Original Research Article:
full paper

(2022), «EUREKA: Physics and Engineering»
Number 5

DYNAMIC ANALYSIS AS A METHOD OF WELLS INTERACTION EVALUATION IN MAKING TECHNOLOGICAL DECISIONS

Samira Abbasova✉
Department of Oil and Gas Engineering[1]
abbasovasamira@mail.ru

Gulbahar Mammadova
Department of Oil and Gas Engineering[1]

[1]*Azerbaijan State Oil and Industry University*
34 Azadliq ave., Baku, Azerbaijan, AZ1010

✉**Correspondingauthor**

Abstract

The complexity of developing oil fields determines the creation and improvement of fundamentally new approaches to the analysis and management of various technological processes of oil production based on indirect methods of interpreting current geological and field information for making strategic and tactical decisions to rationalize it.

This article discusses the formation of stagnant and poorly drained zones of oil deposits due to the redistribution of hydrodynamic flows of reservoir fluids.

In order to analyze and evaluate the effectiveness of applying the technology to change the direction of filtration flows in the reservoir under consideration, it is necessary to study the influence of non-stationary processes on oil production.

Based on the construction of operational maps of total oil and water production, water cut and the degree of interaction by periods of development, the state of the reservoir system is analyzed and conclusions are made about the characteristic features of the direction of water-oil flows with the subsequent formation of stagnant zones.

The proposed approach to decision-making allows to carry out the dynamic regulation of hydrodynamic flows in order to stabilize and reduce oil production losses for the period under consideration and make the necessary decision on the issuance of technological recommendations for the impact on the operation of the exploitation object, taking into account the minimization of energy and resource costs.

The proposed method was tested on the example of the analysis of the state of development of one of the fields in Azerbaijan, which is in the final stage of development. As an information array, the dynamics of changes in oil and water flow rates by wells in various periods of development was chosen.

Keywords: oil and gas field, stages, wells, production, field water cut, maps of the line of equal interactions, stagnant zones, evolutionary model.

DOI: 10.21303/2461-4262.2022.002241

1. Introduction

Currently, analysis, diagnosis, forecasting and management of the development process is carried out, including using complex multidimensional, multiphase, multicomponent deterministic mathematical models that require a large amount of initial information, as well as solving the equations of continuity, motion and state. In the process of mathematical formalization of both geological and hydrodynamic models, certain errors arise at various stages associated with numerous options for scaling, approximations, interpolations, adaptation and approximations. In addition, the modeling process takes a fairly long period of time and requires large financial costs. At the same time, there are alternative ways and various express methods for analyzing the development of oil fields that allow to quickly evaluate the actual field information and interpret it without resorting to complex and time-consuming modeling, or, by combining the results of two approaches, to obtain a more reliable solution [1, 2].

The effectiveness of the development of oil fields with waterflooding is largely determined by the completeness of involvement in the development of commercial oil reserves, the nature and degree of their development. Both the rate of production and the completeness of oil extraction from the entrails depend on this [3–6]. Under conditions of waterflooding, the completeness of production of productive layers primarily depends on the degree of coverage of the development object. In the flooded reservoir oil-saturated layers, lenses and areas, low drained and stagnant zones, which are in direct contact with watered layers and zones or are separated from them by impermeable lenses and layers, are remained. Development of such field objects requires additional capital investments, which in terms of material and technical resources are not always possible.

Currently, there are a large number of methods for determining the location of low drained and stagnant zones of oil deposits, as well as the development of technologies aimed at involving these zones in active development [7]. The main methods include direct (field geophysical research) and indirect (analytical research) methods for determining the location of residual oil reserves. The disadvantage of direct methods is the insufficient information coverage of the whole development object or field. Indirect methods provide information on the location of low drained and stagnant zones.

Thus, new methods and the improvement of already existing methods are of particular importance, allowing together with others, to clarify the picture of reservoir heterogeneity not only in the geological, but also in the hydrodynamic sense.

2. Materials and methods

For the most part, the known methods of analysis do not take into account the mechanism of evolution of the reservoir system during the development of the deposit, and the variety of factors influencing the processes of oil production make it difficult to carry it out and obtain a reasonable solution. For this reason, indirect methods of field data analysis are of great importance, allowing diagnosing the current state of development with a sufficient degree of reliability, both for individual objects and for the reservoir as a whole.

The adoption of timely and reasonable decisions on the choice of strategy for the development of oil fields is largely associated with the determination of the characteristic period (stage) of the development of the deposit.

To identify the boundaries of the development stages, a technique for describing the oil recovery process was applied, taking into account the dynamics of the main technological development indicators based on the Kolmogorov-Erofeev equation [8].

When describing the process of oil production, the oil recovery factor $\eta(t)$ is represented as:

$$\eta(t) = 1 - Q(t)/Q_0, \tag{1}$$

where Q_0 – the initial balance oil reserve in the deposit; $Q(t)$ – the remaining recoverable oil reserve in the deposit by the time (t).

According to the Kolmogorov-Erofeev equation for the dynamics of the oil recovery factor, there is the equation:

$$\eta = 1 - \exp(-K_0 t^q). \tag{2}$$

The statistical analogue of the kinetic equation (2) is the Weibull distribution function, which is widely used in the theory of system reliability:

$$F_x(t) = 1 - \exp(-\lambda_0 t^{\alpha}), \tag{3}$$

characterizing the probability of element failure during the test period (t).

The probability distribution density has the form:

$$f_x(t) = dF_x/dt = \lambda_0 t^{\alpha-1} \exp(-\lambda_0 t^{\alpha}), \tag{4}$$

where the value $\lambda = \lambda_0 t^{\alpha-1}$ – the so-called «mortality rate» (failure rate), is an important characteristic of the Weibull distribution. A typical function of the failure rate in the Weibull statistical distribution has a U-shape, which can be taken as the basis for describing the dynamics of oil recovery in the process of developing deposits and determining the boundaries of the development stages.

One of the ways to diagnose the state of the reservoir system is to determine the indicator of interaction between the wells of the considered exploitation object [9–11]. Diagnostics of the hydrodynamic features of the filtration pattern is carried out on the basis of the construction and analysis of maps of the total oil and water production, water cut and the degree of interaction by periods of the development.

It is known, that in the presence of interaction between two wells, draining a common oil reservoir, any changes occurring in one of them will be reflected in the operation of the other one. A clear consequence of these changes is the correspondence of fluctuations in the flow rates of both wells. Therefore, the time series of oil and water production rates, according to which the degree of well interaction is estimated, are used as the initial information array.

In order to analyze and evaluate the effectiveness of the application of the technology aimed on the change of the filtration flows direction in the reservoir under consideration, it is necessary to study the influence of non-stationary processes to the oil production.

Due to the uneven development of reserves, there are poorly drained zones in the fields. An important and rather difficult task under these conditions is to determine the location of these zones and to attract technologies for the successful and technically and economically efficient additional recovery of residual oil reserves.

To establish the consistency of changes in the values of the two features, the correlation coefficients are used [12–15]. The simplest indicator of the tightness of the correlation is the Spearman's rank correlation coefficient. Based on this correlation analysis with use of production rates the maps of equal well interaction are built. Thus, maps of equal levels of interaction are constructed using a matrix of correlation coefficients based on actual field data – oil, water, liquid and others.

Well correlation coefficients are divided into levels at any step to map. The obtained identical levels from well to well are connected by continuous isolines. Isolines with a correlation coefficient of zero ($P_i = 0$) characterize the lack of drainage and, therefore, the zone is stagnant. Isolines above zero with minimum correlation coefficient characterize weakly drained zones.

On each of these maps, areas with low values of interaction criteria are highlighted with a contour line.

The «Surfer» program interpolated the main process parameters of the wells for the time periods under consideration and mapped the total oil production and water cut. A comparative analysis of the maps was carried out.

3. Results and discussion

An analysis was made of changes in monthly oil withdrawals for one of the fields in Azerbaijan as a whole.

So, conditionally three stages of development are allocated both for groups of wells and for the field as a whole.

The first stage of development: 09.75–06.82 is characterized by an increase in oil production due to intensive commissioning of wells. During this period, there is a redistribution of flow rates between wells. At the same time, the oil field began to be affected by water.

The second stage, covering the development of the field from 06.82 to 12.90, is mainly characterized by relatively stable values of the technological parameters of oil production and water injection without significant changes in the stock of production and injection wells. during this period of time, there is practically no redistribution of oil production rates between wells and the process of oil production is orderly.

The third stage, starting from 12.90, is characterized by a change in the reservoir system towards a decrease in oil production and an increase in water cut (**Fig. 1**). An analysis of the main technological development indicators shows that in this period of time there is a significant excess of the total volume of injected water over the total fluid withdrawal.

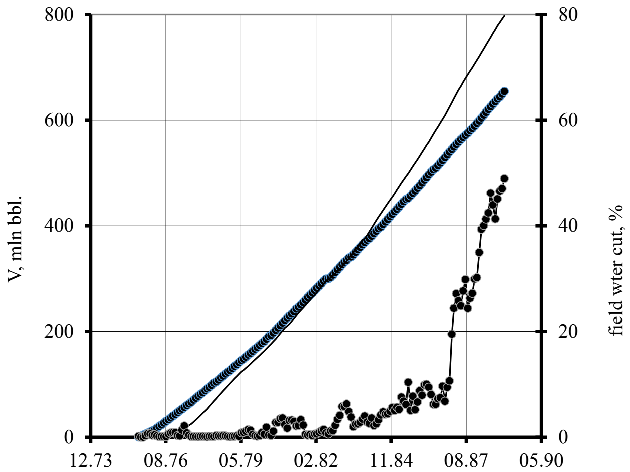

Fig. 1. Dynamics of field development indicators: 1 – liquid sampling; 2 – water injection; 3 – field water cut

It should be noted that the use of various types of regulation of oil production processes is mainly necessary in the first and third stages, since the second stage is characterized by a more orderly development of the development process.

Thus, the application of the kinetic approach to the description of the dynamics of the main development indicators for the operational facility makes it possible to accurately identify the transient development processes, which must be taken into account when choosing decisions to regulate the development strategy.

The construction and evaluation of several maps of wells equal interaction, built for different periods of development, make it possible to identify low drained areas as the primary objects for applying stimulation methods in order to increase production.

The proposed methods were tested on the example of analyzing the state of development of one of the fields in Azerbaijan, which is in the final stage of development. The dynamics of changes in oil and water flow rates by wells during the periods corresponding to the I, II and III stages of development was selected as an information array.

Fig. 2–4 show maps of equal interaction lines for oil flow rates, respectively, for I, II and III stages of development.

As seen from **Fig. 2**, in the first stage of development (September 1975 – June 1982), the geological object under consideration is operated by 8 wells (No. 378, No. 350, No. 288, No. 289, No. 330, No. 296, No. 299, No. 312).

On the presented map, each considered well behaves as an independent object that follows from the values of the correlation coefficient less than 0.5, with the exception of wells No. 330 and No. 378, in which the correlation coefficient is 0.5.

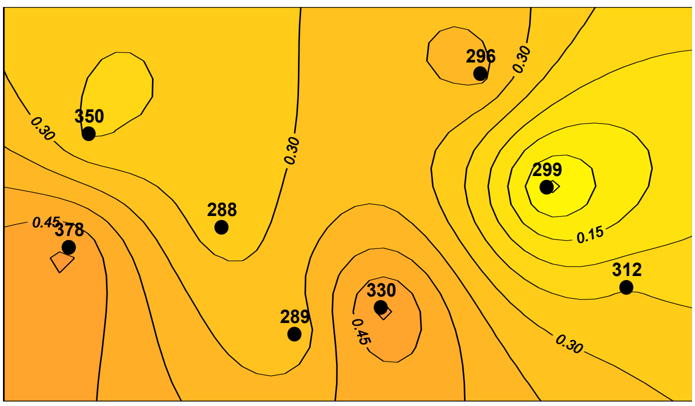

Fig. 2. Maps of the line of equal interactions of oil production (I period)

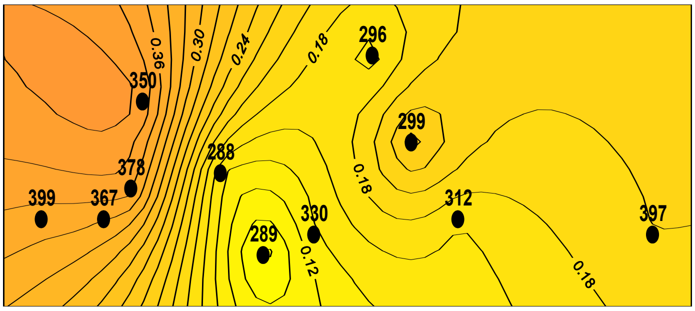

Fig. 3. Maps of the line of equal interactions of oil production (II period)

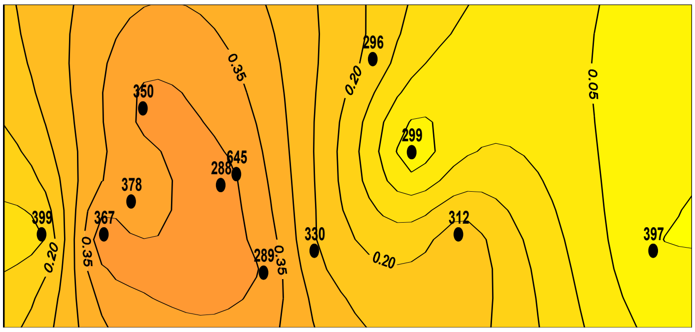

Fig. 4. Maps of the line of equal interactions of oil production (III period)

With the evolution of the oil production process in the II stage of the development period (June 1982 – December 1990) the commissioning of additional wells (No. 399, No. 367, No. 397) practically does not change the tendency for the evolution of interaction between wells, which can be explained by the intensity of evolution of products interaction between the wells, that led to the isolation of the directions of oil flows filtration to each considered well in the general drainage system.

The evolution tendency of well interaction at the third stage is shown in **Fig. 4**. There is an increase in the correlation coefficient for oil flow rates between wells, despite a significant increase in well flow rates for water. Hence, it is possible to draw a conclusion about the existence of the self-organization process of groups of wells (No. 367, No. 350, No. 288, No. 399).

Thus, correlation analysis makes it possible to identify both low drained zones of a well section, (for instance, a section of a deposit operated by wells No. 397, No. 299, and sections of a reservoir for intensification of the development process) depending on the principles of self-organization.

To confirm the results of the correlation analysis, the maps of the change in water cut during well operation were built.

The maps in **Fig. 5–7** show the lines of equal water cut for the area under consideration in the time periods corresponding to the analysis of the wells interaction. A comparative analysis of the presented maps indicates an oscillatory process of changing of production watering. The oscillatory process of water cut is, obviously, can be explained by the non-equal penetration of water into the oil reservoir, that required making decisions of regulating the production rates of wells in each considered period of time.

So, for instance, well No. 296 entered production with a water percentage of 4 % (stage I), then in stages II and III, the water cut increased respectively to 0.5 and 0.83, while the weighted average correlation coefficient decreases, respectively, by development stages from 0.37 to 0.15 and 0.19.

As follows from the dynamics of changes in the parameters of this well, for each considered period of time (stages II and III), a sharp change in the water cut is observed, that led to a significant decrease in the correlation coefficient for oil. The same picture is practically observed for all wells. The analysis shows that the intensive increase in water cut at the III stage of development is explained by the fact that the control of well operating modes did not take into account the peculiarities of the change in the rate of the oil production process, and this caused the uneven advance of the displacement front.

Thus, it follows from the maps of lines of equal water cut that the actual conduct of the development process mainly from the position of maintaining reservoir pressure led to premature water flooding of the area in question, an increase of more than 1.5 times the volume of water taken and losses in oil production.

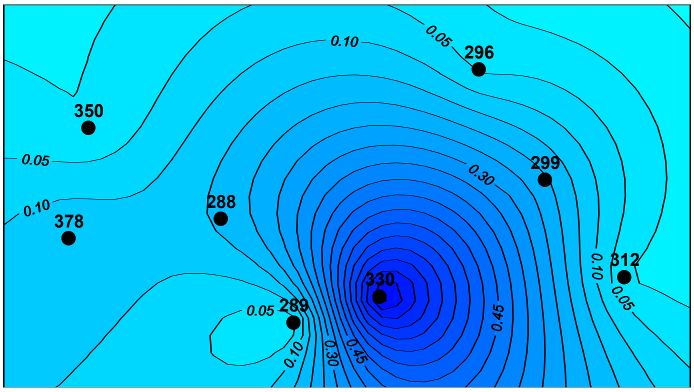

Fig. 5. Equal water cut line maps (I period)

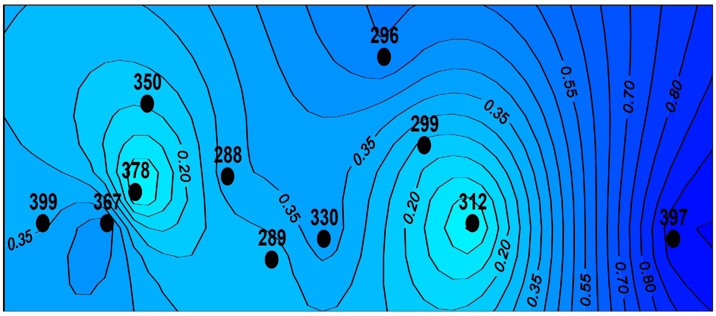

Fig. 6. Equal water cut line maps (II period)

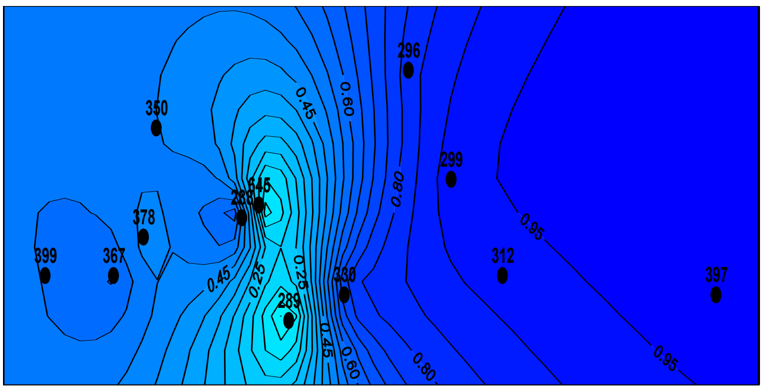

Fig. 7. Equal water cut line maps (III period)

The method for determining the location of stagnant and low drained zones of oil deposits, based on the construction of maps of wells equal interaction makes it possible to establish the relationship of the emerging processes with a change in the direction of filtration flows in the reservoir, to assess the possibility of involving the zones under consideration in active development by the existing well stock without additional economic costs.

The limitation of this method is the lack of consideration of the complexity of the geological structure of the oil reservoir, i.e. the presence of interbeds, their variable thickness over the reservoir area, and various types of heterogeneities and disturbances.

The proposed approach makes it possible to make decisions in conditions of insufficient information on dynamic control of hydrodynamic flows in order to stabilize and reduce losses of oil production for the period of time under consideration, as well as to make the necessary decision on issuing technological recommendations on the impact on the operation of the production facility, taking into account the minimization of energy resources.

This interpretation of field information makes it possible to diagnose and predict changes in the state of the reservoir, which makes it possible to determine both the type and time of geological and technical measures aimed at improving the efficiency of development.

Through the above analysis of the main development indicators, a change in the trend of water cut growth was determined, and predictive decisions on the regulation of development processes based on changes in well operating modes were obtained to redistribute the directions of water-oil flows in the formation system.

The largest increase in water cut was recorded for wells where the design and actual decisions on operation regulation did not coincide.

Examples are wells No. 299, No. 312, No. 397, No. 378, No. 399, No. 367.

Well No. 299 received a decision to limit fluid withdrawal, whereas in fact, the extraction was forced. This led to an increase in water cut from 23 % to 35 %, with a slight change in oil production rate.

A decision was made for well No. 312 to limit fluid production, but in fact the well operating mode was not changed. As a result, water cut increased from 21 % to 43 % with a decrease in oil production by 29 %.

Well No. 397 received a decision not to change the existing operating mode, but actually limited the fluid withdrawal. As a result, the water cut increased from 34 % to 60 % and the oil production rate decreased by 74 %.

Well No. 378 received a decision to increase fluid production, and in fact, it was limited. As a result, oil production decreased by 36 % with virtually no change in water cut.

At the same time, a decision was made for well No. 399 to increase fluid production, which coincided with the actual one. As a result, oil production in the well increased by 11 %, and water cut increased from 2 % to 4 %.

For well No. 367, the received decision to leave the fluid withdrawal mode unchanged coincided with the actual one. In this case, a slight increase in water cut was recorded from 19 % to 26 %, with a decrease in oil production rate by 5 %.

Thus, according to groups of wells with coinciding and mismatched design and actual decisions on control of liquid production in the whole area of the field, there is a decrease in oil production by 6.5 % and 24 %, respectively, and water cut increases by 5 % and 11.2 %.

It should be noted here that the development process is characterized by a natural decrease in oil production and an increase in water cut.A forecast of oil recovery and recoverable reserves was made provided that the parameters of the development system are unchanged in the future based on the evolutionary model of the species [16]:

$$V_{oil} \to A + Be^{-\alpha t}, \tag{5}$$

where A, B, α – the model coefficients at the considered stage of growth characteristics, and at $t \to \infty, V_{oil} \to A.$

To diagnose the behavior of the system in the analysis of the oil production process, information on the dynamics of the total sampling over the studied period of time is used.

Evolutionary modeling of oil production growth and the use of dispersed analysis determined the parameters of models with a sufficient degree of accuracy, describing the dynamics of changes in development indicators over time $V_{oil} = V_{oil}(t)$. Recoverable reserves amounted to about 2.4 billion barrels.

Further, in order to take into account the process of watering the reservoir, similar calculation procedures were carried out for the dependence of oil extraction on the extraction of fluid $V_{oil} = V_{oil}(V_{fluid})$.

This approach makes it possible to analyze the state of the oil production process, excluding subjective factors (shutdown of wells for technical reasons, various emergencies and others). The results are shown in **Table 1**. Here, recoverable reserves amounted to about 2.6 billion barrels (**Fig. 8**).

Thus, the analysis of the results made it possible to determine the values of recoverable oil reserves in the range of 2.4–2.6 billion barrels.

Table 2 shows the calculations of the forecast indicators of annual oil production.

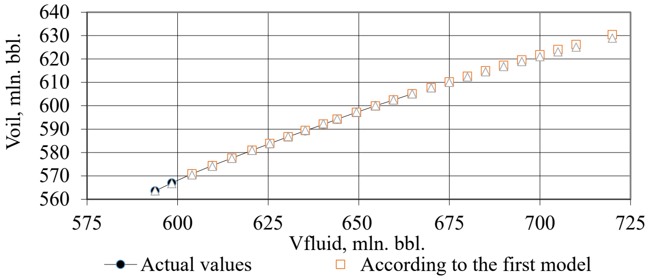

Fig. 8. Oil production forecast for the field

Table 1

Oil production by evolutionary modeling

Fluid withdrawal, billion barrels	Actual oil recovery, billion barrels	Design oil recovery, billion barrels	Difference	Fluid withdrawal, billion barrels	Actual oil recovery, billion barrels	Design oil recovery, billion barrels	Difference
2.2773	2.0230	2.0230	−0.0005	2.4850	2.1269	2.1267	0.0054
2.2872	2.0284	2.0284	0.0004	2.4942	2.1309	2.1309	0.0000
2.2949	2.0326	2.0326	0.0008	2.5027	2.1347	2.1347	−0/0017
2.3036	2.0373	2.0373	−0.0031	2.5117	2.1388	2.1387	0.0075
2.3136	2.0425	2.0427	−0.0050	2.5219	2.1433	2.1431	0.0062
2.3198	2.0459	2.0459	−0.0029	2.5301	2.1469	2.1467	0.0109
2.3272	2.0500	2.0498	0.0054	2.5333	2.1484	2.1481	0.0138
2.3368	2.0550	2.0549	0.0078	2.5374	2.1502	2.1499	0.0170
2.3453	2.0594	2.0593	0.0086	2.5457	2.1536	2.1534	0.0103
2.3513	2.0624	2.0623	0.0006	2.5538	2.1571	2.1568	0.0102
2.3572	2.0653	2.0654	−0.0045	2.5618	2.1604	2.1602	0.0091
2.3649	2.0693	2.0693	0.0003	2.5701	2.1638	2.1637	0.0047
2.3732	2.0735	2.0735	0.0011	2.5776	2.1669	2.1668	0.0051
2.3822	2.0780	2.0780	0.0016	2.5851	2.1700	2.1699	0.0028
2.3912	2.0825	2.0824	0.0039	2.5920	2.1727	2.1727	−0.0028
2.4000	2.0867	2.0868	−0.0032	2.5990	2.1754	2.1756	−0.0085
2.4093	2.0910	2.0913	−0.0160	2.6057	2.1782	2.1783	−0.0030
2.4183	2.0951	2.0956	−0.0235	2.6125	2.1809	2.1810	−0.0058
2.4260	2.0990	2.0993	−0.0166	2.6209	2.1841	2.1843	−0.0093
2.4341	2.1030	2.1032	−0.0083	2.6285	2.1873	2.1873	−0.0001
2.4415	2.1066	2.1067	−0.0069	2.6380	2.1910	2.1911	−0.0054
2.4497	2.1104	2.1106	−0.0090	2.6467	2.1943	2.1944	−0.0047
2.4577	2.1142	2.1143	−0.0033	2.6564	2.1981	2.1982	−0.0051
2.4665	2.1183	2.1183	−0.0036	2.6650	2.2015	2.2015	−0.0003
2.4756	2.1226	2.1220	0.0271	–	–	–	–

Table 2
Oil production forecast for the field

Time, year	Oil recovery	
	Current, million barrels	**Total, million barrels**
1	32.0700	2.2351
2	28.6290	2.2637
3	25.5580	2.2892
4	22.8170	2.3121
5	20.3700	2.3324
6	18.1840	2.3506
7	16.2340	2.3668
8	14.4920	2.3813
9	12.9380	2.3943
10	11.5500	2.4058
11	10.3110	2.4161
12	9.2050	2.4253
13	8.2180	2.4336
14	7.3360	2.4409
15	6.5490	2.4474

4. Conclusions

The necessity of taking into account the characteristic times of transient processes when choosing a solution for regulating the strategy of developing oil fields is shown. The application of the kinetic approach to the description of the dynamics of the main technological indicators of oil production is substantiated using the Kolmogorov-Erofeev equation, which makes it possible to diagnose the boundaries of the times of transient processes with a sufficient degree of reliability.

The possibility of diagnosing the presence and formation of secondary stagnant zones on the basis of a comparative analysis of the features of the dynamics of the rate of oil and water production rates, water cut and the degree of interaction between wells is shown.

The analysis based on maps of total oil production and water cut showed the presence of formation of poorly drained zones, one of which is the predominant flooding of producing wells due to uneven depletion of reserves.

Diagnosis of watering in conditions of lack of data is necessary when making technological decisions on the effective completion of residual oil reserves of formations. The totality of all available information, including identified signs of water flooding, can be used to substantiate recommendations for transferring perforation intervals and changing the directions of filtration flows by changing the operating modes of production wells.

Thus, the dynamics of the indicator of the interaction degree between wells in different periods of development can be considered as diagnostic criteria for the state of the reservoir system. In the evolution process of the oil reservoir development it is necessary to take into account the alternating evolution and replacement of low and highly drained zones of the reservoir.

The performed analysis makes it possible to determine the characteristic features of the movement of water-oil flows and to identify groups of wells that do not participate in the general drainage system. This must be taken into account when making a decision of the dynamic regulation of hydrodynamic flows in order to stabilize and reduce oil production losses for the period under consideration.

In order to analyze and evaluate the effectiveness of the technology for changing the flow direction in the reservoirs under consideration, studies were conducted on the impact of transient processes on oil production with actual changes in the operating modes of the producing wells. It was found that as a result of not taking into account the peculiarities of the change in the rate of oil production and water impact on the reservoir, there is a decrease in oil production by 6.5 % and 24 %, respectively, and the water cut increases by 5 % and 11.2 %.

Timely consideration of the processes of the reservoir watering and the interaction between the wells makes it possible to make decisions of the regulation of their operation modes (forcing or limiting) and would improve the efficiency of the development of oil and gas fields.

Evaluation of the information content of parameters and studies is a significant increase in research on the development of oil deposits. The solution of a detailed problem in order to determine the location of stagnant and poorly drained zones of deposits based on actual field information and express methods is a serious prerequisite for the implementation of this zone in active work. In practice, along with many techniques used in the design of oil reservoir development, the solution of such problems can become an additional tool for analyzing and diagnosing hydrocarbon reserve development processes.

In order to assess the technological efficiency of actual unplanned changes in production well operating modes, annual oil production was forecast.

The evolutionary modeling method has established the limits of change in the forecast values of recoverable oil reserves of 2.4–2.6 billion barrels.

Conflict of interest

The authors declare that there is no conflict of interest in relation to this paper, as well as the published research results, including the financial aspects of conducting the research, obtaining and using its results, as well as any non-financial personal relationships.

Acknowledgments

We are grateful for the support of the Department of Oil and Gas Engineering of the Azerbaijan State University of Oil and Industry.

References

[1] Dean, R. H., Lo, L. L. (1988). Simulations of Naturally Fractured Reservoirs. SPE Reservoir Engineering, 3 (2), 638–648. doi: http://doi.org/10.2118/14110-pa

[2] O'Dell, M., Lamers, E. (2005). Subsurface Uncertainty Management and Development Optimization in the Harweel Cluster, South Oman. SPE Reservoir Evaluation & Engineering, 8 (2), 164–168. doi: http://doi.org/10.2118/89110-pa

[3] Mirzadzhanzade, A. Kh., Khasanov, M. M., Bakhtizin, R. N. (1992). Protcessy neftegazodobychi – dinamicheskaia sistema. Uchenye zapiski, 1, 4–30.

[4] Mirzadzhanzade, A. Kh., Khasanov, M. M., Bakhtizin, R. N. (1999). Etiudy o modelirovanii slozhnykh sistem neftedobychi. Nelineinost, neravnovesnost, neodnorodnost. Ufa: Gilem, 464.

[5] Natarov, A. L., Borkhovich, S. Iu., Popova, N. N. (2016). Primenenie geologopromyslovykh metodov dlia analiza effektivnosti razrabotki mestorozhdenii PAO «Belkamneft». Neftepromyslovoe delo, 4, 10–15.

[6] Ozkaya, S. I, Richard, P. D. (2006). Fractured reservoir characterization using dynamic data in a carbonate field, Oman. SPE Reservoir Evaluation & Engineering, 9 (3), 227–238. doi: http://doi.org/10.2118/93312-pa

[7] Shakhverdiev, A. Kh., Zakharov, I. V., Suleimanov, I. V. (2004). Issledovanie stepeni informativnosti parametrov, opredeliaiushchikh protcess obrazovaniia zastoinykh i slabodreniruemykh zon zalezhei uglevodorodov. Neftianoe khoziaistvo, 8, 64–68.

[8] Loskutov, A. Yu., Mikhailov, A. S. (1990). Vvedenie v sinergetiku. Moscow: Nauka, 272.

[9] Halimov, R. Kh., Nurgaliev, R. Z., Loscheva, Z. A., Makhmutov, A. A., Khisamutdinov, N. I. (2016). A method of building maps of formations heterogeneity when organizing effective geological and technical measures. Geology, geophysics and development of oil and gas fields, 12, 53–55.

[10] Ababkov, K. V., Vasiliev, D. M., Khisamutdinov, N. I. Safiullin, I. R., Shaislamov, V. Sh. (2014). Express method for assessing the degree of well interaction using frequency analysis of the history of the operation of injection and production wells. Neftepromyslovoe delo, 7, 10–13.

[11] Samadov, T., Novruzova, S., Aliev, A. (2018). Selecting the optimal regime for the group of wells with the account of interaction between them (in the field of Sangachal-Duval Khara-Zira adasi). Bulletin of Science and Practice, 4 (6), 188–196.

[12] Schulze-Riegert, R. W., Axmann, J. K., Haase, O., Rian, D. T., You, Y.-L. (2002). Evolutionary Algorithms Applied to History Matching of Complex Reservoirs. SPE Reservoir Evaluation & Engineering, 5 (2), 163–173. doi: http://doi.org/10.2118/77301-pa

[13] Mirzajanzade, A. Kh., Stepanova, G. S. (1977). Matematicheskaia teoriia eksperimenta v dobyche nefti i gaza. Moscow: Nedra, 229.

[14] Filipchuk, O., Marushchenko, V., Bratakh, M., Savchuk, M., Tarwat, S. (2018). Efficiency evaluation of implementation of optimization methods of operation modes of the «plast – gas pipeline & quot»; system by the methods of mathematical modeling. Eureka: Physics and Engineering, 5, 11–26. doi: http://doi.org/10.21303/2461-4262.2018.00717

[15] Ghedan, S. G., Thiebot, B. M., Boyd, D. A. (2006). Modeling Original Water Saturation in the Transition Zone of a Carbonate Oil Reservoir. SPE Reservoir Evaluation & Engineering, 9 (6), 681–687. doi: http://doi.org/10.2118/88756-pa

[16] Zeinalzade, Iu. A. (2001). Prognozirovanie kachestvennykh izmenenii v protcesse dobychi nefti i gaza. Azerbaidzhanckoe neftianoe khoziaistvo, 5, 66–69.

Received date 12.01.2022
Accepted date 18.07.2022
Published date 30.09.2022

How to cite: *Abbasova S., Mammadova G. (2022). Dynamic analysis as a method of wells interaction evaluation in making technological decisions. EUREKA: Physics and Engineering, 6, 32–42. doi: http://doi.org/10.21303/2461-4262.2022.002241*