JPRS L/9958

3 September 1981

USSR Report

ENERGY

(FOUO 14/81)

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APPROVED FOR RELEASE: 2007/02/09: CIA-RDP82-00850R000400050008-4

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CONTENTS

ELECTRIC POWER

UDC 621.311.1:681:140

DYNAMIC METHODS OF ANALYSIS OF THE DEVELOPMENT OF POWER SYSTEM GRIDS

Riga DINAMICHESKIYE METODY ANALIZA RAZVITIYA SETEY ENERGOSISTEM in Russian 1979 (signed to press 17 Jan 79) pp 1, 4-9, 257-260

/Book by V. A. Dale, Z. P. Krishan and O. G. Paegle/

/Excerpts/

Title: DINAMICHESKIYE METODY ANALIZA RAZVITIYA SETEY ENERGOSISTEM (Dynamic Methods of Analysis of the Development of Power System Grids)
Authors: V. A. Dale, Z. P. Krishan and O. G. Paegle
Publisher: Zinatne
Place and year of publication: Riga, 1979

Signed to Press Date: 17 January 1979

Number of Copies Published: 1,000

Number of Pages: 260

Annotation:

Dale, V. A., Krishan, Z. P., Paegle, O. G. Dinamicheskiye metody analiza razvitiya setey energosistem. -Riga: Zinatne, 1979. -260 pages.

In the examples of research results in developing electric power systems are examined the basic methodological problems of modeling the grid development process connected with formulating optimization tasks, selecting criteria, estimating the factor of the dynamics of development, and also conditioned by the complexity of modern systems and the inaccuracy of long-range data.

Set forth are mathematical programming methods intended to optimize the development of electric power system grids as well as methods for calculating the distribution of power flows in complex systems in conformity with the tasks of optimizing development.

The results of research conducted at the Physical Power Institute of the Latvian SSR Academy of Sciences have been used and summarized. Experimental material obtained mainly during the practical use of concrete mathematical models has been widely utilized.

There are 13 tables, 101 illustrations, and 100 bibliographic entries.

Published by the decision of the editorial publishing council of the Latvian SSR Academy of Sciences of 27 October 1977.

The fulfillment of the tasks set by the party and the USSR government on developing the national economy of the country requires an improvement both in the theory and the practice of national economic planning. "A further increase in its scientific level will become a task of paramount importance. The necessity to improve planning methods has ripened. It must be guided by the most precise study of social requirements, the scientific forecasts of our economic possibilities, their immediate and long-term consequences, and the thorough analysis and assessment of the various solution alternatives. In order to solve this crucial and complex problem, it is necessary to extend the horizons of economic planning."[1]

The improvement of planning methods is currently linked to the use of modern mathematical methods based on the use of computers and the creation of automated control systems: "the use of modern computing and control machines leads to a genuine revolution not only in the technology of production but also in economics, planning, accounting, planning and design developments, and in scientific research itself."[2]

This book has been devoted to the problem of the long-term design and planning of the development of system-generating electric power system grids by using mathematical modeling methods. Problems of the long-term design and planning of grid development occupy an important place in the total problem of planning power system development and they have acquired a special urgency in connection with the creation of large-scale power associations and the United Power System of the USSR. At the same time the task of planning grid development is one of the most complex. Starting from the view of an electric power system as a large system with a complex hierarchic structure, it is necessary to consider the following features of these tasks. They are not isolated, but always closely connected with the other tasks in the development of a power system. The adoption of solutions on developing electric power systems is also a complicated process in which, in particular, the trustworthiness of the initial data must be taken into consideration. Therefore, during the analysis of grid development of real systems, the process of seeking solutions is not limited to finding a simple formally optimum solution, but a sufficiently wide range of solutions is studied (1, 31, 52, 53, 56, 61-63).

Research in the area of developing optimization methods for the development of electric power system grids is being conducted in a number of scientific research organizations of our country and also abroad. At the present time the methods of planning grid development through the use of optimum or appraisable mathematical models have already found practical application in all countries with a developed power economy (12, 33-35, 42. 69, 85, 95, 99). The tendency is becoming stronger to switch from the solution of isolated grid tasks to the solution of over-all optimization tasks for the development of electric power associations based on interrelated mathematical model systems using total information(68, 75, 77, 81, 100).

1L. I. Brezhnev, "Voprosy upravleniya ekonomikoy razvitogo sotsialisticheskogo obshchestva. Rechi, doklady, vystupleniya" [Problems in Directing the Economy of a Developed Socialist Society. Speeches, reports, addresses], Moscow, Politizdat, 1976, p 304. 2. Ibid., p 110.

Various optimization methods are being developed because of the large variety of concrete tasks in the long-term planning of grid development. Two approaches have been outlined: statistically, during which the real continuous process of developing grids is not considered, and dynamically, by considering the interdependence of solutions adopted at various points in time. Methods of optimizing grid circuits with a given load level, i.e., statistical methods, have been more fully studied. The method of coordinate optimization, the method of branches and borders and others, for example, are used (36, 45, 47, 58, 60, 72, 78, 86, 89).

Dynamic methods for optimizing the development of grids have been less studied (40, 78, 82, 83, 87, 88, 93). The problem of dimension is basic during the solution of dynamic optimization tasks. Attempts to solve it in some operations have been linked to the use of special procedures: random search, "truncated dynamic programming," and others.

Also the problems of mapping the properties of optimized objects (this concerns the methods of accounting for such factors as multimodality, reliability, etc.) and problems of using mathematical methods in the practice of designing and planning grid development have been inadequately researched in mathematical models.

The dynamic problems examined in the present monograph are being formulated as locating the sequence of measures for the grid development of a system (a variation of grid development) by using an integral technical and economic criterion during the design period. Grid problems in such a set-up often arise in the design and planning process. The requirement for the utilization of appropriate optimization methods has also been linked to the realization of the process of the continuous planning of electric power system development.

The book summarizes the results of the study of the dynamic methods of the optimization of the development in conformity with system-generating grids (grids of the 220 kilovolt and higher class), conducted at the Physical Power Institute of the Latvian SSR Academy of Sciences during the period 1970-1976. At the institute they worked up a number of mathematical models intended for planning the development of grids (22-24, 51), and also experience has been gained in the practical use of dynamic methods during the joint operation work with the Southwestern Branch of the institute Energoset'proyekt/All-Union State Planning, Surveying and Scientific Research Institute of Power Systems and Electric Power Networks/, the united dispatching administration of the power systems of the Northwest USSR, and the Latvian division of total planning of the institute Energoset'proyekt (20, 21, 25, 26, 32-35, 79).

The first section of the monograph examines the general problems of optimizing large systems in power engineering which at the present time have been inadequately studied. Our analysis was aimed at concretizing some general theses in conformity with the tasks of optimizing electric power system development.

Our experience and also the data of other researchers (9, 29, 40, 75) show that during the practical utilization of mathematical models, the decisive role in evaluating solutions belongs to the individual. Any, even perfect, models are only a means for carrying out the required calculations. There are a number of reasons for such a situation: the complexity of the optimization tasks, the interrelationship of them with other tasks of system development planning, the inevitable incomplete enunciation of these tasks, the impossibility of formally describing a number of important (from an engineering point of view) factors in the optimization models, the inaccuracy of the initial data, etc. Therefore the book has paid great attention to the problems of the practical application of mathematical models.

An analysis of methodological questions connected with the modeling of developing systems and the use of mathematical models is based on experimental data obtained under conditions typical of real grid projects. Such projects are characterized by a large amount of data. The book, as a rule, presents simplified illustrations which provide the basic details of the questions studied. The authors have tried to give a quantitative appraisal for the substantiation of one or another recommendation. This, for example, concerns the recommendations touching the calculation of the factor of dynamics during an analysis of grid development, an appraisal of the errors determined by data inaccuracy and circuit equivalency, an assessment of the size of the range of equally economical solutions, etc.

The second section examines the methods for calculating power flow distribution in complex electrical grids in conformity with the tasks of analyzing grid development. The questions on modeling flow distribution are important in the problem of the mathematical modeling of grid development processes because the algorithms used in operational practice for computing flow distribution cannot be used in optimization models because of an insufficiently fast response (32, 34, 51, 86, 93). The material cited in this section represents a summary of the research conducted at the Physical Power Institute of the Latvian SSR Academy of Sciences on the development of special methods for computing grid modes in conformity with the tasks of optimizing their development. The theoretical bases of these methods as far as more conveniently using the special description of equations characterizing the mode of the electrical grid for long-term calculations have been stated in sufficient detail. Moreover the authors start from the position that it must be in agreement with the requirements adopted for long-term planning.

A number of algorithms, well-suited for practical use, have been examined while the main attention has been paid to the questions of providing fast reaction, to an analysis of the conditions of the convergence of iterative algorithms, the agreement of the flow distribution computation accuracy with the accuracy of determining technical and economic indicators during a comparison of alternative methods. The methodological questions and recommendations on the use of the stated methods for computing flow distribution are illustrated by experimental data obtained for real grid projects.

The third section examines the dynamic methods for optimizing grid development for projects, including a large number of elements. For such projects the modeling is conducted, taking into account the presence of existing grids, multi-modality and other factors which have been considered during the long-range planning of the grid development of electric power associations. The indicated modeling features, as a rule, have been connected with the necessity of solving multi-step optimization tasks of great dimension with discrete variables. The methods stated for their solution are based on the use of dynamic programming procedures with the utilization of the structural features of the grid tasks. Some problems in the realization of the dynamic programming method have been stated in work number 19. Bibliographic item 19 has examined the methods used for grid projects described in relation to a simple model. Their immediate utilization for the optimization of system-generating grid development, depicted by a complex model with a large number of profiles, has appeared impossible. Algorithms for realizing the dynamic programming method in conformity with grid projects having a complex structure are based on the calculation of several additional properties of such projects. The present work focuses chiefly on the problems of substantiating the realizability of these algorithms. In particular, the results of theoretical and experimental research in the area of their use are presented. Examples have been presented for the realization of optimization algorithms for concrete tasks. Problems of the approximate optimization of grid development and the solution of multi-mode optimization tasks have been examined.

All of the proposed algorithms have been carried into effect by us in the form of programs and complexes of programs and have been tested during the solution of practical optimization tasks of grid development. The full texts of these programs are not presented in the book. Only the fundamental questions have been examined which are connected with the structure of data computing complexes intended for analyzing grid development with a representation of the developing grid projects in the optimization mathematical models and the organization of the computing process during optimization calculations on a computer.

The experimental data presented in the book have been mainly intended to illustrate methodological situations. They have been obtained on a second generation (M-220, BESM) as well as a third generation computer (united system computer). At the same time the authors have considered it advisable to show in more detail the individual blocks having the most significant importance for the practical realization of the dynamic method of optimization on a computer. Some blocks have been presented in the form of sufficiently detailed flow charts. For a number of blocks characterized by a relatively complex logical structure, the full text has been presented in the appendices in algorithmic language PL-1.

The authors wish to thank the associates of the Physical Power Institute of the Latvian SSR Academy of Sciences I. Ya. Greyvule and I. K. Zvirgzdinya for their participation in conducting the experimental research.

Please send comments on the book and suggestions to the following address: 226006 Riga, 21 Ayzkraukles Street, the Physical Power Institute of the Latvian SSR Academy of Sciences.

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8524
CSO: 1822/205

FUELS

UDC 553.98:550.812"1976-1985"

RECENT RESULTS, FUTURE TASKS OF OIL, GAS EXPLORATION TOLD

Moscow GEOLOGIYA NEFTI I GAZA in Russian No 6, Jun 81 pp 1-7

[Article by V. V. Semenovich (USSR Mingeo [Ministry of Geology]): "The Main Results of Prospecting and Exploration for Oil and Gas During the 10th Five-Year Plan and Tasks for 1981-1985"]

[Text] The development of the fuel and power branch of the national economy is constantly the center of attention of the party and the government. The main tasks for prospecting and exploration for oil and gas are defined accurately in the decisions of CPSU congresses and in many directives. Their realization has been crowned by the creation of a high-capacity oil and gas recovery industry which now provides two-thirds of the country's fuel and power balance. Its further development was defined in "The Main Directions for Economic and Social Development of the USSR During 1981-1985 and During the Period up to 1990," which was confirmed by the 26th CPSU Congress. Comrade L. I. Brezhnev, in the Accountability Report of the CPSU Central Committee to the 26th party congress, in speaking about the necessity to develop heavy industry, emphasized the primary importance of the fuel and power branch.

In executing party and government decisions about creating a mineral raw-materials base for the recovery of oil and gas, USSR Mingeo's oil-and-gas-exploration and geophysical organizations have been promoting work in all the country's promising oil and gas bearing provinces. Broad coverage of large regions by prospecting has led to the discovery of new oil and gas areas, regions and fields in West Siberia, the European part of the USSR, Central Asia and West Kazakhstan.

On the basis of explored reserves, the largest recovery complexes have been created in Tyumenskaya and Orenburgskaya oblasts, the Komi ASSR, and the Dnepr-Donets depression, at Mangyshlak, and in West Uzbekistan and East Turkmenia. In 20 years the country's recovery of oil has risen 3.6-fold, natural gas 8-fold. The Soviet Union has now reached first place in the world in recovery of oil and gas condensate, second place in gas recovery.

Geological exploration in 1976-1980 was targeted at speeding up the prospecting and exploration of new oil, gas and gas-condensate fields primarily in the Middle Ob' region, the North of Tyumenskaya Oblast, West Siberia, the Yakutskaya ASSR, the North of the country's European portion, and the Caspian depression. Much work was done in Central Asia.

In West Siberia prospecting continued over a broad front, together with exploration and preparation for development of fields that had been discovered. The execution of a set of organizational measures enabled drilling volume to be greatly increased here in recent years. In 1980 Glavtyumen'geologiya [Main Administration for Geological Exploration in Tyumenskaya Oblast] associations drilled more than a million meters of exploratory hole--twice as much as in 1975.

As a result of the work performed, it was established that Jurassic sediments in the eastern part of the lowland--in the Krasnosel'kup region--bear oil and gas, and new data was obtained about the presence of oil in Jurassic rocks at the Novyy Port field. Together with previous discoveries of oil in Jurassic deposits in the Krasnolepinskiy area at the Gubkin field and in the Middle Ob', this testifies to the regional nature of the presence of oil and gas in West Siberia's Jurassic sediments. New data was obtained about the presence of oil and gas of the Bazhenovskiy suite at Salym. On the Yamal Peninsula oil deposits were discovered at the Bovanenkovskoye field. Prospecting drilling in Lower Cretaceous sediments at the Zapolyarnoye, Yamburg and other fields of the Tyumen' North indicated the presence of highly productive gas-condensate deposits. The regional nature of the presence of oil in the lensing-out zone of the Lower Cretaceous reservoirs received further confirmation. Work done during the 10th Five-Year Plan confirmed the correctness of the guidance in prospecting and exploring for deposits in this most important oil and gas region of the country.

In the Timan-Pechora province, the gas-bearing region close to Nar'yan-Mar, which covers the northern portions of the Kolva, Shapkino-Yuryakha and Laya arches, was prepared for development. The exploration of a number of gas deposits in the Permian-Carboniferous sediments was completed. Prospecting for deposits in the deeper portions of the profile is being conducted. The Varandey-Adz'va oil-bearing zone in the eastern part of the Nenetskiy Autonomous Okrug was discovered. Here a broad stratigraphic interval of productive deposits--from the Triassic to the Lower Devonian--was noted. The regional nature of the presence of gas in the Kos'yu-Rogovskaya depression was established.

In evaluating the results of work in the Timan-Pechora province, it should be emphasized that in recent years the stratigraphic interval of productivity has been greatly enlarged through discoveries of Triassic deposits in the northern regions and Lower Devonian and Silurian deposits in the Izhma-Pechora and Khoreyverskaya depressions, at the Kolva arch, and in other regions. Deposits in sedimentary formations of the Lower Devonian, Ordovician and Silurian are associated with carbonaceous reservoirs; in some cases, apparently, these are traps in buried reefs.

One of the important results of the 10th Five-Year Plan was establishment of the regional nature of the presence of oil and gas in the Lower Permian-Carboniferous sediments of peripheral parts of the Caspian lowland. In the southwest the Astrakhan gas-condensate field was discovered, on the basis of which an industrial cluster should be created, in accordance with "The Main Directions for the Economic and Social Development of the USSR During 1981-1985 and During the Period up to 1990." In the northeastern part of the lowland, the Karachaganak gas-condensate field was discovered, and in the east--the Zhanazhol oil and gas field and new deposits based upon the Kenkiyak oilfield. Gas and oil fields were also discovered in other parts of the near side of the Caspian depression zone. All these are associated with carbonaceous reservoirs. Their gas contains hydrogen sulfide and carbonic acid, the gas of the Astrakhan field containing up to 25 percent hydrogen sulfide and more than 20 percent carbonic acid, which creates serious difficulties in the sinking of wells and in sampling them. On the southern flank of the Caspian depression, an oil-bearing region on the Buzachi Peninsula, with deposits in Lower Cretaceous and Jurassic sediments, have been explored and prepared for development.

In recent years the amount of regional geological and geophysical research has increased in East Siberia, and the presence of gas in industrial quantities in Lower Paleozoic and Precambrian rocks has been established at the Vanavara and Kamovskiy uplifts of Krasnoyarskiy Kray. Gusher flows of oil and gas have been obtained at a number of areas of the Nepa anticline in Irkutskaya Oblast.

In the Yakutskaya ASSR the exploration of gas-condensate fields in the Vilyuy syneclise has been completed. In southwestern Yakutskaya ASSR, exploration of the Middle Botuob', Upper Vilyuchansk, Vilyuy-Dzherba and other fields of the Botuob' oil and gas bearing region continues. The industrial presence of oil has been established for the Lower Paleozoic and Precambrian sediments at the Middle Botuob' field.

Established reserves in Central Asia have been increased significantly. A most important result of operations was the discovery and exploration of the Dauletabad-Donmez gas field in southeastern Turkmenia. This is the largest field in Central Asia. It will enable gas recovery in the republic to be brought up to 81-83 billion cubic meters, as called for by "The Main Directions for the Economic and Social Development of the USSR During 1981-1985 and During the Period up to 1990." In Western Uzbekistan several gas fields were discovered and are being explored. The gas field of Shurtan, which supplies fuel to the Syr-Dar'inskaya GRES, has been turned over for development.

Thus, in some oil and gas bearing provinces basically new results were obtained, oil and gas fields were discovered, and promising individual stratigraphic complexes were discovered or enlarged. The mineral raw-materials base of the country's fuel and power complex was greatly strengthened, and the prerequisites were created for developing it aand also for increasing UV [hydrocarbon] reserves further.

New areas for prospecting, which will enable the conquest of new regions and lithologico-stratigraphic complexes (Lower Carboniferous-Devonian of the Dnepr-Pripyat' NGP [oil and gas province], the subsalt complexes of the Caspian NGP, the Lower Devonian-Ordovician complex of the Timan-Pechora NGP, the reefogenic Jurassic complex of the Amu-Dar'ya NGP and others) have been defined in accordance with the results of regional geological and geophysical operations. Regional research in East Siberia, where the structure of the Eocambrian-Lower Paleozoic complex was studied, proved to be fruitful. In West Siberia the structure of the Jurassic has been refined and the first information about regional tectonics of the Triassic and more ancient sediments of the northern regions has been obtained.

The results of the regional studies were used in making a quantitative assessment of the prospects for the USSR's oil and gas resources as of 1 January 1979. They enabled the extent to which many territories have been studied to be raised, and up to 460 structures to be introduced annually into the inventory of entities discovered--an appreciable backlog of started work awaiting later detailed preparation.

Space photography has begun to be used in unison with regional studies. The quality of the scientific processing and generalization of the data from regional work has been raised, enabling regional maps for the whole territory of the USSR to be created, using also the results of other stages of the work.

The successes of prospecting and exploration in West Siberia, the Timan-Pechora province and other regions of the country were made possible to a great extent by developments in drilling operations and radical augmentation of the geophysical services with equipment and standard practices. The amount of deep exploratory drilling carried out by the USSR Mingeo system in 1976-1980 was 25 percent higher than in 1971-1975. Thanks to the daily assistance of the party and the government, the labor activity of the collectives of geological explorers, and the organizing work that was done, in 1980 drilling exceeded the 1975 level 1.8-fold in West Siberia (1.9-fold in Glavtyumen'geologiya), 2.5-fold in Arkhangel'skgeologiya [Arkhangel'sk Geological Exploration Association], 1.5-fold in Ukhtageologiya [Ukhta Geological Exploration Association], 2.5-fold in the Turkmen SSR Geological Administration, and so on. The operating base for deep exploratory drilling has been greatly strengthened.

During the 10th Five-Year Plan the amount of grants for geological prospecting, primarily for geophysical work, rose substantially. The basic method for deep underground mapping--seismic exploration--has been augmented radically as to equipment and standard practices. At present, practically all the work by reflected waves is being done by the OGT [common depth point] method, which permits mapping quality and the depth and detail thereof to be improved considerably. The introduction of OGT has created the prerequisites for solving such complicated tasks as discovering reefs and tracing lensing-out zones, surfaces of stratigraphic unconformities, and, in some cases, gas-water contacts in massive-type deposits. Definite successes have also been registered in solving problems of forecasting deposits by geophysical and geochemical methods (the direct methods for prospecting for deposits). However, the labor-intensiveness of seismic exploration has risen considerably, because of which the physical volume has not increased for a long time. As a consequence, the area of prepared structures is not increasing. Although the number of structures prepared in 1976-1980 rose by 13 percent over the Ninth Five-Year Plan, their area was 4 percent less. In some regions a tense situation has prevailed with respect to providing prospecting drilling with an inventory of prepared sites.

The 26th CPSU Congress set the directions and main tasks for further development of the country's fuel and power complex and its mineral raw-materials base. Guided by "The Main Directions for the Economic and Social Development of the USSR During 1981-1985 and During the Period up to 1990," which the 26th CPSU Congress confirmed, and proceeding from 1976-1980 work results and a quantitative assessment of the prospects of the oil and gas bearing regions and of the various stratigraphic complexes, USSR Mingeo plans to intensify geological exploration in West and East Siberia, the European portion of the USSR, Central Asia, and the Kazakh SSR with the following main tasks.

West Siberia

A continuation of exploration in the Middle Ob' district and the northern regions of Tyumenskaya Oblast, with a view to further increasing oil reserves;

further integrated study of whether the Bazhenovskiy suite bears oil and the development of methods for assessing the reserves in its deposits;

the preparation of reserves of condensate-containing gas in the Neocomian complex of the northern regions of Tyumenskaya Oblast;

an evaluation of the presence of oil in the Jurassic sediments of the Krasnoleninsk, Krasnosel'kup, Yamal and other regions; and

a continuation of prospecting for deposits in lithological traps of the lensing-out zone of the Neocomian formations.

The Timan-Pechora Province

Prospecting and exploration for oil and gas fields in the Nenetskiy Autonomous Okrug of Arkhangel'skaya Oblast, in the northern portion of the Kolva arch and in the Laya and Shapkino-Yur'yakh arches;

prospecting and exploration of oilfields in the Varandey-Alz'va zone;

an evaluation of gas deposits discovered in the Koz'yu-Rogovskaya depression;

prospecting and development of oilfields in the southern part of the Izhma-Pechora region and gasfields in the northern part of the Upper Pechora depression; and

prospecting for oil and gas deposits in the Khoreyverskaya depression.

The Urals-Volga Region

A continuation of exploration of the Astrakhan' gas-condensate field;

prospecting for oil and gas deposits in the southern portion of Orenburgskaya Oblast; and

prospecting and exploration of oilfields in Udmurtia and Ul'yanovskaya and Saratovskaya oblasts.

Central Asia

A continuation of exploration and evaluation of reserves of the Dauletabad-Donmez gas field;

prospecting for gas fields in East Turkmenia; and

prospecting and exploration for gas deposits in West Uzbekistan.

Kazakhstan

Evaluation of the presence of gas at the Karachaganak field;

completion of exploration of the Zhanazhol oil and gas field; and prospecting for oil and gas fields in the subsalt sediments of the eastern portion of the Caspian depression.

East Siberia

A continuation of integrated regional operations on the Siberian platform;

discovery of the zone of oil and gas accumulations in the southern portion of the Tungusska syneclise, at the Nepa-Botuob' anteclise, in the Yenisey-Khatanga trough, and in other regions; and

prospecting for and exploration of oil and gas fields and the preparation of oil reserves.

In order to solve the tasks set for growth of oil and gas reserves during 1981-1985 and to create a backlog of prospecting starts for 1986-1990, it will be necessary, according to studies that have been made, based upon analysis of the degree of exploration accomplished and the effectiveness of deep exploratory drilling in the country and in various regions of it, to increase drilling 1.5-fold to 1.6-fold and appropriations for geological prospecting 1.7-fold (which includes a 1.8-fold increase in geophysical prospecting) throughout the USSR Mingeo system during the 11th Five-Year Plan. In so doing, the amount of drilling is to increase 2.1-fold in West Siberia, 2.4-fold in East Siberia, 1.8-fold in the European North, 1.3-fold in the Urals-Volga region, 1.3-fold in Central Asia and 1.2-fold in Kazakhstan.

A sharp increase in geological exploration in 1981-1985 has been necessitated by a reduction in the growth of reserves per 1 meter of drilling, as a result of moving to regions that have been poorly studied and are complex in structure, growth in the depth of prospecting and exploration holes, and the increased complexity of the fields that have been discovered, especially fields associated with carbonaceous reservoirs. A large amount of drilling will be aimed at medium-size and small fields and structures, and also at extremely labor-intensive prospecting for the complicated types of deposits that are confined to lines of lensing-out and stratigraphic shielding by reef massifs and deeplying horizons.

An increase in the amount of geological prospecting, primarily of seismic exploration, will enable 29 percent more structures to be prepared than during the 10th Five-Year Plan; the area of prepared structures will increase by 15 percent. However, as is evident from the figures cited, the necessary balance between the amounts of deep exploratory drilling and the preparation of structures still will not be achieved during the 11th Five-Year Plan, and the strain in providing prospecting drilling with prepared structures will persist. Steps must be taken to alleviate this imbalance, not only by increasing the physical amount of seismic prospecting but also by realizing other possibilities.

One of the measures in this area is improvement of the quality of preparation of the structures. The precision of the structures, particularly of the surface of the subsalt sediments of buried reefs, zones of lensing-out and nonconformities, must be increased, and the depth of reliable mapping must be brought down to at least 5.5 kilometers, and in some regions (the Dnepr-Donets and Kos'yu-Rogovskaya depressions, the Kopetdag trough, and others) down to 6 kilometers.

It is necessary to organize more widely the review and analysis of the papers of preceding years on the basis of a detailed processing of them, taking into account the accumulated data on drilling, seismic exploration and new ideas about the structure and the material composition of the profile. There are many examples where repeated analysis of data will enable a new approach to an evaluation of the prospects that various structures or whole regions will be oil or gas bearing.

An important reserve for increasing the inventory of promising areas is the further development and improvement of geophysical and geochemical methods for forecasting the presence of oil and gas--the singling out of "anomalies of type deposit," based upon use of a set of methods and on joint interpretation of the results of their use.

The tasks that ensue from "The Main Directions for the Economic and Social Development of the USSR During 1981-1985 and During the Period up to 1990," are vast and very complex. For them to be solved effectively, institutes of the oil and gas geology specialty must concentrate their efforts on the top basic and applied problems. As Comrade L. I. Brezhnev indicated in the CPSU Central Committee Accountability Report to the 26th CPSU Congress, the conditions under which the national economy will be developed during the 1980's make the acceleration of scientific and technical progress still more urgent.

The central problem, which is included in the State Plan for the Economic and Social Development of the USSR During 1981-1985, is determination of the most effective areas for prospecting and exploring for oil and gas in the USSR and the economical and geological substantiation of these operations, based upon a quantitative evaluation of the prospects for the presence of oil and gas. This problem is being developed, proceeding from an integrated analysis of the results of prospecting and exploration by institutes of USSR Mingeo, Minnefteprom [Ministry of Petroleum Industry] and Mingazprom [Ministry of Gas Industry], with the participation of producing organizations, as a scientific basis for five-year plans for each pentad.

The effectiveness of prospecting and exploration depends largely upon the work methods used. Improvement thereof at all stages occupies an ever greater place in the research of USSR Mingeo organizations, which covers a large number of questions: the rational division of prospecting and exploration into stages, standard practices for local prognoses on the presence of oil and gas, standard practices for geophysical operations (the various methods, their integration, the processing and interpretation of data, and so on), standard practices for prospecting and exploratory drilling, and other questions. Nuclear and other methods, founded upon the achievements of science, are being introduced into practice increasingly widely.

Recently carbonaceous complexes have been covered increasingly widely by exploration. Fields associated with them have been discovered in the Caspian depression and in West Uzbekistan; it has been established that reefogenic complexes in the Timan-Pechora province and in other areas are oil and gas bearing. However, the finding of these fields has brought up some complicated problems, since hydrogen sulfide and carbonic acid are usually contained there, so corrosion-proof equipment and apparatus, inhibitors, and the development of a technology for drilling in and for testing the formations are required. The study and development of deposits not of ordinary phase composition require a new approach. Since the most widely distributed types of trap in carbonaceous complexes are buried reefs of various ages--from Silurian to Upper Jurassic, mapping methods, forecasting of the location, and other questions associated with prospecting for them are being developed widely. Questions of the lithogenesis of the carbonaceous complexes, the forming of reservoirs in them, the occurrence of hydrocarbons and the forming of their accumulations are acquiring major significance. On the whole, the occurrence of oil and gas in the carbonaceous complexes is a problem that is complicated, both scientifically and practically, and requires comprehensive study on the basis of a systems approach.

Another problem is evaluation of the prospects that zones of lithological substitution in terrigenous reservoirs are oil and gas bearing. Fields in West Siberia, the Timan-Pechora province, and a number of other regions contain such zones. This problem includes a large number of questions of paleogeography, lithogenesis, standard prognostic practices, mapping, and so on. Using new methods of paleogeomorphological analysis and seismic prospecting, we can discover large fields and whole zones of them that are associated with lithological shielding.

East Siberia is a vast territory. The prospect that it bears oil and gas has been studied extremely poorly. However, the work done here, in confirming the great promise of the vast region between the Lena and the Yenisey, testify at the same time to the complexity of conducting prospecting and exploration within its borders. The profile here is extremely difficult for geophysical operations; permafrost rocks cover an enormous expanse and are spread to a depth of more than 1 kilometer. The nature of the reservoirs and traps is very complicated. This region needs special methods for field study and processing of data for the drilling in and testing of formations, and new forms of work organization.

An important problem is evaluation of the extent to which the Bazhenkov suite in West Siberia bears oil and gas. In this suite, which is regionally bituminous over an immense area, industrial-size deposits of oil have already been established. However, the specifics of its structure and the extent of the presence of oil require the solution of a large number of complicated questions. Primarily, questions of evaluating the capacity and filtration characteristics, the thickness of the productive parts of the cross-section, and substantiation of the hydrodynamic characteristics of the deposits, which are necessary for reliable estimation of the total and the recoverable reserves of oil, for working out an optimal technology for the drilling in of the formation and stimulation of the inflow, and so on, should be solved.

It is necessary to develop progressive forms of geophysical and geochemical research at a more rapid pace, to use the potential of high-altitude aeronautical and space methods more widely, to develop and use methods for the accelerated geological and economical evaluation of fields, to provide for further reequipping of geological exploration organizations, and to arrange for them to be supplied with highly effective equipment, devices and transport means.

"The Main Directions for the Economic and Social Development of the USSR During 1981-1985 and During the Period up to 1990," which was confirmed by the 26th CPSU Congress, sets before the geological exploration activity complicated and responsible tasks on preparing reserves of oil, gas and gas condensate that will insure the contemplated level of development of the recovery thereof, and on creating a backlog of prospecting starts for the long term. Their realization requires purposeful, strenuous work by production and scientific collectives, the close integration of science and production, and the acceleration in every way possible of the pace of scientific and technical progress in the industry.

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MELIK-PASHAYEV'S BOOK ABOUT OILFIELD OPERATIONS REVIEWED BY CHOLOVSKIY

Moscow GEOLOGIYA NEFTI I GAZA in Russian No 6, Jun 81 pp 60-62

[Review by I. P. Cholovskiy of MINKhiGP [Moscow Petrochemical and Gas-Industry Institute imeni Academik I. M. Gubkin] of the book, "Geologiya, razvedka i razrabotka neftyanykh mestorozhdeniy" [The Geology, Exploration and Development of Oilfields] by V. S. Melik-Pashayev, Moscow, Nedra, 1980]

[Text] One of the most important national economic tasks, which is constantly at the center of attention of the party and the government, is that of meeting the country's requirements for oil. This task, which is extremely complex and involves many plans, is made up of a multitude of interconnected specific questions that touch on the preparation of the raw-materials base, rational realization of reserves of this most valuable mineral, and insuring more complete extraction of it from the ground. Of paramount importance among these questions are the geological and oilfield-geology questions, with success in carrying out the task as a whole depending upon the completeness of their solution.

Of great interest, therefore, is a recently published new book by a major specialist in the area of oil geology, V. S. Melik-Pashayev. It examines a large number of problems of on-site geological study of oilfields at the stages of exploration, preparation for development, and the industrial mastery thereof.

The first chapter of the book is dedicated exclusively to an important problem--that of raising the effectiveness of geological exploration for oil. The basic principles for choosing the various elements of systems for exploring for oilfields and, in particular, of such an important element as the exploration target, have been laid down here on the foundation of the richest existing experience. The principles of the approach to the substantiation of exploration targets as a function of the geological peculiarities of the profile, and also the procedure (or sequence) for introducing them into exploration, are given in the examples of specific fields in various areas, including the Apsheron Peninsula, the Nizhnevartovsk arch in West Siberia, a number of areas of the Urals-Volga region, and others.

Also interesting is a group of questions that are examined, which touch upon the drilling in and testing of promising productive horizons at the prospecting and exploratory stages. Cases are recalled from which it follows that incomplete use of information obtained when exploratory wells are drilled can lead to a bypassing of industrially valuable deposits, which leads to a reduction in prospecting and exploration effectiveness.

The important role of good quality in conducting test operations of exploratory holes for purposes of evaluating reliably the industrial worth of discovered oil deposits was indicated.

The author pays great attention to standard practices in using production wells to refine exploration data and in making a detailed study of the structure of the oil deposits. Using concrete examples, the geological conditions and the purposes for which the most effective use can be made of a pilot development well are indicated. In particular, it is recommended that pilot wells be used to explore structures that are small or complicated in structure, to lend precision to poorly productive horizons that are situated above or below the main deposit, to obtain data necessary for the planning of drilling, and so on. The role of the establishment of first-priority industrial-test sections when preparing large oilfields for assimilation was indicated.

Oil deposits that are discovered on a continental shelf are playing an increasingly great role in world practice today. Therefore, the chapters of the book that present the experience that our country has gained in exploring and developing offshore oil deposits are of undoubted interest, and a description of the general status of the problem in the world is given.

Among the very specific and interesting phenomena which oil geologists encounter is anomalously high formation pressure (AVPD). Whole regions and stratigraphic complexes have been found for which a considerable difference in formation pressure is characteristic. Back in 1947 V. S. Melik-Pashayev published a report about the connection of AVPD with the mud vulcanism of the Apsheron Peninsula. On the basis of factual material and sources from the literature, the book performs a deep analysis of this phenomenon, a large number of the steps of the geological sequence that leads to its formation in oil deposits is indicated, and an explanation is given of why the appearance of AVPD at great depths can be of a regional nature and cover vast areas of oil and gas bearing basins.

A knowledge of the nature of AVPD has not only theoretical but also practical significance, particularly for forecasting the phase state of the hydrocarbons at great depths, for high-quality planning of the development of oil deposits that have AVPD, for organizing accidentfree sinking of deep wells, and so on.

A separate chapter is dedicated to the extremely important and complex question of substantiating the selection of targets for production. Based upon theoretical premises and experience in develcping domestic and foreign fields with different physical-geology conditions, the author has formulated the basic principles for selecting production targets in conformity with modern systems for developing oilfields.

Among the basic factors that should be considered in selecting development targets are the hydrodynamic tie of the various reservoirs and intercalations, the difference in their reservoir characteristics, their mutual positions in the drill log, with differences in infiltration characteristics, amount of reserves of oil, and so on.

The book cites numerous and very bright examples of differences in the approach to selecting production targets for concrete fields of Azerbaijan, the Urals-Volga region, West Siberia, Mangyshlak, the ChIASSR [Checheno-Ingush Autonomous SSR], and other regions. In so doing, it shows cases where a full and correct accounting of all the basic factors enabled the production targets to be adequately substantiated, and cases in which inadequate consideration of various factors led to a need to change previously selected targets--to amalgamate them or, on the contrary, to break them up into smaller units, introducing, in this connection, radical changes in the whole system of development.

A special chapter publicizes an extremely important question of oilfield geology--study and evaluation of the geological heterogeneity of productive formations for purposes of developing oilfields. It is perfectly correct here to point out the fact that, although the problem of study of heterogeneity of development targets has been given great attention, as yet no generally accepted criteria for evaluation and uniform standard-practice bases for considering it have been worked out, unlike the case both of estimating oil and gas reserves and of designing the development of oilfields. Right now a large number of indicators, with different notation systems, are being used, the physical essence of the coefficients proposed by various authors often being understood differently. All this tells negatively on the potential for an objective evaluation of the variability of the characteristics of productive formations.

The author gives his own formulation, sufficiently precise and all-embracing of the concept of "geological heterogeneity," cites geological-heterogeneity indicators that have been disseminated most widely, and states their physical essence. It is especially emphasized that, in studying the heterogeneity of productive horizons it must be considered that they are often represented as reservoirs of two types, which are characterized by different conditions for working the reserve that they contain and which usually are being moved in the profile and are lying in various combinations. This predetermines extreme complexity of the structure of the productive horizons as natural reservoirs and requires careful study and a separate calculation of the oil reserves that are contained in reservoirs of various types.

In this same chapter certain aspects of an extremely important problem--determination of the lower quality-standardized limit--of the collector rocks are touched on. However, this section is presented too briefly and schematically. Evidently, questions of establishing quality-standardized values for productive formations deserves a more detailed elaboration.

Very interesting information and generalizations on it are cited in the chapter, "Geological Factors That Occasion Change of Bubble-Point Pressure in Oilfields." The basic factors that determine the consistency of change in bubble-point pressure by area and by profile are indicated here in concrete examples of various oilfields and of whole oil and gas bearing provinces. The differences in the consistencies found for platform-type and geosynclinal areas are indicated.

Thus, for gently sloping deposits of the Volga-Urals oil and gas province, a reduction in the bubble-point pressure from the vault to the edge portions is characteristic. At the same time, for deposits of geosynclinal areas with steeply dropping formations and with a large "story" that bears oil and gas (the Sangachaly-Duvannyy-more field) an inverse dependence has been established--the bubble-point pressure increases with the submergence of the deposit and even exceeds the value of the pressure in the gas cap. It was noted for the first time that in deposits of the lower section of red-rock series of the Kotur-Tepe, Barsa-Gel'mes and Chelken fields in West Turkmenia, which have AVPD, the value of the bubble-point pressure exceeds the hydrostatic pressure. This is explained by submergence of deposits that had been formed at great depths, with additional diffusion of gas in the oil.

This work also generalizes the data on changes that occur within oil deposits as a result of the influence of various natural and artificial factors on them. Thus, as a result of the pumping of large amounts of cold water in formations, disturbance of the thermodynamic equilibrium can occur, leading to crystallization and precipitation of paraffin, the precipitation of salt, an increase in the oil's viscosity, and so on. Conditions favorable for the development of sulfate-reducing bacteria, which cause hydrogen sulfide contamination of the formations, with all its negative consequences, are pointed out. It is shown that the conduct of technological measures with a view to increasing withdrawal by injecting liquefied gases without taking the chemical composition of the oil into account can lead to a drop in the pressure of the asphaltenes and hamper conduct of the process. In focusing attention on these negative phenomena, the author notes correctly that the amount of research on study of the geochemical changes that occur in oil deposits while they are being developed is insignificant and clearly inadequate.

In touching upon certain urgent questions of developing oilfields, the author dwells on such questions as geological substantiation of selection of the waterflooding method, meeting well-inventory requirements by drilling doublers, determination of the rational value of the pressure of water injection, the time for starting boosted withdrawal of fluid, and so on. In particular, it is emphasized that, when choosing a waterflooding method, it is always necessary to consider the circumstance that, from the geological standpoint, marginal waterflooding, which produces natural conditions for hydrocarbon migration, is more effective for a large number of oil deposits.

In touching upon the tendency to increase injection pressure in order to increase the waterflooding coverage of heterogeneous producing formations, the author notes, completely correctly, that exceeding the critical injection value that has been determined can lead not to an increase in waterflooding coverage, but, on the contrary, to a reduction of it, as a result of the forming or the expansion of cracks or an increase in the injectivity of the more permeable intercalations. The conclusion about the undesirability, for a number of reasons, of boosted withdrawal of fluid at an early stage of development and the high effectiveness of it at basically a later stage is extremely important.

Various new methods for stimulating the oil reservoir with a view to increasing withdrawal from the producing formations will receive major development in the near term. These include primarily thermal methods. Therefore, the geological substantiation of the criteria of their applicability that is cited in the book is interesting. It is recommended that a breakdown be made of all deposits within the borders of the various oil-bearing provinces, as a function of the amount of reserves, depth of deposition, viscosity of the crude, content of sulfur and other substances, and physical-geology factors, according to the degree of favorability of the various methods, and that introduction of the methods be started when the most favorable effect can be obtained.

In evaluating the work as a whole, it should be said that the author has made a sound and interesting generalization, which covers a large group of interrelated questions about the exploration and development of oilfields, including an analysis of the various factors that govern the conditions for recovering oil from the ground. The book was written on the basis of the most modern views and notions, using recent theoretical studies and the vastest of experience in the development of oilfields, which covers several decades. All the main conclusions and principles are fortified and illustrated with concrete examples, oilfields of various parts of the country being used as such.

V. S. Melik-Pashayev's work is of great interest to the bulk of workers of scientific-research organizations and industrial enterprises of the petroleum industry, and also for students of the petroleum specialty.

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CSO: 1822/202

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UDC 622.276

METHODS FOR ECONOMIC EVALUATION OF OIL RESERVES EXPLAINED

Moscow NEFTYANAYA PROMYSHLENNOST'; SERIYA EKONOMIKA in Russian No 5, 1980 pp 2-6

[Article by A. I. Zhechkov and N. M. Nikolayevskiy of VNIIneft' [All-Union Scientific-Research Institute for Oil and Gas]: "Questions of Standard Practices in the Economic Substantiation of the Quality Requirements of Oil Reserves"]

[Text] An economic evaluation of the quality requirements of oil reserves that aims at breaking them down into reserves that are economically feasible and economically infeasible should rest upon a determination of the maximum national-economic benefit from the use of these reserves, provided that the fields that enable this benefit to be obtained are worked with advanced technology.

The value of the oil reserves, which is computed by means of the indicator of the highest industrywide costs for oil recovery, which is the standard for the maximum permissible expenditures from the national-economic standpoint for growth in oil recovery during the period being examined, is taken as the basic indicator in an economic evaluation of fields of oil reserves. This indicator is established in a centralized procedure as the sole one for the industry, but, as will be shown below, in two values.

Let us examine standard-practice questions of determining the indicators for an economic evaluation of oil reserves.

An economic evaluation of reserves of oil and of casing-head gas, using overall expenditures, is accomplished:

In defining quality requirements during the estimation of oil reserves and the breakdown thereof into the economically feasible and infeasible;

In the economic substantiation of the final oil-formation productivity;

In choosing the sequence of and periods for assimilating fields and portions thereof while making up detailed tasks for a long-term national economic plan; and

In making an economic evaluation of the consequences of the loss of oil reserves during the recovery or refining thereof, in setting technical and economic norms for sizes of losses, and in furnishing economic incentives for achieving optimal oil-formation productivity.

The indicator of a computed (monetary) evaluation of the oil reserves of a field is equal to the difference between the value of the product being recovered and the total expenditures (operating and capital) on recovery thereof for the whole period of development, taking the time factor into account.

The value of the monetary evaluation (R_p) is determined in accordance with the standard practice method for the economic evaluation of useful minerals, in accordance with the formula

$$R_p = \sum_{t=1}^{T} \frac{Z_t - S_t}{(1+\varepsilon_{НП})^t}, \quad (1)$$

where T is the computed period for evaluation of the field (or portion), which is figured from the year of evaluation (or start of development) to the year of completion of development;

Z_t is the value of the annual recovery of crude (including casing-head gas and other components), figured in terms of overall expenditures for the t-th year;

S_t is the sum of the future capital and operating expenditures (not counting amortization deductions for renovation) in the t-th year of operation; and

$\varepsilon_{НП}$ is the standard for citing isochronous expenditures and results, which is adopted as 0.08. Where the period is of identical duration, discounting under the formula $(1 + \varepsilon_{НП})$ is not performed.

The indicators of the evaluation are cited for the year for which the evaluation is carried out. When necessary, the interval between the start of the buildup of the oilfield facilities and the year of the evaluation is considered.

It seems to us that the level of highest expenditures for recovering 1 ton of crude should be established in two values:

a) In accordance with the upper limit of highest expenditures ($Z_В$)--for determining the moment for completion of the object's full output and the final yield, and, consequently, the boundary of the economically infeasible part of the oil reserves at the given object; and

b) In accordance with the lower limit of the highest expenditures ($Z_Н$) for the recovery of 1 ton of oil--for determining the boundary between the economically feasible and infeasible reserves for new objects which are subject to introduction. The computation of S, with $Z_Н$, is cited according to the formula (C + EK), taking into account expenditures for the exploration and recovery of oil for the group of the worst new facilities.

The economically infeasible reserves of new objects that are computed to account of the lower limit of highest expenditures ($Z_Н$) are named economically **infeasible category 1 reserves**, which can be introduced into long-term plans for drilling (capital construction) where there is a worsening of conditions in the inventory of new prepared reserves that are being put into operation. Economically infeasible reserves that are computed to take into account the upper limit of highest expenditures ($Z_В$), are named economically infeasible category 2 reserves, which can be transferred to the feasible portion of the reserves where there is a change in the conditions that determine the level of $Z_в$ (for example, during a rise in world prices for oil).

The indicators for an economic evaluation for future development of a field are computed in two versions. For substantiation of the final formation productivity in formula (1) it is assumed that $Z_t = Z_в$, and for determination of the economically infeasible category 1 reserves during introduction of the field or a part thereof, it is assumed that $Z_t = Z_н$. The computations allow establishment of the amounts of recoverable reserves by year and over the full period that the reserves are worked, the coefficient for final productivity, the total duration of operation of the oilfield, and the year of completion of its production, when $Z_в - S_t = 0$.

It is desirable here to concentrate one's attention on proposals to count as economically infeasible reserves those reserves for which, during the whole period of their recovery, the average annual expenditures were equal to or exceeded the standard level of the highest expenditures (maximum permissible expenditures).

One could concur with this, if the year-by-year dynamics of oil recovery by stage of development were marked by identical productivity and economic characteristics. When recovering oil and gas, there is no such uniformity of withdrawal.

As is known, withdrawals of oil and gas proceed at high prime cost levels for the recovery of oil during the third and, especially, the fourth stages of development. Therefore, in practice, the method of evaluating the quality requirements of the oil reserves according to highest expenditures averaged for the whole period of operation inevitably leads to a rejection of reserves which were completely profitable in the first stages of development, thanks to the higher flow rates of wells then than during later stages.

Consequently, where there is a sharp change in the dynamics of oil withdrawal in time, an economic assessment of the quality requirement of the reserves made with use of the level of highest expenditures, computed as an average for the whole period of development, is unsound.

In order to substantiate the quality requirement of the oil reserves from the economic standpoint, the limiting minimally permissible starting flow rates of new wells and the final flow rates of old wells are subject to determination. For these purposes, computations of the technological, technical and economic indicators of the development variant that was adopted for economic evaluation of the reserves are performed prior to achievement of the limiting rate of flow of the object (or well), which corresponds to the level of the upper and lower limits of the highest expenditures that have been approved by MNP [Ministry of Petroleum Industry].

The limiting final flow rate of the well (for oil) during an evaluation of final oil formation productivity, which will permit the borderline between the economically feasible and unfeasible reserves of the objects to be determined, should be computed according to the following formula:

$$q_к = \frac{З_р + З_{осн} + З_э \cdot Q_ж + З_п \cdot Q_з + З_с \times Q_ж + З_{пт} \cdot Q_ж}{Z_в \, 365 \, K_э}, \quad (2)$$

APPROVED FOR RELEASE: 2007/02/09: CIA-RDP82-00850R000400050008-4

where q_k is the limiting final flow rate of oil from the well, tons per day;

$З_р$ are expenditures for the upkeep and operation of well equipment, including deductions for capital repair thereof, rubles per well per year;

$З_{ос}$ are the basic and additional pay and social insurance deductions, rubles per well per year;

$З_э$ are the expenditures for energy consumed in extracting the liquid, rubles per ton;

$З_п$ are the expenditures for enhanced recovery, rubles per cubic meter of water;

$З_с$ are the expenditures for gathering and transporting the oil, rubles per ton of liquid;

$З_{пт}$ are the expenditures for industrial treatment of the oil, rubles per ton of liquid;

$Q_ж$ is the annual recovery of liquid per well, cubic meters;

$Q_э$ is the annual pumping of water, cubic meters (determined in proportion to the liquid that one production well needs per year);

$K_э$ is the coefficient of well operation;

$Z_в$ is the upper limit of highest expenditures per 1 ton of oil, which marks completion of operation of the well; and

365 is the number of days per year.

The basis for the limiting minimum permissible oil recovery from a new well (its daily flow rate), for determining the boundary between economically feasible reserves and economically infeasible category 1 reserves, which can be located at sections of a deposit that are not productive enough for introduction into development in the long-range plan for the period being examined (lensing-out zones, lenses, water-oil zones, blind alleys and others) is cited by year for the first 15 years, applying the lower limit of highest expenditures ($Z_н$) that was approved at the time of the evaluation. The computation is made according to the formula for the economic evaluation of economically feasible reserves (r_p) that share in the plans for development of the first period (T - 15 years), namely

$$r_p = \sum_{t=1}^{T=15} (Z_н - S_t). \qquad (3)$$

If, when computing according to formula (3), we find that $r_p \leqslant 0$, then drilling of the new well on the given section of the deposit is considered not economically justified and its oil reserves are included in the economically infeasible category 1 oil reserves. Accordingly, the zone for siting such points for drilling new wells is also deemed economically infeasible (category 1). As an exception, new wells for which the designed flow rates are below the minimum permissible can be drilled, where necessary for the realization of common tasks of the system for developing the oilfield (coverage by stimulation, advancement of the

VNK [oil-water contact], the use of casing-head gas resources, monitoring and research of the well's functions, and so on).

On the basis of primary oilfield data and use of formula (3), it is possible to determine the maximum flow rates for new wells that have been sited as a function of the value of S_t, the only variable in formula (3), since the remaining values of T and $Z_И$ are validated and given as industrywide by the appropriate MNP instructions. The value of the sum of capital and current expenditures S_t depends upon the geological and technological parameters for developing the field and is computed as the designed effectiveness indicator in accordance with VNIIneft' standard practice, and also by more simplified methods.

The basic methodological approaches for determining economically infeasible category 1 oil reserves, which restrict the drilling of new wells (or sections) by the amount of the limiting (highest) expenditures $Z_И$, which was established for a long-term period of development of the industry, and for determining category 2--with the expenditures $Z_В$, which determine the dates and the end of production of the object (the final oil production), were laid out above.

How then is the limiting initial flow rate of a new well to be computed in practice, when the point at which it is sunk is adjacent to a formation zone that is considered economically infeasible?

We have proposed two methods for computing the maximum initial rate of flow of the well $q_И$--industrial and regional, which enable a mutual check to be made of the approaches to solving the problem and of the results of the computation.

According to the first method, the maximum initial daily rate of flow of the well $q_И$ is determined in accordance with the formula

$$q_н = \frac{A + И}{Z_н 365 K_э}, \qquad (4)$$

where A is the amortization deductions for the balance-sheet cost of the drilling and of the well equipment, in thousands of rubles; and

И are the other current expenditures, which are a function of the operation of a given well.

The remaining notation is the same as for formulas (1-3). We will make a full computation of $q_И$ in accordance with formula (4) in an arbitrary example with a broad range of possible values of the initial data.

Say we are given 10 variants, in which the differences in the balance-sheet cost of the drilling and of the well equipment (K) are in the 100,000-600,000 ruble range, which are considered in determining the annual amortization deductions for renovation (A) per well that is subject to economic evaluation as to its limiting productivity.

For each variant (K), let us take subvariants with respect to the share of current outlays (И) without amortization in the structure of the operating expenditures and also 30-70 percent of all outlays, considering amortization, within a broad range of values of И. Moreover, it should be brought to attention that over the first 15 years (the amortization period for the well) the productivity of the well being examined will be reduced annually by the coefficient of the annual reduction in rate of flow $K_{п}$, which is arbitrarily taken as 0.9. Since the reduction of the well's rate of flow should be specified for the 15 years (beginning from the second year), then in order to compute the limiting initial rate of flow of the well, taking into account the reduction of its productivity $q_{н}^{пред}$, one can adopt $K^{6}_{п}$, which marks the average pace of reduction during the period that affects the value of $q_{н}$. The coefficient $K^{6}_{п}$ in its turn can be expressed by a reduction ratio equal to 0.531.

Then

$$q_{н}^{пред} = q_{н} : 0{,}531. \quad (5)$$

Formula (5) indicates that the limit of the rate of flow of the new well should be increased in comparison with formula (4) because of the reduction in productivity during the first 15 years of its operation.

Thus, computations of $q_{н}$ were conducted for all variants (at the prescribed values for K, A, И and Z), and also for $q_{н}^{пред}$, taking into account the ratio of reduction of well productivity during the period. Charts of the dependence of the limiting initial daily flow rates of the well $q_{н}^{пред}$ on the balance-sheet cost of the wells K, and the share of the current outlays for the recovery of oil, not counting amorization deductions (И), have been constructed in accordance with previously obtained data (figure 1).

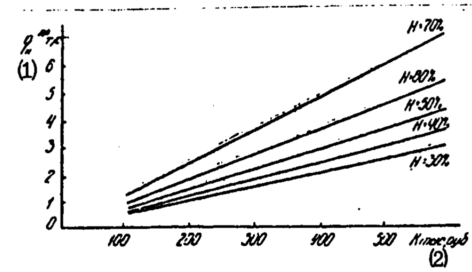

Figure 1. Maximimum Initial Flow Rate of a Well ($q_{н}^{пр}$) as a Function of the Cost of the Well (K) and the Structure of Outlays (И) with Reduction of Its Productivity During the First 15 years.

Key:
1. Maximum initial daily flow rate of the well, tons per day.
2. K, thousands of rubles.

It is sufficient to compute the values of K and И to find, according to the graph, the limiting initial flow rate of crude oil from the well $q_{н}^{пред}$ (figure 1) and thereby determining the limit of the economically infeasible category 1 oil reserves, whose introduction to the drilling-over process during the period being examined (prior to the next review of the value $Z_{н}$) is not desired.

Let us move over to the regional method of solving the problem. The economic substantiation for a minimal initial flow rate of a well, when breaking down the field's oil reserves into economically feasible and infeasible reserves, is done in this case in accordance with formula (3) in the following procedure. For a well that is to be drilled on a section of a specific oilfield of relatively low productivity, the indicators for the recovery of oil, gas and water by year for the first 15 years are determined. The well's recovery of oil by year is then evaluated according to the highest expenditures ($Z_{н}$) and it is substantiated according to formula (3). In the matter of capital expenditures, the value of S_{t} is determined on the basis of the actual or budget-estimated cost of the drilling and the build-up of facilities for the well being operated. An evaluation of current expenditures (not counting amortization of the equipment for renovation) is made by analogy with the level of expenditures at an operating oilfield with similar conditions for recovering oil or in accordance with confirmed planning and design norms for the region being examined. The amount of the economic benefit obtained from the drilling and operation of wells at the field's poorly productive section that is being analyzed is determined on the basis of the evaluation that was conducted of annual recovery, in accordance with the highest expenditures by year for 15 years, and of the sum of future capital and operational expenditures. It is desirable to review the dynamics of the accumulation of this benefit from the well's operation according to the results and to determine the level of limiting initial flow rate of the well which corresponds to the dynamics of increase of the benefit. Figure 2 presents as an example the dynamics of the accumulated economic benefit from operation of the well being analyzed that is 2,500 meters deep and is operating on a water-drive regime. The dynamics have been constructed to take into account changes in the well's productivity over 15 years (the annual coefficient of reduction of the flow rate is assumed to be $K_n = 0.9$).

In figure 2, the curve of the dynamics of the accumulated benefit at a flow rate of 5 tons per day for a definite year of well operation intersects the zero mark on the ordinate and thereby takes a positive value. Consequently, drilling a well 2,500 meters deep is desirable if its initial flow rate is 5 tons per day. Where the adopted limit of expenditures is (Z_H), introducing a well with a flow rate of less than 5 tons per day into operation is undesirable, and the reserves of the section where it is located should be recognized as economically infeasible category 1 reserves prior to an examination of Z_H by way of an increase.

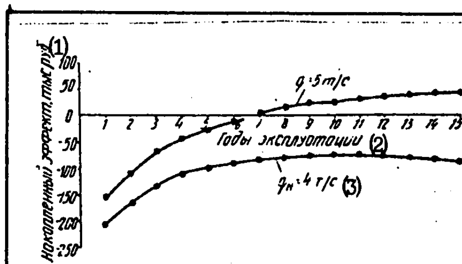

Figure 2. The Accumulated Economic Benefit from Operating a Well 2,500 Meters Deep; q_H Is the Well's Initial Flow Rate, Tons per Day.

Key:
1. Accumulated benefit, thousands of rubles.
2. Years of operation.
3. q_H = 4 tons per day.

The construction of curves of this same type for some wells that differ in depth but are similar in operating regimes and conditions for further operation will enable a nomogram of minimal permissible initial flow rates of new wells to be made up for a specific region. We have constructed an example of such a nomogram, based upon data similar to those of figure 2, and it is shown in figure 3. The nomogram makes it possible to solve responsively the problem of categorizing oil reserves of a section as economically feasible or infeasible category 1 reserves. Of course the construction and use of such nomograms are limited by the concrete physico-geological, technological and economic factors and operating regimes of the formation (or well). A change in one of these factors necessitates a systematic revision of the computations in accordance with formula (3). But the principle and method of economic substantiation that we have presented are retained.

In order to check the results of computation of the limit of the initial flow rate of new wells by the two methods obtained, which define the boundary of economically infeasible category 1 reserves, let us compare the data of figures 1 and 2, and the effectiveness data by separate region presented in figure 3. Let us take as the basis for the check the data for the new well 2,500 meters deep, for which the level of the limiting flow rate of 5 tons per day was obtained (see figure 2).

The balance-sheet cost of the drilling and of the equipment for this well is assumed to be a maximum of 264,000 rubles, which dictates annual amortization deductions in the amount of 17,700 rubles (6.7 percent). According to the cost calculations for the prime cost for recovering oil from the given well, we find the annual average current outlays by subordinate element (not counting amortization), which was 70 percent of all the operating values of K = 264,000 rubles, and on the line И = 70 percent, which determines the desired value of $q_н^{пред}$ = 5.5 tons per day.

Thus, the limiting flow rate for the new well under the conditions assumed in the example should be not less than 5 tons per day, which is also confirmed by a comparison of the results of computation by the two methods.

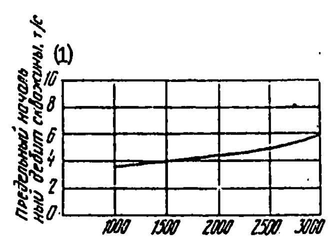

Figure 3. Initial Limiting Flow Rate of a Well as a Function of Depth (Meters).

Key:
1. Limiting initial flow rate of the well, tons per day.

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UDC 622.276.32

WAYS TO COMPUTE OIL WELL FLOW RATES FOR UNDISCOVERED FIELDS TOLD

Moscow NEFTYANAYA PROMYSHLENNOST'; SERIYA EKONOMIKA in Russian No 5, 1980 pp 6-8

[Article by O. I. Dorokhov, V. P. Il'chenko, Yu. A. Lomtev and S. V. Pronin of VNIIOENG [All-Union Scientific-Research Institute for the Organization, Management and Economics of the Oil and Gas Industry]: "Forecasting Flow Rates for Wells During Long-Range Planning for Oil Recovery"]

[Text] In making up plans to develop oil recovery, undiscovered oilfields play an important role in providing for the main growth in oil recovery. Forecasting of the computational parameters that are needed for estimating the flow rates of new wells in undiscovered fields is an extremely complicated and urgent task. Therefore, the oilfield-geology characteristics of the productive formations, their reservoir properties and the physical and chemical properties of the saturating liquids are determined more often than not by the analogy method, enabling possible flow rates for new wells in undiscovered fields to be judged and oil recovery for the long term to be computed.

Consequently, a fairly precise substantiation of the values of the possible initial average daily flow rates of wells for these fields that are obtainable as a result of drilling these fields over has very important significance in providing for planned levels of oil recovery.

At present there is no reliable method for evaluating and determining initial average daily flow rates for new wells by group of undiscovered fields, so an analysis of the values of average actual daily flow rates was made for all three types of fields: a) those under development; b)those being introduced into development, those that have been discovered and are being readied for introduction into development, and those under exploration or in mothballs; and c)undiscovered oilfields.

A retrospective analysis of the values of the actual average daily flow rates for new wells over a lengthy period of the development of oilfields has shown that it is difficult to single out flow rates for new wells at undiscovered fields from the flow rates for the indicated groups of wells.

The drilling over of new oilfields and their introduction into development in the country's oil-recovery regions were performed simultaneously for the three groups of fields, and therefore the actual values of the average daily flow rates of the new wells during the preceding development period reflect all three groups.

At the oilfields that have been introduced into operation, additional drilling of dense production and injection wells was conducted with a view to intensifying the process of operation, stabilization or reduction of the rate of drop in recovery, the wells being drilled in highly productive sections, and the drilling-over being accomplished in various sections or intercalations which were characterized by low collector properties in the productive formations and, consequently, by low average daily well flow rates, and which had not been put into operation previously. All this together did not permit groups of wells to be singled out for undiscovered field. Their flow rates were included in the average daily flow rates of the new wells.

Of the oilfields of the second group, the fields introduced into operation were primarily the more productive ones, as a rule, and the average daily flow rates of their wells were compared with the average daily flow rates of new wells at fields being developed.

Then the oilfields with lower productivity were drilled over, the criterion of the effectiveness of introduction being the limiting permissible values of the adduced expenditures that were established for the oil-recovery region.

It should be specially mentioned that the task of substantiating values for the average daily flow rates of new wells for undiscovered fields cannot be solved unambiguously, and, as a consequence, the obtained results can deviate in one direction or the other from those planned.

A more acceptable approach to solving the problem of substantiating possible values of average daily flow rates of new wells would be obtained where the characteristics of the targets and of the liquids that saturate them are given for undiscovered fields.

However, such data are extremely difficult to forecast. Therefore, considering experience in oilfield operation, a calculation of the expected average daily flow rates of new wells by undiscovered field should use those standard-practice approaches for determining average daily flow rates for new wells for undiscovered fields that later would yield results close to the actual results, and primarily the most reliable statistical methods should be used for this purpose.

With this in mind, it is necessary to study the trends in change in the oilfield-geology characteristics of fields discovered during the previous history of oil-recovery development. A study of the oilfield-geology characteristics of augmented reserves for a past period will help to reveal the trend in change of this characteristic for the long term.

One of the important characteristics that exerts considerable influence on the flow rates of wells is the viscosity of the crude oil. The values of the average daily flow rates of wells, and, primarily, the value of the final oil-recovery factor, depend greatly upon this value.

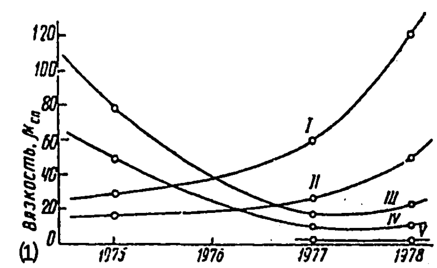
A retrospective analysis of the characteristics of change in the viscosity of the crude oil as reserves are augmented was conducted for various oil-recovery regions of the Urals-Volga province. During a study of actual data of change in viscosity of the crude with increase in reserves, weighted average values for viscosity were determined.

The figure shows the dynamics of the weighted average viscosity for the period from 1975 through 1978. As is evident from the graph, in later years a trend toward an increase in viscosity of the crude is observed with increase in reserves.

The data cited testifies to the fact that an increase in reserves for the industry is accompanied by a worsening of oilfield-geology characteristics in new fields, so the values of the average daily flow rates of new wells are expected to be reduced in the long term.

This is confirmed by the example of development of the Samotlor field, which has already been put into operation, where there are high-flow rate objects, and objects with lower flow rates are being introduced into development, causing a sharp reduction in the values of average daily flow rates of new wells. With the introduction into development of West Siberian oilfields with lower productivity during recent years, the average daily flow rates of new wells has been almost halved.

In conclusion, it must be noted that a characteristic feature for all the country's oil-recovery regions at present is the fact that as an ever larger number of new fields is put into operation, the pace of reduction in values of average daily flow rates for new wells is reduced (approaching, in time, a constant value).



Dynamics of Weighted Average Viscosity of Oil in the Following Associations:

I. Tatneft' [Tatar Oil Production Association].
II. Kuybyshevneft' [Kuybyshev Oil Production Association].
III. Udmurtneft' [Udmurt Oil Production Association].
IV. Permneft' [Perm Oil Production Association].
V. Nizhnevolzhskneft' [Lower Volga Oil Production Association].

Key:
1. Viscosity, centipoise.

The urgency of the problem being examined requires that a major complex of scientific-research operations be performed to create a substantiated methodology for determining average flow rates for undiscovered fields.

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CSO: 8144/1474

FUELS

OFF-SHORE DRILLING OF ENGINEERING-GEOLOGICAL WELLS

Leningrad MORSKOYE BURENIYE INZHENERNO-GEOLOGICHESKIKH SKVAZHIN in Russian 1980 (signed to press 3 Apr 80) pp 2-4, 262-263

[Annotation, foreword and table of contents from book "Off-Shore Drilling of Engineering-Geological Wells" by Igor' Vsevolodovich Arkhangel'skiy, Izdatel'stvo "Nedra," 2000 copies, 264 pages]

[Text] This book examines well drilling in the shelf zone of seas and oceans during engineering-geological explorations. It describes the natural factors which influence well drilling. It describes different methods of drilling operations: from floating and stationary units, from ice and directly from the sea bottom. The focus of attention is the technological processes in drilling wells from floating platforms. It examines the features of drilling wells in the tidal zone, in deep-water and complicated geological conditions, different methods of testing, experimental and geophysical work in wells, organization of work and accident prevention. It covers more extensively the studies of the sea bottom at great depths and at a considerable distance from the shore.

The quality of information received during well drilling is covered in a special chapter.

The book is intended for engineering-technical workers involved in drilling wells in the shelf zone during engineering-geological research, exploration and prospecting of off-shore fields of solid minerals.

Nineteen tables, 63 illustrations and 76 bibliographic entries

Foreword

The volume of construction work on the shelf increases each year. The total expenditures of the USSR for off-shore construction are approximately 2.5-3.0 billion rubles/year. Correspondingly, the total cost of engineering-geological research can be assessed at 50-60 billion rubles annually (1.5-2.0% of the capital investments for construction). The main volume of engineering-geological research goes for drilling wells under very complicated natural conditions. The process of drilling off-shore wells, in addition to geological factors, is significantly affected by wave action, wind, tides, currents, etc. Successful work can only be guaranteed with consideration for all external factors. Lack of knowledge about the features of off-shore drilling can result in the most undesirable consequences.

Definite experience has already been accumulated by now in off-shore engineering-geological drilling, but the number of publications on this question (comprising no more than 1% of the total number of publications covering different aspects of shelf geology) clearly does not satisfy the demand of the specialists who are involved in engineering-geological research in the shelf zone.

The first edition of this book entitled "Bureniye skvazhin v pribrezhnoy zone" [Drilling of Wells in the Coastal Zone] was published by the Leningrad division of the publishing house "Nedra" in 1975. The book went out of print very quickly, which confirms the urgency of the selected topic and the great interest of the specialists in drilling wells in the sea.

The second edition is being issued in a larger volume than the first. It basically does not differ from the previous. The structure and order of presentation are mainly as before, but new sections have been added. According to the recommendations of Lenin Prize laureate Ye. I. Ivanov, new chapters were included in the book: "Environmental Protection," and "Accident Prevention." Greater coverage is given to the questions of studying the sea bottom at great sea depths and a considerable distance from the shore.

The first edition did not have a section covering such an important question as the quality of information obtained during well-drilling. This omission has been compensated for in the second edition. The introductory chapter "Development, Main Directions and Features of Off-Shore Drilling" is new in the book. Certain sections from the first edition have been expanded. For example, more attention has been given to the study of properties of rocks in their natural occurrence. At the same time, part of the text and figures have been omitted that did not have great importance for an understanding of the material presented in the book.

The author is deeply grateful to Lenin Prize laureate Ye. I. Ivanov for valuable advice and wishes that he presented in reviewing the first book which the author took into consideration in the second edition.

Contents

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FUELS

WELL-DRILLING TOOLS

Moscow INSTRUMENT DLYA BURENIYA SKVAZHIN in Russian 1981 (signed to press 19 Dec 80) pp 2-6

[Annotation, table of contents and foreword from book "Well-Drilling Tools" by Igor' Kirillovich Maslennikov and Grigoriy Ivanovich Matveyev, Izdatel'stvo "Nedra," 10,000 copies, 336 pages]

[Text] This book presents a successive classification of different tools used to drill oil, gas, exploratory and core wells. It examines the classes, varieties, series, types and modifications of these tools. It covers and analyzes the modern domestic and foreign designs of cutting, blade, diamond and other tools for drilling wells by continuous and ring face, as well as underreamers, stabilizers, shock absorbers, sludge and metal traps and deflectors.

The book is designed for engineering-technical workers involved in drilling wells for oil and gas.

Fifteen tables, 209 illustrations and 44 bibliographic entries.

Contents

Foreword

Because of the great tasks set by the party and government for the oil and gas industry, it is necessary to technically rearm the drilling equipment and tools, expand their assortment, increase the production of new types of items that meet modern requirements, increase the efficiency of drilling operations, and reduce by 25-30% the periods for well construction through an increase in the drilling rates and introduction of new types of bits.

In order to solve these tasks, we should study, perfect and correctly employ the domestic tools used in drilling wells.

This period is characterized by a radical improvement in tools based on a study of the leading domestic and foreign experience, and the introduction of the latest technological methods. Especially large changes have occurred in the area of rock bits, the most widely used rock-breaking tool, as a consequence of the resolution of the fundamental problem of improving the stability of the cutter support [13, 15, 17].

The wear-resistance of the rock-breaking tools has been improved very significantly by means of using a wider assortment of new hard alloy teeth, strong insertion pieces made of superhard materials, and new wear-resistant coatings. The designs of the washing assemblies of the tools have been significantly improved [24, 20, 31].

However, the new drilling tool with hard alloy outfitting and airtight support which includes the latest friction bearings, can only operate efficiently in a limited range of loads and rotation rates without vibrations and sharp jolts. It is designed for effective use together with stabilizers, shock absorbers, protectors and other protective devices [23].

New versions of technological and auxiliary tools have recently appeared: spiral, jaw, roller and other stabilizers, different underreamers, shock absorbers, vibration dampers, deflectors, etc. Their complex use in well tunneling, especially deep and superdeep wells, affords broad potentialities for a drastic increase in tunneling in a run, improvement in the mechanical rate of drilling, reduction in cost per 1 m of tunneling, increase in the percentage of core sample removal, correspondence of the well shaft to its planned position, and minimizing the number of technical complications. However, this is impossible without extensive knowledge regarding the features of the modern tools.

The purpose of this book is to acquaint a broad circle of drillers, scientific workers and other specialists associated with drilling oil, gas and exploratory wells with the modern tools for tunneling the indicated wells, as well as with the problems of improving and effectively using these tools.

This book is based on the authors' own developments and many years of research in the field of drilling equipment, including an analysis of many hundreds of modern domestic and foreign designs of tools of different purpose which are examined for the first time as a unified complex.

The entire diversity of modern tools is ordered by their successive systematization based on a general classification developed by one of the authors [16]. The material is presented in sections, chapters, paragraphs and points in accordance with this classification, by classes, versions, series, groups , types and modifications of the tools.

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