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USSR Report

RESOURCES

(FOUO 25/79)

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USSR REPORT

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FUELS AND RELATED EQUIPMENT

ACHIEVEMENTS AND PROSPECTS OF THE UKRAINIAN PETROLEUM REFINING INDUSTRY

Moscow KHIMIYA I TEKHNOLOGIYA TOPLIV I MASEL in Russian No 9, Sep 79 pp 3-5

[Article by N. L. Notsek, first deputy chief of the Ukrainian SSR Glavneftekhimprom]

[Text] The petroleum refining industry of the Ukrainian SSR holds one of the leading places among the industries of the republic. Its products -- motor and boiler fuels, bitumens, lubricating oils and greases, paraffins and other petroleum products -- greatly affect the tecnical progress and development of the production forces of the republic. The development of the petroleum refining industry in the Ukraine was always given great attention, but it acquired special importance in the last decade as a result of the intensive development of the machine building, transport, power engineering, agriculture and other industrial sectors.

During that time, the Kremenchug and Lisichansk NPZ [Petroleum refining plant] were put in operation and the capacities of the Odessa, Kherson NPZ and others were expanded. The avergae capacity of a petroleum refining plant in the republic increased by 2.2 times compared to 1970. A special feature of the industry's development in the 10th Five-Year Plan period was the accelerated increase in capacities for primary petroleum refining and for secondary processes by building and putting in operation combined and consolidated installations, as well as modernizing the existing ones.

In 1980, the volume of petroleum refining will increase by 1.9 times compared to 1975. In the last three years the volume of petroleum refining increased 1.5 times; the output of gasoline increased by 30%; diesel fuel -- by 1.5 times and oils -- by 1.4 times. The high rates of increasing production were achieved due to the higher productivity of labor. In 1976-1978, this indicator increased by 27.5% for a plan target of 26.3%; for the five-year plan period it is planned to increase the productivity of labor by 55.9%.

The putting in operation of new new plants, modernizing and expanding existing facilities made it possible to raise the technical standard of petroleum refining considerably. In the current five-year plan period, the basic industrial production capital in the petroleum refining industry increased by 8.4%. The ratio of its active part was 61.3% by the end of 1978. The capital-labor ratio increased by 20.5% in the last 3 years and the power-labor ratio -- by 1.5 times.

With the increase in the volume of petroleum refining, the production of basic types of petroleum products also increased considerably. Republic enterprises produce over 130 kinds of oils, greases, and lubrication-cooling liquids which make up over 50% of the all-union assortment of such products. Some 24 kinds of oils and greases are exported to 27 foreign countries. New lubricants developed in the last 10 years replaced about 100 imported products which made it possible to supply domestic petroleum products to the Volzhskiy, Kamskiy and Zaporozhskiy motor vehicle plants, metallurgical plants and many other enterprises in the country.

In spite of the rapid increase in the output of petroleum products in the republic, the demand for them by their own production forces is not being satisfied fully: for motor vehicle gasoline -- by 70%; diesel fuels -- by 78%; and fuel oils -- by 65%. To reduce the gap between the production and consumption of petroleum products, it is planned to build, in the very near future, new combined and consolidated installations and to modernize existing petroleum refining enterprises.

The most important achievement in this area is putting in operation the Kremenchug NPZ -- a combined installation with units for primary petroleum refining, reforming of the gasoline fraction, hydraulic purification of diesel fuel and gas-fractionation. Compared to individual installations of similar capacities, its operation reduces capital investments by 45%, expenditures for refining petroleum -- by 25% and increases the productivity of labor by 1.5 times. The ELOU [Electric desalination unit] -AVT-6 at the Lisichansk NPZ was partially modernized in accordance with the reequipment plan which made it possible to increase the capacity of this plant. At the Kherson NPZ, the AVT-2 installation was modernized; as a result quality was improved and the yield of light petroleum products was increased.

At the Berdyansk ONMZ [expansion unknown], a shop was put in operation for producing lithium 12-oxystearate used for making high efficiency lithium lubricants for the motor vehicle industry (Litol-29, Fiol-1, Fiol-2, Fiol-3). At the L'vov NPZ, modernization of an installation was completed for making the AKVOL-3 self-emulsifying oil for mechanized mine supports in coal mines.

The intensification of technological processes is receiving great attention. Thus, in the Kremenchug NPZ, the catalytic cracking installation was changed over to a zeolite-containing catalyst which made it possible to increase the efficiency of this unit by increasing the yield of high octane gasoline. Production of raw materials was organized for industrial carbon at catalytic cracking units.

The increase in the production of petroleum products is accompanied by an increase in its quality which brings it up to the level of the best domestic and foreign products. Thus, the production volume of high octane gasolines in 1978 was 73.9% against 66.8% in 1975, low sulfur diesel fuel -- 69.5% against 62% correspondingly of the total production volume. At present, 73 kinds of petroleum products have the government emblem of quality. The ratio of petroleum products of the highest category of quality increased greatly compared to 1975.

The intensive development of the industry required giving special attention to rendering production wastes harmless and protecting natural resources. Considerable financial means are being allotted to protect the environment. Harmful exhausts were classified and typical measures were developed for their elimination. A special feature in petroleum refining exhausts is the prevalence of hydrocarbons -- their share is 60% in atmospheric exhausts. The sources of exhausts into the atmosphere are petroleum reservoirs, pouring platforms, pumping-compressor and refrigerating equipment, fixtures, safety valves etc.

The following measures are being taken to reduce air pollution by hydrocarbons: sealing reservoirs (replacing stationary covers by floating ones, installing pontoons made of synthetic films); building improved samplers, reducing transport operations; blowing-through when preparing equipment for repairs; increasing the efficiency of cooling petroleum products; introducing direct feed of raw materials to installations without intermediate reservoirs; utilizing flare gases and gases of bitumen oxidation; raising the efficiency fo trapping petroleum products in water purification installations;and equipping centrifugal pumps with face seals.

Measures are being taken to reduce exhausts into the air of carbon monoxide, sulfur-containing compounds and particulates. These measures include insuring complete combustion of fuel in industrial furnaces; afterburning of exhaust gases; use of efficient systems to collect dust in low-sulfur fuels; elimination of dumps. Thus, in 1977, an installation was put in operation at the Kremenchug NPZ for purifying hydrocarbon gases of hydrogen sulfide and obtaining sulfur from it.

The efficient utilization of water resources and rendering effluences harmless is receiving great attention. An efficient method for reducing water consumption is using apparatus for air cooling (AVO); their number at petroleum refining plants in the republic exceeds 250. Some 200 million m^3 of water was saved by using them with 11,000 to 12,000 rubles per year of operational costs being saved per one apparatus. The use of AVO reduces not only water consumption, but also the quantity of sewage water, and is a smaller load on purifying installations and sewage pipelines. The use of electric power is reduced considerably as well as the costs for capital and current repairs of the condensation-refrigeration equipment, with the elimination of labor-intensive cleaning of apparatus and pipelines of water-cooling equipment.

Another method for reducing water consumption is to develop the circulating water supply. At present it is used at almost all enterprises and provides

90% of the water required in production. The productivity of circulating systems increased by 1.5 times during the Ninth Five-Year Plan period. During that time, comprehensive purifying installations were built and put into service at the Kherson, Nadvornyansk and Lisichansk NPZ using the latest achievements in this field. For example, the drainage of the Kherson NPZ, after mechanical purification, was sent along with city sewage to biochemical purification facilities after which no petroleum products were found in them. In the 10th Five-Year Plan period, the construction and expansion of purifying facilities are being done at a faster rate. In 1977 alone, purifying facilities were put in operation at the L'vov NPZ, and those at the Odessa and Kremenchug NPZ were expanded. At the Lisichansk NPZ an installation was put in operation for making harmless salt-containing drainages, returning the salt to the plant. At this same plant, for the first time in the republic, an installation was put in operation for burning petroleum sludge.

The plan for the further growth and development of the petroleum refining industry provide for the expansion of existing enterprises and its basis is qualitatively new. The Kremenchug, Nadvornyansk, Lisichansk and other petroleum refining plants will be expanded considerably. It is planned to increase the volume of primary petroleum refining and develop secondary processes considerably. The introduction of catalytic reforming of unit capacity of 1 million tons per year will be expanded.

It is planned to introduce the isomerization process, as well as to change the catalytic reforming over to more efficient catalysts due to the necessity of meeting greater demands for higher octane gasolines Ai-93 and Ai-98. In connection with a greater volume of refining sulfurous and high sulfur content petroleum, the lead will be taken by installations for hydraulic purification of fuels, either separate, or within combined installations.

In connection with the considerable increase in the fleet of internal combustion engines, the output of high quality motor oils is increasing; demand is also increasing for sulfate additives, especially in medium and high-alkali (types S-150, S-300) which must replace fully low concentration additives of the PMS type. It is planned to build a high capacity installation for manufacturing sulfonate additives.

It is necessary to organize the production of imide additives to motor oils that meet the requirements of the operation of carburetor engines with an intermittent operating rate at low temperatures, as well as diesel engines that must use motor oils with high detergent properties.

One of the planned new in principle processes is the production of bitumen by a continuous method of distillation towers. The basic directions of scientific-technical progress in the area of lubricant production are: the use of semicontinuous processes; the introduction of improved brewing apparatus, mixing devices and homogenizers; the development and manufacture of multipurpose lubricants with lithium oxystearate, complex calcium, anhydrous calcium, complex aluminum, barium, silica gel, bentonite and other lubricants.

A qualitatively new basis for the development of petroleum chemistry is an accelerated increase in the capacities for producing ethylene and the propylene associated with it, butylene-divynil, aromatic and other hydrocarbons. Among petroleum refining products, liquid paraffins which are raw materials for the microbiological synthesis industry occupy and important place. Systems of adsorption separation of liquid paraffins will be introduced, as well as the production of liquid paraffins by the "Pareks" method.

The fulfillment of the complex problems faced by the petroleum refining industry of the Ukraine in the the 10th and 11th Five-Year Plan periods will make it possible to increase the efficiency of plant operation and will facilitate the development of all industries of the national economy of the republic.

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CSO: 1822

FUELS AND RELATED EQUIPMENT

UDC 665.63.004.17

PETROLEUM REFINING ELECTRO-DESALINATION UNITS

Moscow KHIMIYA I TEKHNOLOGIYA TOPLIV I MASEL in Russian No 9, Sep 79 pp 29-31

[Article by A. A. Kalinin, S. A. Feygin, A. A. Prokhorova: "Technical-Economic Indicators Installations of High Unit Capacity for Primary Petroleum Refining"]

[Text] For a long time the petroleum refining industry of the USSR proceeded along the path of creating large plants for refining petroleum using especially the process of direct distillation. In the last decade only installations of 3 and 6 million tons per year rated capacity were built, including those built in combination with ELOU [Electric desalination unit] units and secondary distillation of gasoline, as well as in combination with GK-3 and LK-6u installations. In 1976, the ratio of 3 and 6 million tons per year rated capacity installations was over 25% of the total number of installations for primary refining of petroleum, including about 15% of the installations with a capacity of 6 million tons per year.

To improve further the 3 and 6 million ton per year installations and to improve their work, the VNII NP [All-Union Scientific Research Institute of the Petroleum Industry] generalizes and analyzes the data on the work of such installations. The basic purpose of the analysis is to uncover reserves for raising the efficiency of the indicated installations and to develop measures for implementing these reserves. Moreover, it is necessary to compare the technological and technical-economic indicators with the rated indicators and disseminate the experience in operating the best installations. The Table shows the actual data on AT [expansion unknown] installations with rated capacities of 3 and 6 million tons per year which increased in capacity to the same degree in 1975.

The analysis of capacity utilization showed that in 1975 about 90% o the assimilated installations exceeded the rated capacity by over 10%. A considerable increase in capacity was achieved by modernization.

During the period of operation of the 3 and 6 million ton per year installations, a stable trend was noted in the growth of their annual capacities (in % of the rated, without taking into account installations put in operation in the given year): in 1972 -- 110.6; in 1973 -- 114.2; in 1974 -- 118.1;

in 1975 -- 125.5. The increase in annual productivity (an average of 90%) was mainly due to the increase in average daily productivity, i.e., by in tensive use of equipment, as well as an increase in the annual operating time of the installations. At the installations analyzed, the basic attention was given to increasing the average daily productivity. The annual operating time was increased insufficiently (repair time was not reduced enough and the unplanned idle times were not eliminated).

Positive experience on increasing the average annual operating time of installations was accumulated in several NPZ where equipment (small mechanized tools) were used efficiently. This made it possible to reduce the time for repairs, cleaning, assembly and disassembly. Thus, at one of these plants, the average annual operating time for the ELOU-AT-6 installation during 1972-1975 was 95.4% compared to 93% on the average for installations of such a capacity.

Along with a considerable increase in the capacities of the installations being analyzed, the capacities of the individual units of these installations as a whole are not being utilized fully. Thus, units for secondary distilling of gasoline are loaded only to 70 to 80% of the rated capacity and in individual cases are not utilized at all. The loading of vacuum distillation units for fuel oil for 1972-1975 in % of the rated was: for the 6 million ton per year installations -- 0.9; 6; 33.7 and 42.8 respectively; and for the 3 million ton per year installations -- 97.2; 121.6; 126.1 and 106. (in the calculations of average values, the data for the assimilation period was not taken into account).

In individual NPZ that did not have catalytic cracking installations, vacuum units of AVT installations practically did not operate due to the lack in the requirements for vacuum gas oil as raw material for catalytic cracking. A partial loading of the units or not operating them at all leads to a reduction in the effectiveness of capital investments.

To a great extent, stable operation of direct petroleum distillation installations depends on the quality of its preparation. In all the analyzed installations, the preparation of petroleum at field facilities and ELOU units improved before the direct distillation. This is indicated by data on the salt content in milligram per liter for 1972 to 1975: before the ELOU -- 907, 793, 428 and 248 respectively; after the ELOU -- 14.1, 11.6, 9.1 and 6.7. The results obtained at analyzed installations are almost twice as good as the average results at all ELOU installations. This is due to the use of more modern apparatus for desalination in combined ELOU-AT and ELOU-AVT installations.

When the salt content is reduced, the calendar time utilization coefficient and the time between repairs increase. Thus, in 1972 to 1975 inclusive these indicators changed as follows: calendar time utilization coefficient -- from 91.9 to 93%; time between repairs -- from 8.9 to 12.8 months (data for 1972 and 1975). On the average, calendar time utilization coefficent is 10% greater for the analyzed installations than the average for all primary refining installations in the USSR.

Table

Actual indicators for AT* installations

Indicators	Rated capacity million tons/year		Improvement in indicators, %**
	3	6	
Productivity, % of rated	127.2	127.6	-
Cost of installation 100 rubles	8390	12,676	-
Same for installation per 1 million tons/year	2198	1655	24.7
Cost for refining 1 ton of petroleum, rubles	1.13	1.03	9.8
Total staff, men	38	51	-
Same for installation per 1 million tons/year	10	67	-
Volume of refining per worker, 1000 tons	100.7	150	49

*Based on average data for all existing installations in 1975.

**Comparing indicators for an AT-6 installation and two AT-3 installations.

The analysis also shows that with a reduction in salt content in petroleum to 1-3 milligrams/liter, the calendar time utilization coefficient increases to 95-96% which corresponds approximately to an interrepair time of 17 to 22 months, or almost 2 times greater than the actual value for the installations being analyzed. Thus in an NPZ where the best results were obtained by desalinating petroleum in an ELOU unit of an ELOU-AT-6 installation (2.4 milligrams per liter according to the average annual data), it was possible to obtain a continuous run of 18 months between repairs. In 1975, a reduction in the salt content in petroleum at 3 and 6 million ton per year installations saved about 2.5 million rubles.

In 1972-1975, the ratio of installations that operated without idle times due to organizational causes or accidents (without taking into account those being put in operation in a given year) increased substantially: 33.3, 35.7, 37.5 and 61.1% respectively. But as follows from the cited data (even for 1975), the ratio of installations with the above-mentioned idle times is still high (38.9%).

The problem of energy economy is especially urgent for modern high capacity installations. The ratio of fuel in the structure of power consumption is 80 to 90% in the analyzed installations, therefore, to save power it is first necessary to reduce the consumption of fuel. Investigations of arrangements of preheating the petroleum in heat exchangers showed that there are considerable reserves for reducing unit fuel consumption by attaining the rated temperature (210°C) in the heat exchangers. In the analyzed installations the above-mentioned temperature attained was, on the average, 195°C, while in 1972-1975, no noticeable trend was observed to raise it (due to the insufficient heat exchange surface, imperfect heat exchange arrangements and the design of the heat exchangers).

According to calculations in 1975, overconsumption of fuel due to underheating in all installations amounted to about 180,000 tons which is 8% of the actual consumption, or is approximately equal to the annual fuel requirement of one ELOU-AT-6 installation. This is equivalent to over 2.5 million rubles (evaluating fuel in accordance with the average union cost of petroleum).

Project developments in recent years used heat exchange arrangements that made it possible to heat the petroleum to 250-260°C using domestic apparatus. Attaining such temperatures in the analyzed installations would have made it possible to reduce actual fuel consumption by 25% on the average and save over 600,000 tons of fuel per year.

Water steam is in second place after fuel in the energy expenditure structure. Reserves are also available for reducing its consumption in the analyzed installations. One of these reserves is heat-recovery boilers which are being operated unsatisfactorily at most of the installations. Thus, all installations that use heat-recovery boilers can reduce the actual consumption of steam by an average of 70% which is equivalent to reducing operational costs by 4 million rubles on the average.

Average unit consumption indicators for installations rated at 3 and 6 million tons per year are lower than the indicators for all installations of primary petroleum refining: unit fuel consumption -- by 15%; unit steam consumption -- by more than 3 times; unit electric power consumption -- almost by 2 times. Significant reserves are available for raising the efficiency of operation of the considered installations by fuller utilization of units for secondary distillation of gasoline and vacuum distillation of fuel oil, increasing the annual operating time of the installations; lengthening the time between repairs; reducing the use of power with normal operation of heat-recovery boilers; and attaining the rated temperature of preheating petroleum in heat exchangers by using the latest design developments.

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FUEL AND RELATED EQUIPMENT

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EVALUATING ELECTRIC DESALINATION INSTALLATIONS

Moscow KHIMIYA I TEKHNOLOGIYA TOPLIV I MASEL in Russian No 9, Sep 79 pp 31-33

[Article by A. P. Matiychenko: "On Substantiation of a Typical Technological Arrangement for the ELOU [Electric Desalination Installation]"]

[Text] The process of preparing petroleum at electric desalination installations (ELOU) consists of many steps: the petroleum is directed in sequence, first to electric dehydrators of the first and then second stages. Connecting electric dehydrators along the petroleum flows is considered the most characteristic technological solution. Basic versions of ELOU technological arrangements used in project planning or modernization include arrangements with series and parallel connection of the electric dehydrators. To select the optimal version, the ELOU technological arrangement must be analyzed by taking into account the providing of maximum efficiency of the petroleum preparation process at minimal capital expenditures for technological equipment, and monitoring and automation facilities. For this purpose we will analyze each typical arrangement.

To evaluate more fully the efficiency of preparing petroleum for the ELOU for a certain interval of time, comprehensive indicators that take into account the petroleum quality (content of salt and water) and the productivity of the installation [1] must be used. The amount of corrosive-aggressive substances (mineral salts, water) contained in the petroleum prepared in the ELOU during the monitored interval of time is such an indication of quality. The efficiency ff the ELOU operation may be evaluated by a transfer function [2], determined in accordance with a comprehensive indicator at the output $(U_{вых})$ to the value of this indicator at the input $(U_{вх})$:

$$W = \frac{N_{вых} V_{вых}}{N_{вх} V_{вх}} \qquad (1)$$

where W -- transfer function of the ELOU efficiency; $N_{вх}$, $N_{вых}$ -- content of mineral salts and water in petroleum at the input and output of the ELOU respectively; $V_{вых}$, $V_{вх}$ -- amount of petroleum at the output and input of the ELOU respectively.

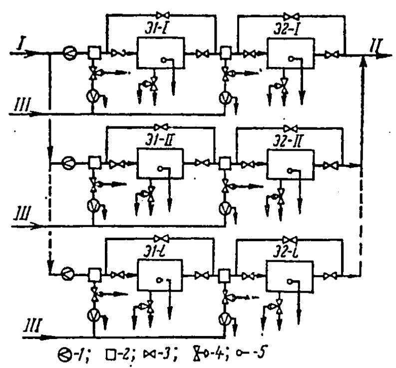

Fig. 1. Technological arrangement of an ELOU with series connection of the electric dehydrators:

1. consumption meter
2. mixer
3. gate
4. regulating valve
5. phase interface level gage

I. raw petroleum
II. desalinated petroleum
III. flushing water

For an ELOU arrangement with a series connection of the electric dehydrators (Fig. 1), the value of the comprehensive quality indicator at the output of the i-th petroleum flow ($U_{\text{вых},i}$) can be determined as follows:

$$U_{\text{вых},i} = U_{\text{вх},i} W_{1-i} W_{2-i} \qquad (2)$$

where W_{1-i} -- transfer function of the operation efficiency of the electric dehydrator of the first stage of the i-th petroleum flow; W_{2-i} -- transfer function of the operation efficiency of the electric hydrator of the second stage of the i-th petroleum flow.

The value of the comprehensive petroleum quality indicator at the ELOU output ($U_{\text{вых}}$) is determined by the sum of the comprehensive indicator values at the output of each flow. Taking the cited information into account, we have:

$$U_{вых} = \frac{U_{вх}}{q_0} \sum_{i=1}^{n} q_i W_{1-i} W_{2-i} \qquad (3)$$

where q_o -- total petroleum oonsumption at the ELOU; q_i -- petroleum concumption in the i-th flow.

Electric dehydrators of the same type are used in the desalination section of powerful combined installations. For a uniform petroleum distribution in each flow, the efficiency transfer functions of the electric dehydrators of one stage are equal. Therefore, the efficiency transfer function of an ELOU with a series connection of electric dehydrators is determined by a product of the efficiency transfer functions of one electric dehydrator of the first and second stages:

$$W_{пс} = W_{1-i} W_{2-i} \qquad (4)$$

For an arrangement with a parallel connection of electric dehydrators (Fig. 2) the value of the comprehensive quality indicator at the output of the first desalination stage (U_I) is determined by the expression

$$U_I = \frac{U_{вх}}{q_0} \sum_{i=1}^{m} q_{1-i} W_{1-i} \qquad (5)$$

where U -- value of comprehensive quality indicator at the ELOU input; q_o -- total petroleum consumption in the ELOU; m -- number of electric dehydrators in the first stage; q_{1-i} -- petroleum consumption in the i-th electric dehydrator of the first stage; W_{1-i} -- efficiency transfer function of the i-th electric dehydrator of the first stage.

The value of the comprehensive quality indicator at the output of the electric dehydrators of the second stage of desalination are determined in a similar way. Comprehensive quality indicator $U_{вых.пр}$ at the ELOU output with parallel connection of electric dehydrators is determined by the following expression:

$$U_{вых.пр} = U_{вх} \frac{\sum_{i=1}^{m} q_{1-i} W_{1-i}}{q_0} \cdot \frac{\sum_{j=1}^{n} q_{2-j} W_{2-j}}{q_0} \qquad (6)$$

where n -- number of electric dehydrators in the second stage; q_{2-j} -- petroleum consumption in the j-th electric dehydrator in the second stage of desalination; W_{2-j} -- efficiency transfer function of the electric dehydrator in the second stage.

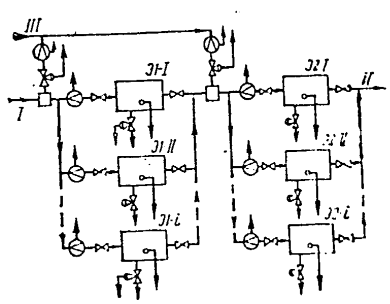

Fig. 2. Technological arrangementoof the ELOU with parallel connection of the electric dehydrators (for designations, see Fig. 1.).

For an equal petroleum consumption in electric dehydrators of one stage, their efficiency transfer functions will be equal. Taking into account equation (5) and (6) the efficiency transfer function of the ELOU with parallel connection of the electric dehydrators is determined by expression

$$W_{\text{пр}} = W_{1-i} W_{2-j} \qquad (7)$$

It follows from (4) and (7) that for an equal number of electric dehydrators in one stage, and an equal number of desalination stages, the ELOU efficiency is determined by the product of efficiency transfer functions of one electric dehydrator in the first and second stages independently of the type of technological arrangement. Inasmuch as the type of technological arrangement of the electric dehydrators has no effect on the efficiency of preparing petroleum for the ELOU, we will calculate the required auxiliary equipment (cut-off valves, regulating valves, mixers) and KIPiA [Control and measurement instruments and automation equipment] equipment for typical technological arrangements with eight electric dehydrators. The number of shut-off valves is determined by taking into account the bypassing regulating valves (see Table). According to the data in the Table, a parallel ELOU arrangement requires (for all other conditions being equal) less KIPiA and auxiliary equipment, i.e., the parallel arrangement is preferable.

Table

Calculation of quantity of auxiliary equipment

Equipment	Number of equipment units in parallel arrangement	in series arrangement
Shut-off valves	46	72
Meters for petroleum and water consumption	10	12
Gage for phase interface level	8	8
Regulating valves	10	16
Regulating devices	10	16
"Water-petroleum mixers"	2	8

Thus, for all other conditions being equal (number of desalination stages, number of electric dehydrators in each stage) the efficiency of the petroleum process in the ELOU does not depend on the technological arrangement of electric dehydrators, i.e., the type of technological arrangement of the ELOU. The parallel technological arrangement of electric dehydrators is more efficient with respect to the required quantity of KIPiA equipment, "water-petroleum" mixers and shut-off valves which, as a whole, raises the economic indicators and the reliability of ELOU functioning. The introduction of the design and modernization of a single typical technological arrangement for the ELOU will make possible a considerable economic effect by reducing the time for design, construction and assimilation of rated capacities and will reduce operational costs.

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FUELS AND RELATED EQUIPMENT

UDC 553.98.2.042+622.323/324(47+57)

FUNDAMENTALS OF LONG-TERM FORECASTING OF THE NUMBER OF PROVEN OIL, GAS RESERVES

Moscow SOVETSKAYA GEOLOGIYA in Russian No 8, Aug 79 pp 3-13

[Article by N. I. Buyalov (VNIGNI [All-Union Petroleum Scientific Research Institute of Geological Exploration]), V. N. Korniyenko (Minnefteprom [Ministry of the Petroleum Industry]) and I. P. Lavrushko (VNIGNI)]

[Text] Development of the economy of the country is largely determined by the state of the fuel and raw material base. The tasks posed by the 25th CPSU Congress dictate a real need to carry out long-term planning of the main indicators of activity of the oil and gas industry for periods which exceed the five-year period.

Successful embodiment of the plans for development of the oil and gas industry will largely be determined by correct and reliable forecasting of the state of oil and gas resources and the ratio of reserves of different groups and categoires. Dependable and reliable forecasting of the variation of reserves and the ratios between them will permit efficient planning of the disposition of future volumes of exploratory and test drilling and financial expenditures and will consequently provide high efficiency of operations during subsequent years and will determine the necessary levels of oil and gas production and the increase of reserves.

The activity of geological prospecting and oil- and gas-producing organizations is characterized by such indices as oil and gas resources, reserves, the volumes of exploratory and test drilling, capital investments, operating efficiency and so on. This series may be regarded as a system of closely related indices developed in time which have specific internal and external connections. A means of studying these complex systems is systems analysis. One of its main tasks includes modelling of the system and determination of its status of the future, i.e., in forecasting [5]. It makes it possible to find the most realistic methods of solving the tasks and problems related to complex systems by thus ensuring the best satisfaction of the posed requirements [7].

The methods of calculating the initial producible potential resources (NIPR) must be improved for more confident justification of future volumes of

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exploratory and test operations and their efficiency. In this regard the authors developed a sequence of long-term forecasting of time variation of oil and gas resources and reserves and also other important indicators of geological prospecting operations based on the concept of practical limitation of oil and gas resources in the interior. The authors proceeded from the fact that study and use of the oil and gas resources existing in the interior are incomparably low in their activity compared to the process of transformation of organic matter and formation of fields. Therefore, the influx of any significant newly formed volumes of oil and gas to known and yet undiscovered fields cannot be counted on. Consequently, all NIPR in the foreseeable future will be determined and then extracted, i.e., the interior will be completely depleted.

We understand NIPR as the amount of oil or gas which is located in the interior can can be extracted. This corresponds to a specific degree to the generally accepted term NIPR, which is understood as the total number of commercial oil and gas reserves contained in known fields prior to the beginning of exploitation and also future reserves and quantitative analysis of forecasting the oil and gas content, i.e., the sum of already extracted reserves (accumulated production Σq_t), proven extractable reserves (categories A + B + C_1), future extractable reserves (category C_2) and quantitative analysis (the extractable part) of forecasting the oil and gas content (group D).

Since NIPR are the objectively existing extractable volumes of hydrocarbons in the earth's interior, then based on the prerequisite of limitation of initial oil and gas reserves in the interior, the sum of their constituent terms should not vary in time, corresponding to the equation

$$Q_{\text{ННПР}} = Q_{D+D_1} + Q_{C_2} + Q_{A+B+C_1} + \Sigma q_t = \text{const.} \quad (1)$$

Only the ratio and levels of the reserves of different groups, categories and production will vary (Figure 1).

It is obvious from Figure 1 that the entire volume of NIPR is completely reppresented by reserves of group D at the very beginning of operations and is represented at the very end of operations only by the volume of oil or gas production accumulated during the entire period of development of the region. During the intermediate periods, NIPR may be expressed in the form of the sum of the volumes of reserves of different groups and categories and of accumulated output. The dynamics of variation of the levels of NIPR terms for different periods of development of a region--from the beginning of operations to completion--are shown in Figure 2.

Variation of NIPR terms is interchangeable. Each of these terms can be expressed in the form of dynamic variables, represented graphically by curves and asymptotically approaching a specific limit which they cannot exceed. Each of the curves, on the one hand, has its own individual configuration and on the other hand, the nature of its variation is determined by variation of the variables which shape the other curves. As a region is studied, the

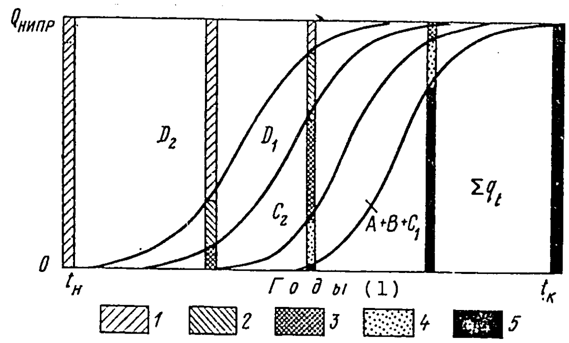

Figure 1. Dynamics of Variation of Internal Structure of NIPR: 1--predicted estimate of subgroup D_2; 2--predicted estimate of subgroup D_1; 3--future reserves of category C_2; 4--commercial reserves of categories A + B + C_1; 5--production from the beginning of exploitation

Key:
1. Years

predicted reserves will decrease and approach zero, whereas the initial extractable commercial reserves and the accumulated output will increase from zero and will approach its own upper limit--the NIPR, and the curve of accumulated output, generally repeating the configuration of the curve of initial reserves, will lag somewhat behind it in time.

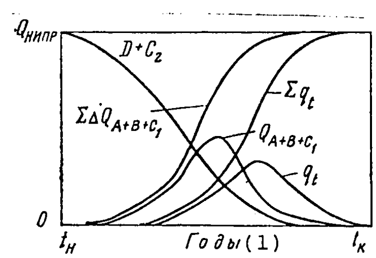

Figure 2. Dynamics of Variation of Absolute Levels of Proposed Extractable Reserves D + C_2, Proven Reserves $\Sigma\Delta_{A+B+C_1}$, Current Commercial Reserves Q_{A+B+C_1}, Accumulated Output Σq_t and Annual Level of Oil and Gas Production q_t

Key:
1. Years

The practice of geological prospecting and exploitation operations for oil and gas in a number of regions with a long history of development indicates the identity of the nature of time variation of almost all indices. Factual data indicate that the values of such indices as current reserves and current production increase during the initial stages, reach their own maximum at some point, after which they gradually decrease and again approach zero (Figure 2). This increase of dQ/d_t can be represented by two differential growth equations

$$\frac{dy}{dt} = ya\left(1 - \frac{y}{k}\right) \tag{2}$$

or

$$\frac{dy}{dt} = ya \ln\left(\frac{k}{y}\right), \tag{2'}$$

where dy/dt is the rate of growth of the index in time, k is the upper bound to which index $y (0 < y \leq k)$ may increase and a is the growth proportionality constant.

After integration, equations (2) and (2') assume the form

$$y = \frac{k}{1 + b \exp(-at)}; \tag{3}$$

$$y = k \exp[-b \exp(-at)], \tag{3'}$$

where b is the integration constant.

Equation (3) is a logistical curve while equation (3') is a Gompertz-Meykem curve. Each of these equations reflects an increase in the values of the initial extractable commercial reserves and production from the beginning of exploitation (curves $\Sigma \Delta Q_{A+B+C_1}$ and Σq_t in Figure 2). The nature of variation of the logistical curve and of the Gompertz-Meykem curve is generally similar. The difference is that the second curve increases more rapidly during the first stage than the first curve and then approaches the maximum value less intensively. If the first derivatives of the equations of initial extractable commercial reserves and accumulated production are taken, we find equations which describe the dynamics of variation of current extractable commercial reserves of categories $A + B + C_1$ and the current level of output (curves Q_{A+B+C_1} and q_t in Figure 2).

The graphs in Figure 2 are similar to those which were presented by M. Hubbert [11,12]. However, the authors of this article, relying on the main principles suggested in the mentioned papers, used them with respect to the existing system of classification of reserves in the USSR.

Since the variations of the indices graphically represented in the form of the curves in Figure 2 are interrelated and regular, then, by knowing the nature of these variations during a specific period which is described by the corresponding formula, one can predict their further behavior.

Since curves $\Sigma\Delta Q_{A+B+C_1}$ and Σq_t asymptotically approach the same limit k, i.e., the NIPR, making use of factual data on the initial extractable commercial reserves and output accumulated since the beginning of exploitation to solve equations (3) and (3'), one can determine the value of the NIPR. To determine the state of extractable current reserves and annual production during the past few years, let us proceed in a similar fashion by solving the equations which describe the nature of variation of curves Q_{A+B+C_1} and q_t.

We analyzed the variation of current extractable reserves, annual production, initial extractable commercial reserves and production from the beginning of exploitation for a number of oil- and gas-bearing regions of the country, characterized by a long period of exploratory-test and exploitation operations. A forecast of the state of the parameters enumerated above for the future was made on the basis of this analysis. The sequence of conducting the operations for accomplishing the forecast is described below.

The first and most important problem is to determine the value of the NIPR. The predicted estimates of group D, reserves of category C_2, reserves of categories A + B + C_1 and production since the beginning of exploitation are usually summarized when determining the NIPR. The values of the NIPR are recalculated periodically. The values of the NIPR seemingly become more and more accurate, approaching the initial value, with each recalculation as our knowledge about the geological structure of the studied region, the essence of the processes of genesis, migration and accumulation of hydrocarbons and methods of quantitative analysis of forecasting oil and gas content is improved and also as the future and commercial reserves are calculated. If one assumes that the accuracy of the value of the NIPR increases, then the reliability of such components of NIPR as the values of quantitative analysis of the forecast (group D) and reserves of category C_2 should also increase. In other words, we should acquire greater and greater confidence in time in the fact that the calculated volumes of extractable reserves of categories D and C_2 will actually be discovered and will then be extracted from the interior. However, practice shows that reserves of group D and category C_2 remain unrealized over a very long time period in some regions characterized by a high degree of study. This naturally raises doubts of the accuracy of estimating the predicted and future reserves and does not permit one to judge the quantities of commercial reserves which will still be determined. Doubts about the estimate of reserves of group D and categories C_2 provide no bases to determine the value of the NIPR by simple addition of production and reserves of different categories.

In this regard, the NIPR should be calculated on the basis of the tendency established during the entire prolonged period of exploration of a region in variation only of commercial reserves and output by extrapolation of the curves of the initial extractable reserves $\Sigma\Delta Q_{A+B+C_1}$ and production since the beginning of exploitation Σq_t up to their asymptotic limit k, i.e., the NIPR, in regions with a long history of development where a specific trend in variation of the increase of reserves and production has already been noted and where a sharp increase can be expected only under extreme circumstances (for example, in case of unexpected discovery of large fields, which is hardly probable). Having thus determined the value of the NIPR and knowing the initial extractable reserves of category A + B + C_1 for the present, one can calculate the volumes of the yet undetermined commercial extractable reserves. The number of commercial extractable reserves determined by this method and still remaining in the interior can be compared to the total of existing reserves of group D and category C_2 calculated by traditional methods. The value of the ratio of yet undetermined commercial reserves, calculated from the curves, to the sum of the reserves of group D and category C_2 will reflect the reliability of this sum, i.e., it will show which part of it, which we have called the extractable reserves D and C_2, will actually be converted to reserves of commercial categories and will be produced.

All the parameters contained in the formula of the logistic curve and the Gompertz-Meykem were calculated on a computer and their values for subsequent years were also established to determine the value of the NIPR (limit k).

The value of k was calculated independently by five methods [9, 10, 13, 14, 15]. Not only the numerical values of k, but also their reliability and also the error of the estimate were determined. The values of k found by different methods differed from each other by a value not exceeding 5-10 percent of the absolute value with confident probability greater than 95 percent.

Since the values of NIPR are are the most important indicators, they were calculated by two additional methods as a check: by analyzing the variation of the density of initial reserves and by analyzing the variation of proven reserves as meterage of exploratory-test drilling during the entire period of developing a region is accumulated (Figure 3).

The quotient from division of $\Sigma \Delta Q_{A+B+C_1}$ by s, where s is the total future area of a region, was taken for the density of initial commercial reserves for each date. The nature of variation of the density of initial reserves should totally repeat the nature of variation of the level of initial reserves: at the beginning of operations this density is equal to zero due to the absence of reserves and as a region is studied, it approaches some maximum value which is equal to the specific density of the initial potential resources completely converted to the accumulated production. The maximum value was also determined in a similar manner, i.e., by using the five methods which were used in calculations for the accumulated output and the initial commercial reserves [9, 10, 13, 14, 15]. The five values of q_s found upon multiplication by the value of the future area yielded values of the initial potential resources of a region. The maximum values of k calculated by the corresponding methods by specific densities of reserves are in good agreement with previously obtained estimates with reliable probability of more than 95 percent. One of the five derived values of k was selected and mainly that which was determined by methods which yield the highest correlation relations and the least mean square errors [10, 14, 15].

Parameters a and b contained in these equations were then determined to solve equations (2) and (2') and to determine the configuration of the desired curves, for which the mean value of k was used. Determination of the coefficients was accompanied by an estimate of the confident interval necessary for forecasting.

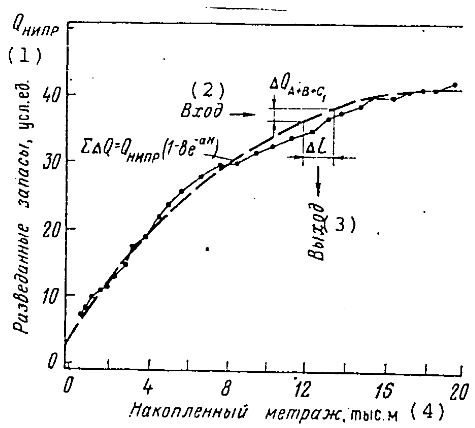

Figure 3. Graph of Variation of Proven Reserves (Sums of Increases of Reserves oc Categories A + B + C_1) as Meterage of Exploratory-Test Drilling is Accumulated. The solid lines were plotted from factual data and the dashed lines are analytical curves (that is, those in Figures 4-6)

Key:

1. Proven reserves, arbitrary units
2. Input
3. Output
4. Accumulated meterage, thousand meters

The reliability of estimating parameters k, a and b was determined three times. The sampling was limited by 1) the first half of available observations, 2) by the first two-thirds of observations and 3) by the complete set of observations. Matching of the calculated (predicted) and observed values was checked in this case. The check of matching by the Darbin-Watson criterion, which was carried out for calculations 1 and 2, showed that the predicted values agree with the actual values with reliable probability exceeding 99 percent. It was also established that coefficients a and b, despite the difference in the volume of initial information, vary insignificantly. This indicates that the derived equations give a good description of the time variation of the initial indices. Consequently, they permit one to make a reliable forecast.

It was established that the volume of proven commercial reserves can be adequately well approximated by an equation of the Gompertz-Meykem curve as a region is drilled with an increase of exploratory-test meterage:

$$\Sigma\Delta Q_{A+B+C_1} = Q_{НИПР} e^{-be^{-aH}}, \tag{4}$$

where Q_{NIPR} are the initial extractable potential resources, b is the integration constant and a is the growth proportionality constant.

This functional dependence differs from the equation of the curve proposed in the paper of A. Zapp [16]. The given reserves essentially do not increase in the given case during the initial stage with an increase of meterage, whereas, according to A. Zapp [16], the growth of reserves is highest during the initial stage, which clearly contradicts the factual data.

If we take the first derivative of equation (4), we find the functional expression of the variation in the increase of proven reserves per meter of sinking wells with an increase of meterage, i.e.,

$$\frac{d\,(\Delta Q_{A+B+C_1})}{dH} = Q_{НИПР}\, ab\, e^{-be^{-aH}} e^{-aH}. \tag{5}$$

The nature of variation of efficiency is essentially similar in all regions: efficiency is low or almost equal to zero during the early stages of geological prospecting operations, it then begins to increase and at some moment reaches a specific maximum, after which it gradually decreases. However, in view of the specifics of regions, the characteristics of distribution and disposition of fields and their reserves, the nature of variation of efficiency may vary from region to region with retention of the overall trend.

The given nature of variation of the initial extractable commercial reserves and the increase of reserves per meter of sinking wells was also noted previously [8, 12, 16]. A graph of variation of equations (4) and (5) is presented in Figures 3 and 4.

Based on the assumption that the growth of reserves will also subsequently decrease exponentially after a maximum, the values of the increases of reserves during the past few years were calculated up to the moment when the increase stops and the values of commercial reserve not yet extracted from the interior and the NIPR were also calculated.

The values of the NIPR calculated by analyzing the variation of the density of initial commercial reserves and increase of reserves per meter of drilling were very similar to values of NIPR calculated by the logistic curve and the Gompertz-Meykem curve. This indicates that the method of determining the NIPR from these curves is logically and mathematically justified and can be used in practice.

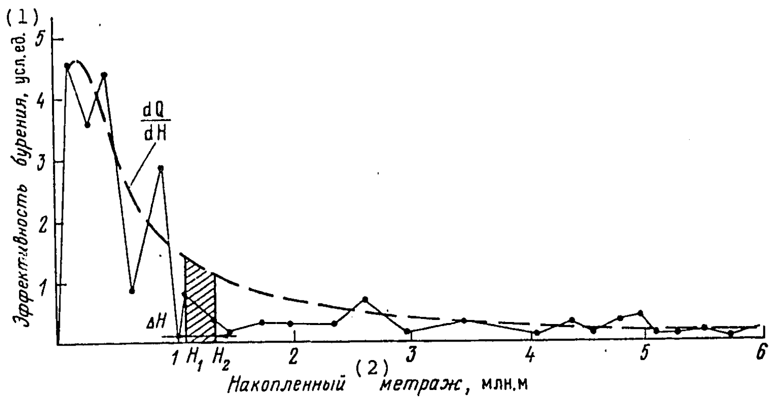

Figure 4. Graph of Variation of Annual Increase of Reserves of Categories A + B + C_1 Per Meter of Exploratory-Test Drilling During the Entire Period of Operations in the Region

$$\Delta Q = \int_{H_1}^{H_2} Q_{\text{НИПР}}\, be^{-be^{-aH}} e^{-aH};\quad \Delta Q = \left(\frac{dQ}{dH}\right)\Delta H$$

Key:

1. Drilling efficiency, arbitrary units
2. Accumulated meterage, million meters

Bes es the value of the NIPR, the volumes of production, current reserves and future increases of reserves and also variation of the total extractable predicted estimates and future (assumed) reserves were calculated for the same regions and a number of associations (Figures 5 and 6).

By calculating the volumes of NIPR and the commercial reserves not yet extracted, we assumed that the values of the oil yield coefficient in the future as equal to its current value. One may also determine the NIPR and the volumes of commercial reserves not yet determined by introducing corrections into the calculations for variation of the oil yield coefficient in time, taking into account progress in the technology of field exploitation.

When plotting the graphs (see Figure 6), the authors proceeded from the proposition that all the reserves can be conditionally separated into proven (the total accumulated production and commercial reserves of category A + B + C_1) and assumed (the total future reserves of category C_2 and predicted estimates $D_1 + D_2$).

In those regions where the confirmability of the future reserves of fields is low, they can be included in the assumed reserves. If the confirmability of the future reserves of fields is sufficiently high, the assumed reserves will

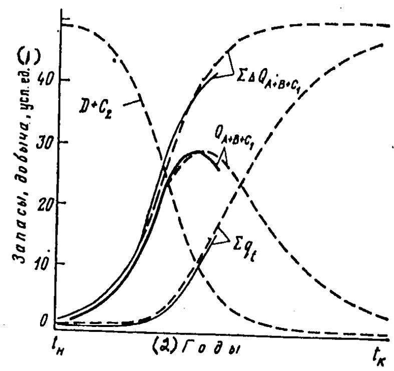

Figure 5. Dynamics of Variation by Years of Accumulated Production Σq_t, Proven Reserves $\Sigma \Delta Q_{A+B+C_1}$, and Assumed Extractable Reserves D + C_2

Key:
1. Reserves, production, arbitrary units
2. Years

be represented only by the sum of the quantitative estimate of group D and reserves of category C_2 of promising structures. In this case reserves of category C_2 of fields will also be included in initial extractable reserves when calculating the NIPR by extrapolation of the curves of initial extractable reserves. Based on equation (1), the assumed reserves were arbitrarily combined in the given case under the index D + C_2 and were determined in the following manner:

$$Q_{D+C_2} = Q_{НИПР} - Q_{A+B+C_1} + \Sigma q_t \qquad (6)$$

or

$$Q_{D+C_2} = Q_{НИПР} - \Sigma \Delta Q_{A+B+C_1}. \qquad (7)$$

The sum of derivatives $d(\Sigma q_t)/dt$ and $d(Q_{A+B+C_1})/dt$ presented in Figure 6 yields values of the increase of commercial reserves due to exploratory-test drilling, which is expressed by the formula

$$\frac{d(\Sigma q_t)}{dt} + \frac{d(Q_{A+B+C_1})}{dt} = \Delta Q_{A+B+C} = \Sigma \Delta Q_{A+B+C_1} - \Sigma q_t. \qquad (8)$$

The actual values of the increases of reserves due to exploratory-test operations and also current levels of production are presented in this same figure for comparison. The theoretical values of Δ_{A+B+C_1} correspond completely in their absolute value to variation of the level of reserves D + C_2, i.e.,

$$\left|\frac{d(D+C_2)}{dt}\right| = \Delta Q_{A+B+C_1}. \qquad (9)$$

Variation of the efficiency of exploratory-test drilling, expressed in the increase of reserves per meter of drilling, corresponds completely to the curve ΔQ_{A+B+C_1} presented in Figure 6.

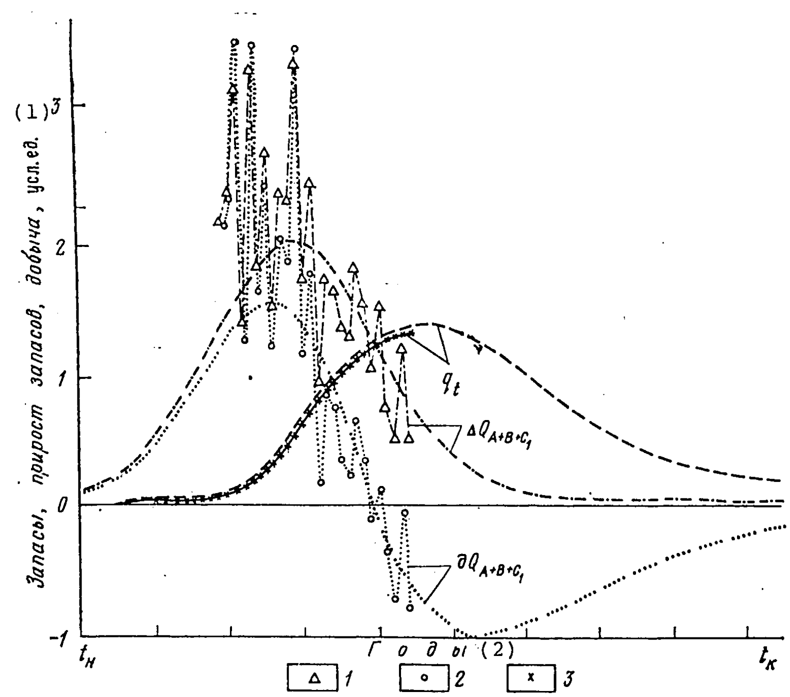

Figure 6. Graphs of Variation of Annual Production Levels q_t, Increase of Reserves from Exploratory-Test Drilling ΔQ_{A+B+C_1} and Increase of Extractable Reserves dQ_{A+B+C_1}: 1--increase of extractable reserves per year; 2--increase of extractable reserves; 3--annual production

Key:
1. Reserves, increase of reserves and production, arbitrary units
2. Years

The nature of variation of the levels of reserves, production and increases of reserves in the future is shown in Figures 5 and 6. All this together permits one to determine the date of the maximum level of production, the length of the period of production stabilization at this level and the date of the beginning of its decrease. The possibility of determining the volumes of the increases of reserves, required to support production, and also of calculating the approximate date of total depletion of the interior within a specific oil- and gas-bearing region are represented by these graphs.

The method of long-term forecasting, based on the concepts and calculations outlined above, permits one to make a forecast not only for areas with long history of development, i.e., with sufficient volume of statistical material, but also to plan the possible nature of development of the fuel and raw material base of the new region where exploratory-test operations are only beginning on the basis of directive instructions.

One must have the following data to make this forecas

1) the initial extractable potential resources of the new territory estimated by different methods (volumetric-genetic, comparative-statistical [3, 4, 6] and so on);

2) the year since the beginning of operations for which it is planned to provide maximum production and the highest level of current commercial reserves;

3) the given growth rates of production and the increase of reserves.

The need for these data is determined by the following circumstance. Parameter a in equations (2) and (2') is a dimensionless value of the growth rates. The logistical curve and the Gompertz-Meykem curve accordingly have inflection points (when the first derivative has a maximum value) with the coordinates:

$$t = \frac{\ln b}{a} \text{ at } Q = 0{,}5\,k; \tag{10}$$

$$r = \frac{\ln b}{a} \text{ at } Q = \frac{k}{e}. \tag{11}$$

Knowing the given values of parameters a and k, one can determine parameter b and can describe the required equations on the basis of which the necessary calculations are made and the graphs of the assumed dynamics of variation of all indicators are constructed similar to the graphs in Figures 5 and 6.

It is also important to analyze the dynamics of variation of technical-economic indicators which determine the efficiency of exploratory-prospecting operations and namely the specific increases of reserves per meter of drilling, per ruble of expenditures and per completed well and also the cost of exploratory-test drilling in rubles per meter of drilling for long-term forecasting of development of the sector within a specific territory. Forecasting the variation of the efficiency indices with regard to some technical-economic limitations permits one to estimate the volumes of drilling meterage and the financial expenditures which are required to find the necessary increases of reserves. This forecast is a three-level two-stage correlation-regression model

$$\left.\begin{array}{l}[\eta_{i_t}=f(t)] \\ [\Delta Q_{i_t}=f(t)] \\ [\Sigma \Delta Q_{i_t}=f(H)]\end{array}\right\} \rightarrow [L_i, \Phi_i=f(\eta_{i_t}, \Delta Q_{i_t})], \qquad (12)$$

where t is time, η_i is different efficiency indices, ΔQ_i is the increase of reserves for different associations and regions, F_i is financial expenditures, L_i is the necessary exploratory-test drilling meterage; $\Sigma \Delta Q_i$ is the accumulated increase of reserves and H is the accumulated exploratory-test drilling meterage.

Soil analysis and forecasting of the prospects for developing the structure and levels of reserves permits one to analyze the economic feasibility of a further increase of new reserves. Problems of economic analysis are considered in more detail in [1].

Analysis of calculations and forecasting of the dynamics of variation of different indicators according to the proposed methodical approach should be carried out four hierarchical levels: the USSR as a whole, large petroleum geological regions, administrative regions (union republics and oblasts) and oil-producing associations.

The described procedures for calculations may be represented by a number of sequential blocks:

1) calculation of the maximum values of k and determination of the parameters contained in equations (3) and (3');

2) calculation and plotting of graphs of different indices and their derivatives from the predicted values found in block 1;

3) calculation of possible trends of development of new promising regions based on planned indices of exploratory-prospecting and exploitation work and their cost;

4) estimating the required expenditures to develop resources and to prepare reserves, i.e., economic analysis of operations 1, 2 and 3.

5) optimization of corresponding expenditures to provide the necessary expenditures with restriction of material-financial resources and for possible reduction of expenditures and an increase of operating efficiency.

The proposed approach to long-term forecasting and planning of the system of indicators of exploratory-prospecting and exploitation work permits one to justifiably plan the development of the given system of indicators for the long term with regard to the geological characteristics of a specific region.

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FUELS AND RELATED EQUIPMENT

COAL MINES IN UKRAINE ARE MORE MECHANIZED, BUT STILL UNDERWORKED

Kiev UGOL' UKRAINY in Russian No 8, Aug 79 pp 1-4

[Article by V. A. Voronin, first deputy minister of the coal industry of the Ukrainian SSR: "Ukraine's Underground Miners--Looking Forward to Miners' Day"]

[Text] The republic's miners, just like Soviet people everywhere, celebrate their traditional occupational holiday on 26 Aug 79--Miners' Day. Confidently one can state that the republic's coal industry has moved significantly forward. Our mines have equipment with good productivity and they are enterprises with sophisticated production practices.

Designing, making and introducing new equipment combinations for mechanizing stopes, along with the broadened scope of use for existing equipment, raised (compared with 1970) the amounts of coal recovered with mechanized equipment combinations by 3.5 times (by 19 times for coal seams up to 1.2 m thick), combine exploitation of workings--by 3.3 times and conveyorization in steeply pitched workings--by 1.4 times. Work is just about finished in the mechanization of the most labor-intensive processes, namely, loading in stopes (97.4 percent) and cutting through overburden-removal and development horizontal workings (95 percent); and in converting stationary and production-line equipment combinations at mine surfaces to automatic and remote control (95 percent). Work was done in improving underground transportation with belt conveyors, high-capacity cars and heavy-duty electric locomotives and in the mechanization of auxiliary work. Conveyorization in steeply pitched workings is now 50.6 percent and in horizontal workings--20 percent.

Persons initiating many valued beginnings contributed greatly to coal industry progress: in boosting the use efficiency of mining equipment, in accomplishing thousand-tons-a-day loadings and in rapid operations in workings. In the Ukraine 132 production gangs each load 1000 tons or more a day. These gangs, a mere 10.1 percent of all such gangs, supplied 24.7 million tons of coal during six months in 1979, or 34.1 percent of the recovered amounts in gently sloping seams with slope angles to 35°. The longwall loading of the thousand-tons-a-day gangs was 3.4 times greater than the mean-daily amounts recovered from stopes; the labor productivity of these gangs is 2.8 times higher than the industry-wide mean indicators. For 20 gangs the mean labor productivity of the gang members reached 500-1000 tons a month.

Broadly supported in the mines of the republic is the initiative--approved by the Central Committee of the Ukrainian Communist Party--of ten front-rank gangs who are stepping up competition for higher loading at longwalls and who are exploiting thin seams. Following the examples of the innovators, 182 gangs have already been extracting 500 tons or more of coal a day from thin seams.

Since the gangs of machine operators work at high rates, on-time preparation of the production zone takes on very critical importance. Right now a disproportion prevails in how much production and development work is mechanized. Several factors (higher temperatures and higher blow-out dangers, the need for cross-sectionally bigger workings under exploitation, more closely spaced timbering and so on), growing out of increasingly deeper exploitation are slowing down the pace of development workings. Much work has been done in Ukrainian mines in the past few years for updating the equipment on hand in development faces and in more mechanization of drift operations. There is 4.5 times more (compared with 1970) high-capacity 1PNB-2 and 2PNB-2 loaders; 2PNB-2B loaders with mounted drilling equipment have begun to be introduced. By late 1979 the stock of these machines will number 1020 units. The stock of drift and cutting combines went up by 3.1 times and they are being constantly improved: 4PP-2 heavy-duty combines capable of breaking up rocks rated up to 6 in strength are being introduced; GPK combines are replacing PK-3 units and KN cutting combines are coming on the scene. The amount of development workings where coal and rock are loaded by machines went up by 17.2 percent and is now 76.6 percent, including 23.2 percent--by drift combines.

Ways have been determined in improving mine preparation at mines and bringing in forward-looking technology. Primarily, these ways include:

organizing operations in development faces under production-line arrangements that are based on forward-looking technical and technological solutions

concentration of preparatory work that cuts the number of development faces worked at the same time, by setting up consolidated multifunction gangs

adding to the number of high-speed drift gangs

organizing the work of drift gangs under a contracting method

setting up specialized gangs to make development workings ready for drifts and gangs of riggers supplying materials to the face

The high level of engineering solutions, scientific organization of labor together with the occupational skill of workers, solidarity and labor discipline enabled a number of front-rank gangs to improve their performance indicators significantly. A large part in mastering advanced technology and in organizing drift operations on a new qualitative basis belongs to the gang led by Lenin Prize Winner I. D. Zinchenko, Hero of Socialist Labor, from Mine imeni Abakumov of the Donetskugol' Association. This gang drove 1113.2 m of drift as early as Oct 1963 with a PK-3m combine in Jan 1966--1826 m and in Jun 1967--1851 m of drift in two faces. The gang's innovations, its advanced methods and its operating procedures gained acceptance across the industry.

V. G. Vendilovich's gang, working at the Mine imeni Abakumov, has excellent performance indicators--it cut through 14 km of workings in 3.5 years of the five-year plan period. In 1979 the gang made its mark with a number of initiatives: achieving a mean-monthly drift cutting rate of 295 m in 1979; fulfilling the plan for four years of the five-year plan period by the second anniversary of the new USSR Constitution; fulfilling the five-year plan by the 110th anniversary of the birth of Vladimir I. Lenin; and giving assistance to D. A. Goncharov's drift gang. In backing these initiatives, 31 drift gangs in the Donbass took on commitments to cut through 85 km of workings in 1979.

The gang of drift workers led by D. G. Khomich, from the Chervona zirka Mine of the Torezantratsit Association is systematically scoring high performance indicators. In three years of the five-year plan period the gang drove through 9.4 km of workings with a 1PNB-2 loader and in Mar 79--1117 m of consolidated drivage.

After carefully studying the processes of high-speed exploitation of workings and drawing up a clear-cut schedule, the gang from the Mospinskaya Mine of the Donetskugol' Association headed by I. N. Vinskiy, drove 405 m of crosscut through tough rock in Apr 1979.

By setting up high-speed drift gangs, the volumes of development workings were significantly increased in a mine of the Dobropol'yeugol' Association. In Apr 1979, I. S. Suslev's gang in the Pioner Hydraulic Mine drove 703 m of vent drift and in May N. Ye. Stepin's gang (from the Krasnolimanskaya Mine) drove 1335 m of vent drift in 31 working days. The mean-daily pace was 43.1 m; the labor productivity of the drift gang member was 12.2 m per month. The face was equipped with a GPK combine and a prototype of the 1LTP-80 telescoping belt conveyor.

The best drift teams of mine builders are also scoring large successes. A. N. Nosov's gang in the Zhdanovskaya-Kapital'naya Mine drove more than 1.9 km of workings in 7 months. V. I. Bubnov's gang is building the Zapadno-Donbasskaya Mine No 16/17; it drove about 1630 m of workings in 7 months of 1979, at mean-month rates of 233 m.

At the Mine imeni Kalinin of the Donetskugol' Association, the gang led by V. A. Nelepinskiy, from the Mine-Driving Construction Administration No 4 of the Donetskshakhtoprokhodka Trust, used an SK-1u shaft-driving complex in Mar 1979 to drive 160 m of a vertical shaft with a drivage cross-sectional area of 46.5 m^2 in 30 working days; a record per-shift labor productivity was set for the gang member--15.02 m^2 of finished shaft.

All told, in 1979 212 high-speed gangs in the mines of the Ukrainian SSR Ministry of the Coal Industry completed 26 percent of the total volume of workings exploited; the mean rate was 212 m a month, which is 2.4 times higher than the ministry-wide average.

A challenging task confronts miners in the republic: in the very near future to modernize mining practices in a number of mines, to cut back on the transportation cycles and eliminate segments therein, to better ventilate mines and to convert high-capacity production faces to forward-looking ventilation arrangements, to continue converting high-productivity production faces to operations baced on the pillar systems and so on. Meeting this challenge is to be based on a significant increase in the volumes of driving of development faces, including special-purpose workings for upgrading mine practices and the driving of vent and technological shafts and boreholes. Already in 1979 there is a need to drive 3193.4 km of development workings by the economic cost-accounting method (which is 280.6 km more than in 1978); 360.5 km of workings must be driven by mine builders. In readying a worthy welcome to Miners' Day, the miners are coping successfully with the established plans and targets and are taking on heavier commitments. Topping the 6-month plan, 43.1 km of all development workings has been driven, including 8.3 km of overburden-removal and development production faces.

Because the volumes of mine preparatory work must be increased, new tasks have been posed in organizing drivage; requirements on the technical level and on designing and building efficient equipment have been considerably tightened. Undergoing testing in the mines of the republic are the 4PP-5 and GPK-2 combines with arrowlike working part for use in workings at combined faces for rocks up to 6 in strength value. Improvements are still going on in the Soyuz-19 rotary drift combine for making trunk field workings in rocks having strength values of 6-8 and cross-sectional areas of 17-20 m^2. Series production has begun of the Titan crushing-filling equipment complexes, built at the Dongiprouglemash enterprise jointly with Donugi. This equipment most decidedly improves the engineering-economic indicators for use in workings with fill. Employing the equipment complex at the Trudovskaya Mine of the Donetskugol' Association in the sector headed by I. I. Strel'chenko, twice Hero of Socialist Labor, promoted the mechanizing of working in rock filling, reducing the strength of the drift gang by 25 persons, improving the condition of the supported working and raising the load at the longwall to 4000 tons a day.

Donugi jointly with the Kopeysk Machine Building Plant imeni Kirov, Giprouglemash and other organizations developed the KSV technology and equipment complex for use in paired workings with outpacing common coal face and filling of the worked-out space between the workings with rock. In 1979 manufacturing will come to an end and tests will begin for the prototypes; from 1981 their series manufacture is projected. Equipment has been designed and built for use in gently sloping seams up to 0.9 m thick in paired workings with drill-auger excavation of coal between the workings.

The scientific-designing and production division will make it possible in the immediate future to begin the production of drift equipment complexes. Studies are aimed at building the following types:

drift complexes based on the GPK-2, 4PP-2 and 4PP-5 combines, for full mechanization of the breaking up and loading of rock and of timbering, including a complex with remote control, model 4PP-2ShCh for use in workings at blowout-dangerous seams

equipment complexes for cutting operations at gently sloping and steeply pitched seams 0.9-1.6 m thick; and KGV-1 drill-blasting drift complexes for driving and supporting horizontal workings with a cross-sectional area of more than 19.3 m^2 through rocks with a strength value higher than 6.

With increasing depth, questions of timbering and protection of workings take on ever-growing importance. The primary timbering in development workings is an arch metal pliant structure made of special corrugated section. A parametric series of SVP sections has been developed for this timbering as functionally dependent on the width of workings with standard cross-sections. Introduction of five type classes of SVP sections has meant savings of more than 5 million rubles a year.

Special shoring was developed--with oriented design resilience. These are metal arches AP-5 and AKP-5 for gently sloping seams and PAK arches for steeply pitching seams. Resilient shoring with increased load-bearing capacity, rectangular in shape, is being introduced into workings. The year 1979 saw production begin for shoring made of low-alloy steels, significantly lowering the specific consumption of metal shoring. Connections for segments of AP shoring have been designed and are being introduced; they provide a reliable characteristic and increase shoring reliability and safety in work procedures.

Erecting shoring remains an arduous and laborious process in the drift cycle. The Central Scientific Research, Planning and Design Institute of Underground Mining Machines and Uglemekhanizatsiya Scientific Production Association. But there are no solutions for mechanizing the entire process of shoring, including placement of framing, tensioning and filling of the shored-up space.

Miners in the Ukraine are directing the attention of scientists and machine builders toward the need to build new kinds of drift equipment. Thus, the possible volume of use for PK-9r and GPK combine has already been depleted, but machines that can extend the volume of combine drivage (4PP-2 combine and the KN cutter complex) are being delivered in too limited numbers. There is a lack of a drift combine capable of effectively breaking down rock that have a strength of 600-800 kg/cm^2. Because there are not enough 1PNB-2B and 2PNB drill-loaders with mounted drilling equipment, only 5 percent of the possible volume of workings is exploited. The technology of exploiting workings using PNB type machines without mounted equipment is extremely unimproved, since the process of drilling boreholes is considerably complicated, especially with column electric drills. All the time savings from higher productivity in loading is lost because borehole drilling takes longer.

The 1PNB-2u machine transferred to series production status, for use in inclined workings, is not being manufactured. Development faces are still not being adequately supplied with means for mechanizing auxiliary transportation (4DMK and 6DMK monorail lines) and mechanizing of shorting (KDM) and loading and unloading work (tractors and TP hoists), which is holding up progress in integrated mechanization of drift operations.

In spite of the Titan complexes having high efficiency, the Yasinovataya Machine Building Plant is making them in small lots. Development faces of mines where steep seams are being exploited are being extremely slowly converted to high-capacity equipment with electric drive. Mine builders are not being supplied with enough specialized drift equipment: BUK-2 concrete-placing complexes, OMP mobile metal falsework and complexes for driving and deepening shafts.

In Apr 1979 All-Union Scientific and Engineering Conferences on the Status and Prospects of Improvements in Drift Operations in Coal Industry Enterprises were held in the cities of Shakhty and Karaganda. Conference recommendations for improving the structure of managing mine preparations, planning of volumes and the organization of labor and production and mechanization technology and facilities are being successfully introduced in the republic's mines.

The rich traditions and the operating experience of the front-rank collectives together with the privileges and advantages for miners, along with the continued equipment updating of the industry, provide propitious opportunities for high-productivity labor, fuller use of reserves and on this basis, the carrying out of tasks placed before the republic's miners by the 25th CPSU Congress on supplying the national economy with cheap and good-quality fuel. [531-10123]

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