ANNOTATION

dissertation work of Kunaeva Gauhar Ermekovna on the topic:
"Improving the development of oil fields, operated horizontal wells"
submitted for the degree of Doctor of Philosophy (PhD) degrees in the educational program 8D07210 (6D070800) – Oil and Gas Business

The relevance of research:

The main operational facilities of the oil fields of the Republic of Kazakhstan are at a late stage of development. The reserves of these objects are difficult to recover, due to factors such as high oil viscosity, low permeability of reservoirs, as well as high layer-by-layer and zonal heterogeneity, low effective thickness of reservoir layers, the presence of gas zones and low-power oil fringes. Residual hard-to-recover reserves require the introduction of new technologies.

The technology of drilling horizontal wells has huge prospects associated with the possibility of increasing the efficiency of oil production, extending the period of waterless operation of the well and increasing the oil recovery coefficient, involving in the development of reservoirs with low reservoir properties and high-viscosity oil, reducing depression on the formation and the effect of cone formation.

The growing interest, worldwide, in the use of horizontal wells, there is a need to develop a theory and study the processes of fluid filtration to the bottom of these wells, taking into account the above factors, and this becomes an urgent scientific and practical task.

Rationale for the need for this research work:

Analysis of the current state of the problem of exploitation of deposits by horizontal wells has shown that the following aspects are promising in the field of design, construction and operation of horizontal wells: analysis of geological conditions and justification of the need to use horizontal wells, as well as operational management of the profile of the wellbore, primarily in productive horizons.

This circumstance provides for the widespread use of geophysical research, the widespread use of mathematical methods, software for processing and interpreting data, analyzing the effectiveness of horizontal wells in the development of oil and gas fields; determining the performance of multi-hole horizontal wells, taking into account the perforation of the deformable formation; studying the characteristics of stationary fluid inflow to horizontal wells on the model of non-isothermal filtration; determining the optimal design horizontal borehole, etc. These issues are not limited to the range of urgent tasks that fill the gap in the problem under consideration. However, their solution, in our opinion, will undoubtedly be a decisive step in achieving the intended goal.

The purpose of the dissertation: is to develop new hydrodynamic methods for determining the productivity of horizontal wells in the development of oil fields with deformable reservoirs.

Adaptation of the hydrodynamic model to the history of the development of an oil field fragment for the calculation of forecast development options.

Research objectives:

1. Analysis of the effectiveness of horizontal wells in the development of oil and gas fields.
2. Determination of the productivity of multi-hole horizontal wells, taking into account the perforation of the deformable formation.
3. Study of the characteristics of stationary fluid inflow to horizontal wells on the model of non-isothermal filtration.
4. Determination of the optimal design of the horizontal borehole.
5. Adaptation of the hydrodynamic model of the reservoir fragment according to the history of development, in order to justify its operation by horizontal wells.

Object of study – The object of research is a field development system with branched horizontal wells in a deformable porous medium.

Subject of study – The process of stationary fluid inflow to horizontal wells, models of non–isothermal filtration with optimal design of the horizontal wellbore.

Research methods: to perform the above tasks, complex methods of research of the processes of development and operation of oil fields were used.

Basic provisions for defense:

The main scientific provisions are justified by their formulation, resulting from the analysis of the current state of the problem, the correct application of scientifically based modeling methods, as well as modern probabilistic and statistical methods of data processing and information analysis.

The use of standard equipment and proven measurement methods in experimental studies, the basic classical provisions of the mechanics of fluid and gas movement in pipes and porous media, as well as the development of an adequate hydrodynamic model of a reservoir fragment based on the history of development, based on real field data, confirm a fairly high degree of reliability of conclusions and recommendations.

Scientific novelty of the work.

1. The knowledge and experience of using horizontal wells in the development of oil and gas fields are summarized, the scope of their effective application is shown.
2. A mathematical model and its solution for steady-state liquid filtration to branched-horizontal wells in a deformable porous medium are proposed, scientifically substantiated and implemented.
3. A mathematical model of the mechanism of steady-state fluid movement in a deformable reservoir during inflow to a horizontal well has been refined, taking into account the dependence of fluid properties on pressure and temperature.
4. A methodology has been developed for the automated solution of the

problems of adapting the hydrodynamic model of a reservoir fragment according to the history of development, which makes it possible to evaluate the operation of its horizontal wells taking into account the probabilistic and statistical nature of geological data.

The practical significance of the work:

On the basis of three-dimensional hydrodynamic modeling, the adaptation of the sector model to the actual performance of the surrounding wells was carried out.

A comparison of the calculated and actual indicators of the development of the sector model of the field showed a high degree of reliability, the construction of a geological and hydrodynamic simulation model of the reservoir, sufficient to bring forward calculations with various well designs

Using the example of a real object, a quantitative assessment of the possible improvement in the dynamics of the development of oil reserves from the reservoir due to the transformation of the existing development system based on horizontal wells was obtained.

Compliance with the directions of scientific development or state programs: The dissertation corresponds to the priority direction of scientific development, approved by the Higher Scientific and Technical Commission under the Government of the Republic of Kazakhstan in direction 1. Ecology, environment and rational use of natural resources: incl. 21) Development and operation of oil and gas fields.

The author's personal contribution consists in determining the purpose of the work and setting research objectives, actively participated in the discussion of the results of the dissertation, writing articles and abstracts. In addition, the author investigated the main methods and results of adapting the hydrodynamic model in the history of oil field development in order to use the model to calculate forecast options. All the main results of the work were obtained personally by the author. The author independently conducted structural studies, calculation and analysis of horizontal wells. The author took part in the processing and analysis of the simulation results. The results given in this dissertation work have been repeatedly reported by the author at international and national conferences.

Reliability of the results: The reliability of the results is ensured by the validity of the applied hydrodynamic models, the use of modern methods for solving initial boundary value problems, as well as verification of the results obtained by other authors.

Description of the main research results: Based on the results of the research, the following main conclusions can be drawn:

1. A hydrodynamic model of fluid inflow to branched horizontal wells in a three-dimensional formulation in a deformable porous medium is proposed, scientifically substantiated and implemented.

2. The flow pattern is investigated depending on the deformation and geometric characteristics of the formation and the number of trunks, taking into account the density of perforations, the effectiveness of the adopted model is shown.

3. The problem of identification of the relative phase permeability function by the method of modern optimal control of the hydrodynamic model of the multiphase fluid filtration process in the sector model of the Kenkiyak deposit is posed and solved.

4. On the basis of the constructed geological model, the possibility of purposeful and effective refinement of the hydrodynamic model of the process, and thereby correction to improve the forecast of technical and economic indicators of the sector model of the field using horizontal wells, is shown.

5. Calculations have established the degree of influence of various geological and technological factors on the determination of the optimal design of the horizontal borehole. It is established that the optimal well injection option can be determined based on the analysis of anisotropy in permeability and reservoir thickness.

6. A significant influence of changes in the thermodynamic conditions of the formation on the indicators of well development has been established.

7. The analysis established that the basic principles of development worked out with the use of vertical wells, concerning in-depth study and detailed analysis of geological conditions, reasonable allocation of operational facilities, assessment of the impact of the grid density of wells on current production and oil recovery, establishment of the operating mode (optimal and minimum allowable values of reservoir and bottom-hole pressures), control and regulation of development processes, also require attention in relation to the development of deposits by horizontal wells. Moreover, these issues have to be paid much more attention when using horizontal wells than when exploiting deposits with vertical wells (this is especially true for studying the details of the geological structure, well operation modes, control and regulation of development processes.

8. The presence of a relationship between the initial flow rate of the HS and parameters such as the length of the horizontal shaft in the formation, the thickness of the opened interval, anisotropy in permeability, etc.

9. The main factors and positions on which it is necessary to focus attention when designing the optimal design of horizontal boreholes, namely:

• the optimal option for completing wells can be it is determined based on the analysis of the anisotropy and thickness of the formation, which will increase the reliability of the choice of wiring of horizontal wells;

• to achieve the potential effect of the use of HS, it is necessary to create separate technological cells.

10. An improved calculation scheme is proposed for estimating the distribution of hydro conductivity based on data on geological features, filtration and capacitance characteristics of an oil reservoir, the implementation of which makes it possible to justify the drilling site of the most efficient horizontal wells in terms of the orbit. Almost the same approach was applied to the development of a large number of deposits in other regions, which we also recommended for the conditions of Kazakhstan.

11. An expression is obtained for approximate forecast calculations of the relative productivity of horizontal wells depending on the length of the horizontal trunk according to generalized literature data for Kazakhstan fields.

Approbation of work results: The results of the dissertation and its main points were reported and discussed at the International Scientific and Practical Conference "Financial, economic and legal aspects of international cooperation of the Caspian states", dedicated to the program of modernization of public consciousness "Rukhani Zhangyru". Aktau, 2018; International Scientific and Practical Conference "Modern technological solutions in the petrochemical industry", Aktau, 2022; International Scientific and Practical Online Conference «Modern Technologies in Science and Education». Aktau, 04/28/2021; at the Ith International Forum « Transport. Development horizons ». Nizhny Novgorod, May 25-28, 2021; at the International Scientific and Practical Conference « Advances in Oil and Gas Geology and Geotechnologies ». Baku, May 23-26, 2023.

Publications:

The main results of the dissertation are published in 15 scientific works, including in the leading peer-reviewed scientific journals recommended by Committee for Control in the Sphere of Education and Science of the Republic of Kazakhstan, as well as on the basis of foreign scientific materials Scopus.

Volume and structure of the dissertation work: The dissertation consists of an introduction, three chapters, main conclusions and recommendations, a list of used literature, including 74 titles and 2 applications. The work contains 96 pages of text, 9 tables and 32 drawings.