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Study on the Workover Fluid Formula and Performance of the Prevention Reservoir

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Abstract

In the workover treatment of Yakela condensate gas field, the workover fluids are easily leaked, and many problems such as clay expansion, rate sensitivity, migration of fines, and change of wetting property will occur, which will induce serious reservoir harms. In the article, the performances of the existing workover fluid of the Yakela condensate gas field with high temperature and high pressure are evaluated, and the influencing factors harming the reservoir are analyzed and obtained, and the effective measures and methods preventing the reservoir harm are confirmed. The technical principle, material composing, performance index, and the evaluation of stratum liquid compatibility are introduced in the article. The result of performance evaluation indicates that the core return permeability of the workover liquid system can achieve above 80%, and it is an ideal low-harm workover fluid system.

Keywords: Workover fluid, Stratum harm prevention, Permeability

Because of many years' exploitation, the reservoir conditions of the Yakela condensate gas field have changed a lot. The pollutions of the wells which still adopt the original workover fluid system occur in succession, and the reservoirs were harmed to different extents. According to existing materials of tested wells, the average skin coefficient after pollutions is about 35, and the upper gas layer skin coefficient of the Well 15 achieves 131.4, which seriously influences the production energy design and normal production of single well. To make clear the cause of reservoir harm, it is necessary to analyze and evaluate the harm mechanism and the harm degree of the original workover fluid, and based on room researches, the good workover fluid which can fulfill the reservoir of the Yakela condensate gas field can be selected, which can reduce the harms of the oil gas field in the workover process as more as possibly.

1. Mechanism analysis of reservoir harm

1.1 Performance analysis of existing workover fluid

At present, the workover fluid used in the Yakela condensate gas field mianly is the stratum water. Only to comprehensively analyze and study the performance of the existing workover fluid and completion fluid, the reservoir harm induced by the workover fluid and the completion fluid and the main harm mechanism can be scientifically diagnosed and analyzed. The analysis result is seen in Table 1.

From the experiment result in Table 1, the stratum water belongs to the calcium chloride of super high salinity, and in the workover process, the stratum scaling will be easily induced because of the invasion of exterior fluids, and in the production process, the potential problem of the production string (oil/ casing string) erosion may exist, and corresponding protective measures such as corrosion mitigation and scale inhibition should be adopted to effectively prevent the invasion of exterior fluids. The total iron content in the stratum water has achieved the standard, so the corrosion resistance of the production string should be considered.

1.2 Analysis of reservoir harm factors

Yakela condensate gas field mainly is the low permeability reservoir, and combining with the geology of the oil reservoir and the character of the liquid, the reservoir harm factors mainly include following four aspects from the harm mechanism.

(1) The clay expansion plugging induced by the water sensitivity

In Yakela condensate gas field, some parts conclude 20%~35% mixed-layer minerals of illite and smectite, and the highest content can achieve 50%. When the workover fluid filters into the stratum, the smectites will be expanded quickly to reduce the hole-tunnels on the oil layer. In addition, the dispersion and transfer of clay after hydrating expansion will prick up, which will make the plugging more seriously.

(2) Plugging of water locking

The experiment of the water locking plugging shows that the harm of water locking to the reservoir is serious and the harm rate achieves 50%~70%.

(3) Organic scaling and inorganic scaling plugging

Because the mineralization of stratum water is quite high and contains large number of Ca^{2+}, so the inorganic scaling ($CaCO_3$ and $CaSO_4 \cdot 2H_2O$ scaling) is one of main harm mechanisms. The organic scaling mainly occurs in the oil extraction. Giving priority to gas reservoirs, the condensate oils contain certain paraffin, so the possibility of paraffin deposit (organic scaling) exists, which should be emphasized in the middle and post terms in the oil and gas field development.

(4) Emulsion plugging

In the operation process of low-pressure well, the workover fluid and the stratum crude oil could easily form high-viscosity emulsion fluid under the function of surface active materials to plug the filtering pass of the oil and gas reservoir, which will induce the increase of filtration-resistance.

2. Study of new workover fluid technology

According to the survey of materials, the basic idea of developing the workover fluid of Yakela condensate gas field is to take the reservoir protection as the premise and fulfill the requirements of the workover works simultaneously, i.e. new workover fluid system should possess many characters such as good compatibility of stratum liquid, little corrosion and low stratum harm. At the same time, comparing with the existing workover fluid, the new workover fluid has many advantages such as good expansion resistance, small filtration loss, easily flowing-back, obvious reservoir protection, and high corrosion inhibition rate.

2.1 Technical principle

New low-harm workover fluid system is mainly composed by viscosity increaser, fluid loss additive, inhibitor, and special particles with temporary plugging function on the pore throat of reservoir (Yan, 2001). The technical principle is to add oil temporary plugging agent matching with the pore throat of reservoir, and under the function of certain pressure difference, the temporary plugging agent will form thin layer of low filtration shielding at the entrance of stratum hole to effectively prevent the further invasion of workover fluid to enter into the reservoir. When the workover is completed and the oil well begins to produce oils normally, under the reverse pressures, part of oil temporary plugging agents will be washed out from the holes, and the other part will be dissolved by the produced condensate oil to recover the filtration rate of the reservoir (Lin, 1999 & Li, 2005, P.24-28 & Luo, 2006, P.16-20) and protect the oil and gas reservoir.

2.2 Material composing and main performance indexes

(1) Oil temporary plugging agent is new product, and its oil solution ratio exceeds 90%, and the softening point is 140℃.

(2) HTB mutual solvent is water-soluble non-ionic surface active agent, and when it is added, the oil-wetted surface of the oil temporary plugging agent will be converted into hydrophilic surface, which can help the oil temporary plugging agent to be decentralized into new low-harm workover fluid system.

(3) For the thickening agent, XC with good salt resistance which still has thickening ability in high-concentration salt solution can rapidly dispersed and increase viscidity in water without the support of other solutions (Zhao, 2002, P.75-76), and the “fish eye” and “block mass” don’t exist in the solution.

(4) Main performance indexes. The adjustable range of density is 1.00~1.30kg/L, and the proper temperature is in 100~140℃.

(5) Selected workover fluid formula. Stratum water + 1%DG-HS1 (inhibitor) + 0.3%HTB (discharge aiding agent) + 1%DG-NW1 (clay stabilizer) + 1%SMP-2+ 0.3%XC + 2%NaCOOH + 1%PAC141

2.3 Experiment result and discussion

2.3.1 Experiment method

According to the petroleum gas industry standard SY/T 6540-2002, the JHCF-1 dynamic core pollution harm evaluation laboratory instrument (seen in Figure 1) is adopted to implement the room experiment. (1) Vacuumize the experimental core, saturate it for 24 hours by the stratum water, and measure the initial permeability of the core positively drove by the coal oil, (2) under the pressure difference pressure of 3.5 MPa, simulate the borehole and circulate the drilling fluid for 12 min, and measure the dynamic filtration loss of drilling fluid, (3) stop the circulation of drilling fluid, and measure the permeability of the harmed core positively drove by the coal oil (Fan, 1996).

2.3.2 Rheology and lubricity and formation protection ability

Measure the rheology of the low-harm workover fluid system by the six-speed rotating viscometer, and the result is seen in Table 2. From Table 2, the workover fluid has good rheology which can fulfill the requirement of the locale construction.

New workover fluid is the low solid fluid which can not form compact mud cake, and the temporary plugging method is used to reduce the filtration loss, and in the research, the fluid loss additive and temporary plugging agent are added to reduce the filtration loss, which can obtain good effect, and before and after hot aging, the filtration loss all can be controlled in 8ml.

2.3.3 Return permeability

By the core flow test, the reservoir protection of the workover fluid is evaluated in the laboratory, and the permeability of the workover fluid before and after pollution in the experiment are respectively measured, and the loop-pressure high-temperature and high-pressure core laboratory instrument is used to reversely pollute the core sample, and the result is seen in Table 3. From Table 3, for the reservoir core sample of YK10 in Yakela condensate gas field, respectively use the stratum water and selected workover fluid to pollute, when the mud cake (without solid fluid pollution) can not be formed basically, the return permeability of core could be enhanced form 65.21% to above 80%, which indicates that the selective workover fluid harms the reservoir little, and it can protect the reservoir well.

2.3.4 Study of workover fluid and reservoir rock compatibility

Use the selected new workover fluid formula and the reservoir core sample of YK10 well to make the experiment of compatibility. Take certain core for drying and weighing, mix them with the workover fluid after being mashed, filter, clear, drying and weigh after 16h' hot aging in the temperature of 150℃, compare the qualities before and after the experiment. The result of the experiment is seen in Table 4.

From Table 4, after mixing with the workover fluid, the change of core quality is not obvious, which indicates that the dispersion degree is not high, and three kinds of workover fluids all have good compatibility with the reservoir rocks.

2.3.5 Study of workover fluid and reservoir liquid compatibility

By the turbidity experiment, the compatibility between the workover fluid and the stratum water is evaluated. Mix the selected new workover fluid filtrate with the stratum water according to two different proportions, and the data measured by the turbidity meter is seen in Table 5.

From Table 5, after mixing the workover fluid filtrate with the stratum water, the turbidity of the fluid can not be changed basically, and in eyes, there are not any depositions, which indicate that the above selected formula has good compatibility with the stratum water.

3. Conclusions

(1) The present workover fluid in Yakela condensate gas field is analyzed, and the possible reservoir harm mechanism is also analyzed.

(2) Aiming at the characters of Yakela condensate gas field, the formula of the low-harm workover fluid system can be confirmed as follows.

Stratum water + 1%DG-HS1 (inhibitor) + 0.3%HTB (discharge aiding agent) + 1%DG-NW1 (clay stabilizer) + 1%SMP-2+ 0.3%XC + 2%NaCOOH + 1%PAC141

(3) New low-harm workover fluid system has many characters such as oil temporary plugging function, good plugging effect, good flow-back and plugging solving, small harm permeability, and extended applied temperature range. The laboratory return permeability recovery of the workover fluid can achieve above 80%.

(4) New low-harm workover fluid technology has wide application prospect in the workover of Yakela condensate gas filed.

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Table 1. Performance analysis of workover fluid (Unit: mg/l)

Water type	Total mineralization	Cation						Anion			
		Total Fe	Zn^{2+}	Si^{+}	Ca^{2+}	Mg^{2+}	Ba^{2+}	Cl^{-}	SO_4^{2-}	S^{2-}	HCO_3^{-}
$CaCl_2$	255000	106.3	68.3	29.4	2790	574.1	8.8	153000	468	Null	3.45

Table 2. Rheology of the system

Formula	Experiment condition	Density (g/cm3)	AV mPa·s	PV mPa·s	YP Pa	API Vf ml	pH
New workover fluid	Before hot aging	1.17	20	10	10	6.5	8.0
	Hot aging (120℃×16h)	1.17	13	9	4	8	8.0

Table 3. Evaluation test result of reservoir core permeability recovery

Core No.	Perm-plug method (10-3μm2)	Brine permeability (10-3μm2)	Oleic permeability before pollution (10-3μm2)	Oleic permeability after pollution (10-3μm2)	Return permeability (%)	Pollution medium
13	18.7	14.1	10.717	6.989	65.21	Stratum water
25	35.2	26.4	15.312	12.676	82.78	New workover fluid

Table 4. Workover fluid and reservoir rock compatibility study

New workover fluid	Rock sample quality before mixing (g)	37.26
	Rock sample quality after mixing (g)	35.15
	Difference (g)	2.11

Table 5. Turbidity test result of workover fluid filtrate

Formula	Liquid	Turbidity	Phenomenon
New workover fluid	Workover fluid filtrate	12.8	Without depositions
	Mixing of workover fluid filtrate and stratum water by 1:1	13.1	Without depositions
	Mixing of workover fluid filtrate and stratum water by 2:1	13.0	Without depositions

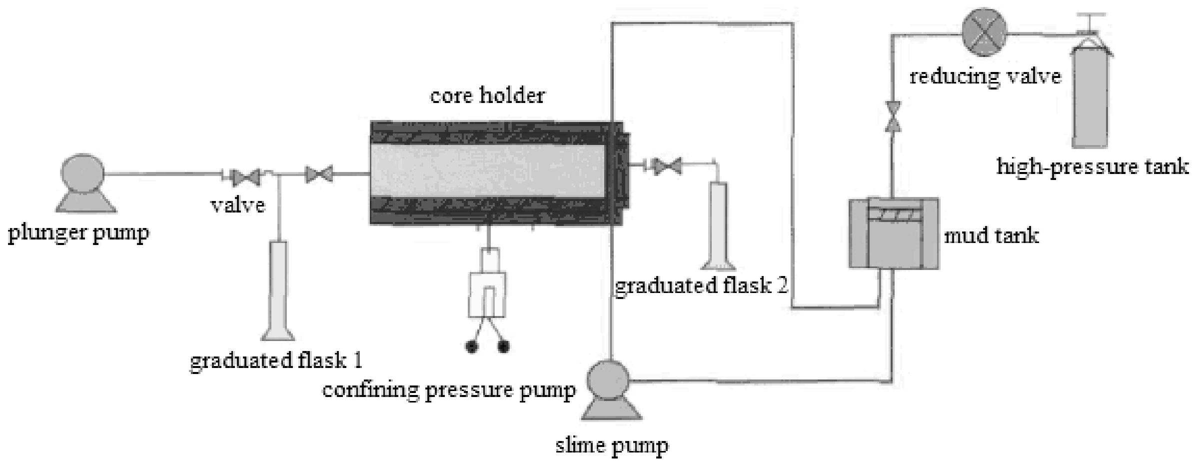

Figure 1. Laboratory Instrument of Dynamic Core Pollution Harm Evaluation