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Research paper

On Modern Possibilities of Research on Gas and Gas-Condensate Wells in Any Filtering Mode

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Abstract

The analysis of studies examining gas and gas condensate wells in industrial practice indicates the positivity of carrying off work on the study of wells in the case of stationary filtration according to the traditional technology or technology of research in one mode actually worked out. In the case of examining high-permeable layers with nonstationary filtration, the studies are reduced to obtaining the pressure recovery curves and applying mathematical techniques for obtaining required information about the studied layers by means of interpretating them.

It has been emphasized that it is the possible to use a new method of research and create of a methodology for interpreting the data obtained.

In addition, a method is proposed for preliminary estimation of the value of initial gas reserves. It provides simplifying the calculation method by reducing the amount of output data; reduction of a considerable amount of geophysical research (one mode of research, is enough which combines the operation of the well in the mode and the closure of the well for the removal of PBU curve). If one adds the possibility of application of the software product to these advantages, then we can state that solving task of calculating gas reserves in a wider spectrum can be optimized.

The position on compliance with the limits of the technological corridor in the process of exploitation and research of wells has also been outlined. The method of its determination does not depend on what the filtration process is, that is whether it is stationary or non-stationary. It is characterized by relative simplicity and accessibility.

Keywords: *gas hydrodynamic parameters, gas reserves calculation, non-stationary mode, research of wells.*

1. Introduction

In solving industrial problems gas-hydrodynamic, geophysical and laboratory studies are used for studying geometrical characteristics of a deposit.

Geometric characteristics are the sizes of product tanks, the change in the overall and effective capacity of the reservoir.

Collector and filtration properties of the formation are porosity, permeability, gas conductivity, piezoelectricity, compressibility, formation, vibration, utter pressure and temperature.

Physico-chemical properties of gas and gas condensate are viscosity, density, coefficient of compressibility, gas saturation, humidity.

The hydro-gas-dynamic and thermodynamic conditions in the wellbore during the operation and the technological operation of the wells are also important. They change in the presence of various factors. These include destruction of the hinterland, the presence of planting water, the design and properties of the equipment used and ground communications.

Laboratory studies are mainly focused on the study of the physical and chemical properties of gas-containing objects and of the gas and fluid in them. In most cases conditions for obtaining reservoir parameters (porosity, permeability, gas saturation) for small samples in laboratories differ significantly from those parameters in natural conditions. In addition, they are point-specific. It is therefore incorrect to distribute them to the entire field.

Geophysical methods characterize areas close to the walls of the wellbore. These include logging, nuclear magnetic resonance, thermometry and debitometry. With their help, it is possible to determine the productive intervals or interlayers the debits of individual interlayers, the coefficients of filtration resistance, permeability, and piezoelectric conductivity.

Gas-dynamic research methods include the removal of the PBUC after the stop of the well, the removal of the curves for pressure stabilizing and debit when starting of the well on a particular mode (washers, fittings, diaphragms) and removal of the indicator curve. It represents the relationship between blunt pressure and debit during well operation in different modes. These studies provide factual data for their interpretation and obtaining reliable information about the studied layers. Moreover, studies under the conditions of stationary filtration are described in various ways. But studies performed in nonstationary mode have a problem. It consists in the absence of a research method in general, and even more so in one non-stationary mode.

2. Main body

The study of the actual material from researches of wells in the conditions of stationary and non-stationary filtration revealed advantages and disadvantages [1]. The availability of research methods of gas and gas condensate wells in stationary mode filtering, is a positive feature. It is them that are used by manufactures. At the same time, they work out 5-8 operating modes of wells. It takes a long time if the well is medium to low-productive. As far as the research of high-performance wells is concerned, it should be mentioned there are no methods for their research in the domestic or in the world practice.

Thus, gas hydrodynamic studies of wells can occur under the conditions of stationary and non-stationary filtration.

Of course, there are no absolutely stationary regimes in the nature because of the limited size of the volumes of gas and gas condensate fields. However, under certain conditionality, it is possible to consider a stationary regime as a non-stationary regime, in which the change in pressure and flow during a period of time is not fixed by the most accurate devices. In this case, the measurement time of the required parameter should be significantly less than the time of depletion of the deposit. Stationary modes are well studied. They are investigated by well-known methods: steady selections methods, isochronous methods, monotonically-stepped pressure drop methods and express method. In order to do that the well is investigated on 5-8 modes of direct motion and on several modes of the reverse. Each mode consists of two processes occurring in time. The open period process, when the well is open and is operating in a mode to remove the pressure curve and the stabilization curve. The closed period process in the process when the well is closed and is removed by the PBUC. That, is as a result of the research, they receive 5-8 curves of the tide, 5-8 curves of pressure recovery and several curves in the reverse of the research. It takes some time depending on the performance of the well. As one mode can last from an hour to a month. That is for this reason, you can only imagine the duration of the work of 5-8 modes at adverse conditions because of the low productivity of the well.

Interpreting the obtained data of the research, using known methods make it possible to obtain from 5 to 8 parameters of investigated layers.

But there is another way of research and data processing. They use the results of one actually practiced research mode. This allows us to obtain analytically, without basing on laboratory or geophysical data of researches, at least 20 parameters of productive investigated layers [2, 3].

This method and methodology of interpretation have been tested in production conditions on №54 Matvievska and №2 Kaverdinska. They have showed a good result.

Due to this, the component of the economic effect can be considered to include:

- determinating not 5-8, but more than 20 gas-hydrodynamic parameters of investigated wells with increased accuracy (analytically);
- saving time for working out 1 mode in comparison with the time for working out 5-8 modes;
- gas savings when the well is not operating into the gas pipeline, but in to the release into the atmosphere;
- time saving for mathematical interpretation of research results.

There are different approaches for gas wells that are not valid. For example, artificial deceleration of the process of inflow or restoration of pressure is one of them. Such wells are characterized by high productivity. When opening or closing such wells for the removal of tide curves or PBU processes take place very quickly. Therefore, operators can not fix simultaneously two parameters - pressure and time, or the flow rate and time. In order to solve this problem, a method of researching wells under non-stationary filtration has been developed and patented [4]. Also, searches for theoretical bases for the creation of a method for calculating at least 20 gas-hydrodynamic parameters of investigated layers for gas and gas-condensate wells are carried out. In order to increase the accuracy of the information received, it is also desirable to receive it analytically. Then you will not need to use the approximate laboratory or geophysical methods.

An attempt has been made to solve this problem by using advanced technical means: a small-sized gas-dynamic action latch, a gas flow meter, a shut-off and swiveling flushing valve. They can solve the research problem of wells, stacked with columns. They can also be applied in the open wellbore, which are in the process of drilling.

Currently, the technique of interpretation is also being developed. It takes some time. In addition to the scientific fundamentals of the methodology, it is necessary to draw up a clear algorithm for solving this problem. The theoretical foundations of the methodology of interpretation will be based on differential and integral methods.

According to the actual data of a well research in one non-stationary mode, it is possible to calculate the preliminary value of the initial reserve of products in the investigated facility. In order to do that you must apply the method presented in the publication [6].

Due to the new method for researching gas and gas condensate wells in one non-stationary mode, the component of the economic effect can be considered as the following:

- a fundamental opportunity to research high-quality gas and gas condensate wells, after which the operation is stopped, and the pressure is restored instantaneously;
- a new method of research which has not existed until now;
- the ability to determine the gas hydrodynamic parameters for the characterization of the well-reservoir system;
- reduction of research time due to one non-stationary mode instead of 5-8;
- determination of more than 20 gas-hydrodynamic parameters of investigated wells with increased accuracy due to the analytical method of their finding;
- gas savings due to research on a single mode, if the well worked not in the gas pipeline, but on the release into the atmosphere;
- time saving for the mathematical interpretation of the results of the research due to the mathematical model.

Evaluating the concrete economic effect achieved in absolute terms would be an incorrect task. Because the cost of researching wells in stationary or non-stationary filtration regimes for different wells will be different. A specific well requires specific individual costs for its research. But it is possible to talk about the economic effect in relative terms. The general economic costs will be several times smaller than the cost of similar work performed by other possible approaches and methods. This is possible due to the reduction in the number of research modes in each particular well. That is, the cost of research work on a specific well in any traditional way should be reduced several times. This will correspond to the cost of research on the new technology [4].

Ability to solve problems and the calculation of the value of the initial gas reserves in a productive gas object is realized as follows:

- initially they should measure the total gas extraction during the period of excitation of the gas flow, purge and well study (in one mode) under atmospheric conditions, ΔV_{at}, m^3;

- then the initial value of the formation pressure and the value of the formation pressure after the study, respectively P_l, P_{l1}, Pa;

- then the initial value of the reservoir pressure and the value of the formation pressure after the study, respectively, T_l, T_{l1}, K;

- they determine the coefficients of gas compressibility in reservoir conditions before the study and after the completion of the study z_l , z_{l1}, dimensionless;

- on the basis of the given initial data, preliminary estimation of the value of the initial gas reserves is carried out according to the formula [5, 6]:

$$V_{at} = \Delta V_{at} \frac{P_l \, z_{l1} T_{l1}}{P_l z_{l1} T_{l1} - P_{l1} z_l T_l} \quad (1)$$

Also, when discussing the operation and exploration of wells, it is also necessary to consider the problem of defining the technological mode. Typically, the technological mode of exploitation of wells in the presence of the possibility of the hinterland destruction is established according the composition of the rock particles from which the productive layer forms, in the rock digger on the mouth of the well. This indicator may be the necessary and sufficient condition for the establishment of the technological mode of operation of the well only when the structure of the well and the flow rate along its barrel ensure the transfer of rock particles to the surface. If, however, the destruction of the catchment zone of the formation occurs, and at the same time the velocity of the gas stream does not ensure the removal of the rock particles, it leads to the formation of sand casts.

Until now, in the conditions of the reservoir destruction and reliable criteria for establishing the optimal technological well operating conditions have not been developed.

One of the main tasks of the hydrodynamic research of wells is the research of the dependencies between the squeezing (abdominal) pressure, the depression on the formation, the flow rate, the design of the well, the physical and chemical properties of the porous media and the liquids and their saturated gases, and other parameters in order to substantiate and select the technological mode of their operation.

Reliability of the selected technological mode of operation depends on the reliability of the information obtained in gas-hydrodynamic and industrial-geophysical studies of wells. Therefore, when establishing the technological mode of wells exploitation, they use the data accumulated in the process of exploration, exploitation and exploitation by researching its geological section, conducting gas-hydrodynamic, gas condensate, geophysical and laboratory investigations of the properties of the porous medium and gases, condensate, oil and water contained therein. The quantity and quality of these studies do not always correspond to the norms and regulations, the observance of which according to the rules and regulations is mandatory. In most cases these deviations depend on the specifics of the gas industry. This is due to the fact that as a rule gas deposits, are heterogeneous in area and section, their capacitive and filtration parameters are not determined accurately. This is typical for the early stage of development, when there is not enough wells from which to receive information.

In general, the technological mode of wells operation is influenced by so many factors that, with insufficient knowledge of at least one of them, the established mode turns out to be incorrect. To establish the technological regime, it is necessary to consider:

- geographical and climatic conditions of the location area; form, type and mode of deposit; Capacitive and filtration parameters of the beds, depth and sequence of their occurrence, the presence of a hydrodynamic relationship between them; product reserves;
- conditions for opening the formation during the drilling process, the properties of the washing liquid, the degree of contamination at the bending zone with the washing liquid, formation to the destruction resistance the effect of pressure change on the reservoir parameters, the perfection of the well according to the degree and the nature of the disclosure;
- gas composition equipment;
- conditions of using gas and liquid at the rate of extraction, unevenness of extraction, calorific value of gas, etc.

Taking into account all the factors is practically impossible, because at least one of the factors often contradicts the other. In addition, some of these factors are beyond control. In order to establish the technological mode of well operation, taking into account all the factors, there is a need for the development of appropriate prescribes and mathematical criteria. In general part of the factors can be eliminated and they should be enterprise only the most important ones should be emphasized:

- deformation and resistance to the fracture of a productive section;
- presence of active plantar or boundary water (oil), capable to quickly flood a well;
- conditions, degree and nature of the layout opening, taking into account its anisotropy;
- possibility of sand cakes formation during operation;
- temperature and flow velocity in the column.

In order to optimally approach the identification of the technological corridor during the wells operation, it is possible to use the data obtained in its study according to the results of the research of gas and gas condensate wells.

A new approach is proposed for determining the optimal mode-technological corridor in the research of wells [7] .

Regardless the nature of research regimes if the well operation indicators shift and their exit from the technological corridor into the area of man-made seals, it will inevitably affect the usage indicators. Flowrate begins to decrease, permeability in the well zone of the formation also becomes worse.

If the indicators characterizing the operation of the well during the operation or during its study will not go beyond the technological corridor, then for any formation fluid filtration regimen, this is a guarantee of the preservation of the integrity of the catchment zone of the formation and the observance of the optimal amount of depression on the reservoir, etc. Compliance with the technological corridor will ensure the optimal operation of the gas or gas condensate well during the entire period of presence of these indicators within its limits. It will also increase the accuracy of the information on the layer and the product saturating it. It is especially important to adhere to this approach in the case of dealing with collectors of a fissure type.

Therefore, in order to optimally approach the identification of the technological corridor during wells operation, it is possible to use the data obtained in study it by the results of the research of gas and gas condensate wells.

3. Conclusions

It is obvious that application of methods for gas or gas condensate wells research for stationary filtration of products to the wells in one mode have significant advantages over traditional methods of research. The method of research the gas wells in the case of non-stationary filtration has no analogues in domestic and world practice at all. Patents were obtained for both methods. Therefore, it would be advisable to take more bolder steps forward their practical application in industrial practice.

This would save time for research. At the same time, the necessary funds for the work would decrease. This would increase the reliability of the information received about studied layers.

The methodology, presented in the paper, for calculation of gas reserves at the research stage has been solved for the first time has theoretical and practical value, and contains elements of novelty and is also protected by the patent of Ukraine [6].

Thanks to the application of the proposed calculation method, it was possible to simplify and reduce the volume of computations, reduce the number of basic data and increase their availability, since for receiving them it is not necessary to conduct previous geophysical studies. It is enough to conduct a study of a gas object on a single stationary or non-stationary mode and register all the

necessary indices of physical quantities that are necessary for the application of the technique. The software is not very complicated. In order to use it, is enough to have programmer engineering skills, therefore, it is not offered in this paper. But it is definitely an element of optimization of gas reserves in the investigated gas facility.

The purpose of the use of the proposed method for calculating gas reserves is that it can be used in industrial conditions for the operative preliminary estimation of the value of the initial gas reserves.

Availability and relative simplicity of the identifications of the boundaries of the technological corridor can undoubtedly be considered as one of the areas for improving the technology of exploration and exploitation of wells.

Keeping within the limits of the technological corridor in the process of exploration or exploitation of wells is a guarantee of their optimal exploitation in technological and economic terms.

Taken together, using as the basis of more qualitative and wider information, one can draw conclusions about the productive characteristics of the investigated gas objects and approach rationally the extraction of hydrocarbon raw materials from the earth's interior .

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