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DUAL COMPLETION PETROLEUM PRODUCTION ENGINEERING FOR SEVERAL OIL FORMATIONS

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Abstract:
Cost-efficient, enabling technologies for keeping and increasing the reservoir recovery rate of oil-formations with high water cut of produced fluids and exhausted resource are really essential. One of the easiest but short-term ways to increase oil production and incomes at development of oil deposits is cost of development and capital cost reduction. Therefore, optimal choice and proper feasibility study on the facilities for multilayer oil fields development, especially at the late stage of reservoir working, is a crucial issue for now-day oil industry. Currently, the main oil pools do not reach the design point of coefficient of oil recovery. The basic feature of the late stage of reservoir working is the progressing man-made impact on productive reservoir because of water injection increasing for maintaining reservoir pressure. Hence cost-efficient, enabling technologies for keeping and increasing the reservoir recovery rate of oil-formations with high water cut of produced fluids and exhausted resource are really essential. To address the above concerns the dual completion petroleum production engineering was proposed. The intensity of dual completion of formation with of different permeability is determined by rational choice of each of them. The neglect of this principle results a disproportionately rate of highly permeable formations development for the time. In effect the permeability of the formations or their flow rate is decreasing. The problem is aggravated by lack of awareness of mechanics of layers' mutual interference in producers and injectors. Dual completion experience in Russian has shown, that success and efficiency of the technology in many respects depend on engineering support. One of the sufficient criteria for the choice of operational objects should be maximal involvement of oil-saturated layers by oil displacement from seams over the economic life of well producing oil. If it is about getting high rate of oil recovery for irregular formations there is no alternative to dual completion and production. The recommended dual completion petroleum production technology enables development several formations by single well at the time. The dual completion petroleum production technology has been more important than ever because it is right not only for formations but for thin layers with undeveloped remaining reserves.

Key words: *dual completion, wells, deposits, layouts, hydrocarbons*

INTRODUCTION

The following findings can be drawn from the study regarding development and state of subsoil deposits of Udmurt Republic:

1. The main reserves of oil are concentrated in multi-layers with high layer-wise and zonal heterogeneity, also carbonate reservoirs are chaotic with cracked, cavernous structure, pinholes and have low permeability and porosity. Oil deposits are high-viscosity and extra-heavy oil with significant content of petroleum resins and tarred-paraffin compounds.
2. Development of deposit occurs with high rates of watering wells by injected water and a sharp decline in crude oil production levels due to unfavorable geological and physical parameters of deposits. Complicate factors are the high fragmentation of the formations, the presence of gas caps and bottom waters, as well as the prevalence of highly viscous oils in the reservoirs.

It is crucially relevant to increase oil recovery and well production due to development inter-layers with low permeability and multi-permeability of several objects by the same

well grid through the dual completion petroleum production engineering.

THE MAIN SECTION

One of the most important issues in the design of the rational development of the multi-layered hydrocarbon deposit is how the operational facilities can be identified. The regulatory documents and numerous of publications are focused on this issue [1, 2, 3, 4, 5,6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25]. Currently, there are some drawback if it is about apportion of the operational facilities in a multi-layer deposit, including:

- there are no clear and justified criteria for objects to be selected;
- there is no a universal method for objects to be selected;
- there is a lack of information on the worst reservoir properties of the formation.

Therefore, the development of scientifically-based methods of the reservoirs treatment to enhance the productivity of oil reserves is an urgent scientific and production challenge.

As a result of the current practice of the oil deposits development in the Udmurt Republic, it is ascertained that each oil pool and trawl contains several layers with different characteristics that require an individual approach to their development. Even within a single layer, which is distinguished by sufficient geological uniformity, there are seams with different permeability, separated by thin non-permeable sub-layers. Filtering on such seams can occur independently, which makes it necessary to develop with independent well pattern. Thereby, the problem arises of combining these or other inter-layers, layers or oil-pools into one or more development facilities that could be operated by a well pattern, which enables perforating several layers along the wells and operating them with a shared filter.

However, at a late stage of field development, some oil-saturated reservoirs, instead of giving up liquid, absorb it as a result of opening by a shared filter. These events are found when down-hole flow-meters take the profile of influxes. Absorption occurs due to the fact that the reservoirs have different pressure because of the presence or absence of connections with the injection wells. Due to a strong decrease in bottom-hole pressures, it is possible to take liquid out of the formation with reduced reservoir pressure. In this case, the depression for these layers will be different, and their share in the development process will be different. This results in lagging in the oil reserves recovery from these layers, premature water-cut of reservoirs with high permeability, and conservation of oil reserves in the layers with poor permeability. In order to correct the backlog of the reserves production, it is necessary to create an independent development system with individual well pattern for each layers. For this purpose, reservoirs with similar characteristics are grouped into single object and operated with a shared filter. Advantages of this method include better development of the seams, the ability to manage development processes, simplicity in organizing operating well stock geophysical studies. However, this approach requires more significant economic costs for drilling, since the number of injectors will grow in proportion to the number of operated facilities.

Often, in many fields, drilling a well with an individual well pattern is unprofitable, especially for low-permeability formations or formations with with thin oil-saturated beds. Under these conditions, the only economically sound method is the ability to develop a multi-layer deposit with a common well pattern, which also enables the well spacing density for each formations to be increased. The most expedient is the Dual Completion Petroleum Production of the oil field, which involves drilling ones by single of wide spaced wells drilling or by set of well patterns, depending on the number of seams, drilling group of reservoirs by production well or injectors with subsequent dis-assembly in the bore-hole by disconnectors for dual completion. The development of multi-layer oil fields with a single well grid enables oil company:

- to increase the period of profitable well operation;
- to reduce the meterage drilled in a multi-layer deposit by 2 to 4 times;
- to reduce in 1.5-2 times the operating costs for specific volume of oil production.

The introduction of the equipment for the dual completion petroleum production will enable operator not only to carry out separate monitoring of reservoir properties, but also to manage the development oil-bearing formation by varying the injectivity and selection profiles for each of the jointly operated reservoirs, and to put into development additional oil-bearing horizon.

The technological and economic efficiency of the implementation of the dual completion petroleum production depends on many factors. The main factor is the operability and reliability of deep-pumping equipment.

The analysis of current layouts of the dual completion system is in the Table 1.

Existing dual completion petroleum production technologies differ from each other in the number of layers being opened and the method of their exploitation (oil extraction and injection into a workpiece). The advantages, disadvantages and recommendations for all types of technologies are given in Table 2.

Table 1

Layouts for Dual Completion System

Manufacturer	Characteristics/Possible Disadvantages
Baker	Production casing of more than 168 mm; High cost; Long delivery time; There is no possibility to measure the flow rate and water cut in the layers
Schlumberger (electric centriugal pumps - electric centriugal pumps)	Production casing of more than 168 mm; Productivity more than 50 m^3/day; High cost; Long delivery time; High metal consumption
TATNEFT (sucker rod pump - sucker rod pump)	Running depth to 1200 m; Productivity fewer than 20 m^3/day; Impossibility of direct measurement of production rate and water cut; High metal consumption
LLC "Research Institute" SibGeoTech " (electric centriugal pumps with sensors and a multi-packer mandrel system)	Complexity of the installation into the directional well; Uncertainty of measurement of the water cut in low-yield wells (there is a column of water below the intake of a pump); Uncertainty of measurement of the flow rate (the effect of free gas); regulation of reservoir selection only when well servicing and workover go on
NPF Packer (1PROK-UOA-1 Stand-alone Single-packer BHA for Well Pumping Used to Reduce the Water-Cut of Produced Fluid with electric or hydraulic controlled valve)	The production casing with 146-178 outside diameter is 114 mm; Pressure on 35 MPa, depends on the number of installed pins in tubing or annular space; Control of the valve is either hydraulic, which leads to complexity of maintenance and complexity of installation, or electrical, which does not always perform its functions; If a distance between layers if 50 meters, bottom-hole pressure at the lower seam will be greater than the upper one by the value of the hydrostatics

Table 2

The Dual Completion System Comparison

Systems for the dual completion petroleum production	Advantages	Disadvantages	Recommendations
1.1. Single-line monitoring systems with one method of mechanized production without seam separation	- dynamic geophysics; - research in different modes; - lower cost	- mutual influence of the fractions; - there is no possibility of regulation; - products mixing; - impossibility of pressure recovery curve identification; - the need for interpretation of the data of the field geophysical studies - low reliability of the flow-meters; - risk of cable damage during lowering and lifting operations; - there are restrictions on the size of the electric centriugal pumps and the risks of removing the sealing devices if bypass units are used - there are curvature constraints (2 degrees a dozen meters, inclination angle up to 20 degrees)	- use in wells where the seam separation is impossible because of their technical condition (condition of columns, cement) or there are some complicating factors of extraction (high removal of mechanical impurities, gas factor, etc.) - used in wells where the geology of the seams, the physico-chemical properties of fluids and the energy state are close - use mainly on the old stock of wells, where the introduction of systems with separation is unprofitable
1.2. Single-line monitoring and control systems with one method of mechanized production with seam separation	- less mutual influence of the layers; - possibility of more reliable accounting	- mixing products during the ascent; - difficulty in elevation of packer equipment when there is sand or proppant removal; - unreliability downhole flowmeters; - the need for cable work for the adjustment of fittings and the elevating of geophysical instruments with underground well maintenance; - limited opportunities for control of the seams	- diameter of the production string from 146 mm; - use on wells that do not require frequent interventions; - the technical condition of the well (production string, cement, etc.) justifies the installation of the packers; - there are no complicating factors of extraction; - there is difference in geology of reservoirs and physical and chemical properties of the oil

Table 2 (cont.)
The Dual Completion System Comparison

Systems for the dual completion petroleum production	Advantages	Disadvantages	Recommendations
1.3 Single-lift systems with separation layers with two ways of mechanized production	- less mutual influence of the layers; - accounting and research without geophysics; - production string (146 and 168 mm) and with standard Christmas treble-differentiated depression	- complexity of maintenance for the lower pump; - difficulty of the installation; - sensitivity to fracturing and treatment of the bottom-hole zone; - stopping one of the pumps for separate metering; - mixing products in the elevator; - impossibility of crimping the packer during installation; - checking the quality of separation during the operation phase	- diameter of the production string from 146 mm; - the necessary productivity of the seams (the lower object is operated with the electric submersible pumps, the upper one is operated with the sucker rod pumps); - perfect condition of the columns and cement ring; - there are no complicating factors of extraction; - sufficient reserves of seams to get an economic effect; - there is difference in geology of reservoirs and physical and chemical properties of the oil
2.1 Double-lift systems with parallel elevators	100% independent production from each reservoir	- diameter of the production string from 168 mm; - limited depth with sucker rod pumps; - the complexity of the design; - the need to use specialized equipment, including a preventor; - high cost at a greater depth of bedding; - minimal interventions (bottom-hole treatment, hydraulic fracturing); - no more than two separated objects;	- difference in properties of fractions and oil; - small spatial angle; - depth of installation for sucker rod pump to 2,500 m; - perfect condition of columns and cement ring; - there are almost no complicating factors of extraction; - good reservoir potential
2.2 Two-lift systems concentric construction	independent production from each reservoir	- Diameter of the production string is 178 mm with standard electric submersible pumps (for the electric submersible pumps + electric submersible pumps configuration) - the complexity of the design; - the complexity of maintenance to meet one the highly qualified specialized personnel have to be brought in; - greater sensitivity to hydraulic fracturing and interventions; - high cost of installation and maintenance; - no more than two separated objects;	- reservoir potential (for electric submersible pumps and profitability); - perfect condition of columns and cement ring; - there are almost no complicating factors of extraction; - the distance between fractions is more than 10 m; - difference in properties of fractions and oil; - for the "sucker rod pump+ electric centriugal pumps" layout the diameter of the production string is over146 mm; - bottom flow rate (electric centriugalpumps) - not more than 400 m^3/day topsheet rate (sucker rod pumps) - not more than 80 m^3/day

CONCLUSION

The technology and equipment for dual completion petroleum production operation have to carry out all technological measures which are applied at autopsy of seams by separate wells. The core issue for dual completion system to be used prolifically is a construction of unmisgiving, durable and economically viable equipment.

The study of technologies and layouts of the dual completion system showed that in recent years interest in this type of technology has been increasing.

The dual completion petroleum production engineering for several oil formations is relevant and promising for development and operation of multi-layer deposits. An important advantage of this technology is that it meets norms of the Russian mining legislation and hence the technology is viable for oil fields with multi-layer deposits to be developed.

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