УДК 622.276

Skidanov V. D., Master in Specialty 185 Oil and Gas Engineering and Technologies
Supervisor: Pashchenko O. A., Ph.D. in Technical Sciences, Associated Professor of the Department of Oil and Gas Engineering and Drilling
(Dnipro University of Technology, Dnipro city, Ukraine)

IMPROVEMENT OF TECHNOLOGY FOR EXTRACTING HARD-TO-RECOVER OIL RESERVES

The extraction of hard-to-recover oil reserves represents a critical challenge in the modern oil and gas industry. As conventional oil deposits deplete, the focus shifts to reserves located in complex geological formations, such as low-permeability reservoirs, high-water-cut zones, and thin layers. These reserves, often characterized by low productivity and high extraction costs, require innovative technological approaches to enhance recovery efficiency. This article analyzes existing methods and proposes improvements based on geological assessments, reservoir modeling, and equipment optimization, drawing from a comprehensive study of oil fields in regions [1, 2].

Global energy demands continue to rise, necessitating advancements in extraction technologies. Traditional methods fall short for hard-to-recover reserves, which constitute a significant portion of remaining resources. For instance, in mature fields, up to 78% of reservoirs exhibit complex structures, prompting the need for targeted interventions. Key challenges include low permeability, high viscosity, and environmental constraints. This work aims to refine extraction processes through detailed geological analysis, method evaluation, and technological enhancements, ultimately improving recovery rates while minimizing operational complexities [3].

Understanding the geological framework is foundational for optimizing extraction. The studied oil complexes trace back to Devonian and Carboniferous periods, with sediments comprising limestones, sandstones, and clays. The Vasyugan region exemplifies terrigenous reservoirs with varying permeability and porosity. Productive layers are heterogeneous, featuring zonal variations in permeability, which necessitates further hydrodynamic studies [4].

Reservoir properties include total, effective, and oil-saturated thicknesses, alongside collector attributes like permeability and open porosity. Heterogeneity is assessed via sandiness and dissection indices, with oil saturation playing a pivotal role. Oils in these fields vary in density (from light to heavy) and composition, containing resins, paraffins, and gases, influencing extraction strategies. Associated gases include methane, propane, and butane, posing risks during production.

Formation waters exhibit mineralization up to 43 g/L, with elevated chloride ions and acidity (pH 6.4-6.6), affecting equipment durability. Hard-to-recover reserves dominate due to low permeability, high water cut, and depleted primary zones. Experimental polygons have been established to test technologies for these reserves, emphasizing the need for tailored approaches.

Current methods for enhancing oil recovery from hard-to-recover reserves include hydraulic fracturing (HF), horizontal drilling, and thermal stimulation. HF, widely applied post-drilling, increases inflow by creating fractures in low-permeability collectors. The company employs eight HF variants: high-volume, acid-based, tip-screenout, combined breakers, linear gel, partial perforation backfill, secondary sidetracks with stringers, and gas-condensate-specific techniques.

HF aims to boost debit and maximize oil extraction, outperforming other stimulation methods. Simulators like RN-GRID model fracture geometry, incorporating geomechanical data, diagnostic injections, and fluid/proppant databases for precise design.

Additional techniques involve reservoir modeling for debit forecasting, water cut prediction, and long-term planning (up to 10-15 years). This enables efficient field development. Composite materials in submersible equipment extend service life to 800-1000 days, a 6-10 fold increase over predecessors. Installations like ESP (Electric Submersible Pumps) and rod pumps are standard, with ongoing projects to enhance reliability using "white" metals and polymers, achieving average failure-free periods of 873-1107 days.

Water cut reaches 89% in some areas, yet advanced technologies sustain production. Over 40% of fields are equipped with modern tools, though only 10-30 million tons of projected reserves (2019-2025) are economically viable without further innovation.

Equipment selection is crucial for operational efficiency. ESP installations, such as REDA and Centrilift series, dominate due to superior performance over domestic analogs. These handle productivities from 25 to 1500 m^3/day, optimized via software like SUBPUMP 8.0, incorporating Hagedorn-Brown correlations for multiphase flow.

Alternative systems like rod pumps (SRP), screw pumps (PCP), hydraulic piston pumps (HPP), and jet pumps are evaluated. SRP is limited by depth and loads; PCP suits viscous fluids but shows low reliability; HPP offers high efficiency (0.65-0.7) and low energy use (3.8-5.4 kWh/ton) but requires complex surface setups; jet pumps resist complications yet have low efficiency. ESP modular designs (UETsNM and UETsNMK) cater to neutral or aggressive environments, pumping mixtures of oil, water, and gas with up to 0.01% solids and 25-55% free gas (with separators). Components include intake modules, section modules, heads, check valves, and drain valves. Gas separators (counterflow or centrifugal) mitigate gas locks.

Performance curves detail head, efficiency, and power as functions of flow rate, tested at 3500 rpm on fresh water. Wellbore profiles, inclination data, and inflow equations (Darcy, Vogel with water cut corrections) inform equipment sizing. Mechanized extraction via high-head imported ESPs proves most cost-effective, given domestic units' assembly quality issues.

Computer modeling integrates seismic, well logging, lab, and hydrodynamic data to predict exploitation efficiency. Models must be intuitive, incorporating geometry, saturation, capillary pressure, porosity, absolute/relative permeabilities. This identifies untapped zones, reducing costs in mature fields.

From 2012-2017, modeling reduced expenses by 14-17% in applied fields. Forecasting incorporates production history and deposit structures, enabling scenario analysis for technology implementation. Enhancing extraction technologies for hard-to-recover oil reserves demands integrated geological insights, method refinements, and equipment upgrades. Geological heterogeneity underscores the need for customized approaches like advanced HF and modeling. ESP systems, bolstered by simulators and composites, extend operational life and efficiency. Modeling optimizes planning, cutting costs and boosting recovery. These advancements ensure sustainable production amid depleting easy reserves, supporting energy security.

References:

1. Kravchenko, V., Hankevich, V., Pashchenko, O. & Kuts, O. (2020). *Some effective methods of processing copper concentrate*. (In English).
2. Hankevich, V.F., Pashchenko, O.A. & Kyba, V.Y. (2015). Impact of vibrations on the drilling tool. *Vibrations in engineering and technology*, (4), С. 132–135. (In Ukrainian).
3. Shapoval, V.G., Pashchenko, O.A., Zhilinska, S.R., Khomenko, V.L. & Ivanova, H.P. (2021). Application of criterion Shashenko to predicting the strength of sandy loam soils during horizontal directional drilling. *Instrumental materials science*, 24(1), С. 114–120. (In Ukrainian).
4. Pashchenko, O., Khomenko, V. & Korovyaka, Ye. (2024). Strategies for managing intellectual property rights and the process of commercialization of technology transfer. *Creation, protection, protection and commercialization of intellectual property objects*. (In Ukrainian).