    | 7.0 | 6.5|
| 220            | 100              | 13.0       | 3.0    | 4.0 | 3.0|

It can be seen from the table, the colloid rate, AV and YP of the organic clay remain unchanged after the temperature reaches 200°C. This shows that the newly prepared organic clay has a good ability to resist high temperature.

3. Optimum emulsifier
There are several mechanisms of action for emulsifier [3]: First, a protective film of a certain strength is formed at the oil and water interface. Secondly, it can be very good to reduce the tension of the oil-water interface. Thirdly, the emulsifier can increase the viscosity of the external phase. Use of compound emulsifier in oil based drilling fluid can improve the performance of drilling fluid, so we choose SP-80(Sorbitan monooleate) and TW-80(Polyoxyethylene sorbitan monooleate) as emulsifier. SP-80 is a high lipophilic emulsifier, HLB=4.3, stable performance, using it as the matrix of the compound emulsifier. TW-80 is a hydrophilic emulsifier, HLB=15, it has the same lipophilic group as SP-80, so the mixture of the two has good coordination and can enhance the emulsification.
Table 2. Evaluation of emulsifying effect of compound

| Emulsifier   | Dosage | Demulsification voltage |
|--------------|--------|-------------------------|
| SP-80+TW-80  | 3% (2:1)| 1150                    |
| SP-80+TW-80  | 3% (3:1)| 670                     |
| SP-80+TW-80  | 3% (4:1)| 1250                    |
| SP-80+TW-80  | 3% (5:1)| 1050                    |

It is known from the above table that when the ratio is 4:1 and the addition amount is 3% the emulsifying effect of compound emulsifier is the best.

4. Wetting agents are preferred
The WETA-1 wetting agent was selected in the experiment, and the performance of the wetting agent was evaluated.

Table 3. WETA-1 Wetting agent suspended barite volume

| Dosage | Time | 50 min | 110 min | 170 min | 230 min | 290 min | 250 min | 410 min |
|--------|------|--------|---------|---------|---------|---------|---------|---------|
| 0.4    |      | 95.5   | 92      | 90      | 86      | 80.5    | 72      | 68.5    |
| 0.9    |      | 94.5   | 91.5    | 88      | 86.5    | 83      | 77      | 72      |
| 1.9    |      | 94.5   | 93      | 89.5    | 87      | 85      | 79.5    | 76.5    |
| 2.9    |      | 95     | 94.5    | 90.5    | 88.5    | 86      | 81      | 77      |

The rheological property of the drilling fluid can be improved by adding 0.4% wetting agent, so 0.4% of WETA-1 is chosen as the wetting agent.

5. Optimization of fluid loss agent
The modified resin class II and synthetic resin have been added to the oil based drilling fluid system to evaluate the fluid loss effect of the two fluid loss agent [4], as shown in the following figure.

Table 4. Optimization experiment of fluid loss agent

| Fluid loss agent dosage | Reaction conditions | AV mPa·s | PV mPa·s | YP Pa | Φ6₀/Φ₃ | FLAPI ml | FLHTHP ml |
|-------------------------|---------------------|----------|----------|-------|--------|----------|-----------|
| 0                       | Pre-aging           | 15       | 13       | 2     | 5/3    | 16       | 26        |
|                         | After aging         | 28       | 24       | 4     | 6/4    |          |           |
| 4% Synthetic resin      | Pre-aging           | 15       | 11       | 4     | 7/5    | 5        | 10        |
|                         | After aging         | 28       | 24       | 5     | 8/6    |          |           |
| 4% Modified resin class II | Pre-aging       | 13       | 10       | 3     | 3/2    | 4        | 6         |
|                         | After aging         | 36       | 29       | 6     | 9/7    |          |           |

It can be seen from table 4 that adding the modified resin II in oil base drilling fluid can make the filtrate loss less than 7mL at high temperature and high pressure, so we choose this kind of fluid loss agent.

Final determination the formula of new oil based drilling fluid: oil based+ organic clay+3%10g compound emulsifier (SP-80+TW-80) + 0.4% Wetting agents (W ETA-1) + 3%fluid loss agent (modified resin class II) + calcium oxide+ barite.

6. Performance evaluation of new oil based drilling fluid

6.1. Evaluation of inhibition
The inhibition performance of drilling fluid directly affects the stability of the wellbore [5], the measure of inhibition is the rate of recovery. The cuttings is added to the drilling fluid of clear water.
and different formulas, measurement of recovery rate of drilling fluid at the same temperature for 24 hours with hot roll.

**Table 5. Experimental results of drilling fluid inhibition performance**

| Formula | Species                  | Hot rolling temperature (℃) | Rate of recovery (%) |
|---------|--------------------------|----------------------------|----------------------|
| 1       | Clean water              | 200                        | 7.52                 |
| 2       | Ordinary drilling fluid  | 200                        | 74.75                |
| 3       | Oil based drilling fluid | 200                        | 80.73                |

As can be seen from table 5, the recovery rate of the new oil based drilling fluid of No.3 is 80.73%, which can meet the requirements of the drilling fluid.

6.2. **Stability evaluation** [6]

Oil based drilling fluids with density of 1.4 g/cm³, 1.6 g/cm³ and 1.8 g/cm³ were aged for 24 hours at a temperature of 100℃ and 200℃, and their stability was measured.

**Table 6. Stability of drilling fluid with different density**

| Density g/cm³ | Base fluid            | 100℃ Es/V | 200℃ Es/V |
|---------------|-----------------------|-----------|-----------|
| 1.4           | Oil based drilling fluid | >2200     | >2100     |
| 1.6           | Oil based drilling fluid | >2100     | >2000     |
| 1.8           | Oil based drilling fluid | >2000     | >2000     |

As can be seen from Table 6, the demulsification voltage of the oil-based drilling fluid at different densities is both ≥2000V, indicating good stability.

6.3. **Lubricity evaluation**

In the experiment, three different drilling fluid systems were selected, and the lubricating property of the drilling fluid was observed by comparing the mud cake adhesion coefficient of the three kinds of drilling fluid and the E-P extreme pressure value [7].

**Table 7. Performance evaluation of different drilling fluid system**

| Drilling fluid system       | Adhesion coefficient of mud cake | E-P Extreme pressure value |
|-----------------------------|----------------------------------|---------------------------|
| Gas oil drilling fluid      | 0                                | 8~9                       |
| Diesel oil drilling fluid   | 0.056                            | 12~13                     |
| New oil based drilling fluid| 0                                | 5~6                       |

It is not difficult to see from table 7 that the lubrication performance of the new oil based drilling fluid is obviously superior to the other two kinds of drilling fluid.

6.4. **Reservoir protection evaluation**

Reservoir protection is evaluated by gas oil drilling fluid, diesel drilling fluid and new oil based drilling fluid. Based on the experimental data in the following table, we can see that the permeability recovery value of the new oil-based drilling fluid is over 90%, which can reduce oil layer contamination [8].
Table 8. Permeability recovery values of cores in different systems

| Drilling fluid system          | Core | Diameter (mm) | Length (mm) | Gas permeability (md) | $K_0$ (md) | $K_1$ (md) | $K_1/K_0$ (%) |
|-------------------------------|------|---------------|-------------|-----------------------|------------|------------|---------------|
| Gas oil drilling fluid 1#     | 1#   | 26.37         | 32.58       | 163.11                | 68.10      | 50.14      | 72.95         |
| Diesel oil drilling fluid 2#  | 2#   | 26.41         | 33.17       | 190.17                | 58.58      | 49.78      | 85.04         |
| New oil based drilling fluid 3# | 3#   | 25.29         | 31.19       | 140.45                | 50.21      | 49.23      | 98.04         |

7. Conclusion

Through the preparation of organic clay and the optimization of emulsifier, wetting agent and filtrate reducing agent, determination of basic formula for oil based drilling fluid system: oil based+organic clay+3%10g compound emulsifier (SP-80+TW-80) +0.4%Wetting agents (WETA-1) +3% fluid loss agent (modified resin class II) + calcium oxide+ barite.

The performance evaluation of oil based drilling fluid shows that drilling fluid has strong inhibition, good stability and good wettability, and it can protect oil and gas reservoirs.

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