Interior Research of Resistance to High 220 Degrees Heat Resistance Drilling Fluid System

Fulei Zhao[1], Yuxue Sun [2], Shizhong Ma[3] and Binqi Yuan[4]

Petroleum Engineering Department in Northeast Petroleum University, Daqing, China
Email: 104648885@qq.com

Abstract. Focusing on high temperature rheological stability and filtration control of high temperature resistant drilling fluid system, in this context, futher research has been made on mud formula and the formula of high temperature resistant drilling fluid system was optimized, Finally, a kind of organic silicon drilling system with high 220 degrees heat resistance and good performances was developed, in combination with the evaluation of the validity for the overall performance of the drilling system. In virtue of the behavior of high temperature stabilizing agent, the system provided excellent shale inhibition, lubrication and tough hole stabilization. The filtrate value is low, the mud cake is thin and tough, which are good for bit balling prevention; the capacity of cuttings transportation is efficient, as well as the easy-control rheological property. In high salinity conditions, the entire drilling fluid properties maintain stability; limit the pollution of 6% NaCl or 0.5%$CaC1_2$. The composition of fluid is non-toxicity, non-fluorescence, which is fitful for deep drilling.

1. Introduction

Indoor research and field applications show that the properties of new high-performance water-based drilling fluid should be consist of better hydraulic parameters, high temperature flow stability as well as shale stability and lubricity. From the rheological point of view, for reducing friction losses and improve hole cleaning capacity [1], the best drilling fluid system would contains stable shear thinning characteristics, which are depend on the specific organic polymers, mixtures or the content of bentonite drilling fluid system. As deep and ultra-deep wells are playing a more and more vital role in Daqing Oilfield, higher demands on the drilling fluid are required for the higher bottom hole temperature, and the complex strata pressure system. Based on the features of Daqing Oilfield, the resistance to high temperature deep drilling fluid system has been exploited. Fluid loss additive in the system plays a role to reduce the system of high temperature and high pressure filtration; it also has a crucial impact on the flow variability. Thus, the control of the rheology and filtration loss is based on a reasonable proportion of the viscosity reducer, fluid loss additive and bentonite content [2].

2. The initial formula before optimization

2.1. Initially set the original test of organic silicone anti-high temperature drilling fluid formulation, processing agents and concentration (%) were

(3.0%—6.0%) bentonite+0.4%soda ash+0.25% KFT+ (0.5%—1.0%) GWJ+1.5% YGT+1.0% YGY180+1.0% lubricants+0.1% KOH+ (0.1%—3.0%) SF260+ 1.0%YGB-1+ ultra-fine carbide + barite powder + water;

KFT—High temperature anti-sloughing salt fluid loss agent, a major role for anti-filtrate loss;

GWJ—Stabilizer for the poly silicon fluoride, the main role for the control of the drilling fluid viscosity;

YGT—To block anti-sloughing agent, play a vital role for collapse prevention;

YGY180—Inhibitor of organic silicon, mainly in order to limit the hydration expansion of mudstone;

SF260—Poly silicon fluoride viscosity reducer, the crucial function is to reduce viscosity, ensure that SF260 and CWJ are used in conjunction to guarantee the drilling fluid in the high temperature state with a stable rheology.

2.2. Rheological properties of high temperature sensitivity test

Through a series of experiments with the initial composition of drilling fluid, to observe the impact of two silicon-fluorine viscosity reducer SF260 and CWJ, as well as bentonite content on rheological properties and filter loss control performance of drilling fluid.

(1) When the polymer stabilizer GWJ fluorine content of 0.5%, viscosity reducer SF260 and bentonite content on the system, plastic viscosity and dynamic shear force of Figure 1 to Figure 4.

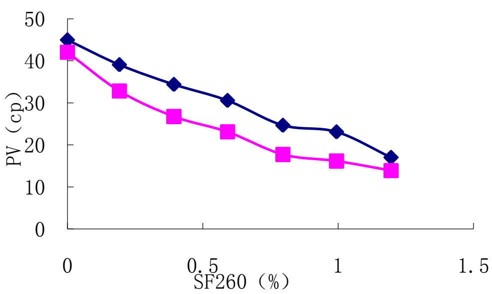

Figure 1. GWJ 0.5% of the content of content on the PV of SF260

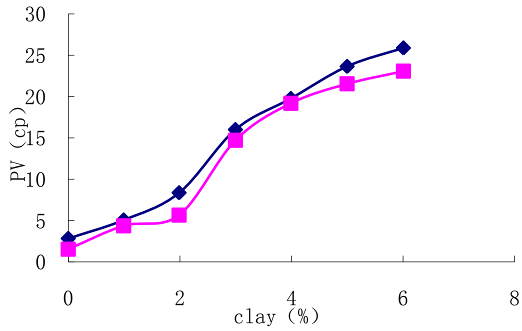

Figure 2. GWJ content of 0.5% of bentonite content on the PV

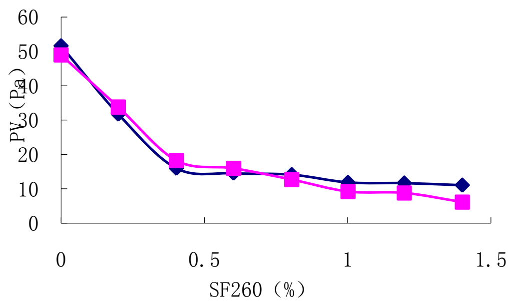

Figure 3. GWJ content of 0.5% of SF260 content on YP

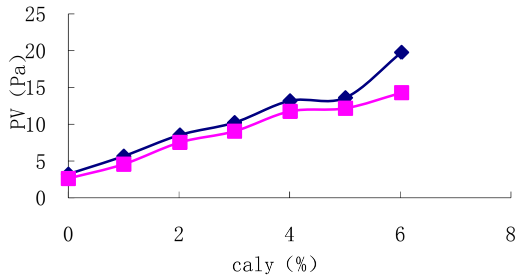

Figure 4. GWJ content of 0.5% of bentonite content on the YP

Detailed analysis show that, ultimately determine that 5% viscosity reducer SF260 and 0.6% bentonite are added in the organic silicon resistance to high temperature system due to cost factors.

(1) The optimum amount of viscosity reducer SF260 and bentonite has been identified. Then, tune the additional quantity of poly-silicon fluoride stabilizer from 0.5% to 1%, to observe the change in performance before and after the changes in the quantity of stabilizer to be added. Specific results are shown in Table 1.

Table 1. GWJ increase the amount of the thermal stability of silicone after the comparative data table

Drilling fluid formulation number		PV(cP)	YP(Pa)	Dynamic plastic than	API filtration
1#	Before the hot rolling	50	29		
	After hot rolling	29	13	0.25	3.5
2#	Before the hot rolling	43	22		
	After hot rolling	25	8	0.32	3.8

Table 1 show, the added amount of CWJ tuned from 0.5% to 1%, leading to the decrease of dynamic shear and plastic viscosity; the extended dynamic plastic ratio from 0.25 up to 0.32; the improvement of dilution of shearing, therefore, determining the dosage of CWJ is 1.0%.

2.3. Adjust the system fluid loss dosage

Data in Table 2 show that: observe the control of system filter loss, nevertheless, system filtrate volume is slightly higher, adjustments of the amount of fluid loss additive are needed, as well as the filtrate reducer KFT tune from 0.25% to 0.3%. Silicone fluid system property data (hot rolling temperature is 220 ℃) in Table 2.

Table 2. The amount of fluid loss additive added after the drilling fluid performance

Drilling fluid formulation number		PV(cP)	YP(Pa)	Dynamic plastic than	API filtration
1#	Before the hot rolling	50	29		
	After hot rolling	29	13	0.25	2.9

Data of Table 2 reveal that, according to the increase amount of system fluid loss additive, filtrate volume of high temperature system reduced to 2.9, and plastic viscosity and dynamic system slight changes, the rheological parameters and filter loss volume of the new optimized drilling fluid within a prescribed range.

Estimate the dynamic filtration of Daqing Oil Field Xujiaweizi natural core curves over time, under the condition of temperature 180 ℃, pressure 3.5MPa, drilling fluid flow 200s-1, shown in Figure 5.

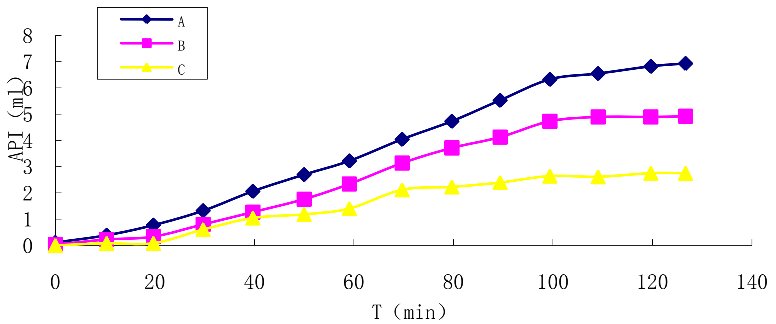

Figure 5. Dynamic filtration with time

Overview the result: the dynamic filtration of organ silicon drilling fluid system was 5.6mL after 30 minutes. Time-varying, the dynamic filtration incremental became zero after 90 minutes, comprehensive investigations of the values revealed that filtrate reducer loss agent adjusted to achieve the specified requirements, additionally, it shows that oregano silicon drilling fluid is valid for preventing the collapse of the shale and protecting the gas reservoir.

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2.4. Optimization of the amount of inhibitor YGY180

Experiments above have identified the optimal amount of silicone clay, viscosity reducer SF260, the poly silicon fluoride stabilizer CWJ and filtrate reducer in the organ silicon drilling fluid system. Changing the amount of the inhibitor YGY180, determining the optimum amount of YGY180 by high temperature inhibitor recovery experiments. 1 # fluid formulation containing 0.5% YGY180; 2 # containing 1.0% YGY180; 3 #: containing 1.5% YGY180;

Table 3. The recovery of high-temperature inhibitor results

Formula	40 Target rate
1#	82.19%
2#	89.42%
3#	89.91%

The results show that: the inhibitor increased with the amount of system recovery, but when YGY180 reach 1.5%, no significant increase in inhibitory effect, taking into account the economic factors that ultimately determine the best dosage YGY180 is 1.0%.

3. Optimized formulation

3.1. Silicone high temperature water-based drilling fluid system optimized formulation

Based on the experiments above, screen and evaluate the property of drilling fluid indoor, through compatibility experiments determine the standard recipe of the organ silicon drilling fluid:

5.0% bentonite+0.4% soda ash+0.3%KFT+1.0%GWJ+1.5%YGT+1.0%YGY180+1.0% BST-3+1.0%lubricants+0.1%KOH +0.6%SF260+1.0%YGB-1+ultra-fine carbide + barite powder.

Where: BST-3 is protective agent for the low permeability reservoir; the main role is to form a hydration film with almost no penetration around the borehole wall, to avoid drilling fluid into reservoir.

3.2. Anti-silicone fluid temperature and fluid system performance evaluation

Measure rheological properties, heat loss in the filter process and high temperature and pressure filtration. This study tested the rheology and fluid loss of two different density drilling fluid at different temperatures listed in Table 4 and Table 5.

Table 4. 1.06g/cm^3 drilling fluid density at different temperatures after aging properties

No.	Temperature ℃	Aging(16 h)	AV mPa s	PV mPa s	YP Pa	G10″/10′ Pa/ Pa	API FL mL	HTHP FL mL	pH
1	25	Before the hot rolling	22	17	7	1.5/4.5	2.4	13.0	9
2	180	After hot rolling	17.5	13	3.5	0.5/2	2.9	14.0	9
3	220	After hot rolling	21.5	16	5.5	1/4.5	3.4	18.0	9

Table 5. 1.20g/cm^3 drilling fluid density at different temperatures after aging properties

No.	Temperature ℃	Aging(16 h)	AV mPa s	PV mPa s	YP Pa	G10″/10′ Pa/ Pa	API FL mL	HTHP FL mL	pH
1	25	Before the hot rolling	20	17	6	2/4.5	3.2	10.2	9
2	180	After hot rolling	21	16	4	0.5/2.5	3.9	14.6	9
3	220	After hot rolling	22	16	6	1/7	3.9	16.6	9

It can be seen from the data above, the rheological properties of high temperature resistant organ silicon drilling fluid become more efficient after the hot rolling at 220 ℃ without thickening and gelling. It shows that the drilling fluid meet the temperature of 220 drilling requirements.

3.3. Evaluation system of anti-pollution

Select NaCl and $CaC1_2$ as evaluation of soil as a pollutant; evaluate the anti-pollution ability and cuttings pollution resistant performance of high temperature resistant silicone drilling fluid. Results listed in Table 6 and Table 7.

Table 6. Salt contamination of organic silicon system results

Salts	Dosage (%)	Conditions	Rheological parameters				APIB/APIK (mL/mm)	PH	Tempera ture(℃)
			AV (mPa s)	PV (mPa s)	YP (Pa)	G10″/G10′ (Pa)			
NaCl	0	Temperature before	24.5	16.0	8.5	2.0/5.0	4.8/0.5	9	25
		220°C /16h	21.0	16.0	5.0	1.5/3.0	6.4/0.5	9	
	4	Temperature before	14.0	12.5	1.5	1.0/3.5	5.2/0.5	9	
		220°C /16h	10.5	10.0	0.5	0.5/1.5	8.4/0.5	9	
	6	Temperature before	13.5	11.5	2.0	0.5/3.0	5.6/0.5	9	
		220°C /16h	11.0	10.0	1.0	0.5/2.0	8.6/0.5	9	
	8	Temperature before	9.5	9.0	0.5	0.5/2.5	8.8/0.5	9	
		220°C /16h	7.0	6.5	0.5	0.5/1.0	12.0/1.0	9	
$CaCl_2$	0.25	Temperature before	24.0	19.0	5.0	2.5/4.0	5.6/0.5	9	
		220°C /16h	16.5	12.0	4.5	1.5/3.5	7.2/0.5	9	
	0.5	Temperature before	23.5	19.0	4.5	1.3/3.0	6.4/0.5	9	
		220°C /16h	14.0	11.0	3.0	0.5/3.0	8.6/0.5	9	
	1	Temperature before	15.0	13.0	2.0	0.5/6.5	7.2/0.5	9	
		220°C /16h	13.5	12.0	1.5	1.0/2.5	12/0.5	9	

Table 7. Cuttings of silicone anti-pollution system results

Performance Formula	Conditions	Rheological parameters				APIB/APIK (mL/mm)	PH	Temperature (°C)
		AV (mPa s)	PV (mPa s)	YP (Pa)	G10″/G1′ (Pa)			
Organic silicon system	Temperature before	24.5	16.0	8.5	2.0/5.0	4.8/0.5	9	25
	220°C /16h	21.0	16.0	5.0	1.5/3.0	6.4/0.5	9	
Organic silicon system+10% Cuttings	Temperature before	32.5	22.0	10.5	3.5/7.5	5.6/0.5	9	
	220°C /16h	22.5	16.5	6.0	2.5/4.5	6.6/0.5	9	
Organic silicon system+15% Cuttings	Temperature before	33.0	23.0	10.0	3.5/8.0	6.8/0.5	9	
	220°C /16h	23.0	14.5	8.5	3.0/7.0	7.0/0.5	9	
Organic silicon system+20% Cuttings	Temperature before	45.5	28.0	17.5	6.0/17.0	10.4/1.0	9	
	220°C /16h	37.5	25.0	12.5	5.5/15.0	14.4/1.0	9	

The results of the experiments above can be summarized that the organic silicon system has good resistance to soluble salts (NaCl, $CaC1_2$) fouling. Silicone high temperature water-based drilling fluid system, work 16 hours at a high temperature of 220 ℃, anti-NaCl 6%, anti-$CaC1_2$ 0.5%, 15% anti-cuttings.

4. Conclusion

1. On basis of the results of drilling fluid additives, the initial formulations of drilling fluid silicone are determined, furthermore, the quantity of drilling fluid component has been optimized and adjusted;

2. Finalize the standard formulations of the resistance to high temperature organic silicon drill fluid:

5.0% soil powder +0.4% soda ash +0.3% KFT +1.0% GWJ +1.5% YGT +1.0% YGY180 +1.0% BST-3 +1.0% lubricant +0.1% KOH +0.5% SF260 +1.0% YGB-1;

3. Silicone anti-high temperature drilling fluid system has significant capacity of anti-high temperature, excellent inhibition, unique rheology and outstanding capacity of anti-pollution.

5. References

[1] Wu Xiaohua. Tacan - 1 of drilling fluid rheology and application of high temperature [J]. Drilling & Production Technology, 2003, 26 (3): 89-90.
[2] Wangli. High temperature of deep well water based drilling fluids [D]. Beijing: China University of Petroleum, 2007.
[3] Huang Jinjun, Pu Xiaolin, Li Jabot. 220 ℃ high temperature resistant water-based drilling fluid of lower viscosity [J]. Oilfield Chemistry, 2003, 20 (3):197-199.
[4] C.J.Thaemlitz. The new environmentally friendly high-temperature water-based drilling fluid system [J]. Party Junfang translation. Petroleum Exploration and Development, 2001, 4 (2) : 34-36