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FORMATION OF FILTRATION BARRIERS IN HORIZONTAL WELLS IN THE GRANULATED RESERVOIRS ON THE EXAMPLE OF ARYSKUM FIELD

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ABSTRACT

Through the example of wells with granulated reservoirs at the Arsykum field (the Republic of Kazakhstan), it is shown that the degree of influence of filtration barriers preventing inflow into the hole increases with the increase of the length of a horizontal section. Careful consideration of the content and size of particles to benefit the acid solubility of additives in drilling fluids ensures mud filtration while drilling through the reservoir and effective mud removal during stimulation.

Keywords: permeability of borehole environment, filter cake, acid soluble filler, cake removal, mixture of carboxylic and amino carboxylic acids.

INTRODUCTION

In a number of South Turgai Basin oilfields with terrigenous-porous reservoirs, geological conditions allow to drill and complete wells with open hole reservoir sections.

In the Aryskum field of Kyzylorda region, reservoir rocks are represented by conglomerates and sandstones. In a wide range of core samples, rock layers are represented by various coarse-clastic rocks and sandstones, coarse rocks tend to occur in the bottom section of the M-II productive zone.

High-quality drilling fluids tend to create low-permeability filter cakes thus forming a filtration barrier. On the other hand it is a challenging process to chemically break down the clay structure and to wash it away from the formation.

It is therefore an important scientific task to establish certain conditions when filter cakes are easily destructed. In particular this applies to wells with horizontal sections and during stimulation.

In Aryskum, 10 horizontal wells were drilled for oil from the productive deposits of the M-II Cretaceous (Blocks IX, VIII and VII). Geological and geophysical characteristics of the M-II reservoir rocks, penetrated by the wells AK-3 HW, 4 HW, 6 HW (Block IX), AK-1 HW, 7 HW, 8 HW (Block VIII) and AK-2 HW, 9 HW, 5 HW (Block VII) prove their uniformity in composition and type of the filtering structure (granular reservoir, sand factor in the range of 0.84 - 0.88; number of permeable intervals in the range of 1.9-2.4; porosity of 9.8 - 29,2% and permeability of 0.05-0.3 mkm2). Properties of the reservoir oil in the blocks are almost the same, whereas clay content is 15.88% and carbonate content is 10% on the average [1].

During completion phase of all horizontal wells, well stimulation is performed by swabbing. Following the stimulation process, production rate mostly increases during the oil production and gets stabilized in a period from two to several days. The difference of initial and constant production rates increases along with the extension of horizontal wellbore length in the pay zone.

Production rate increment based on the filtrating area expansion expectedly draws out attention to the fact that the difference of rate settled during the oil inflow stabilization and initial rate obtained during inflow stimulation, grows along with extension of the wellbore length (Figure-1):

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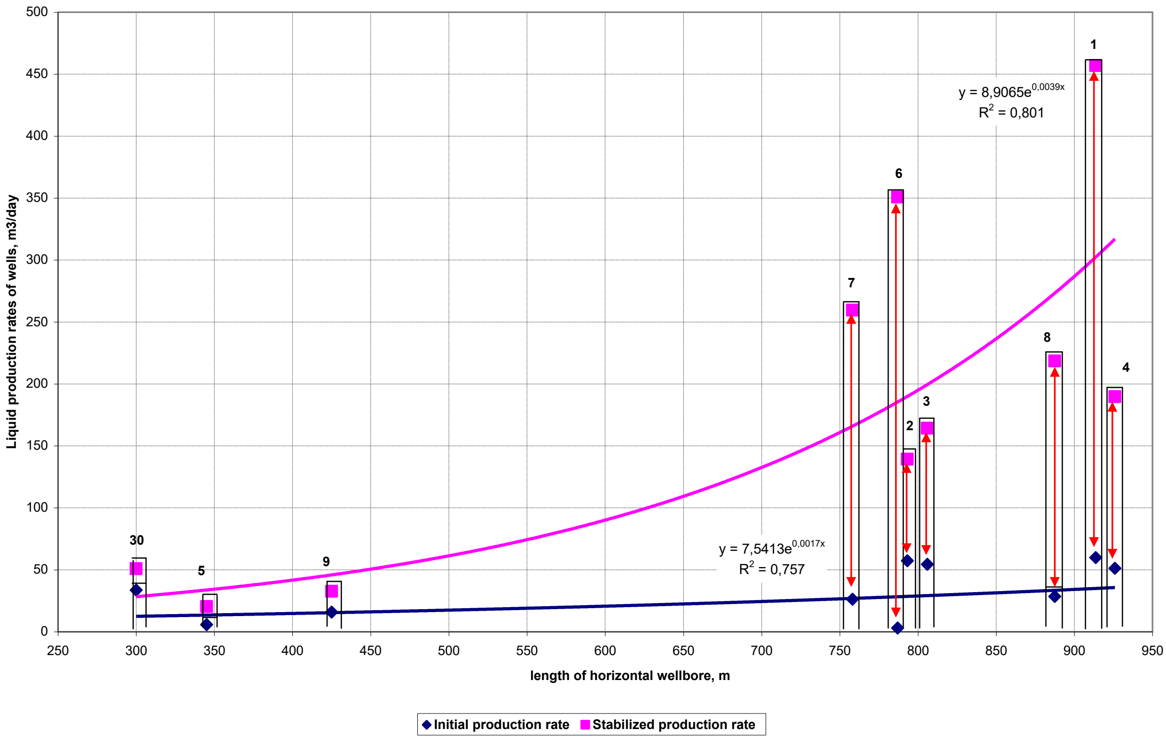

Figure-1. Initial and stabilized production rates vs. length of horizontal wellbore in Aryskum (horizon M-II), and Arys wells (well No. 30, horizon J-0-3).

The reason for this pattern is the filtration barriers that are created in the borehole environment (BE) as a result of the longer-term near wellbore to drilling mud contact during completion, and due to the hydrodynamic characteristics of horizontal wellbores circulation.

Filtration barriers are formed under the action of differential pressure, i.e. borehole pressure being excessive against the pore pressure in the reservoir.

While drilling a straight hole, the overburden on reservoir does not change all the way along the wellbore, since correlation of reservoir pressure and flowing pressure marginally changes in a well. Formation pressure, which builds up going deeper, resists hydrodynamic pressure while deepening the well.

When drilling in the reservoir with horizontal section, reservoir pressure does not change with the wellbore length extension, while the flowing pressure builds up in proportion to the length of wellbore, thus increasing the overburden on formation and thereby hardening the filtration barriers in the borehole environment around the horizontal wellbore. Under certain conditions, borehole environment pollution cannot be surmountable by traditional methods of inflow stimulation. [2, 4]

EXPERIMENTAL PART

V. I. Krylov and V. V. Kretsul indicated that according to findings of horizontal wells borehole environment pollution simulation with the use of a cylindrical coordinate system, wells efficiency can reduce by 50% or more through additional filtration resistance being created by filter cake (FC) and mud fill section (MS). [3, 5, 6]

It is a common knowledge that a clay filter cake is a basic filtrating barrier in the “reservoir-wellbore” hydraulic system with open hole completions. Its permeability is determined by the size of the clay mineral particles and density of layer structure being formed directly on the wellbore wall during drilling in to the reservoir. [7, 8, 10]

The basic structure of the FC is an active dispersed phase (high-quality bentonite). In this case, the structure of the FC is laid at the beginning of the filtration process and changes little during the subsequent filtration of suspensions through it. (Figure-2).

For open hole well completions, it is necessary to ensure that the filtering barriers being created by filtration of drilling mud in the reservoir, are removed to the highest possible degree.

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Disordered structure of photonic crystals with an excess content of the solid phase B = 10 cm^3 in 30 min.

Layered structure of FC made of high-quality clay B = 2 cm^3 in 30 min

Figure-2. The figure shows sections of FC obtained by filtering drilling fluids with the same filler concentration, but of different sizes.

Clay mud filter cakes are chemically and mechanically hard to remove. Drilling fluids with acid-soluble additives allow destroying the FC structure by acid during the well completion. [11, 12] However, any additives in the drilling mud will jeopardize the quality of filter cakes and its properties to create the barrier. Thus, chemical treatment of drilling fluids is required.

RESULTS AND DISCUSSIONS

In order to work out an optimal composition of the additives in drilling dispersions for open hole well completions, which, whilst drilling in permeable formation, limited penetration of mud solids into the borehole environment, and facilitated the removal of FC during stimulation treatment, we have carried out experimental studies of FC forming on the sand packs of fraction RCP-1250 microns (*sand pack* 1) and sand fraction of RCP-300 microns (*sand pack* 2) at differential pressure of 0.1 MPa and 0.7 MPa.

The given studies suggest that both sand packs decreased the filtration rate by two orders of magnitude (100 times) after contact with drill mud. Adding the additive increases the filtration rate 4-5 times (Figure-3).

At that, the core role belongs to the FC, permeability of which depends not only upon the structure-forming clayish phase, but also the shape and size of the additive particles.

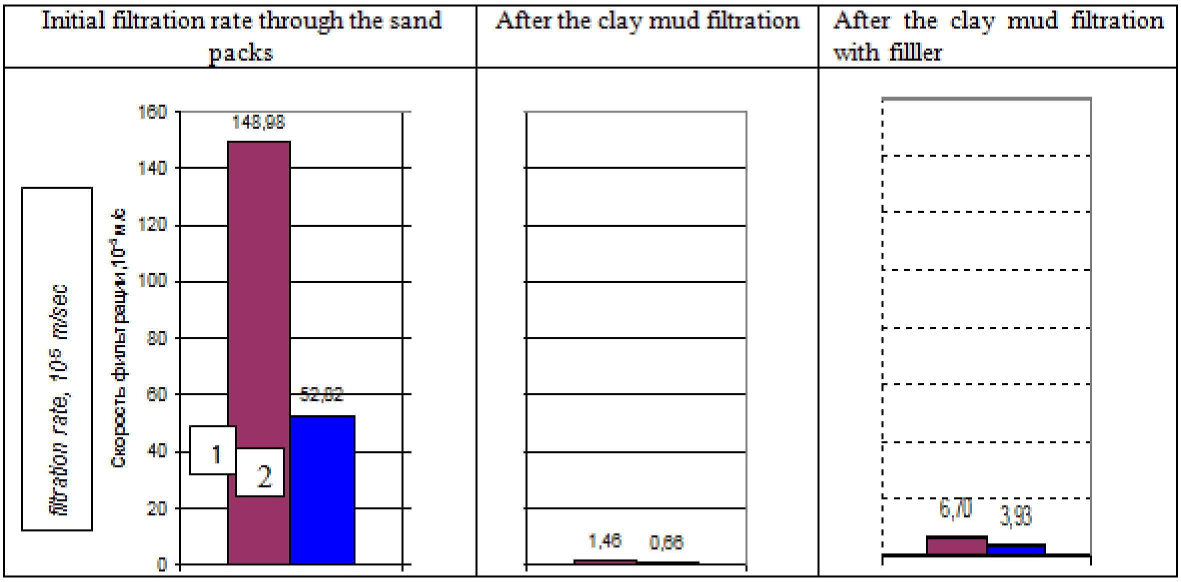

Figure-3. Water filtration rate through the sand pack before and after the filtration of high-quality drilling mud. 1-sand pack r_{cp}- 1250 microns; 2- sand pack r_{cp}- 300 microns.

If fine-grained additive particles do not substantially destroy the layered structure of the filter cake, being created by high-quality clay minerals, then, introduction of large additive particles move apart or break

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this structure, and encourage the filtration rate to increase through FC, thus intensifying the formation of filtration barriers in the well bore environment.

In this case, acceptable filtration characteristics remain unchanged at the content of fine-grained additive (<160 microns) in FC less than 7%. Adding fractions of particle size of r > 240 microns into drilling mud result in enhancement of high-quality clay mud filtration performance.

At the second stage of the study, after the formation of FC, sand packs were treated with different acid compositions. [5, 9]

The efficiency of restoring the permeability of sand packs was estimated by the parameter **$\theta = П_{к2} / П_{к0}$.**

The experiment was carried out in the following sequence of 5 stages: 1. Water filtration to determine $П_{к0}$ - an indicator of the initial permeability of the partition; 2. Filtration of the drilling slurry in the forward direction for the formation of FC and ZK; 3. Filtration of water in the opposite direction to determine $П_{к1}$ - the permeability index after the formation of FC and ZK; 4. Treatment with an acidic composition in the forward direction to destroy FC and ZK; 5. Filtration of water after treatment with an acid filler in the opposite direction to determine $П_{к2}$ - an indicator of the restored permeability of the sand pack.

The acid solutions used were: 15% HCl; 15% maleic acid; 15% sulfamic acid.

Table-1. Results of removal of filter cakes of clay-free polymer solution KCl and clay solution with optimal concentration of carbonate filler

Parameters	FANN - Filter press	Experiment condition	FC before and after treatments with various acids
$П_{к0}$ $П_{к1}$ $П_{к2}$ θ	0,0037 74,96 0,0128 3,5	Impact of 15% sulfamic acid on KCl biopolymer crust	
$П_{к0}$ $П_{к1}$ $П_{к2}$ θ	0,0037 74,96 0,0464 12,5	15% Maleic Acid Exposure to KCl Biopolymer Crust	
$П_{к0}$ $П_{к1}$ $П_{к2}$ θ	0,0037 74,96 0,0128 3,5	Impact of 15% hydrochloric acid on KCl biopolymer crust	
$П_{к0}$ $П_{к1}$ $П_{к2}$ θ	0,0037 82,46 0,0202 5,5	Impact of 15% Sulfamic Acid on Filtered Clay Cake	

The choice of sulfamic acid as an acidic solution is acceptable both from the point of view of the efficiency of removal of FA and a low pH value, and because it does not form secondary deposits, and also does not have a strong corrosive effect and does not require the use of corrosion inhibitors.

CONCLUSIONS

a) When planning the fractional composition of the carbonate filler in the drilling fluid for clogging the reservoir, it is necessary to take into account the dependence of the efficiency of acid interaction during well completion on the size of filler particles in the structure of the FC.

b) To exclude "focal" destruction of the filter cake, it is necessary to limit the content of coarse filler fractions and exclude the use of hydrochloric acid.

c) If it is necessary to completely remove the filter cake, it is desirable to carry out acid treatment in the mode of equal pressures at the bottom hole and the formation.

d) Sulfamic acid with a low rate of acidic interaction with carbonate filler is preferable to hydrochloric acid for removing FC from the wellbore walls.

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