Efficience of multistage fracturing in horizontal wells of the Kashiro-Podolsk deposits

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Abstract. The article is devoted to the methods of extracting reserves from complex carbonate reservoirs based on a complex of geological and technical measures. The parameters influencing the technological efficiency and the increase in oil production are analyzed. These include geological and filtration-capacitive heterogeneity, as well as technological parameters. The division of carbonate rocks into petrotypes is considered in order to assess their impact on input technological indicators – water content, oil flow rate. Geological conditions have been studied, as well as geological and technical parameters that have a significant impact on oil production and reservoir flooding during the multistage acid fracturing. The studied relationships allow for a detailed analysis of the success of events and a detailed approach to the selection of candidate wells.

1 Introduction

The main directions of the symposium: the reserves of the middle carboniferous carbonate formation considered in this work are classified as hard-to-recover. Due to the deterioration in the quality of reserves, there is a need to apply methods to improve field development, for example based on combining technologies for extracting residual reserves by drilling horizontal wells with their completion using multi-stage acid fracturing; the work examines geological and technological parameters that affect the efficiency of acid fracturing of horizontal wells [1-5].

2 Methods and Materials

Due to the deterioration in the quality of reserves, there is a need to apply methods to improve field development, for example, by combining technologies for extracting residual reserves by drilling horizontal wells and completing them with multi-stage acid fracturing [6].

To conduct a geological and statistical analysis, we examined the area where wells with a horizontal end were drilled with multi-stage hydraulic fracturing. In this case, parameters such as the number of stages of multi-stage hydraulic fracturing, the magnitude of reservoir

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pressure in the extraction zone, and the distance to injection wells were considered. In addition, the ratio of the discovered thicknesses of petrotypes h_2 (deteriorated petrotype 2) to h_1 (improved petrotype), permeability and their effect on the starting flow rate of oil and liquid, as well as the incoming water cut of drilled horizontal wells were considered

3 Results and Discussion

The reserves of the production object considered in this work - the carbonate strata of the Middle Carboniferous - are classified as difficult to recover. The layers C3pd, C2ks.1, C2ks.2, C2ks.3, C2ks.4 are characterized by significant variability in properties both laterally and vertically. Promising in terms of drilling and further exploitation of interests are the C3pd, C2ks.1 formations [7].

In the section of Kashiro-Podolsk deposits, according to GIS data, two petrotypes can be distinguished: 1 - characterized by good petrophysical properties, 2 petroclass - a deteriorated petrotype with low permeability and a predominance of high initial water saturation. The identification of the second petrotype (mainly water-saturated) among porous-permeable layers well saturated with oil at elevated hypsometric elevations (above the water contact layer) explains the production from them of products with a high degree of water cut, since this petrotype contains only bound water. Due to the complexity of the geological structure of the object under consideration and low filtration and reservoir properties, the development of such deposits, as a rule, occurs with the drilling of horizontal wells with multi-stage acid fracturing [8-10].

The C2ks.1 layer of the Kashir horizon is represented by limestones and dolomites, crystalline, brownish-gray, and organogenic-clastic interlayers. Characteristic is the alternation of porous oil-saturated layers with layers of mudstones and silty marls. The total thickness varies on average from 18.7 to 22 m, the porosity coefficient is about 20%, the average permeability coefficient is 50 mD, the effective thickness according to petrotype 1 varies from 1 m to 9.4 m. Within the field under consideration, an area was selected where an analysis of the geological and technical activities carried out was carried out [11-14].

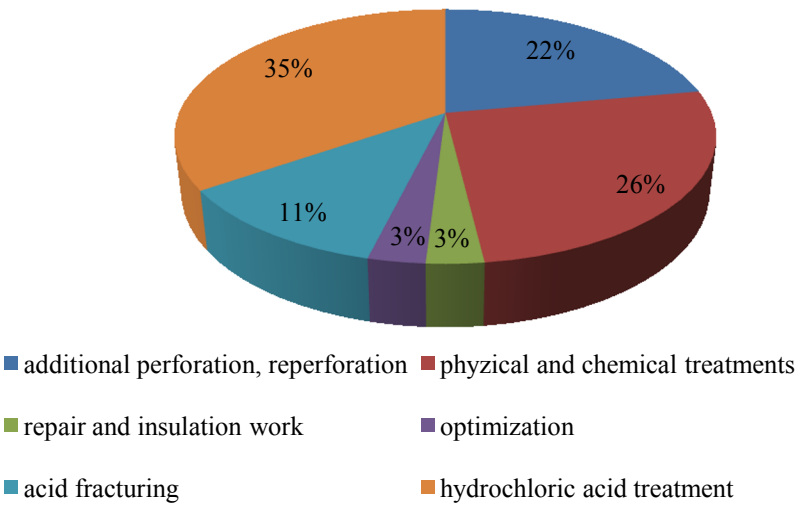

Fig. 1. statistics of geological and technical activities carried out.

Within the field under consideration, an area was selected where an analysis of the geological and technical activities carried out was carried out. The greatest technological efficiency is characterized by acid fracturing with an average increase in oil production rate of 4.13 tons/day, followed by measures for completion of formations and reperforation - 2.86 tons/day. The most frequently carried out activity was hydrochloric acid treatments, although the average increase in production rate for them was only 1.64 tons/day.

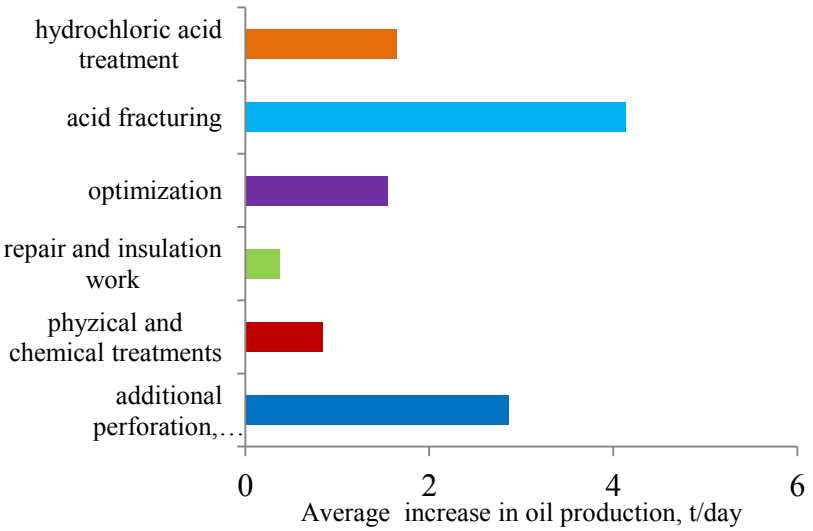

Fig. 2. effectiveness of geological and technical measures carried out within the area under consideration.

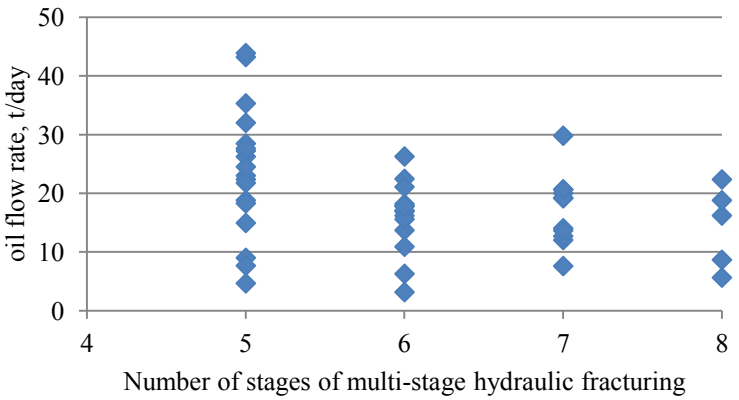

Fig. 3. dependence of oil production growth on the number of stages of multi-stage hydraulic fracturing.

As can be seen, with an increase in the number of stages of multi-stage hydraulic fracturing, there is no significant increase in oil production. This is explained by the large dissection of the section and also depends on the quality of penetration and opening of the formation. In addition, the share of the recovered petrotype also affects the initial water cut of the well [15-16].

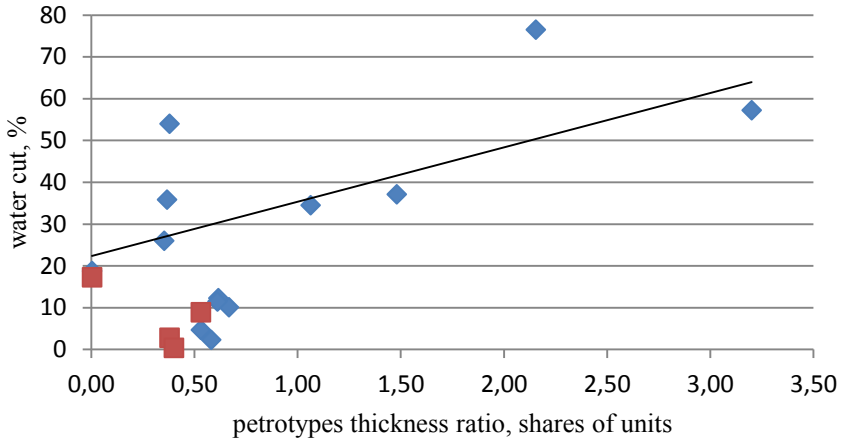

Fig. 4. graph of water cut depending on the ratio of recovered petrotypes.

When the share with a deteriorated petrotype in the section increases more than twice, the starting flow rate decreases several times. There are areas on the graph where, with a thickness ratio of and less than 0.5 units. the flow rate is also not high. To analyze the explanation for the reasons for this, a graph of the permeability-oil flow rate relationship was constructed, presented in Figure 5.

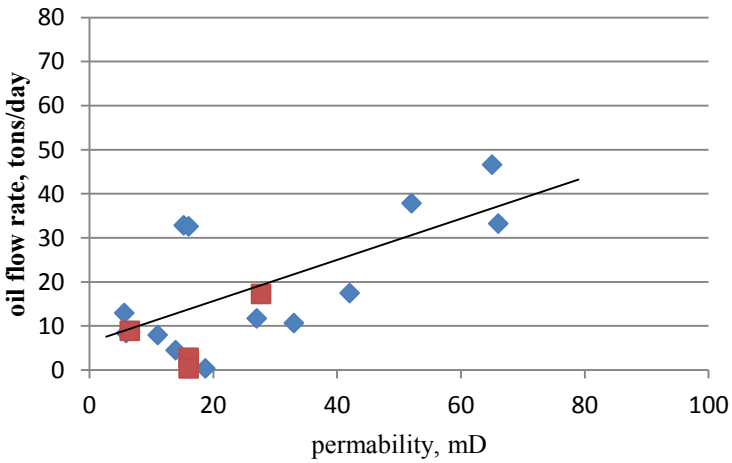

Fig. 5. graph of oil flow rate depending on permability.

As follows from this dependence graph, the red points with a small h_2/h_1 ratio fall into the area of low permeability, which explains the initially low oil production from these wells.

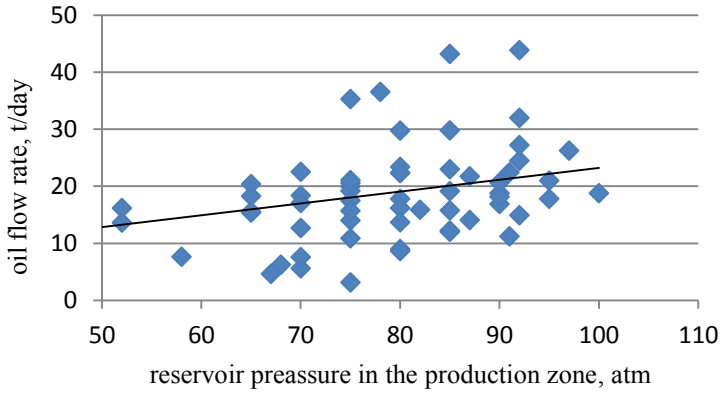

Fig. 6. Graph of oil flow rate depending on the reservoir preassure in the production zone.

With an increase in reservoir pressure growth, a slight trend towards an increase in oil production is observed. To ensure a higher input oil flow rate, the reservoir pressure in the proposed drilling zone should not be reduced by more than 1.5 times from the initial one, or in these areas of the reservoir measures should be taken to optimize the system of stimulation of the reservoir in order to ensure compensation for extractions by injection.

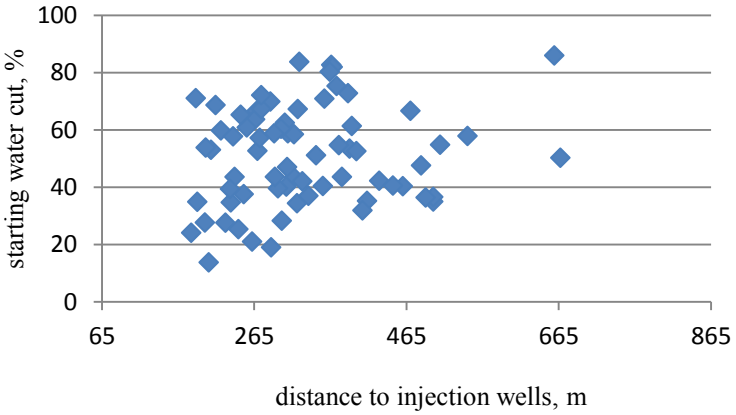

Fig. 7. graph of starting water cut depending on the distance to injection wells.

As can be seen from Figure 7, with increasing distance to the injection well, there is not always a trend towards a decrease in water cut, this is explained by the fact that when the well is opened with multi-stage hydraulic fractures, the fracture grows vertically, while at fracture heights from 5 to 21 m, the joining of all interlayers located along the section, including “2” of deteriorated petrotype, with high initial water saturation. Thus, the oil production rate is primarily affected by the structure of the current oil reserves in the drilling area. This explains the fact that at a large distance to the injection well (more than 500 m), the wells in Figure 7 have a high inlet water cut.

4 Conclusion

Thus, having analyzed the effectiveness of multi-stage hydraulic fracturing within the area under consideration, the following can be noted:

- within the considered field area, the event is characterized by high technological efficiency, average input flow rates of oil are 22 tons/day, liquids are 50.9 m3/day with an average water cut.
- with an increase in the number of stages of hydraulic fracturing, a significant increase in oil production does not always occur, since in most cases this is due to the high geological layering and areal heterogeneity of the reservoirs of the Kashiro-Podolsk deposits, as well as the nature of opening and drilling the well along the section - reservoir pressure in the extraction zone of a horizontal well should be reduced by no more than 1.5 - times, otherwise measures to optimize the reservoir stimulation system should be considered.
- the value of the input water cut for wells is influenced not only by the distance to the injection well, but also, first of all, by the structure of current reserves in the area of proposed drilling. The structure of reserves, in turn, depends on the ratio of identified petrotypes in the well section. Since with an increase in the share of opening of the second petrotype in the section (including due to multi-stage acid fracturing of wells) more than 1.5, the starting water cut of wells also increases.
- when choosing a location for laying wells, it is necessary to take into account the stressed state of rocks in order to prevent premature water breakthrough through auto-fracs from injection wells, which in turn depends on geological and geomechanical parameters.

Thus, in the course of the analysis, it was found that in the conditions of oil production from complex carbonate reservoirs of the KTSK, the starting flow rates of horizontal wells will be influenced not only by field parameters, such as the magnitude of drawdown, reservoir pressure in the well extraction zone, but also by petrophysical parameters : ratio of exposed petrotype thicknesses and permeability distribution. The trend of dividing rocks into petroclasses helps to consider the complex structure of initial and current oil reserves and to more carefully approach the issue of choosing drilling sites for future candidate wells.

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