World Applied Sciences Journal 31 (6): 1078-1081, 2014
ISSN 1818-4952

DOI: 10.5829/idosi.wasj.2014.31.06.306

Development of a New Well-killing Fluid Based on Oil-wetting Agent Ng-1 for Polymineral Low-permeable Reservoirs

Pavel Gladkov

Federal State Budgetary Educational Institution of Higher Professional Education
"National Mineral Resources University "Mining"

Abstract: Well-killing operation is the one of the most important operations which can significantly influence on the characteristics of the bottom-hole formation zone. This problem is particularly topical when occur in difficult geological and physical conditions. For instance decrease of permeability in low permeable polymineral reservoirs caused by appliance of standard water based brines as well-killing fluid may reach 60-80%. In order to increase an efficiency of the well-killing operation technological fluid based on oil-wetting reagent NG-1 was developed. According to large amount of experimental data it is shown that this kind of technological fluid minimizes negative impact on the reservoir rock and causes low rate of downhole equipment`s corrosion in wide range of downhole pressures and temperatures. It is noticed that if core samples are saturated with the technological fluid than it would lose mechanical strength. This feature of the developed well-killing fluid may be useful before well stimulation operations like hydro-fracturing of formation.

Key words: Priobskoe field · Well-killing, filtration · Thermostability · Corrosion · Low permeability

INTRODUCTION

Well-killing is one of the most widespread well operations which is a set of measures for selection, preparation and injection into the well of special kill fluids to ensure safe and trouble-free preventive maintenance. In the process of geological and field work each well exposed killing at least once a year because of the need for underground repairs, change of pumping equipment, washing the bottom-hole from contamination, etc. [1].

On the Russian oil fields traditional technologies of well-killing by means of water solutions of mineral salts are widely applied. In this case volume and density of utilized fluids and compositions specifies intensity of hydrodynamic forces occurred in formation during drilling, completion and killing a well. The maximum values of an overburden pressures are justified by "Oil and Gas industry safety rules and regulations" [2]. However practice of such operations shows that real value of an overburden pressures is usually higher than acceptable one. It leads to active penetration of the technological fluids into a bottom-hole formation zone and interaction of them with rock constituents and formation fluids. As a result permeability and porosity of a bottom-hole formation worsen as well as well performance [3]. It especially appears on low permeable polymineral reservoirs of Western Siberia.

In some cases depth of formation damage is about tens to hundreds meters. The greater the depth is the severe results of physical and chemical interaction between technological and formation fluids and oil and gas saturated formation influence on capillary and hydrodynamic forces are. According to the results of well tests considerable part of production wells in Western Siberia have well perfection coefficient within the limits 0,2 to 0,5, i.e. only 20% to 50% of well potential is used.

Therefore fluids for well-killing must meet certain requirements that are specified in "Rules of workover operations in oil wells" [4]. What is more in low permeable reservoirs technological fluids with minimum amount of solid particles should be used unless it is required by a well-killing technology.

Besides physical impact chemical processes influence greatly on condition of bottom-hole formation zone. It can be easily shown on Priobskoe oil field (Western Siberia, Russia). Composition of oil and gas saturated reservoir is

Corresponding Author: Pavel Gladkov, 199106, Russia, Saint-Petersburg, Vasilievskiy ostrov, 21-st line, 2.
Tel.: +7(812)328 84 20, Mob.: +7(911)154 98 41.

polymineral and mainly include quartz, feldspar, hydromica. All minerals cemented by membrane-pore type of kaolinite cement. The clay minerals are in an equlibrium with formation oil and water and permeable channels exist before drilling the formation. When drilling the formation with the water based drilling mud which salt content differs from the formation water an equlibrium in a system brakes and it causes to active cation exchange between water-wettable clay particles and the drilling mud.

Penetration of ions and separate molecules of drilling mud filtrate into interlayer space of kaolinite particles is excluded due to strong and solid crystal structure of clay. In this regard interaction of clay particles with surrounding fluids goes only on facial layer.

According to authors [5] an inhibition of clay hydration can be reached by several ways among them by changing a wettability from water wetting to oil wetting by means of special oil wetting agents.

Researchers have different attitude to a process of hydrophobisation but the following is clear. Due to effect of different factors` (frequent workover operations, high water/oil ratio, etc.) in the bottom-hole formation a zone with increased water saturation occurs and so called "film water" forms on the surface of minerals. If water saturation increases then water permeabilty would increase too. Moreover an oil permeability decreases and an oil filtrations conditions from formation to a bottom-hole worsen as result.

If oil wetting agent is injected into the formation zone then "film water" leaves bottom-hole zone and is displaced deeper into the formation so water saturation decreases and oil permeability increases.

MATERIALS AND METHODS

Complex of tests for the development of a new well-killing fluid were carried out in Laboratory of Enhanced Oil Recovery of National Mineral Resources University "Mining".

Oil-wetting agent NG-1 (manufactured by LLC "Sintez TNP", Ufa, Russia) is a mixture of triethanolamine and tall-oil fatty acid reaction product or high-boiling fraction of synthetic fatty acids with solvents and additions like aromatic hydrocarbons-solvents, ether- and alcohol containing mixtures, products of oxyethylation and alkylation of industrial alcohol, paraffins and other solvents and additions which provide oil-wetting agent with high performance of application and dispersability in aqueous media.

Aggregative stability of oil-wetting agent NG-1 emulsions is a required property of the fluid in high temperature conditions (80°C). Table 1 shows some results of oil-wetting agent NG-1 emulsions aggregative stability research under 20°C è 80°C. Aggregative stability was obtained by visual method.

One of the important properties of well-killing fluid is its low corrosivity. The parameter was obtained by means of polarization resistance method. This method is a corrosivity test which provide researcher with rapid highly accurate results. In the paper [6] some results of laboratory studies of steel plates` corrosion velocities in oil-wetting agent NG-1 emulsions in accordance with gravity method were published and obtained results shows high resemblance with polarization resistance method. More than that if polarization resistance method

Table 1: Results of thermal stability tests of water solutions of oil-wetting agent NG-1

	Components, % (mass)						
No of formulation	NG-1	$CaCl_2$	KCl	Fresh water	Density, g/cm^3	Stability under 20°C, days	Stability under 80°C, days
1	0,15	0	0	99,85	1,0	>7	5
2	0,3	0	0	99,7	1,0	6	4
3	0,5	0	0	99,5	1,0	5	4
4	0,6	0	0	99,4	1,0	3	2
5	0,7	0	0	99,3	1,0	3	1,5
6	1	0	0	99	1,0	2	1
7	0,15	20	0	79,85	1,16	3	1,5
8	0,3	20	0	79,7	1,16	3	1
9	0,5	20	0	79,5	1,16	3	1
10	0,15	0	5	94,85	1,02	>7	3
11	0,15	0	10	89,85	1,06	6	2
12	0,15	0	15	84,85	1,1	5	1,5
13	0,15	0	20	79,85	1,13	5	1
14	0,15	0	24	75,85	1,16	3	1

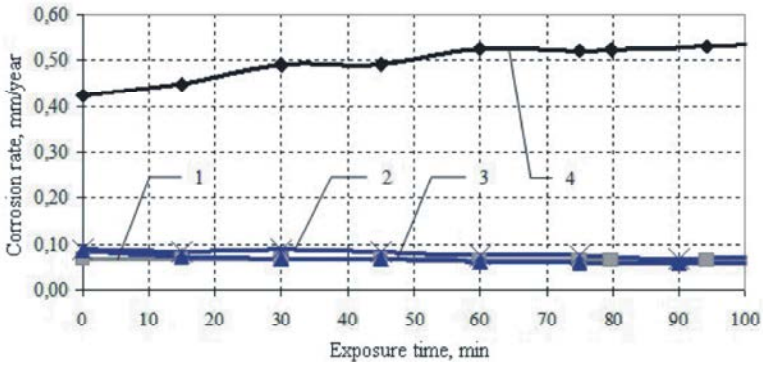

Fig. 1: Steel samples` corrosion rates in different solutions vs. exposure time.
1 – fresh water; 2 – 0,15% solution of NG-1 in KCl brine (24% wt.); 3 – 0,15% solution of NG-1 in fresh water; 4 – KCl brine (24% wt.)

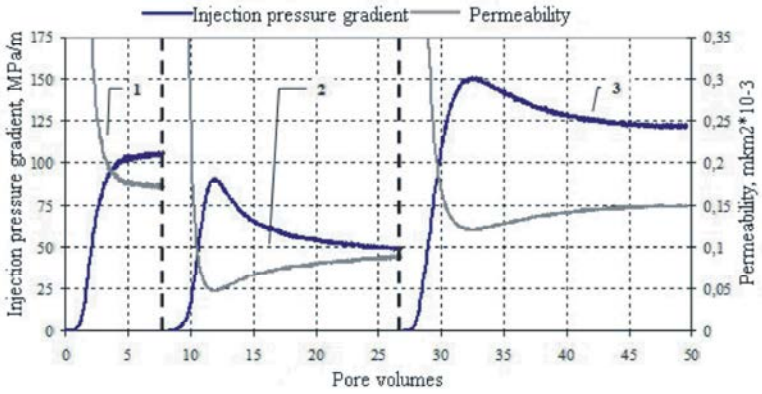

Fig. 2: Permeability of core sample and injection pressure gradients vs. pore volume
1,3 – oil of Priobskoe filed; 2 – 0,15% water solution of NG-1.

is used then duration of the test run significantly decreases- from several days to one hour. That is why polarization resistance method is recommended to be an express-method of corrosivity measurement.

On the Figure 1 charts of rates of steel plates` corrosion in water solutions of oil-wetting agent, brine and fresh water versus exposure time are shown.

As it was mentioned above an important property of well-killing fluid is an ability not to worsen oil permeability of bottom-hole formation zone. In order to measure this parameter the filtration experiment was conducted. It included preparation of Priobskoe field low-permeable core sample (extraction, drying, saturation with water and oil, aging in formation pressure and temperature conditions) and fluids (oil, water, 0,15% fresh water solution of oil-wetting agent NG-1), sequent filtration of oil, water solution of NG-1 and oil and definition of phase permeabilties. During an experiment standard core sample was used (diameter 3 cm, length 6cm). Initial gas permeability was $1,5 \cdot 10^{-3}$ mkm^2 (method of nitrogen filtration), porosity- 17,8% (Boyle-Mariotte method).The modelled well-killing fluid consist of fresh water and 0,15% of oil wetting agent NG-1. During the experiment oil permeability of the sample had reached $1,7 \cdot 10^{-4}$ mkm^2. The filtration process was carried out under the temperature 80°C and pore pressure 25 MPa. On the Figure 2 the chart of core sample permeability and injection pressure gradient versus pore volume is shown. During the test real directions of flow were modelled: forward direction- oil flow from a formation to a bottom-hole; backward direction- penetration of well-killing fluid from a bottom-hole into a formation.

RESULTS AND DISCUSSION

According to the Table 1 the most aggregative stable solutions include less than 0,5% of oil wetting agent NG-1 without potassium and calcium chlorides. These solutions are stable and do not divide to water and oil parts within 4-5 days. Addition of potassium chloride dramatically

decreases an aggregative stability while addition of calcium chloride leads to flocculent precipitation. Therefore density regulation of NG-1 water solutions should be realized by potassium chlorides because if emulsion brake during the workover operation potassium cations would promote decrease of clay hydration and keeping a permeability of bottom-hole formation.

According to the papers [4] and [7] the velocity of steel plates corrosion (steel type St3) must be lower than 0,1-0,12 mm per year. As it shown on the Figure 1 average velocity of steel plates` corrosion in fresh water solution of 0,15% oil wetting agent (curve 3) equals to 0,07 mm/year that is lower than threshold value.

Corrosion rate of steel samples in KCl brine (curve 4) significantly exceeds threshold value but addition to this brine 0,15% of NG-1 (curve 2) reduces corrosivity to a level of fresh water (curve 1). From there the oil wetting agent NG-1 has corrosion inhibitor properties and can be used for development of well-killing fluids which are inactive to a metal of downhole equipment and casing.

As a result of conducted filtration experiment it was obtained that after 15 pore volumes of injected well-killing fluid (fresh water+0,15% NG-1) oil permeability reduced on 12% and reached $1,5 \cdot 10^{-4}$ mkm^2. This effect is positive because further filtration of the fluid leads to a full recovery of oil permeability. At the same time an application of traditional well-killing and perforating fluids based on water solutions of salts in low permeable reservoirs may reduce oil permeability up to 50% and more.

Carried investigations of oil wetting agent NG-1 water solutions brought results which make it possible to say that these solutions satisfy the requirements for well-killing fluids and can be used in well-killing operations in low permeable clay containing reservoirs, i.a. on Priobskoe oil field.

REFERENCES

1. Analysis of modern technical and technological solutions in well-killing and well flushing operations/ Shadymukhamedov S.A., Smikov Yu.V., Vakhitov T.V., Safuanova R.M. // Investigated in Russia, 2008 – p.724-736, http://zhurnal.ape.relarn.ru/ articles/2008/068.pdf (4.02.2014)
2. Safety Instructions 08-624-03. Oil and Gas industry safety rules and regulations.-Confirmed by a decision of State Committee for Supervision of Safe Working Practices in Industry and for Mine Supervision of Russia Federation (5.06.2003), ¹56.Moscow.: Rossiyskaya gazeta, ¹120/1, 21.06.2003.
3. Development of well-killing technologies in low permeable reservoirs /Nyunyaikin V.N., Generalov I.V., Rogatchev M.K., Zeygman Yu.V.// Oil industry. 2001, ¹10: 74-75.
4. Regulation document 153-39-023-97. Rules of workover operations in oil wells.- Confirmed by a decision of Ministry of Fuel and Energy of Russian Federation (18.08.1997), Krasnodar, R and D «Burenie», pp: 1997.
5. Pulya, Y.U., A., Egorova and E.V. Theoretical 2007. background of apllication of drilling muds inhibitors based onwillow pitch// Bulletin of Northern Caucasian state technical university, ¹4: 13.
6. Investigation of the corrosion-preventing properties of the process liquids for the borehole oil production /Mavliev A.R., Rogatchev M.K., Mardashov D.V// Oil and Gas Business/ 2011, ¹3: 462-471, http://www.ogbus.ru/authors/Mavliev/Mavliev_1. pdf (Дата обращения, 4(02): 14.
7. Well control in workover operations. Well control when gas, oil and water inflow: study guide/ Anokhin K.P., Kagarmanov I.I., Maltsev I.V., Chernik A.A. Samara: Publishing house “ROSING”, 2006, pp: 56.