Bottomhole formation zone treatment process modelling with the use geological and geophysical information

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Abstract. The study of West-Siberian Siberian Oil and Gas Province terrigenous reservoirs geological structure peculiarities influence timed to the Jurassic age deposits on defined according to the wells’ geological and geophysical data on the bottomhole formation zone treatment success with acid compositions on the basis of compositions Aldinol-20 application. On the basis of the generalizations conducted it was established, that in bottomhole formation zone treatment efficiency predicting it is necessary to rely on the geophysical research data, and at the oil-field commencement stage in case of lack of information it is enough to use only this information. The method based on geological and statistical models application, constructed on the basis of various efficiency criteria at various information volumes using, allowing the set tasks solving at various development stages and in the context of limited information about deposits due to insufficient volume of field research owing to the reasons of organizational and financial character, and also at the enterprises tactics and strategy in the market economy conditions change is offered.

1. Relevance of the study

In field experience, the results of the accumulated information generalizing are quite often used to improve the decisions effectiveness. One of the directions of such activity is the bottomhole formation zone treatment experience generalization [1-5]. However, the weak point of such researches is the lack of their application possibility in case of conditions and development situations scenarios changes in a follow-up both on the analyzed object, and on analogous objects. An important point, in the case, is the possibility of using the experience gained in the following conditions: different stages of development; lack of complete necessary information; heterogeneous information availability; limited information availability; changes in the market situation, etc.

According to the bottomhole formation zone treatment experience geological information generalization results [6-9], treatment effectiveness is determined by the three large groups of factors. These are the geological, physical and physico-chemical properties of beds and the saturating them fluids; wells and deposits performance technological data; technological parameters of the impact.

The degree and nature of their influence on the performance indicators are different in the conditions of different objects and their groups [10, 11], which indicates the need for a differentiated approach in the analysis and use of the results obtained.
2. Objective
With the purpose of refunded weaknesses elimination oil production intensification of in conditions of low permeability Western Siberia Jurassic age terrigenous deposits with the acid composition based on the Aldinol-20 application experience generalization was carried out. The main task of this generalization was to establish the initial geological and geophysical parameters influence degree, as well as determined by them the beds’ filter-capacitance and thickness properties for various impact effectiveness indicators. The choice of this group of parameters is due to their availability, representativeness and uniform standards allowing to use them regardless of the place and time.

3. Methods
Aldinol-20 acid composition consists of a mixture of polyhydric alcohols, cations and non-ionic surfactants, a corrosion inhibitor, hydrochloric acid and Aldinol-MK modifier. The addition of the Aldinol-MK modifier to the acid formulations increases the efficiency of the latter by deeper penetration into the formation, the hydrocarbon film on the impurities surface destruction, and also further inhibits the corrosive aggressiveness of the acids, thus allowing the acid composition to be transported and stored without compromising its quality.

On more than 120 wells the effect on the efficiency indexes have been studied reflected by the absolute ($Y_1$) and relative ($Y_2$) oil flow rate increase, the absolute ($Y_3$) and the relative ($Y_4$) water cut reduction, the total production growth during the effect time ($Y_5$) and complex efficiency parameter ($Y_6$) [12-16], geological and physical properties of the reservoir (according to geophysical research data), wells and deposits’ operation technological parameters and technological parameters of the impact.

Geological and physical properties of the formation in the well were reflected with the help of the following parameters: total ($H_{total}$, m), effective ($H_e$, m), effective oil-saturated ($H_{eo}$, m) formation thickness; sandiness ($K_s$), compartmentalization ($K_c$), open porosity ($m$), oil saturation ($K_{so}$); permeability coefficients ($K_{pc}$, $10^{-3}$ µm$^2$), induced potential logging ($a_{ip}$); lateral logging readout in the reservoir ($M_{LLR}$, Ohm·m), SP logging amplitude ($A_{LA}$), according to the lateral logging sonde 1 (A0.4M0.1N) ($A_{1.0}$, Ohm·m), according to the lateral logging sonde 2 (A1.0M0.1N) ($A_{1.0}$, Ohm·m), according to the lateral logging sonde 3 (A2.0M0.5N) ($A_{2.0}$, Ohm·m), according to the lateral logging sonde 4 (A4.0M0.5N) ($A_{4.0}$, Ohm·m), according to the potential sonde (A0.5M6.0N) ($A_{0.5}$, Ohm·m), gamma ray logging ($\gamma$, µR/hr), large NNKt sonde ($\beta'$, NNKt), small NNKt sonde ($\beta''$, NNKt), induction sonde ($\rho_{IS}$, Ohm·m); sonde true resistivity according to the induction logging ($\rho_{IL}$, Ohm·m), according to the lateral logging ($\rho_{LL}$, Ohm·m), by the complex of electric logging probes ($A_{comp}$, Ohm·m); penetration zone according to the complex electric logging sonde ($A_{comp}^2$, Ohm·m), the mud filtrate penetration zone diameter to the well diameter ratio ($d_{f1}/d_{w1}$).

Parameter values were used both for the whole of the cross-section ($X_i$) and for the perforated part ($\bar{X}_i$).

The technological parameters of the wells and reservoirs performance characterized the parameters: time ($t$, months), maximum oil production rate ($Q_{max}$, tons per month) from the beginning of the well operation to the moment of treatment; flow rate ($Q_{iop}$, tons per month), water cut ($f_i$, %), accumulated oil production ($Q_{aop}$, tons) at the time of treatment; initial oil production rate ($Q_{iopr}$, tons per month), treatment frequency ($N$).

Among the treatment technology parameters were the following: Aldinol-20 consumption (ALD, tons), 22% hydrochloric acid (HCl, tons); injected solution volume ($V$, m$^3$), and various specific indicators as well.

4. Results
Using the stepwise regression analysis, the models of all performance indicators dependence on the geological and technological parameters under consideration were constructed in three variants:

1 - using the whole set of parameters;
2 - using parameters reflecting the geological and physical properties of the formation and the treatment technology;

3 - using parameters reflecting peculiarities of wells and deposits, as well as the treatment technology.

Models reflecting the parameters influence on the absolute increase in oil production are as follows:

- **variant 1:**
  \[
  Y_1 = -1333.083 - 90.481K_s + 22.523K_c - 2.255\alpha_{LA} + 14.912\tilde{H}_{EO} + 42.403\tilde{K}_s + \\
  +1650.692\hat{\bar{m}} + 157.254\bar{a}_{ip1} + 61.853\bar{p}_{pl} + 5.145\bar{A}_{0,4} - 68.513d_{zd}/d_c + \\
  +9.664\beta_{NNKl} - 0.001Q_{lopr} + 0.46t + 0.057Q_{max} + 1.735f_1 - 0.466Q_{hi} - \\
  -125.543ALD + 37.437V + 46.205N + 79.679V/\tilde{H}_{EO} + 1009.308ALD/V - \\
  -31.301ALD/\tilde{H}_{EO} \quad (R = 0.793);
  \]

- **variant 2:**
  \[
  Y_2 = -745.687 - 159.44K_s + 16.781K_c - 1.668A_{LA} + 21.271\tilde{H}_{EO} - 56.541K_s + \\
  +1636.759\hat{\bar{m}} - 418.022\bar{a}_{ip1} + 39.659\bar{p}_{pl} - 16.85\bar{A}_{0,4} + 7.752d_{zd}/d_c + \\
  +6.135\beta_{NNKl} + 195.85ALD + 72.25V + 76.62N + 55.79V/\tilde{H}_{EO} + \\
  +1362.594ALD/V - 29.818ALD/\tilde{H}_{EO} \quad (R = 0.640);
  \]

- **variant 3:**
  \[
  Y_3 = -385.698 - 0.185t + 0.019Q_{max} + 0.086f_1 - 0.425Q_{zd} - 142.704ALD + \\
  +66.176V + 52.021N - 29.26V/\tilde{H}_{EO} + 943.908ALD/V + 63.45ALD/\tilde{H}_{EO} \quad (R = 0.518).
  \]

A similar series of geological and statistical models have been obtained for other performance indicators. The values of multiple correlation coefficients (R) presented in the table make it possible to propose them for practical use in diagnosing and selecting wells for treatment on the quantitative and qualitative level. This level is explained by the fact that the obtained models errors vary from 20 to 70\% and make up on average 32\%, although in the calculations for 7-10 wells the forecast is quite satisfactory.

**Table.** The values of the multiple correlation coefficients of the obtained models.

| Variant | Efficiency factor |
|---------|------------------|
|         | \( Y_1 \) | \( Y_2 \) | \( Y_3 \) | \( Y_4 \) | \( Y_5 \) | \( Y_6 \) |
| 1       | 0.793 | 0.824 | 0.753 | 0.793 | 0.818 | 0.727 |
| 2       | 0.640 | 0.742 | 0.705 | 0.640 | 0.739 | 0.681 |
| 3       | 0.518 | 0.533 | 0.547 | 0.518 | 0.602 | 0.534 |

The results analysis shows that the naturally smallest error in the forecast have models constructed with the entire complex of geological and technological parameters under consideration using. In the absence of reflecting the technological parameters of wells and deposits (variant 2) parameters which is typical for the field bringing into the development stage, the error increases and the accuracy decreases. However, at this stage, the use of geological and geophysical data allows with a sufficient degree of accuracy to solve the tasks of the efficiency predicting and wells for treatment selection.

In the absence of parameters characterizing the geological and physical properties of the formation in the well (variant 3), a significant decrease in the predictive capabilities of the models is observed, which indicates the need to use such data for geophysical studies of wells when solving similar problems. Although in some situations this group of models can also be used in practice for quantitative and qualitative assessment.
5. Conclusions
1. It was established that when the bottomhole formation zone treatment effectiveness predicting, it is necessary to use geophysical survey data, and at the stage of field bringing into development, it is sufficient in case of absence of information to use only this information.
2. A technique based on the geological and statistical models application based on the use of various efficiency criteria for different volumes of information is proposed, which allows to solve the tasks at different stages of development and in the conditions of limited information about deposits due to insufficient volumes of field research owing to the reasons of organizational and financial nature, as well as because of the enterprises’ tactics and strategy changing in market economy conditions.

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