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Peculiarity of Application of Lightweight Drilling Fluids Based on Glass Microspheres in Long-Life Fields

Ziyavutdinov Asadulla Sunnatullaevich, Osyunikhin Aleksandr Alekseevich, Kurbanov Davron Ikboljon ogli

Head of the department for design and technological support of well drilling of JSC "O'ZLITINEFTGAZ", Republic of Uzbekistan, Tashkent
Leading engineer of the department for design and technological support of well drilling of JSC "O'ZLITINEFTGAZ", Republic of Uzbekistan, Tashkent
Engineer of the Drilling and Grouting Fluids Laboratory of JSC "O'ZLITINEFTGAZ", Republic of Uzbekistan, Tashkent

ABSTRACT: The article examines the issues of light drilling muds on the basis of glass microspheres for prevention of occurrence of big repressions on a formation and carrying out of qualitative opening of productive horizons on long-term exploited fields with the purpose of reception of residual stocks of hydrocarbon raw materials are considered.

KEY WORDS: anomalously low formation pressures, microspheres, horizons, xanthan, drilling mud, consististometer, drill cuttings.

I. INTRODUCTION

At long-term exploited fields of hydrocarbon raw materials due to a large degree of depletion of hydrocarbon raw materials reserves there is a drop in reservoir pressure. In order to maintain the necessary stock of production wells it is necessary to carry out drilling operations with penetration of productive horizons with anomalously low formation pressures (ALFP), both in the process of construction of new wells and during high-tech well workover by cutting a 'window' in the production string and drilling a sidetrack. At the same time, the anomaly coefficient of such formations reaches below 0.3. In such conditions drilling in the intervals of occurrence of productive horizons can be accompanied by catastrophic absorption of flushing fluid with loss of its circulation [1].
In the world practice there are various methods and technologies of wellbore cleaning in the process of penetration of horizons with ALFP [2]. The requirements of qualitative penetration of gas reservoirs with formation pressure anomaly coefficient below 0.8 are satisfied to a certain extent by the use of aerated and foam agents to clean the wellbore from the drilled rock.
However, they are not widely used in drilling oil and gas wells with ALFP.

II. METHODOLOGY

We have considered one of the effective technologies, introduced in the world practice, when penetrating productive horizons with ALFP - application of syntactic foams based on hollow glass microspheres as flushing fluids [1, 3]. This technology is based on the creation of so-called syntactic foam systems with preservation of liquid characteristics of washing agents, due to which many main disadvantages associated with the use of foam and aerated systems, which are not sufficiently effective in cleaning the wellbore from the drilled rock, are excluded.
In the long-operated fields of Bukhara-Khiva region, we have considered the use of syntactic foams in the form of ultra-low density drilling mud based on glass microspheres to reduce the repression on the productive formation, which ensure the preservation of the rheological characteristics of the solution and prevent colmatisation of productive reservoirs.
We have also investigated a variety of drilling mud formulations using several types of glass microspheres with different characteristics (Table 1).

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Due to the fact that glass microspheres have very low density and their suspensions in water are unstable in terms of sedimentation, the structured biopolymer solution based on xanthan gum [4] was used as a base solution during the studies.

The research methodology consisted in the preparation of light washing fluids with their successive testing for compliance with different downhole thermobaric conditions.

Simulation of downhole conditions was carried out on reconstructed for microspheres laboratory consististometer KC-3 with pressure up to 300 atm. and temperature regimes up to 95 ºC, which corresponds to the maximum possible downhole conditions in the long-term developed gas condensate fields of Bukhara-Khiva region of the Republic of Uzbekistan.

Table 1. Characteristics of the glass microspheres used

Name	Color	Particle sizes, μm	Compressive strength, atm	Flotation, %	True density, g/cm^3	Bulk density, g/cm^3	% of intact micro-spheres	Sediment not more than, %	Humidity mass fraction, %	
									min.	max.
ForeSphere 1500	white	40-60	100	80-88	0,35-0,45	0,21-0,27	90	7	0,3	0,5
3M Glass Bubbles HGS8000X	white	12-55	545	90-97	0,39-0,45	0,23-0,27	90	4	-	-

For testing 3 samples of drilling mud with density from 0,75 to 0,86 g/cm^3 in the volume of 1500 ml each were prepared:

1. Biopolymer mud based on xanthan gum and glass microspheres (FORES) with a density of 0,84 g/cm^3. The solution was obtained viscous due to the concentration of xanthan in the amount of 2,0% of the total volume. After stirring the solution after one hour, the density of the sample was reduced to 0,81 g/cm^3, and its viscosity was reduced by adding a carbon-alkali reagent (CAR) in an amount of 10%.
2. Lightened solution based on bentonite and glass microspheres (FORES) with a density of 0,86 g/cm^3 with the following components: bentonite - 50 g, microspheres - 250 g, gummate-alkali reagent (GAR) - 50 g.
3. Light solution based on HGS8000X microspheres of the Belgian company 3M, density 0,75 g/cm^3 with the component composition of the solution: bentonite - 30 g, microspheres - 50 g. Due to filtration of the solution over 15 cm^3/30 min according to the VM-6 device, xanthan - 3 g in the form of powder was added to it in order to reduce water release and viscosity during stirring, followed by liquefaction with CAR and ferrochromolignosulfonate (FCLS). Before testing on KC-3, gas condensate in the amount of 300 ml was added to the solution with subsequent stirring on a high-speed stirrer.

According to the results of the conducted tests on the KC-3 consistometer during 3 hours, all samples showed positive results with insignificant changes (Table 2).

After performing the tests, repeated measurements of the solution samples were made, which revealed a slight increase in the density of samples, caused by partial destruction of glass microspheres under the action of the considered thermobaric conditions in Table 2.

Table 2. Results of laboratory tests on the KC-3 consistometer

Name of sample	Density, g/cm^3		Conditional viscosity, s		Water loss, cm^3/30 min.		SSS 10 sec/10 min, mg/cm^2		DSS, mg/cm^2		Plastic viscosity, cP	
	before KC	after KC	before KC	after KC	before KC	after KC	before KC	after KC	before KC	after KC	before KC	after KC
Xanthan + microspheres (FORES)	0,81	0,81	120	80	4	10	15/20	15/20	5,7	7,5	40	30
Bentonite + microspheres (FORES)	0,86	0,86	80	50	6	5	24/29	10/15	6,3	7,6	20	15
Xanthan + Bentonite + microspheres (HGS8000X)	0,75	0,76	100	26	10	12	29/39	15/20	7,3	7,7	38	20

Laboratory studies (Table 2) have shown that the introduction of water-polymer systems based on water-soluble polymers with coagulation structure, for example, polysaccharide - xanthan, allows to obtain dispersed systems similar to clay solutions. As well as for them the addition of xanthan allows to influence the conditional viscosity with formation of thixotropic structure and low filtration through porous materials practically without formation of filtration crusts.

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Besides, unlike three-phase foams, syntactic foams practically do not react to moderate heating and their rheological properties almost do not change. The same applies to the filtration - water yield indicators.

The main task of the conducted research was to obtain ultra-low density flushing agents, satisfying effective wellbore cleaning from drill cuttings due to the presence of coagulation structure in them. The presence of coagulation structure is also necessary to obtain sedimentation stability of the solution, which was achieved by using high quality bentonite clay and water-soluble polymer capable of forming the described structure due to the presence of hydrogen bonds between molecules. Such polymers include branched macromolecules from a number of polysaccharides. The latter include xanthan, simusan, dextran and others [5].

Due to the lack of a generally accepted methodology, no research has been conducted in the area of downhole microsphere fracture during drilling. The only generally recognized factor in this area is the manufacturers' instruction not to use shear deformation mechanisms when moving microsphere suspensions, e.g. not to use Cope's agitators and gear pumps or 3-roller milling cutters. In this case it is necessary to pay attention to shear-type cutting tools, e.g. «Polycrystalline diamond compact» (PDC) bits, while avoiding working pressures exceeding the allowable pressures for the product under static conditions. Unfortunately, no such studies have been conducted or mentioned in this field [6].

After repeated measurements in a water bath at temperatures ranging from 40 to 95 °C, the following patterns were found as shown in Figures 1-3:

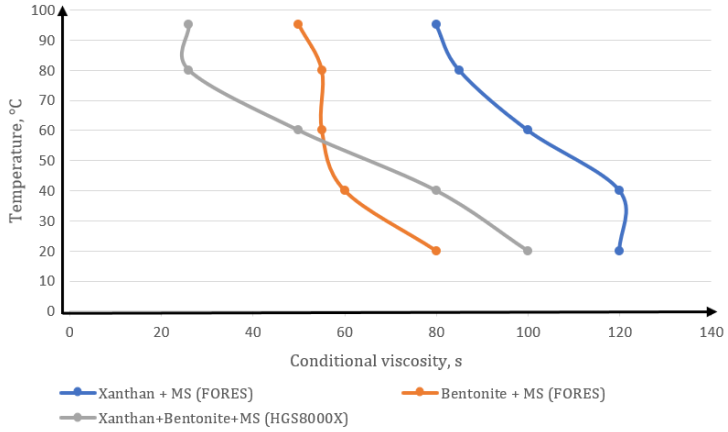

Fig. 2.1 Dependence of conditional viscosity of solutions on temperature.

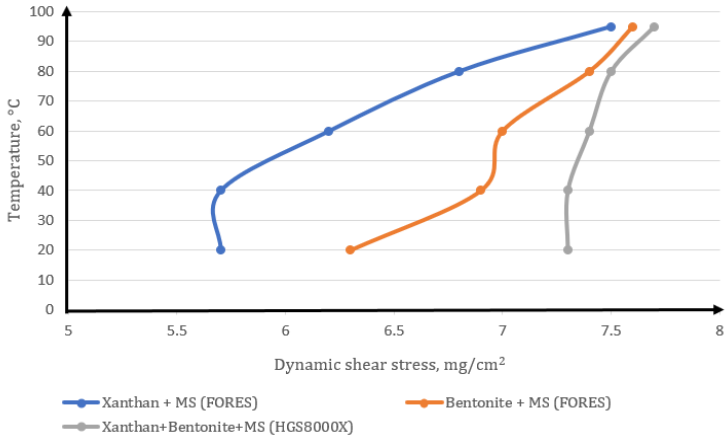

Fig. 2.2 Dependence of dynamic shear stress of solutions on temperature.

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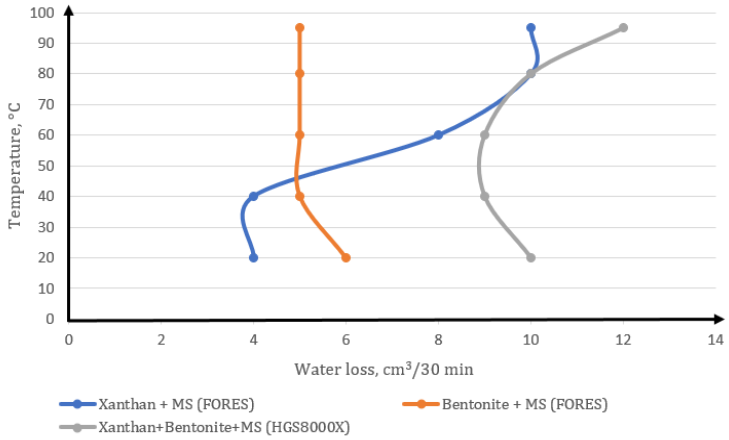

Fig. 2.3 Dependence of water loss of solutions on temperature.

III. CONCLUSION

1. Syntactic foams as flushing agents are expedient to use for drilling of horizontally oriented boreholes at long-term exploited fields under ALFP conditions.
2. The use of glass microsphere suspensions - syntactic foams based on biopolymer solutions is recommended for drilling wells in long-operated fields under ALFP conditions with anomaly coefficient below 0,8.
3. The possibility of repeated application of the studied solutions in a group of wells is preserved, which determines the economic effect from the use of such solutions in the fields with ALFP.
4. Despite the relatively high cost of glass microspheres, the economic efficiency from the introduction of this technology is achieved due to the maximum cleaning of the borehole of deviated wells and preservation of natural permeability of formations.

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