SOI: 1.1/TAS DOI: 10.15863/TAS
International Scientific Journal
Theoretical & Applied Science
p-ISSN: 2308-4944 (print) e-ISSN: 2409-0085 (online)
Year: 2023 Issue: 02 Volume: 118
Published: 16.02.2023 http://T-Science.org

Issue Article

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BASICS OF OIL FIELDS DEVELOPMENT

***Abstract**: The article discusses the basics of complex development of oil fields for which it is necessary to study their geological features, hydrodynamic calculations and economic justification. As well as the analysis of various methods of grid development during the operation of deposits under different operating modes.*

The necessary satisfaction of the selected objects for the development of the requirements for the most complete and rational extraction of oil from the reservoir is considered.

This work can be used to develop a field in order to ensure a given level of oil production at minimal costs and high oil recovery, as well as to establish a rational system for developing a deposit by constructing and feasibility analysis of a large number of very different well placement schemes and development options.

***Key words**: depletion, flooding, development grid, viscosity, baseline horizon, volume coefficient, contour, oil capacity, oil fields, horizon, hydrodynamic method.*
***Language**: English*
***Citation**: Deryaev, A. R. (2023). Basics of oil fields development. *ISJ Theoretical & Applied Science, 02 (118),* 289-292.
***Soi**: http://s-o-i.org/1.1/TAS-02-118-24 ***Doi**: crossref https://dx.doi.org/10.15863/TAS.2023.02.118.24
***Scopus ASCC**: 2209.*

Introduction

Under the rational development of an oil field, we mean such a development in which the field is drilled out with the minimum permissible number of wells, ensuring specified rates obtaining of oil production, high final oil recovery with the lowest possible capital investments and the minimum cost of oil.

For the rational development of the field are important right choice and justification of the allocation of production facilities.

Usually, an operational object is called that part of an oil reservoir that is allocated for drilling and operation with an independent grid of production and injection wells.

Allocation of production facilities - an integral part of the design of rational development of oil fields - must be conducted in a comprehensive manner based on the study of geological features of field, hydrodynamic calculations and economic justification. In this case, it is necessary that the selected object meets the requirements of the most complete and rational extraction of oil from the reservoir.

Geological field conditions for the selection of facilities can be formulated as follows [1].

1. A production facility must contain sufficient oil reserves for its cost-effective extraction with an independent well pattern.

2. A production facility can be one powerful or several smaller oil layers, separated over a large area from the higher and lower sediments by a pack of impermeable rocks.

3. A production facility must have an adequate effective capacity, the value of which is determined by economic profitability.

4. Formations with the same lithological composition and approximately the same permeability and porosity should be combined into one production facility.

5. One object should include formations containing oil, with identical or similar physicochemical properties and oil saturation of about the same area.

6. Oil-bearing layers combined into one object should be characterized by close values of the reduced reservoir pressure.

When considering operating conditions, it is necessary to take into account the proposed methods of stimulation of the formation [2].

If a geological deposit section contains a large number of oil reservoirs, they can be grouped into several production facilities, among which mark the base horizon and return objects.

Basic horizon necessarily is high-yield, having a primary economic importance, lies at a depth that is available for mass production wells drilling at the present level of technological development [3].

All overlying oil-bearing layers are divided according to their importance:

1) for objects of self-development; they can be developed with the reference horizon at the same time;

2) to objects of return; these include low-yield layers, the development of which is carried out by returning wells after depletion or watering them in the underlying layers.

Depending on the geological structure of productive layers, the field is drilled out along a uniform grid (according to some correct geometric scheme), in rows (batteries) or unsystematic (from a geometric point of view). A uniform grid can be triangular (or hexagonal at the same time) and square. In oil fields, when using a uniform grid, a triangular grid is used, for which a relation between the conditional recharge area *f* (in hectares) located per well and the distance between the wells y (in meters) is expressed by the ratio:

$$y=1{,}0\sqrt{f}.$$

In the US oil fields, a square grid is usually used, which is explained by the convenience of placing wells along the boundaries of individual oil areas, which, as a rule, have a square shape [4].

With a square grid, the dependence of the conditional feeding area of one well f_1 (in hectares) on the distance between the wells y_1 (in meters) can be expressed by the relation

$$y_1=\sqrt{f_1}$$

Uniform solid grid of wells is used in deposits development with a fixed cone of oil-bearing capacity (deposits isolated from the pressure of water are massive “waterfowl” deposits with the pressure of bottom waters.

The distance between the wells is chosen depending on the geological and technical conditions and economic considerations.

On oil deposits with pressure regimes (moving oil-bearing contours), wells are arranged in rows parallel to the moving contours: in the gas-driven regime - parallel to the gas-bearing contour, and in the water-driven regime - to the water-bearing contour [5].

Distance between the rows of wells for each individual reservoir may be constant or vary from row to row.

Distance between wells in a row may also be the same for all rows or different for each row. These distances are established when drawing up a reservoir development project.

An important indicator is an oil extraction rate - total oil production from the field for a certain period of time (day, month, year). For a given number of wells drilled for each specific reservoir, their average flow rates, and thereforecurrent production can be very different and depend on the established operating mode of each well.In turn, the operating modes of each well, and the entire field as a whole may vary over time depending on changes in geological and technical factors, and the energy field factors.

Natural conditions that determine the reservoir energy reserve in the reservoir cannot always ensure high rates of oil extraction from it due to the rapid decrease in reservoir pressure. For improvement of reservoir development conditions, as a rule, an artificial pressure regime is created, which is achieved by injecting water or gas into the reservoir to maintain a reservoir pressure at a high level [6, 7, 8].

When developing oil deposits using methods of artificial stimulation of reservoirs, sparse wells are usually used with a drainage area per well of 12-60 hectares or more, depending on the geological and physical conditions of the deposit.

Design system of each oil reservoir can be very different in both: grid placement of wells, the order and pace of drilling area and in terms of fluid extraction. In addition, an oil reservoir can be developed with or without artificial stimulation techniques.

As in nature there are a wide variety of oil deposits in size and power, bedding depth, geological and physical properties of oil-containing rocks and characteristics of the oil, content in gas and water formation, the general recipe for the selection of oil fields development systems can not be given. A purely individual approach should be applied to each deposit so that the development is the most rational and efficient, while observing the rules for the protection of subsoil.

Design development of oil deposits lies in the selection of this option, which would satisfy the requirements described earlier. Therefore, when establishing a rational development system, they are guided by following sequences:

a) determining the initial geological and physical data;

b) establishing of technical indicators for a particular reservoir development system by using hydrodynamic calculations;

c) assessment of the economic efficiency of various development options;

d) selection of the most rational development option based on a comparison of geological and technical and economic indicators.

Geological exploration of the field begins with the drilling of the first wells on it. General geological characteristics of the field are determined, its stratigraphy and tectonics are established, oil-bearing, gas-bearing and aquifers are identified, a connection is established between them, as well as between individual layers within one stratigraphic horizon, and operational objects are identified.

Characteristics of rocks (porosity, permeability, etc.), their oil and water saturation, gas content in oil, quality of oil and its properties in reservoir conditions (saturation pressure, volumetric coefficient, viscosity, etc.), characteristics of formation waters are determined for each object [9,10].

During a trial operation of exploration wells, reservoir pressure and well productivity are determined, the energy characteristics of the reservoirs and their modes are studied.

During exploration drilling, oil deposits size and configuration, oil-bearing contours, the position of oil-water and gas-oil contacts, the thickness of the layers in different zones are determined.

Based on obtained data, geological reserves of oil and gas are calculated and the commercial recoverable reserves are determined.

After geological and physical data accumulation on a field and determination of oil reserves, a procedure for the individual production facilities development is established and the design of the development of its individual horizons and deposits begins.

The main objectives of the design development oil deposits are as follows:

1) determination of a rational allocation pattern of production and injection wells and the procedure for their commissioning;

2) determination of production rates of wells at various stages of development, as well as the dynamics of changes in the current production of oil and associated water and gas as a whole for the reservoir;

3) determination of the operating time of individual groups of wells, as well as the full development period of the reservoir; identification of characteristic features of the advancement of the oil-water or oil-gas interface.

To solve the problem immediately by direct is not possible, since there is no method to directly determine the number of wells, their solutions scheme, procedure and operation of wells, providing a predetermined level of oil production at minimum cost and a high oil recovery. Therefore, it is possible to establish a rational system for the development of a deposit only through the construction and technical and economic analysis of a large number of very different well placement schemes and development options.

For each option of allocation wells in the area, hydrodynamic calculations are conducted to determine the current oil production from the reservoir, its change in time due to watering of the wells, the development period, etc.

In order to simplify the design of the development of oil deposits, the following are used:

1) physical parameters averaging of the reservoir according to a limited number of core studies (porosity, permeability, oil or water saturation, etc.);

2) reduction of the problem to the flat problem of filtration theory;

3) reduction of the reservoir configuration to a more correct geometric shape (schematization).

Calculating pressures in formations with large dip angles, reduced pressures are used.

A physical meaning of reduced pressures introduction is that an inclined layer is replaced by a horizontal one, an initial pressure in which is the same everywhere and in which, therefore, liquid and gas movement can arise only after the violation of this pressure constancy.

Hydrodynamic calculation methods basis is to identify a quantitative relation between well flow rates and pressure in them, in determining rates and timing of the formation fluid movement depending on the form of the reservoir, the parameters of the productive layer, oil and water viscosity, the number of relative positions of wells. Calculation formulas for hydrodynamic calculations are based on the basic laws of fluid filtration in porous media, the laws of interaction of individual wells in the process of their joint work [11].

Conducting calculations, resources of natural reservoir energy are taken into account, and, if necessary, a replenishment of this energy from the outside is provided.

In most cases, the natural reservoir energy supplies are limited. Therefore, modern technology for the development of oil fields provides for the use of artificial methods of stimulating the reservoir to replenish reservoir energy consumed in the development of oil reservoirs [12].

At present, processes of artificial influence on oil reservoirs, theoretically developed, are the main element in modern systems for the development of oil fields. Therefore, all hydrodynamic calculations of the main development parameters provide for the use of reservoir pressure maintenance methods.

At the same time, number and system of placement of injection wells, volume and pressure of liquid or gas injected into a layer are established.

Because of hydrodynamic calculations, which are additionally checked on electric reservoir models, a number of options are obtained for reservoir development with different technical indicators: a different number of wells in the area, different rates of oil extraction from the reservoir, different development periods, etc.

For each development option, the volume of capital investments and operating costs is determined, the cost of oil is identified, and production per worker is established. As a result of economic calculations, a relation is determined between labor cost, metal, capital investments, on the one hand, and number of wells in the area and the volume of current and total oil production, on the other.

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