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## Article

Consideration of the principles for stabilizing and increasing oil production at the later stage of field development (on the example of Ukraine fields)

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Volodymyr Doroshenko,  
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## CONSIDERATION OF THE PRINCIPLES FOR STABILIZING AND INCREASING OIL PRODUCTION AT THE LATER STAGE OF FIELD DEVELOPMENT (ON THE EXAMPLE OF UKRAINE FIELDS)

*The object of research is the oil industry. One of the most problematic issues in the industry is the transition of deposits to a late or final stage of their development. A significant number of deposits in Ukraine, USA, Russia, Poland, Azerbaijan began to be developed in the middle of the 19th century. To date, all the «old» fields are mostly depleted both in terms of hydrocarbon reserves and energy potential (reservoir pressure), and some are still in development, but in the so-called «late stage». At the same time, a significant number of relatively «young» fields have also entered the late stage of development, which is characterized, first of all, by a significant production of oil reserves, a progressive increase in water cut in wells, and an increase in the share of hard-to-recover reserves. As well as the transition to mechanized methods of oil production and the gradual increase in the stock of marginal wells, physical and moral deterioration of fixed assets of oil production with the threat of their mass retirement, deterioration of the ecological balance of the environment, and the like. Therefore, this work is devoted to the consideration of the principles of stabilizing and increasing oil production at a late stage of field development (using the example of Ukrainian fields). In the process of research, the original methods of classical scientific research were used, the main of which are analysis and synthesis, induction and deduction. An example of this is the proposed distribution of the structure of oil reserves into active and hard-to-recover ones. The study is based on statistical processing of a significant array of real information about the state and problems of oil production, which is typical and characteristic not only of Ukrainian fields. A wide range of directions for investment activities in the field of oil production was obtained. These are, mainly, directions for increasing the resource base, enhancing the completeness of its production, organizing a controlled and controlled displacement of oil by water, including with the use of «reverse» technology, unification of equipment for oil production, and ensuring environmental protection. Owing to the comprehensive application of these investment directions for improving the systems of field development at a later stage, it is possible to stabilize and gradually increase production, the value of which is determined by the relevant design documents.*

**Keywords:** late stage of development, high water cut, production from oil reserves, low-debit fund.

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## 1. Introduction

The most problematic in the world practice of oil production are fields that are at the final stage of development. A significant number of deposits in Ukraine, USA, Russia, Poland, Azerbaijan began to be developed in the middle of the 19th century. To date, all the «old» fields are mostly depleted both in terms of hydrocarbon reserves and energy potential (reservoir pressure), and some are still in development, but in the so-called «late stage». At the same time, a significant number of relatively «young» fields have also entered the late stage of development, which is characterized, first of all, by a significant production of oil reserves,

a progressive increase in water cut in wells, and an increase in the share of hard-to-recover reserves. As well as the transition to mechanized methods of oil production and the gradual increase in the stock of marginal wells, physical and moral deterioration of fixed assets of oil production with the threat of their mass retirement, deterioration of the ecological balance of the environment, and the like.

Let's consider, using the example of Ukrainian fields, the principles of stabilizing and increasing oil production at a late stage of field development.

Ukraine is one of the oldest oil-producing countries in the world. The first oil field was established in 1771 in the village of Sloboda Rungurska in the Carpathian region.

For more than 120 years, such deposits as Boryslavske (1883), Strilbichske (1881), Skhidnytske (1890), Ripninaske (1887), Bytkivske (1899) have been in development. Oil production in Galicia in 1909 reached 2 million tons, after which it gradually decreased and in 1945. It amounted to only 245 thousand tons. 32.9 million tons of oil were produced from old fields in the Western region. In the 1950s–1960s, high rates of exploration work made it possible to discover new relatively large oil fields in both the Western and Eastern regions – Dolynske, Bytkivske, Spaske, Leliakivske, Glynsko-Rozbyshivske, Kachanovske, etc. [1, 2].

In 1971, oil production in Ukraine increased to 13.35 million tons. The active introduction of waterflooding in the 60s of the last century contributed not only to an increase in oil production, but also to a rapid increase in the water cut of well production (Fig. 1).

In the 50s of the last century, a qualitatively new stage in the development of oil production technology began in Ukraine – implementation of various waterflooding systems both at energetically depleted fields and at fields put into development.

The widespread use of waterflooding was facilitated by such factors as the availability of water supply, the relative ease of implementation of the technology, and a sufficiently high efficiency of oil displacement by water. Due to this, high rates of oil production were ensured at the first and second stages of development [3, 4] (Fig. 1). However, since 1972, production has been gradually declining. This is due to a decrease in exploration and production drilling, a progressive increase in water cut, a transition to mechanized oil production and a gradual increase in the stock of marginal wells, which is typical for the classical third stage of development [5–7].

In the 90s, the final stage of development began, when the water cut of production increased on average to 88.6 %, and for wood in some fields up to 95 %. With a water cut of over 90 %, the following are being developed: Hnidynsivske, Bohdanivske, Prylutske, Malodivyske, Matlakhivske, Shchurivske, Milkivske, Trostianetske, Glinisko-Rozbyshevske, Sagaydatske, Kachanivske, Turutynske, Pivdenno-Panasivse and Skhidnytske fields.

High water cut causes problems not only with the «infringement» of oil by water in the reservoir, but also with its collection, treatment and disposal or reverse rotation into the reservoir. Various attempts to reduce the rate of increase in water cut, as a rule, do not give the desired result, but only cause additional financial costs for the subsoil user [8, 9].

Currently, the overwhelming majority of oil fields in Ukraine are at a late or final stage of development.

So, the *object of research* is the oil industry. The *aim of research* is to consider the principles of stabilizing and increasing oil production at a late stage of field development (using the example of Ukrainian fields).

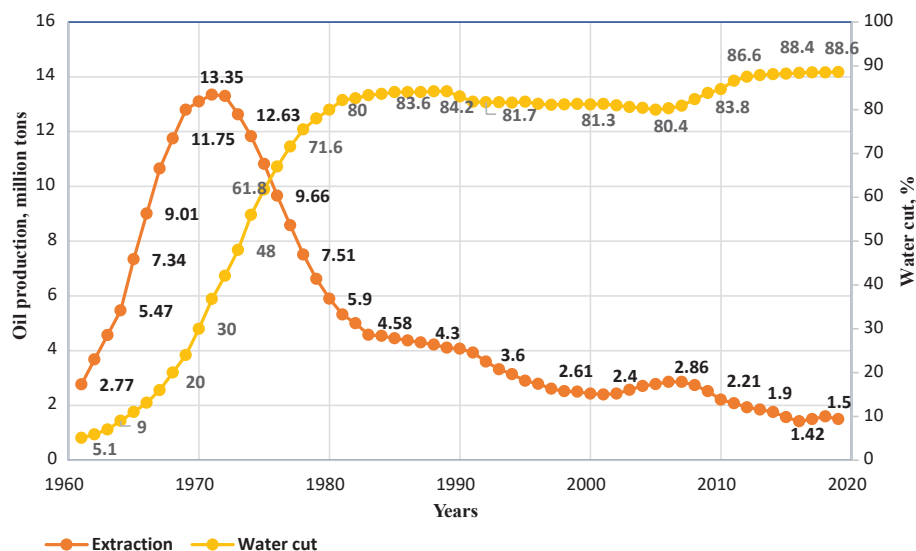


Fig. 1. Profile of oil production and water cut in Ukrainian fields

## 2. Methods of research

The analytical part of the work is based on the methodological principles of scientific research. Actually, in the process of research, fundamental methods of scientific research were used [10], such as collection and grouping of factual material, its analysis and synthesis, induction and deduction.

## 3. Research results and discussion

Among the factors that determine the state of the late stage of development of deposits in Ukraine can be distinguished: geological-production, organizational, economic and social.

Geological production factors are determined by:

- significant production of oil reserves (about 70 %), and the main production volumes are provided by «old», depleted fields, mainly due to the recalculation of their reserves;
- lack of compensation for hydrocarbon extraction by an increase in their reserves due to prospecting and exploration drilling;
- high water cut of wells production (Fig. 1), in fact, almost 4 tons of formation water rises to the surface from each ton of oil, which causes a significant increase in operating costs for water production, its separation from oil, collection and disposal;
- redistribution of the structure of reserves due to an increase in the share of hard-to-recover reserves (Fig. 2);
- low flow rate of the predominant share of wells – about 40 % of the operating well stock operate with flow rates up to 2 tons/day and provides only 26 % of the total oil production (Fig. 3);
- most of the representation of mechanized methods of oil production, the prevailing share is sucker rod pumps (Fig. 4);
- a gradual increase in the number of unprofitable wells, that is, those that, in the technological aspect of the well, are still capable of performing the tasks of lifting fluid to the surface, and in the economic aspect, their work brings losses to oil and gas producing enterprises, and the elimination of the problem by mass liquidation of the unprofitable fund, on the one hand, will lead to violation of the field development

system and significant deterioration of the ecological balance, and on the other – significant stranded costs for liquidation work;

- physical and moral deterioration of fixed assets of oil production with the threat of their mass retirement;
- poor-quality demarcation of layers in the process of well construction, causes crossflows and deformation and ruptures of production strings;
- non-compliance with the design ratio of the number of injection and production wells;
- selective development of the most productive areas of deposits;
- stagnation in the development and implementation of new methods for increasing oil recovery, intensifying the impact on the bottomhole formation zone and limiting the inflow of formation water.

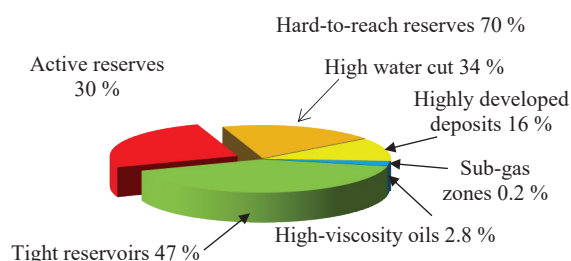


Fig. 2. Average statistical distribution of the structure of oil reserves

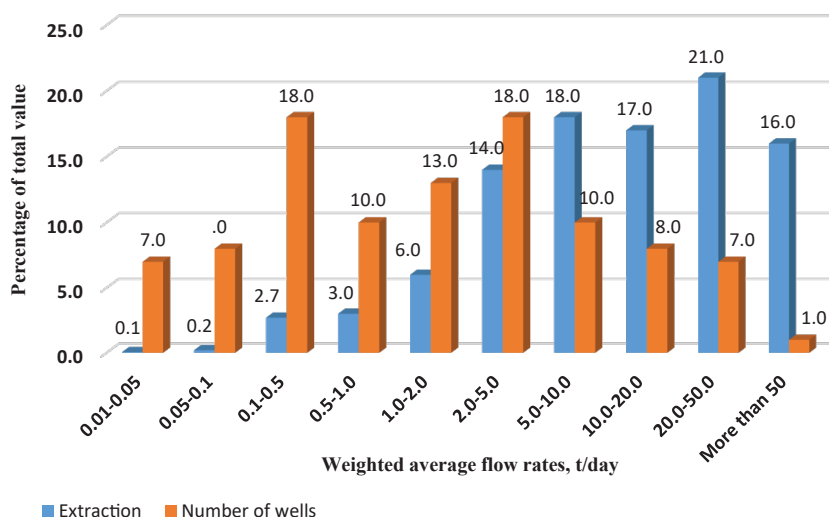


Fig. 3. Distribution of the operating fund and oil production by the value of well flow rates, % of total values

Organizational factors are characterized by:

- gradual loss of the available production and technological potential;
- imbalance in the structure of economic activity with the presence of production and service enterprises that ensure the process of oil production.

Economic factors include:

- growth in the cost of oil production;
- significant decrease in the level of profitability;
- sensitivity to fluctuations in price dynamics and tax regulation;
- permanent change in the structure of oil production costs due to the growth in the cost of liquidation works and measures to preserve the environment;

- lack of a mechanism for the implementation of benefits for the development of deposits with hard-to-recover reserves.

Social factors are determined by the possible loss of the worked-out infrastructure and professionally trained engineering and technical workers, the aggravation of the problem of releasing and ensuring employment of labor resources, and the deterioration of the ecological balance of the environment.

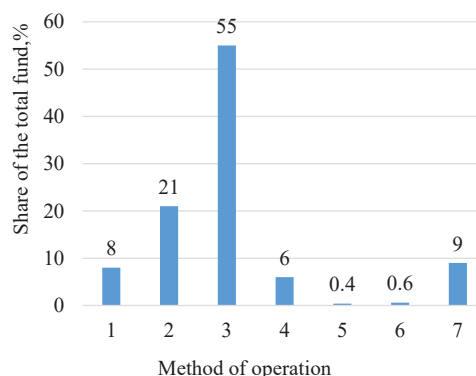


Fig. 4. The share of oil production methods from the total fund: 1 – fountain; 2 – electro-centric pumps; 3 – sucker rod pumps; 4 – gas lift; 5 – diaphragm pumps; 6 – screw pumps; 7 – bailer method of extraction

The combination of factors is decisive in the formation of the main directions of stabilization and increase in oil production in Ukraine and the architecture of the investment strategy of companies operating oil fields at a late stage of development.

In this aspect, the priority areas of investment activity should be:

- building up the resource base by intensifying the drilling of exploration and production wells;
- conducting modern seismic surveys and reinterpreting their available results and the results of geophysical studies of wells;
- viewing and restoration of the well stock from abandoned, high-water supply and in need of complex capital repairs;
- monitoring the state of development by using permanently operating hydrodynamic models of reservoir systems;
- active introduction of indicator studies and streams of squeezing technologies aimed at leveling the injectivity profile and increasing the sweep efficiency by squeezing out the agent;
- application of «reverse» waterflooding technologies by periodically changing (for 2–3 years) the functional purpose of production and injection wells within the development target.

The presence in Ukraine of significant production potential, professionally trained personnel, possession of its own technologies accompanying the process of prospecting and developing fields provides the reality of the implementation of the proposed directions for stabilizing and increasing oil production.

#### 4. Conclusions

Research has identified and formulated the main problems of oil fields at a late stage of their development, conditionally differentiated into geological-production, organizational, economic and social. Applying a cluster approach to identify problems and their elimination or prevention, the main directions of activities of scientific and production units aimed at stabilizing and increasing oil production are proposed.

Such an algorithm for solving problems is of scientific and practical importance not only for the fields of Ukraine, but also for all the others, which are developed in a late stage.

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