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Drilling Fluid Technology for the Third Interval of Sunan 23-113H2 Well

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Abstract. In the construction process of Sunan 23-113H2 well, there wasYanchang well, Liujiagou well and Shihezi well, when passing through the well, the mudstone collapse of the large slope section caused the difficulty of reaming off, after repeated reaming off, the wellbore still cannot be unblocked. Finally, the well structure was changed from the conventional Third Interval to the optimized Third Interval, and the technical casing is lowered to the depth of the inclined 45° well in the inclined shaft section. After the Third Interval, the mudstone of the large inclined section and the horizontal section collapsed, and the well leakage of the inclined well section and the horizontal section was still prominent. According to the construction situation of the Third Interval of the well, this paper optimizes the drilling fluid and refines the leak prevention and plugging measures through indoor experiments to provide technical support for safe drilling.

Key words: Sunan horizontal well; Third Interval; anti-collapse; sealing up; drilling liquid

1. Introduction

In First Interval and Second Interval, there were well leakage phenomenon in Sunan 23-113H2 well, and the risk of mud and rock collapse and leakage is high, which cannot solve the stability problem of the well wall, and the collapse contradiction is prominent[1-3]. After the Third Interval, it still faces the collapse of mudstone and horizontal section, the collapse of the inclined well section and the horizontal section, and the contradiction between collapse and leakage is still prominent. According to the construction of Sunan 23-113H2 well, the best treatment agents were determined by screening the field treatment agents and classifying them according to their efficacy[4-6]. Different drilling fluid formulations were designed to test the different formula density, API water loss, HTHP-FL(Filter loss under high temperature and high pressure), apparent viscosity, plastic viscosity, dynamic shear force, etc., to determine the best drilling fluid formulation, the system formula and plugging measures were optimized, and to conduct field experiments to provide technical support for safe drilling[7-10].

2. Materials and methods

2.1 The treatment agents were classified and screened according to their different functions

Materials used for the study such as: KCl(Sinopharm Co., Ltd.); XCD; water loss agent: NAT-20, PAC-LV; wall blocking: NFA-25, FT-401, ZDS, prehydrated clay; aggravating agent: barite.

2.2 Performance control requirements of each well section

Slant well section: ρ: 1.30-1.35 g/cm^3; Fv 50-60 s; FL≤3 mL; HTHP≤12 mL; Φ6: 5-7.
Horizontal segment: ρ: 1.35-1.36 g/cm^3; Fv: 65-75 s; FL≤3 mL; HTHP≤12 mL; Φ6: 6-8.

3. Results and discussion

3.1 Indoor formula experiments, to determine the amount of treatment agent added

After rolling all drilling fluids at 120℃ for 4 h, the performance of the drilling fluids were tested, the results were shown in Table 1.

Table.1 Formulation experiment

	Formula	Density/g.cm^{-3}	API water loss/mL	HTHP-FL/mL	apparent viscosity	plastic viscosity	dynamic shear force	Φ6
1#	water+0.15%+0.1%XCD+1%NAT-20+3%NFA-25+2%ZDS+8%KCl+barite	1.30	4.2	16.8	21	15	6	3
2#	water+0.15%+0.1%XCD+1%NAT-20+3%NFA-25+2%ZDS+10%KCl+barite	1.30	4.6	17.2	14	11	3	2
3#	water+0.15%+0.1%XCD+1%NAT-20+1%PAC-LV+3%NFA-25+2%ZDS+10%KCl+barite	1.30	4.0	16.2	17	13	4	2
4#	water+0.15%+0.1%XCD+1%NAT-20+1%PAC-LV+2%NFA-25+2%FT-401+2%ZDS+10%KCl+barite	1.30	3.6	14.4	24	16	8	4
5#	water+0.15%+0.1%XCD+1%NAT-20+1%PAC-LV+2%NFA-25+3%FT-401+2%ZDS+15%KCl+barite	1.30	3.2	12.6	30	22	8	5
6#	water+0.15%+0.1%XCD+1%NAT-20+1%PAC-LV+2%NFA-25+3%FT-401+2%ZDS+15%KCl+2%Pre-hydrated drilling fluid+barite	1.30	3.0	11.8	32	24	8	6
7#	water+0.15%+0.1%XCD+1%NAT-20+1%PAC-LV+2%SMP-2+3%FT-401+2%ZDS+15%KCl+2%Pre-hydrated drilling fluid +barite	1.30	3.0	12.0	34	24	10	6

Through the above experiments, the performance of 6# and 7# drilling fluids meet the construction requirements, Therefore, the final drilling fluid formula was determined as: water+0.15%+0.1%XCD+1%NAT-20 + 1%PAC-LV +2%NFA-25 （2%SMP-2） +3%FT-401 +2%ZDS +15%KCl +2%Pre-hydrated drilling fluid.

3.2 Water loss performance test

When the drilling fluid circulates in the wellbore, with the increase of density, the liquid injection pressure will increase, if the quality of the mud cake is poor, the water loss is large, the filtrate pressed into the formation is gradually increasing, exacerbating the collapse of the debris formation prone to collapse, so while increasing the density of the drilling fluid, it is necessary to reduce the water loss, the medium pressure water loss control is less than 3.0 mL, and the high temperature and high pressure water loss is less than 12.0 mL[11,12].

Table.2 Medium-pressure water loss value at different pressures

Pressure(MPa)	Compared to 0.7 MPa pressure added value(MPa)	Medium pressure water loss(mL)
0.7		3.0
0.8	0.1	3.1
0.9	0.2	3.3
1.0	0.3	3.5

Table.3 Liquid injection pressure at the same vertical depth and different density (vertical depth 3780m)

Density (g.cm^{-3})	Compared with the added value of the density of 1.30 g/cm^3 (MPa)	Fluid Injection Pressure(MPa)
1.30		48.16
1.32	0.74	48.90
1.34	1.48	49.64
1.36	2.22	50.38

3.3 Optimize the displacement and reduce the annular air pressure consumption

Ring-air pressure consumption was calculated at a well depth of 4000 m, a density of 1.35 g/cm^3, and a plastic viscosity of 40 mPa·s.

Table.4 Different displacement and annular return speed

Cylinder size(mm)	Pump rushed	Displacement(L/S)	Ring empty return speed(m/s)	Ring air pressure consumption(MPa)
100	108	12.2	1.20	3.574
110	108	15	1.48	5.184
	95	13	1.28	4.334
120	108	17	1.68	6.494

Through the above calculation, the displacement plays a decisive role in the size of the annular air pressure consumption, so when drilling normally, the annular air return speed can reach more than 1.2 m/s, and the displacement is 12-13 L/s.

3.4 Anti-spill and plugging measures

Circulating tank is always prepared with 35 m^3 sealing drilling fluid, formula: drilling fluid+ 10% fine plugging, immediately after the leakage is lost, immediately pumped into the plugging drilling fluid, all replace the water eyelet, drilled into the casing for squeezing or static plugging. When increasing the density, each 1 ton of barite mixed with 200 kg of leak plugging agent with drilling, 1 ton of plugging agent with drilling is added to each tank of supplementary pulp, and single seal and KSD-1 are selected for plugging agent with drilling[13-15].

Table.5 Different effects of drilling plugging agent on the performance of drilling fluid

Formula	Density (g/cm³)	Medium pressure water loss (mL)	High temperature and high pressure water loss (mL)	Apparent viscosity (mPa·s)	Plastic viscosity (mPa·s)	dynamic shear force (Pa)
Drilling fluid	1.36	2.6	10.8	40	30	10
Drilling fluid+0.5%DF-A	1.36	2.6	11.2	43.5	32	11.5
Drilling fluid+0.5%KSD-1	1.36	2.6	11.2	48	35	13
Drilling fluid+0.5%GT-MF	1.36	2.6	11.4	51	36	15

3.5 Solid phase control requirements

All drilling fluids were sieved, and the vibrating sieve screen cloth is selected at more than 180 meshes. Check the sediment volume of the conical tank per shift, reach 1/2 and immediately clear the tank. After 3-4 hours of use of the high-speed centrifuge, it is necessary to remove harmful solid phases such as inferior soil in the system. When preparing the supplemental drilling fluid, glue + KCL is mainly used for system maintenance, less barite is consumed, and the supplementary drilling fluid density is adjusted according to the system density[16-18].

4. Field application

4.1 Prepare drilling fluid before Third Interval: 1.31/60/4.0/9, HTHP-FL: 12.2 mL, Then a small experiment was carried out to further adjust the performance. After adjusting the performance: 1.32/90/3.2/9, HTHP-FL: 11.2 mL, then start the Third Interval[19].

Table.6 Performance of Third Interval drilling fluid in Sunan 23-113H2 well

Well deflection	Density (g/cm³)	Medium pressure water loss(mL)	High temperature and high pressure water loss(mL)	Apparent viscosity (mPa·s)	Plastic viscosity (mPa·s)	dynamic shear force(Pa)	Φ6
45	1.32	3.2	11.2	67	47	20	6
55	1.33	3.0	11.0	71	51	20	7
65	1.34	3.0	10.0	65	47	18	6
75	1.35	2.8	10.0	64	46	18	7
Entrance window	1.35	2.8	9.8	59	42	17	7
Horizontal segment	1.35-1.36	2.6-2.8	8.0-9.0	58	43	15	6-8

4.2 After tuning the performance in the Third Interval, the viscosity of the ground funnel is high (82-98s), heated to 50 °C, 95 °C, rheology was measured, there was no obvious change, so as to analyze the performance of the drilling fluid in the well after circulating heating, and insist on monitoring the rheological parameters at the same temperature of heating on a daily basis during the later construction, and adjust it in time after the abnormality occurs[10].

Table.7 The rheological energy of third drilling fluid in the Sunan 23-113H2 well at the same temperature

Well total depth (m)	Heat the raw drilling fluid to 50℃				Heat the raw drilling fluid to 95℃			
	Funnel viscosity(s)	Apparent viscosity (mPa·s)	Plastic viscosity (mPa·s)	dynamic shear force (Pa)	Funnel viscosity (s)	Apparent viscosity (mPa·s)	Plastic viscosity (mPa·s)	dynamic shear force (Pa)
3700	86	55	40	15	63	41	30	11
3800	88	59	44	15	62	40.5	30	10.5
3900	82	64	40	14	64	40.5	30	10.5
4000	85	56	41	15	62	40	29	11
4200	87	58	44	14	61	39	29	10
4400	85	54	39	15	62	40	29	11
4600	78	53	37	16	57	36	27	9
4800	79	49	36	13	57	38	29	9
4900	78	51	36	15	59	37	28	9
5000	76	54	38	16	56	33	24	9
5100	76	56	41	15	58	36	27	9
5200	77	59	42	17	59	38	28	10
5300	78	59	43	16	56	37	28	9

4.3 The third drilling process occurred two leakage in the drilling process, one squeeze and seal, one time with the drilling, only the drill pipe is drilled to plug the leak without drilling..

Table.8 Statistics on the Third Interval leakage of Sunan 23-113H2 Well

Well total depth (m)	Leakage speed (square / hour)	Properties of drilling fluid	Treatment measure	Lost time (h)
3965	10-12	1.35/86/ 2.8/9	With 30 m^3 plugging drilling fluid, 1 ton KSD-1 + 1 ton single seal + 1 ton of sawdust, plugging drilling fluid will fully cover the naked eye section into the casing extrusion, the maximum sleeve pressure 9.0MPa, hold pressure 30min sleeve pressure 4.8MPa, 1 hour sleeve pressure does not drop, well cycle, normal consumption, resume drilling.	9
4727	10-20	1.36/88/ 2.6/9	Add 1 ton of DF-A with drill and drive high speed centrifuge for 3h, consumption is normal and resume drilling.	3

4.4 After the Third Interval session, monitored the solid phase content every day, opened the centrifuge to clear the solid phase in time according to the solid phase content, and cleaned up the conical tank for each drill.

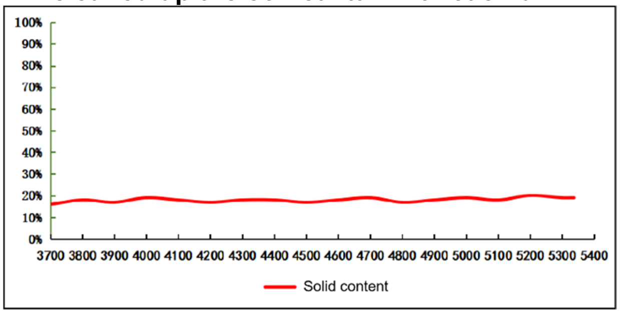

Fig.1 Solid phase content of Sunan 23-113H2 Well

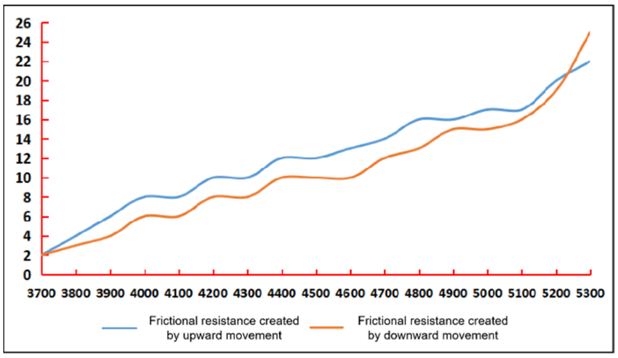

Fig.2 Frictional resistance created by upward movement and downward movement in the third drill of Sunan 23-113H2 Well

4.5 After the well is drilled into the window for 20m, it encountered dark gray mudstone, and the drilling fluid treatment ensured the KCL content of the system at 15% at first, while enhancing the blockage of the system, the medium pressure water loss < 3.0mL, the high temperature and high pressure water loss < 12mL, the mud cake was dense and smooth, and there was no obstacle in the drilling mud rock well section.[20].

Table.9 Horizontal section mudstone condition of Sunan 23-113H2 Well

Lithology	Well section(m)	Segment length (m)	Gamma	Function	HTHP-FL/mL	Up and down the drill
Dark gray mudstone	4047-4062	15	170-190	1.36/90/2.6/9	9.6	Normal
Dark gray mudstone	4206-4269	63	160-195	1.36/92/2.6/9	9.2-9.4	Normal
Dark gray mudstone	4280-4297	17	170-190	1.36/89/2.6/9	9.0-9.2	Normal
Gray mudstone	4297-4306	9	150-170	1.36/86/2.6/9	9.0-9.2	Normal
Dark gray mudstone	4306-4318	12	170-193	1.36/88/2.6/9	9.0-9.2	Normal
Gray mudstone	4332-4364	32	160-170	1.36/85/2.6/9	8.8-9.0	Normal
Dark gray mudstone	4364-4470	106	170-190	1.36/88/2.6/9	8.8-9.0	Normal
Dark gray mudstone	4730-4734	4	160-180	1.36/86/2.6/9	8.7-8.8	Normal

Fig.3 Dark grey mudstone of the horizontal section of Sunan 23-113H2 Well

Fig.4 High temperature and high pressure for mud cake and water loss

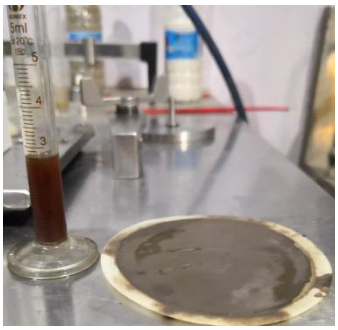

Fig.5 Medium-pressure water loss and mud cake

5. Conclusions and suggestions

The drilling fluid formula was determined as: water +0.15% +0.1%XCD + 1%NAT-20+1% PAC-LV +2%NFA-25(2%SMP-2) +3%FT-401 +2%ZDS +15%KCl + 2%Pre-hydrated drilling fluid. The KCl content of large slope well section reacheed 15%, and the system had strong inhibition and can effectively prevent mudstone collapse. The drilling fluid improved the system pluggability, reduced water loss, and can effectively reduce the collapse pressure of the formation, which can reduce the density of drilling fluid and reduce the risk of well leakage. It is very important to reasonably select the displacement of small wellbore. On the premise of meeting the requirements of sand carrying, the displacement should be reduced as far as possible, which can greatly reduce the annular circulation pressure consumption and prevent the leakage of horizontal section Wells. When adjusting the performance of the system, it is necessary to carry out small experiments first to avoid blind operation and causing performance adjustments to be in place for a long time, causing downhole complexity.

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