Studies of the hydrodynamic properties of the formation of an oil and gas condensate field

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Abstract. This paper presents the experience of well testing conducted by several geological associations. The studies were conducted to assess the characteristics of productive formations, such as hydroconductivity, productivity, saturation pattern and operating mode. Various methods and equipment were used, including various types of drilling rigs and drills. Some disadvantages of the tests are also described, such as the erroneous choice of perforation intervals or poor-quality gas condensate studies. The data on the tools and techniques used, as well as the results of studies on stationary and unsteady filtration modes are presented. The findings of the study will help to improve understanding of the geological characteristics of the formations and improve production efficiency.

1 Introduction

Drilling and testing of wells were carried out by some geological associations. Well tests were carried out in order to search for productive formations, assess their productivity, hydroconductivity, the position of the WOC, GOC, GWC, the nature of saturation, the mode of operation of the formations, and the hydrogeology of deposits. Wells were tested from drilling rigs A-50, Azinmash-8M, BU-25 DSU. After installing the wellhead equipment, the column was checked for tightness by pumping process water to a pressure of 9.8-22 MPa [1-5].

During the perforation, a perforating valve was installed at the wellhead. The borehole was filled with a clay solution with a density of 1.10-1.26 g/cm^3, a viscosity of 23-60 sec, and a water output of 5-8 cm^3/30min. Perforators PKO-89, PK-105, PK-80, PK-20, ZPKS-80, PKKS-80, PKKS-105, PR-43, PR-54 were used to open the formation. The perforation density is 12-20 rel/m with a total number of 24-150 holes. Tubing descended to an interval of 1-41 m above or 1-87 m below the upper limit of the perforation interval [6-8].

The inflow was caused by replacing the clay solution with water, followed by lowering the level with a compressor or swabbing. The number of drops is 3-6, the time of standing on the tributary is 6-24 hours. The level was tracked with a float or a depth gauge. When gushing wells, the column was cleaned of process water and mortar. After that, studies were conducted on 2-6 modes of forward and reverse travel. The tests were carried out on 2-24

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mm fittings. The working time is 9-55 hours. In gas condensate wells, the time of a standard study in one mode reached 185 hours.

Tests of wells in the open bore were carried out by the KII-2M-146 and KII-95 plasto-testers. In a number of wells, a reservoir tester on the OPN-140 cable was used. In a number of cased wells, tests were carried out with a set of KII-95, KOIS-116D. Tests using the KOIS-116D kit in a number of wells were carried out poorly, which led to overflowing and the production of mixed inflows in reservoirs uniquely oil-saturated according to GEW [9-12].

Well and reservoir hydrodynamics is an important aspect in the oil and gas industry and plays a key role in determining well productivity, understanding operating modes and optimizing production. Well productivity is one of the important criteria for determining the success of a well. It depends on factors such as reservoir throughput, reservoir pressure and well operation mode. The analysis of the results of hydrodynamic studies allows us to determine the prospects for increasing the productivity of the well and make appropriate decisions aimed at optimizing the production process.

The operating mode of the well includes the entire range of measures aimed at achieving optimal parameters of the production process. Proper modification of the operating mode can lead to an increase in the flow rate of the well, reduce maintenance costs and extend the service life. The analysis of the results of the hydrodynamics study makes it possible to determine the best operating mode for each specific well, taking into account its geological and technical features.

2 Methods and Materials

The main method of studying the hydrodynamics of wells and reservoirs is the analysis of the results of stem tests and field data. Stem tests are used to obtain flow parameters (flow rates, pressures, temperatures) and properties of the reservoir fluid (viscosity, density, oil and gas content). Field data, which includes information about the operating modes of the well and input data for calculating models, are also an integral part of the analysis of the result [14-16].

After receiving the initial data, their analysis and interpretation are performed. Mathematical modeling of hydrodynamic parameters, such as pressure distribution in the reservoir, effective throughput, productivity coefficient, etc., is carried out using special programs. These calculations allow us to assess the state of the reservoir, its potential and opportunities for increasing production.

3 Results and Discussion

Next, we present the tables that describe the main results of the study (Table 1-2).

Table 1. The given data.

h, m	μ, mPa^{-c}	Q, m^3/day	m	$\beta_{sm}, \frac{1}{atm}$	β_c
5	1.5	50	0.2	$1.16 * 10^3$	10^{-10}

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Table 2. The data obtained as a result of well research.

t, min	ΔP, MPa
0	3.18
100	5.064
210	6.618
313	7.727
418	8.574
510	9.129
599	9.539
700	9.902
785	10.161
870	10.535
955	10.62
1045	10.702
1135	10.777
1225	10.846
1315	10.911
1405	10.971
1495	11.028
1585	11.081
1675	11.131
1750	11.171
1825	11.209
1900	11.246

According to the research data, a pressure recovery curve (KVD) is constructed in the coordinates ΔP = f (ln(t)).

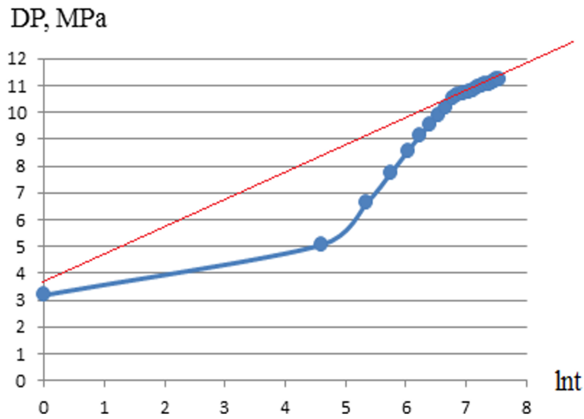

Fig. 1. Pressure recovery curve.

Let's allocate a rectilinear section to the KVD and find the angular coefficient b. Using the MS Excel function (trend line equation), the coefficient b = 3.5 Mpa.

Let's determine the hydraulic conductivity of the reservoir by the formula:

$$\varepsilon = \frac{Q}{4\pi b} = \frac{50}{4 * 3.14 * 3.5} = 1.14 \frac{\text{м}^3}{\text{MPa} * \text{day}} = 0.132 * 10^{-10} \frac{\text{м}^3}{\text{Pa} * \text{d}} \quad (1)$$

Let's find the permeability coefficient of the reservoir using the formula:

$$\varepsilon = \frac{\varepsilon * \mu}{h} = \frac{0.132 * 10^{-10} * \ 1.5 * 10^{-3}}{5} = \ 0.0396 * 10^{-12}\mathrm{m}^2 \quad (2)$$

Let's determine the reservoir conductivity coefficient by the formula:

$$\frac{k}{\mu} = \frac{0.0396 * 10^{-12}}{1.5 * 10^{-3}} = 0.264 * 10^{-10}\frac{\mathrm{m}^2}{\mathrm{Pa} * \mathrm{d}} \quad (3)$$

Let's determine the piezo conductivity coefficient by the formula:

$$\chi = \frac{k}{\mu(m * \beta_{\text{см}} + \beta_c)} = \frac{0.0396 * 10^{-12}}{1.5 * 10^{-3}(0.2 * 1.16 * 10^3 + 10^{-10})} = 1.14 * 10^{-7} \quad (4)$$

The study of the hydrodynamics of wells and formations aims to obtain information about the physical properties of the formation, flow parameters and well throughput. This information is necessary to determine the optimal operating mode of the well and plan measures to increase its productivity.

The study of the hydrodynamics of wells and reservoirs is an integral part of the oil and gas production process. Analysis of the results, productivity and optimal operating modes of wells make it possible to effectively use oil and gas reserves, increase the economic efficiency of projects and improve overall production efficiency. This ensures the stability and sustainability of the development of the oil and gas sector and the country as a whole.

4 Conclusion

Thus, the interpretation of the results of well studies in unsteady filtration modes allows us to quantify the values of the parameters characterizing the formation and the well (hydroconductivity, permeability, piezoconductivity of the formation and reservoir conductivity. This data is necessary for:

- Using them in the calculations of development indicators in the preparation of field development projects.
- Comparing them (characterize the remote zone of the formation) with similar data obtained from the results of studies under steady-state operating conditions (characterize the PPP).
- Determination of reservoir parameters over time to assess the technological effectiveness of measures related to the use of methods to increase oil recovery and to control development.

The discussion of the results of the study of the hydrodynamics of wells and reservoirs allows the authors to express their opinions and make recommendations for further work in the field of hydrodynamics. This may include suggestions for further research, possible applications of the results obtained, or discussion of problems related to the implementation of the proposed recommendations. First of all, it is important to note that this study is of great practical importance, since well testing is an integral part of the development process of oil and gas fields. The accuracy of forecasting the inflow and flow rate of a well, as well as determining its current state and evaluating the possibilities of increasing production, depends on properly conducted tests. The study allowed us to determine the characteristics of formations, the hydrogeology of deposits and the productivity of wells, however, there are disadvantages that may affect the accuracy and reliability of test results.

To improve the accuracy and reliability of the results, it is necessary to use modern equipment, monitor the quality of testing and carefully process the data obtained. It is also important to carry out additional checks and control tests to confirm the results obtained. All this will increase the reliability and usefulness of research for decision-making in the field of geology and hydrogeology.

References

1. L.F. Yusupova, R.R. Khusnutdinova, R.A. Gilyazetdinov, E.M. Almukhametova, A study of the effect of the limiting shear gradient on the pressure recovery curve during hydraulic fracturing, IOP Conference Series: Earth and Environmental Science (EES), **1021**(**1**), 012010 (2022)
2. L.F. Yusupova, K.M. Khalikova, R.R. Khusnutdinova, Technological feature of water shutoff operations, IOP Conference Series: Earth and Environmental Science (EES), **868**(**1**), 012086 (2021)
3. R.Z. Nurgaliev, I.G. Fattakhov, R.R. Khusnutdinova, A.S. Zhirkeev, A.K. Sakhapova, A method for assessing the effectiveness of water isolation works based on the development of a hydrodynamic model, SOCAR Proceedings, **1**, 94–99 (2023)
4. R.R. Khusnutdinova, L.V. Petrova, L.F. Yusupova, R.A. Gilyazetdinov, Experience of applying the shock wave impact method for the bottomhole zone, IOP Conference Series: Earth and Environmental Science (EES), **1021**(**1**), 012070 (2022)
5. G.R. Izmailova, Research on the high-frequency electromagnetic acoustic heating of an oil reservoir with further pumping of a solvent, High temperature, **56**, 6 (2018)
6. G.M. Siraeva, I.G. Fattakhov, L.S. Kuleshova, R.R. Stepanova, Use of acid fracturing to increase the production potential of subsoil users, IOP Conference Series: Earth and Environmental Science, **1021**(**1**), 012055 (2022)
7. A.V. Kochetkov, I.G. Fattakhov, L.S. Kuleshova, R.R. Stepanova, A.R. Safiullina, Justification for proppant concentration choice during hydraulic fracturing, IOP Conference Series: Earth and Environmental Science, **1021**(**1**), 012058 (2022)
8. M.V. Goryunova, L.S. Kuleshova, A.I. Khakimova, Application of signal analysis for diagnostics, International Conference on Industrial Engineering, Applications and Manufacturing (ICIEAM) (2017)
9. V.N. Polyakov, A.P. Chizhov, Yu.A. Kotenev, V.Sh. Mukhametshin, Results of system drilling techniques and completion of oil and gas wells, IOP Conference Series: Earth and Environmental Science, **378**(**1**), 012119 (2019)
10. A.V. Stenkin, Yu.A. Kotenev, V.Sh. Mukhametshin, Sh.Kh. Sultanov, Use of low-mineralized water for displacing oil from clay productive field formations, IOP Conference Series: Materials Science and Engineering, **560**(**1**), 012202 (2019)
11. N.T. Thanh, M.M. Veliev, Kh.L. Viet, Oil and Gas Territory. 10 (2015)
12. T.M. Aggour, M.J. Economides, SPE 36902 (1996)
13. R. Dusterholf, S. Vitthal, D. McMechan, H. Walters, SPE 30103.4 (1995)
14. H.E. Mason, M.M. Smith, International Journal of Greenhouse Gas Control, 87 (2019)
15. A.S. Zakaria, H.A. Nasr-El-Din, SPE Journal, **21**(**3**) (2016)
16. V.V. Mukhametshin, V.E. Andreev, Search and argumentation of decisions aimed at increasing the efficiency of bottom-hole zone stimulation in oil accumulations with challenged reserves, SPE Russian Petroleum Technology Conference (2017)