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TECHNOLOGY FOR RESTORATION OF INDUSTRIAL PRODUCTION FROM DEPLETED AND UNREVITALIZED OIL FIELDS

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Abstract : The article presents the results of a study, the purpose of which was to collect, systematize and analyze theoretical material on traditional and innovative geological and technical measures aimed at increasing oil recovery in the later stages of field operation.

Key words: geological and technical measures, residual oil reserves, production intensification, field.

At the initial stage of field exploitation, oil is extracted from production wells using high initial pressure in the formation, exceeding the pressure at the bottom of the well. Oil flow rate as production progresses field falls synchronously with a decrease in reservoir pressure. To maintain the production rate, water is pumped into the subsurface through injection wells to increase reservoir pressure (RPM method). Wherein A "skin layer" forms near production wells, limiting the flow of oil to production wells.

The reason for the formation of a skin layer near production wells is the Joule-Thomson effect, which provides cooling and increase in oil viscosity in the formation near production wells. Viscous heavy oil is more readily adheres to the walls of pores and cracks than light oil.

Nowadays, mostly water is extracted from Russian wells, although about 60% of explored water remains in the depths, but "non-recoverable" oil reserves (NOR), the mass of which exceeds the mass of oil extracted from the subsoil during the entire history of its production. In recent years, a solution to the skin layer problem has emerged using thermochemical technologies of binary mixtures (BS).The relevance of the study is due to the fact that as the field is exploited, part of the reserves goes into the category of hard-to-recover, which, against the backdrop of a general decrease in flow rates, as we move to the later stages of exploitation, leads to the fact that in order to maintain economic indicators, subsoil users are forced to resort to various methods of enhancing oil recovery.

If we focus on TRIZs, they can be divided into two categories, namely, those determined by the geological structure (development objects characterized by low permeability, high dissection, small effective thicknesses and their inconsistency) and those determined by the physical properties of oil (highly viscous, bituminous oils). This is due, first of all, to the fact that in geology there are no isotropic environments, each field is unique, therefore it is impossible to select an operation scheme in which the appearance of undeveloped reservoir sections could be completely eliminated. Of course, an important role in this issue is played by and a rational approach to operation in general. Incorrectly chosen methods for increasing oil recovery at the first stages of operation, or choosing to intensify production, to the detriment of oil recovery, at later stages of operation will have a significant impact on the oil recovery factor. In any case, the unevenness of waterflooding and withdrawal rates, the increase in oil viscosity as reserves are depleted, lead to the need for geological and technical measures (GTM), which are works aimed at increasing oil recovery and/or intensifying production. Well intervention allows oil producing enterprises to ensure not only fulfillment of the production plan, but also to maximize the oil recovery factor as a whole for the development object. GTM differs from other works in that the result, as a rule, is an increase in oil production. Each mining company carries out the classification of activities, in terms of identifying them as geological and technical measures, independently, on the basis of its own LND. GTM are divided into traditional (well-studied, tested in practice, and used in the oil industry for many years) and innovative (at the pilot testing stage or recently introduced into production). Traditional geological

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and technical measures are used at all stages of field development. In fields at stages 3–4 of operation, geological and technical measures can minimize the overall decline in production. Therefore, one of the main tasks of the geological and technological services of the enterprise is the selection of the most effective geological and technical measures that meet modern requirements, allowing to maximize oil recovery from reservoirs.

In general, the geological and technical measures plan is intended to protect the business plan of the oil producing enterprise, however, adjustments are made to it on a monthly basis. Some of the effective measures to increase oil recovery are hydraulic fracturing (fracturing), drilling of horizontally directed wells, and sidetracking. These and other events are covered in detail in the works of R.R. Ibatullina [1], V.M. Osadchy [2], V.M. Telenkova [2], V.V. Popova [3] and others. The study and analysis of the works of these and other scientists led to the conclusion that hydraulic fracturing is an almost integral operation when developing fields with low reservoir properties, even in the 1st stage of field exploitation; in fact, at the moment, hydraulic fracturing is carried out literally "from under the machine." In addition, this method is used to connect overlying strata and to combine development objects. Economides M.J., Oligney R., Valko P. worked on methods for increasing profitability and mean time between failures, who formulated a unified methodology for modeling hydraulic fracturing [4]. A practical approach to controlling development by waterflooding is described in the works of Satter A., Thakur G. and others. Scientists have proven that waterflooding is one of the most effective methods for increasing oil recovery [5]. Domestic scientists paid a lot of attention to TRIZ. So R.R. Ibatullin[1], S.F. Mulyavin [6] and others formulated a scientific and methodological basis for the development of oil fields. The intensification of oil field production using geological and technical measures is devoted to the work of A.D. Savich [7], A.A. Sementsova [7], V.F. Sizova [8], A.A. Tolstonogov [9]. An analysis of their work led to the conclusion that the efficiency of waterflooding is directly related to the quality of hydraulic fracturing, both primary and refracturing, thus, competent planning and modeling of hydraulic fracturing in the first stage of field operation will avoid many problems at later stages.

Data from observation statistics on the efficiency of additional oil production at later stages of operation confirm the conclusions drawn. Monitoring of oil development efficiency was carried out and analyzed by A.D. Savich and other scientists. Thus, the result of their study is statistical data that hydraulic fracturing allowed an additional 52 million tons of oil to be produced in 2017, or 41% of the total additional oil produced in the country. However, in 2018 this figure decreased slightly, but still remained at a fairly high level [7].

Drilling horizontally directional wells is another effective method of increasing the involvement of reserves in development.

Analysis of statistical data showed:

− the average increase in flow rates when drilling using this technology in 2018 amounted to 42.2 t/well operation;

− the number of drilled horizontal and directional wells is growing annually, despite certain difficulties with their operation (low inflows, growth of the ARV fund).

Compared to 2008, in 2018 the number of horizontal wells almost doubled. As a consequence, additional oil production due to this increased multiple (more than 2 times) [9]. Conducted traditional geological and technical measures, especially with hydraulic fracturing (HF), do not solve the problem of reducing productivity in wells. Therefore, effective additional oil production is a pressing topic today. The main reasons for the decline in oil production are: salt deposition, asphalt, resin and paraffin deposits (ARPD), removal of mechanical impurities (including volleys of proppant), deterioration of the condition of the bottomhole formation zone (BZZ), and, as a consequence, an increase in the skin factor (S).

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The identified problem can be solved by increasing well productivity through the use of innovative geological and technical measures. Scientists such as Moritis G. have shown in their works that a significant part of modern oil fields have been developed for a long time (mature), so the rate of replacement is continuously decreasing. To meet the growing energy demand, recoverable oil reserves in developed wells can be developed using advanced innovative IOR and EOR technologies [10]. A number of researchers (T.K. Apasov [11], K.P. Latyshenko [12], etc.) proposed for practical use a complex vibration-wave method of influencing the PZP, which is used in combination with chemical and depressive methods of influence. This method creates conditions for increasing the degree of purification of the near-wellbore formation zone from contamination by applying elastic vibrations with a wave hydraulic monitor, radially directed fluid flows, with low frequencies and with different amplitudes. Industrial tests of the vibration-wave method have shown that multi-frequency pulses effectively cope with the cleaning of PCP, however, in order to achieve maximum results, one should not deviate from the classical PCP methods.

The vibration wave method can be used comprehensively for waterproofing work; this method is also effective in wells with low reservoir pressures, with low-permeability terrigenous reservoirs, where there have been repeated acid treatments or hydraulic fracturing. Work is also underway to improve the efficiency of repair and insulation work (RIW). The results of work in this area are presented in the publication by A.M. Kireev [13].

The work discusses the goals of carrying out insulation work, namely: restoring the tightness of the cement ring to isolate the filter from interlayer flows; elimination of defects in the production casing that can lead to leaks and, as a consequence, a sharp increase in water cut; restoration of insulation of a working well filter when returning to overlying development sites. Today, the most relevant innovations in the field of RIR are bridge plugs: retrievable PM-I; electromechanical PME; open hole filler PMZ-OS. Bridge plugs were developed for carrying out intervention work using cementing material, installing bridges, multi-stage hydraulic fracturing, well abandonment or reservoir conservation.

Installation is carried out using the hydraulic installation assembly of the GUK, by creating excess pressure in the tubing.

Thus, the study and analysis of theoretical material on traditional and innovative geological and technical measures for additional production of residual oil reserves allowed us to draw a number of conclusions:

− geological and technical operations differ from other activities in oil developments in that it is their implementation that results in a significant increase in oil;

− geological and technical measures are divided into traditional and innovative depending on the conditions and timing of their application;

− effective measures for additional production of residual oil reserves include hydraulic fracturing (fracturing), horizontal wells, and sidetrack drilling;

− innovative geological and technical measures include, in particular, the complex vibro-wave method and developments in the field of geological exploration: extractable PM-I, electromechanical PME, pouring bridge plugs for an open hole PMZ-OS.

To summarize, we can emphasize the importance of competent planning of geological and technical measures already at the first stages of development; any technological decision made at the early stages, starting with drilling and ending with hydraulic fracturing at the development stage, will inevitably affect further operation. Often, intensification of production in the early stages of development, to the detriment of rational subsoil use, leads to a general drop in oil recovery and oil recovery factor, and, as a consequence, to a decrease in cumulative production.

The facts presented can be regarded as a turn from more than a century of accumulation of non-recoverable reserves of fossil hydrocarbons in the depths to their profitable production. In the

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depths there are hydrocarbons, mass which is many times greater than the reserves in the fields currently being developed. The discovery of the possibility of extracting “unprofitable” oil reserves is tantamount to the discovery of a new largest field practically without the cost of searching and reconnaissance.

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