# ANNOTATION

for the dissertation thesis submitted on the Requirements for the Degree of Doctor of Philosophy (Ph.D.) in Petroleum Engineering (8D07202) Satbayev University by Durmagambetov Berik Oralovich

## «Hydraulic fracturing efficiency study and optimization of reservoir performance at the Arystan field»

### General Characteristics of the Dissertation Research

The present work is devoted to optimizing the performance of the Arystan oil field. At the current stage of development, the decrease in oil production is mainly due to multiple depletion of reservoir pressure, so revising approaches to oil production intensification for stable operation of the mechanized well stock is the main task for the profitability of the project as a whole. The development of methods for oil production intensification using hydraulic fracturing (HF) on the research object was accepted as the main methodology for production. Hydraulic fracturing increases well productivity, however, its efficiency is not always high, taking into account the negative energy dynamics of the research object.

**The relevance of the study** lies in the fact that the available field data required for hydraulic fracturing design is mainly presented in the form of pressure change over time, which does not allow determining the actual geometry of the artificial fractures created by hydraulic fracturing. Therefore, designing and managing the HF process is only possible relying on complex multi-physics and numerical models.

In this study, a method based on "Lagrangian" mechanics was used to simulate (multi-physics) hydraulic fracturing using methods for measuring crack height, which represents a new approach in the field of intensification. Thanks to this study, some parameters that affect HF, such as crack length, fracturing fluid injection rate, proppant concentration, and fracturing fluid composition, were estimated and analyzed. In the next stage, a three-dimensional reservoir model was simulated to predict the accumulated oil production in the reservoir sandstone for different scenarios using the most accurate HF modeling method for numerical methods.

**The goal of this study** is to optimize the parameters that have a significant impact on the effectiveness of hydraulic fracturing operations. The maximum well productivity index, which depends on the resulting (effective) half-length of the fracture, was used to evaluate the highest efficiency of hydraulic fracturing operations.

In this study, the "Sensitivity Analysis Method" of various parameters was used to determine their impact on the effectiveness of hydraulic fracturing operations. After determining the effective parameters using the sensitivity analysis method, the values of these parameters were optimized using "Intesect," "Kinetics" simulators and "Techlog" software in this study. A new method for optimizing hydraulic fracturing parameters was proposed in this study, taking into account the thermobaric conditions of the reservoir during the fracturing process, including the length of the fracture and the injection method. The result of this work is the development of a new approach to predicting and designing hydraulic fracturing operations.

**Based on the stated goal and the analysis of the problem, the following main research tasks were formulated:**

1. Review of similar studies and analysis of existing hydraulic fracturing theories.
2. Modeling and optimization of geometric parameters of fractures created in the reservoir for oil-bearing sandstone using the simulators "Intesect", "Kinetics" and the program "Techlog".
3. Forecasting the impact of fracture geometric parameters on well productivity and cumulative oil production after hydraulic fracturing.
4. Laboratory studies of the composition of mechanical impurities and the nature of deposits that reduce permeability.
5. Development of a new strategy for designing well stimulation taking into account the thermobaric conditions of the reservoir.
6. Investigation of key parameters that influence the well productivity coefficient.

**Research methods**

The methodology for solving the tasks is based on studying and summarizing theoretical knowledge related to the problem, using multi-physics and numerical simulators, as well as modern software for analyzing laboratory and field research results.

**Scientific novelty:**

1. A new model based on the "Lagrangian" method has been proposed for modeling hydraulic fracturing using methods of measuring fracture height (multi-physics).
2. A new approach for optimizing hydraulic fracturing parameters in oil-bearing sandstone using numerical modeling has been developed.
3. A new method for estimating permeability parameters taking into account the thermobaric conditions in the bottomhole zone has been proposed.
4. A new method for estimating the skin factor of fractures after hydraulic fracturing has been proposed.
5. A new method for forecasting accumulated oil production after hydraulic fracturing has been proposed.

**Main theses to be defended:**

1. An optimization model for hydraulic fracturing in oil-bearing sandstone using the "Intersect" simulator.
2. A model for predicting the effective permeability reduction of salt deposits under aggressive thermobaric conditions.
3. A hydraulic fracturing process model and a new approach for optimizing fracture length parameters and injection methods under conditions of active reservoir depletion using the "Kinetix" software.
4. A method for forecasting accumulated oil production after hydraulic fracturing.

**Practical significance and implementation of the research results:**
Based on the new mathematical model for predicting the hydraulic fracturing pressure and evaluating the impact of fracture geometric parameters on well productivity, a new approach to optimizing the parameters of hydraulic fracturing in an oil-bearing sandstone reservoir at the Arystan field has been developed. The research results were applied by Ken Sary LLP when planning hydraulic fracturing operations. In general, the research results can be used in planning and conducting hydraulic fracturing operations at fields with similar geodynamic conditions.

The validity and reliability of the results, scientific propositions, and conclusions contained in the dissertation are confirmed by the consistency of the calculation results obtained with known theoretical and experimental data published in authoritative scientific publications.

**The author's personal** contribution includes setting the goal and objectives of the research, choosing methods for solving the assigned tasks, carrying out the main volume of theoretical and practical research presented in the dissertation, analyzing and summarizing existing theoretical material and field data on the subject matter.

**Publications of the research results:**


1. *B. Durmagambetov D. Abdrazakov, D. Urmanova. 2022. Advanced methods of fracture geometry analysis and parameters sensitivity study. News of the National Academy of Sciences of the Republic of Kazakhstan /Series of geology and technical sciences, Volume 6, Number 456 Pages 45-57 ,2022, ISSN 2224-5278 https://doi.org/10.32014/2022.2518-170X.237*
2. *D. Urmanova, B. Durmagambetov, John D. Humphrey,S. Zagranichniy 2022. Geological and hydrodinamic modeling of an oil field of the pricaspian region of the republic of Kazakhstan. News of the National Academy of Sciences of the Republic of Kazakhstan /Series of geology and technical sciences, Volume 5, Number 456 Pages 266-288 ,2022, ISSN 2224-5278 https://doi.org/10.32014/2022.2518-170X.237*
3. *B. Durmagambetov, D. Urmanova. A. Temirkhasov 2022. Geological and geochemical features of an oil field of Precaspian region Scientific and technical journal Oil and Gas №2 2022. УДК 553.982.233.2/.3; https://doi.org/10.37878/2708-0080/2022-2.03 32-41*
4. *B. Durmagambetov, D. Urmanova. A. Temirkhasov 2022. Problem Research salt formation at the field Caspian region Scientific and technical journal Oil and Gas №5 2022. УДК 553.982.233.2/.3; https://doi.org/10.37878/2708-0080/2022-2.03 40-64*
5. *B. Durmagambetov, D. Urmanova. A. Temirkhasov 2022. Using a special complex logging to study the properties of reservoir fluids and reservoir ocks Cretaceous and Jurassic deposits periods of the Arystan field Scientific and technical journal Oil and Gas №6 2022. УДК 550.8 https://doi.org/10.37878/2708-0080/2022-2.03 6-18*

**Volume and structure of the dissertation** The dissertation consists of an introduction, 5 chapters, conclusions, and a list of references. The materials of the dissertation are presented in 127 pages of text, containing 141 figures . The list of references includes 47 sources.

The first chapter provides information on the geology of the Aryshtan oil field and the features of its complicated development.

The second chapter describes the numerical reservoir model that was used to evaluate the uncertainty of well productivity decline. The analysis of the main uncertain parameters that affect pressure drop and liquid production was carried out. As a result, a list of recommendations for further research was created.

The third chapter demonstrates a new approach to modeling hydraulic fracturing suitable for the field as a whole.

The fourth chapter contains recommendations on methods for controlling the formation of salt deposits.

The fifth chapter describes a revision of the hydraulic fracturing design. The economic efficiency of intensification techniques was calculated, taking into account the depletion of reservoir pressure.