Isolation of Gas with the Self - Sealing Compositions

Mirzadzhanzade A. Kh., Ametov I. M., Shandin S. P., Cherskaya N. O.

**All Russian Oil & Gas Scientific and Research Institute
(VNIIneft), Russia**

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ABSTRACT

Operation of the oil producing wells at the oil fields, possessing a highly fractured reservoirs and a high gas-oil ratios is extremely complicated due to complexities in performing of workovers, as well as due to unreliability of the existing technologies.

At such oil fields a low degree of oil withdrawal has been detected, production from many wells has been stopped due to complexity of the exploitation.

Hence, development of the new technologies for gas influx isolation in oil wells with a high gas-oil ratio and a high buffer pressure, initiated by gas breakthrough along the formation (gas coning in monolith formation) via the most permeable inter-layers or gas circulation in the borehole annulus is extremely important.

INTRODUCTION

Various technologies, based upon application of isolating systems, are being developed for isolation of gas influxes to the producing wells. Many of them have been based on the application of gelation compounds. However, their efficiency is not reliable every time, in particular, on course of workovers, when there is a necessity to create a reliable isolating screen, which is able to withstand high pressure fluctuations in the bottom-hole zones, prohibiting the fluid breakthrough during workovers.

An efficient technology to isolate gas breakthrough by application of the novel composite systems as a plugging material has been developed at the VNIIneft Institute.

These composite systems are rheologically complex media, which possess viscoelastoplastic and viscoelastogranular properties. The shift of the composite system results in appearance of the

expansion forces, leading to tightening of the compound, which form the composite system, enhancing of the elasticity properties and preventing of gas breakthrough.

Referred to as a remarkable feature of the composite systems is a possibility to regulate rheological properties by adding chemicals and treatment of the viscoelastic compound by physical fields (magnetic, acoustic, barometric, etc.).

LAB TESTS

As it is well known various gelating compounds, mainly polymer-based ones, are widely used on for workovers. However, majority of these compounds possess insufficient strength. Their plugging and other properties are difficult to regulate.

New polymer-based gelation compounds for plugging have been developed. They differ from the existing ones by high isolating properties, by a possibility to vary rheological parameters at different stages of the compound manufacturing and by a possibility to regulate the time of structuring.

To study isolating properties of gelation compounds different polymer system have been analyzed and chemicals, influencing the quality of the plugging material, have been chosen. Basing upon the lab experiments a new composite system has been developed on the basis of polymer brine with surfactants and cross-linked additives. Isolating properties of the composite system were tested on the sandpack model (Fig. 1). 50 cm³ of the fresh composite system were pumped into the sandpack model of formation with 0.5 m in length, having permeability of 17 D. Then the composite system was displaced by water up to the middle of the tube. After the induction period of the composite system maturation was over the sandpack model was placed vertically so the space filled with water turned out to be at the top. A pressure

was created by gas inflating from the bottom. After the pressure was distributed along the sandpack length a pressure was inflated again and the gas outcome through the open valve was watched over during two days. Two days of observation resulted in detection of no gas outcome. Application of pressure to the compound resulted in appearance of the expansion forces, thus leading towards toughening of the composite system and prevention of gas coning.

Further a granular medium was added to the composite system to study its influence at stepping up of the expansion forces in the composite system. The optimum ratio of granular medium to the total volume was defined.

The composite systems with the granular medium added were tested on course of their flow in a capillar tube. It is for this purpose that viscoelastic composite system was pumped through at various pressure values. It has been shown that increase of pressure differential resulted in a complete sandpack plugging and stop of the flow. Results of the tests are presented in Fig. 2.

In addition a viscometer was used to test rheological parameters of the composite system to define a dynamic viscosity and the threshold pressure of the system.

It is a matter of common knowledge that different physical fields (such as acoustic, magnetic, barometric, etc.) produce a various influence at the rheological properties of viscoelastic systems. The influence of magnetic field at the rheological parameters of the composite system under treatment of the system's components was studied. Water solutions of the composite systems were driven through the magnetic field afterwards the system was cross-linked. It has been discovered that the composite system passed through the magnetic field is getting dilute, and the subsequent

adding of the cross-linking agent leads to its toughening. At that, elasticity properties of the magnetically treated system are better if compared to the untreated one. The results are presented in Table 1.

Table 1
Regulation of Rheologic Properties of Viscoelastic Compounds by Magnetic Field

#	Composite System Before and After the Magnetic Treatment	Viscoelastic Properties		
		η_{eff} , Pa·s	G, Pa	τ_0 , Pa
1.	PAA Solution + Cross-linking Additives	199	119	80
2.	Magnetized PAA Solution + Magnetized Cross-linking Additives	162	109	110
3.	Magnetized PAA Solution + Magnetized Cross-linking Additives	139	113	100
4.	Magnetized PAA Solution + Magnetized Cross-linking Additives	80	105	80

PAA - polymer
 η_{eff} - Effective Elasticity
G - Elasticity Module
 τ_0 - Initial Shift Tension

Further explored was how the barometric field influences the rheological properties of the compound. It has been found that cyclic pressure treatment dissolves the system. Subsequent cross-linking of the composite system enhances elastic properties of the composite system if compared to the untreated one. The results are shown at Fig.3.

Thus, it is possible to conclude that an opportunity does exist to regulate rheological properties of the composite systems used for gas influxes prevention not only by adding of chemicals but also by magnetic and barometric treatment of the system.

FIELD TESTS

The technology for gas influxes isolation has been tested at Lyantor Field in the West Siberia. Resorting to the new technology was required by a big number of oil wells idling due to the high gas-

oil ratio(> 600 m³/t) and high buffer pressure (> 5 MPa). Analysis of the producing wells at the Lyantor Field showed that there were 17 wells where repair works to isolate gas influx were necessary to conduct. Repair works, based on the existing technologies for gas influx isolation gave no positive result. Gas breakthrough to the wells, occurring after the conducted repair and isolation, made their further operation impossible. First of all repair and isolation had been conducted in 5 wells. Drilling of the wells was completed in 1988-1990. At the very beginning their production was 25-30m³ of oil per day in average (water excluded), while the average gas production was 300m³ per day and the buffer pressure was 3-4 MPa. A year of their exploitation resulted in decrease of oil production down to 2-7m³/day, while the buffer pressure increased up to 15-17MPa.

Analysis of the available log data exposed that the wells were producing from the oil/gas pool formed by fractured terrigenous-porous reservoir.

Main geological properties of the test area at the Lyantor Field are presented below:

Thickness of the gas cap	8 m
Width of the oil/gas zone	1.5-5 km
Occurrence depth in dome	1980-1990 m
Gross thickness of the oil pool	20 m
Water/oil contact	2049 m
Gas/oil contact	2039 m
Initial formation pressure	21.4 MPa
Initial formation temperature	61°C
Gas cap overall dimensions	31m x 41.3m x 7m
Net gas saturated thickness	7-8 m
Reservoir permeability	414 mD
Initial gas saturation ratio	0.79
Gas content	methane (86,3%), ethane (2.2%), propane (4.4%), others (7.1)
Gas cap pressure	0.114 MPa

Fig. 4 represents geological cross-section of the Lyantor Field.

Analysis of the available log data and production data allowed to develop a technological scheme, specifying on the receipt of the isolating material, its preparation technology, sequence of operations with technological parameters observed.

The isolating screen is formed by a composite system with viscoelastic properties. Expansion force arising during the composite system shift leads towards self-sealing of the plug, toughening of the isolating screen and blocking of gas breakthrough. The composite system is being prepared on the basis of saline solution of polymers with surfactants and cross-linking agents added. A viscoelastic composite system with the density, descending the density of water, was used to prevent migration of gas to the bottom-hole zone. The main portion of the isolating screen is formed by the water which displaces gas away from the bottom-hole zone.

Sequence of operations includes injection of water passed through a magnetic unit. Magnetically treated water reduces swelling of the clay interlayers and facilitates a more intensive displacement of gas away from the bottom-hole zone.

After that viscoelastic composite system creating buffer, which prevents gas breakthrough to the wellbore, is injected.

Use of the composite system for workover in 5 gassed and abandoned wells allowed to put them back to production in 1993 with average oil rate of 10-15 tons/day per well. These wells keep producing since the mid of 1993 with no gas breakthrough.

CONCLUSIONS

1. New polymer-based gel composite systems have been developed. They reliably block the gas breakthrough, especially in monolith fractured reservoirs. They are used as plugs, which allow to enhance isolating properties of the compound at cost of the expansion forces, appearing on course of movement via porous medium channels. These composite systems can be used along with various granular media.

2. It has been proved and confirmed by the practical measures that treatment of the composite systems by different physical fields (acoustic, magnetic, barometric, etc.) allows to regulate their rheological properties.

3. Use of physical fields on course of preparing of the composite systems allows to reduce chemicals consumption, while preserving their isolating properties. Besides, it allows to upgrade environmental security of the applied technologies.

Figure 1

SCHEME
A BENCH TO DEFINE A SEPARATING ABILITY OF THE COMPOSITE SYSTEM AT THE EDGE OF GAS/WATER CONTACT IN
POROUS MEDIUM

LEGEND:

- 1. Gas reservoir
- 2. Needle cock
- 3. Pressure gauges
- 4. Sandpack model
- 5. Space filled by gas
- 6. Composite system
- 7. Space filled by water
- 8. Gas meter

Figure 2

Diagram : Viscoelastogranular Compounds Flow Curves

DIAGRAMS

DEPENDENCE OF SHIFT TENSION UPON SHIFT SPEED FOR VISCOELASTIC COMPOUNDS UNDER PRESSURE TREATMENT WITH THE AMPLITUDE 0.2 MPa (A) AND 0.8 MPa (B)

A Pressure Amplitude 0.2 MPa

1. Solution of Polyacrylamide + Cross-linking additive.
2. Solution of Polyacrylamide + Cross-linking additive. 40 cycles of pressure treatment are repeated within 1 hour.
3. Solution of Polyacrylamide. 40 cycles of pressure treatment are repeated within 1 hour, and then the Cross-linking additive is added.
4. Solution of Polyacrylamide. 30 cycles of pressure treatment are repeated within 1 hour, and then the Cross-linking additive is added.
5. Solution of Polyacrylamide. 27 cycles of pressure treatment are repeated within 1 hour, and then the Cross-linking additive is added.

B Pressure Amplitude 0.8 MPa

1. Solution of Polyacrylamide + Cross-linking additive.
2. Solution of Polyacrylamide + Cross-linking additive. 40 cycles of pressure treatment are repeated during 1 hour.
3. Solution of Polyacrylamide + Cross-linking additive. 75 cycles of pressure treatment are repeated during 1 hour.
4. Solution of Polyacrylamide. 40 cycles of pressure treatment are repeated during 1 hour, and then the Cross-linking additive is added.
5. Solution of Polyacrylamide. 25 cycles of pressure treatment are repeated during 1 hour, and then the Cross-linking additive is added.
6. Solution of Polyacrylamide. 20 cycles of pressure treatment are repeated during 1 hour, and then the Cross-linking additive is added.
7. Solution of Polyacrylamide. 15 cycles of pressure treatment are repeated during 1 hour, and then the Cross-linking additive is added.
8. Solution of Polyacrylamide. 12 cycles of pressure treatment are repeated during 1 hour, and then the Cross-linking additive is added.

Figure 4

The Lyantor Field: Well #3262 Treatment