

OIL AND GAS EXTRACTION

The main directions of the field development systems improvement and the potential of oil extraction increase in Ukraine

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The main reasons for reduction of oil and gas extraction in Ukraine are presented. The priority directions for improving the oil and gas field development systems and the potential increase of oil and gas extraction volumes in Ukraine are substantiated. The possibility of involvement of passive reserves of oil in active development and increase of the annual oil extraction by implementation of modern oil and gas technologies are forecasted.

The petroleum industry of Ukraine, like in the most oil-extracting countries, passed the period of the maximum amount of extraction, followed by the inevitable downturn. The maximum level of oil and condensate production (14.4 million tons, 1972) was ensured by commissioning of a number of large oil and gas fields located in Dnipropetrovsk and Donetsk basin. Their role remained unchanged, and now about 20% of deposits provide 80% of hydrocarbon extraction, and the remaining 80% - only 20% of extraction [1]. The attempts to reduce the rate of decline in production, which were made primarily by increasing the operating drilling area, as well as identification of the previously omitted intervals and segments, had an episodic character and for various reasons were not able to change the overall trend of the oil and condensate extraction curve for more or less considerable period (Fig. 1).

The key reason for decrease in oil production in Ukraine is a natural transfer of most fields major by production and stocks to the later stages of development, characterized by significant depletion after extraction of 80...85% of oil from the approved initial extraction reserves [2, 3]. On the other hand, the time of commissioning of large deposits ensuring the growth of stocks has expired and the geological exploration opens mostly very small, small and medium-sized deposits at the depths of 4.5...6 thousand meters. The developed reserve gains, therefore, do not compensate even the current oil production. The comparative analysis shows that the intensity of systems for exploration of oilfield in Ukraine, especially with large values of initial stocks, corresponds to the world standards achieved, and sometimes even exceeds the same, but small fields are developed much slower than usually in the world [3].

Over the past 15 years, the resource base of oil and gas complex of Ukraine has deteriorated significantly, its competitiveness in the introduction of modern petrochemical technologies has decreased, the volume of seismic studies and exploratory drilling and thus, the gain of hydrocarbon reserves have been reduced significantly. The share of hard-extraction hydrocarbons is growing in

the structure of hydrocarbon reserves [4]. For 30-year period their number in Ukraine has nearly tripled and exceeded 68% of total reserves. The structure of the remaining oil reserves is deteriorated due to the fact that the selection of hydrocarbons is carried out mainly from the active parts stocks.

The exhaustion of deposits in Ukraine is accompanied by the increased water content of products up to 80...85% and more. Thus, 14 fields of the oil company UkrNafta JSC are developed with average water content greater than 90%. The mean extraction coefficient has reached about 30% of the designed value 36.5%, while the global level for the corresponding mode of development is 40-50%. For example, in neighboring Belarus the state oil and gas company Belorusneft PO RUP has reached the oil extraction coefficients of 50-55% on the major development sites. Considering the current resource base of oil fields in Ukraine, which are being developed (Figure 2), we can note a significant proportion of the residual oil which substantially exceeds the current amount of extractable reserves. Actually, the residual stocks of deposits accounted for the public companies exceed 740 million tons.



Figure 1. Dynamics of oil and condensate production in Ukraine

Therefore the main focus of increase in the levels of hydrocarbon extraction and achievement of high values of the terminal coefficients of their extraction is a massive improvement of the existing oil and gas deposit development systems using the modern high technologies.

Major oil fields of Ukraine are developed with the method of flooding, which is currently the most affordable and effective. Still, due to the complex geological structure, high filtration heterogeneity, separation and reservoir non-continuity, transfer of fields into the final stage of development, the effectiveness of flooding at this stage is low. The direct flow-metric studies show that deposit is cut by the pressurized water into separate blocks, plots (Fig. 3). This, in turn, leads to the formation of undiscovered, little permeable layers and non-drained zones, which, according to expert estimates [5], present about 46% share in the general distribution of residual oil (Fig. 4).

Based on the results of numerous studies it was established that about two-thirds of the residual oil occurs due to incomplete coverage of the reservoir by development, and its remains are kept in the pore space by capillary and surface forces.

The domestic and international experience [5, 6] suggests that the modern oil industry has a wide arsenal of technology for localization and removal of residual oil stocks.

In Ukraine the efforts of many professionals for stabilization and increase of the levels of oil extraction have led to establishment of scientific principles to improve the existing oil and gas development methods, which are aimed at improvement of technical and economic efficiency of introduction of modern innovative technologies for extraction of hydrocarbons and an increase in hydrocarbon extraction in the environment of stock structure deterioration [7-9]. Firstly, they should include:

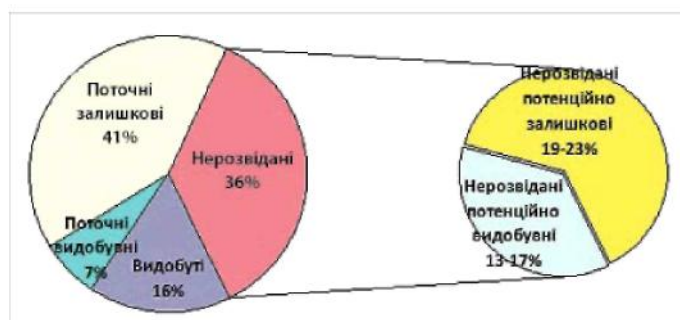
- permanent stock-development monitoring system based on hydrodynamic modeling;

method of rapid assessment of the technological efficiency of oil and gas development systems and formation of the primary recommendations aimed at their improvement;

methodological basis of long-term forecasting of oil and gas extraction levels;

method of localization uncultivated areas of the reservoir and the optimal location of sealing wells;

technologies for enhancement of productivity of wells, limitation of reservoir water inflow,



elimination of overflows over the column etc.

Figure 2. Resource oil base in Ukraine

The modern instrumental controls over the development of fields and complete exhaustion of production stocks, the results of theoretical, experimental and industrial researches, advanced scientific methodological and software technical means of monitoring mining, evaluation of technical efficiency, construction of geological and technological models allow localizing the places of concentration of residual stocks with sufficient certainty and optimizing the systems and the location of wells.

Based on the methodology for long-term forecasting of oil extraction [10] and assuming that subject to systemized and programmed approach the investment and, consequently, the rate of the development of additional reserves can be compared with the results achieved during the exploration and development of new deposits in Ukraine. We performed the stock growth scenario forecast (Fig. 5) and oil extraction therefrom (Fig. 6). The pessimistic scenario corresponds to 90%, plausible - to 50%, and optimistic – to 10% confidence level. As you can see, even in the pessimistic scenario the implementation of modern technology to improve the existing system of oil field development will enable the involvement of about 80 million tons of oil in active extraction. It can provide the annual production growth over the next five years to 0.5 million tons, accounting for 12% of the current level of oil production in Ukraine. According to plausible scenario, these figures are even more optimistic, i.e. the additionally attracted stocks will amount to 120 million tons, an increase in annual production for the next five years will be 0.5...1 million tons, which is 12...25% of the current level of oil production in Ukraine.

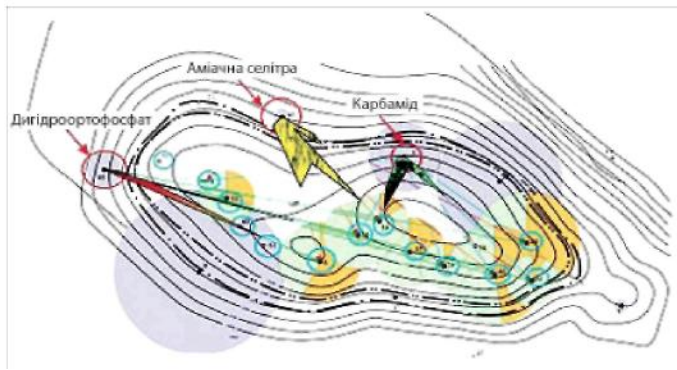


Figure 3. Rose-diagram of water distribution from injection to production wells, received based on the results of the indicator flow-metric studies

So, it is economically and technologically justified to involve 100...150 mio tons of oil from the current residual stocks in development in the fields of Ukraine, which is equivalent to achieving the final factor of the oil extraction of 46...51%, which corresponds to the modern global development systems [11].

To ensure the implementation of these scenarios it is required to solve a number of urgent technological and organizational problems.

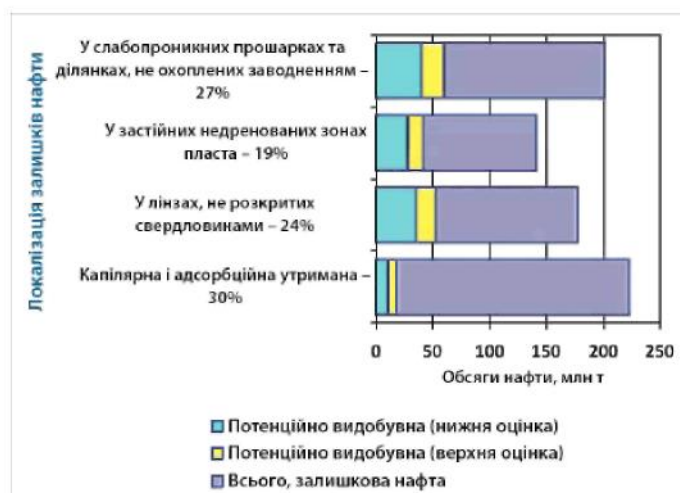


Figure 4. Average statistical distribution of residual oil and its potential involvement in the development

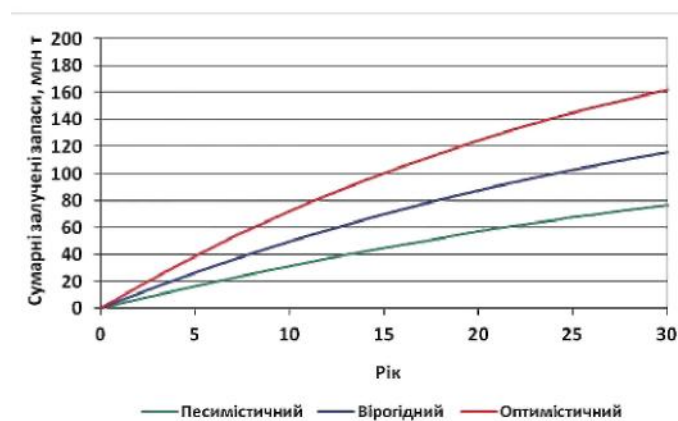


Figure 5. Scenarios of involving the residual stocks in development

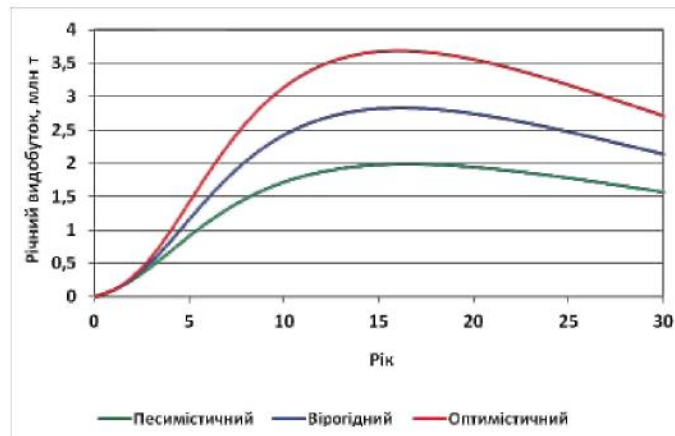


Figure 6. Scenarios of extraction from involvement of the remaining oil reserves in development

The first technological challenges are:

- deployment of wide industrial and scientific researches for localization of residual oil;
- introduction of modern methods of oil extraction;
- optimization of the production wells grid;
- boring of wells with complex architecture, including the multi-drilled with horizontal shaft;
- high-quality primary and secondary exposure of productive layers;
- application of flow-deflecting technologies directed methods of enhanced extraction and limitation of inflow of the formation waters etc.

In this area, the principles and technologies of the system targeted insulating and intensifying effect on the bottomhole zone, filter, borehole, reservoir and reservoir areas between wells have been developed:

- methods and technologies of oil deposits development;
- methods of formation water flow restriction and removal of leaks in the space after the columns with various filterable and non-filterable plugging materials in the injection and production wells;
- ways of intensification of oil production combining the mechanical, thermal and chemical actions in one technological action;
- ways of identification of gaps in the flooded reservoir, modern approaches to reinterpretation of seismic study findings and geophysical wells researches;
- methodology of development of permanent hydrodynamic models of hydrocarbon deposits.

Among the organizational tasks, it is important to develop the respective branch-specific and industrial applications, development and intensification of the system for state control and regulation of mining, provision of conditions for attracting investment and reduction of risks, especially the financial ones, for implementation of programs to improve the development the systems of oil fields development in Ukraine.

So, with the limited opportunities of opening new fields with significant reserves in Ukraine for the preservation of the achieved level of production and its capacity enhancement it is required to improve the systems of the existing fields development. According to the forecasts made, the solution of this problem is technically and technologically feasible.

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