Oil Withdrawal Technological Advancement for Multilayer Field

Gusmanova, Aigul*[+]; Bekbayeva, Raushan[●]; Koyshieva, Aigerim; Koyshiev, Abylai
Yessenov University, Aktau, KAZAKHSTAN

ABSTRACT: *The authors discuss the technology for dual pumping technology of oil-producing wells and show its advantages and shortages. It is concluded that the simultaneous-separate oil production project proposed is economically attractive due to increment in oil production, high-income terms, and short pay-off period even in small and depleted reservoirs. Furthermore, the potential of the proposed project is evaluated in terms of the required facilities and incremental oil production. Dual pumping technology becomes of ever-more use today since the unified well-spacing pattern envisioned for multilayer field development and operation ensures the feasibility of multiple-zone production, and, as a consequence, ramp-up of reserves recovery and oil drainage amount as well. At the same time, the practicability of multiple-zone production depends on a number of fraught factors and requires thereof appropriate inventory and current status analyses to be fulfilled with regard to reserves recovery operations. As influx performance study and fluid-bearing characteristics of reservoirs are often incomplete due to field situation, the authors, therefore, follow the task to carry out an efficient analysis of multi-zone productions based on dual completion technologies.*

KEYWORDS: *Dual completion wells; Geologic characteristics; Multilayer fields; Reservoir performance.*

INTRODUCTION

Special pumping facilities affording dual completion operations in multilayer fields are among the advanced technologies adopted today by oil-producing companies. By means of a unified well-spacing pattern technique, the Dual Completion (DC) technologies can have a facilitative effect on the system of stage development facing difficulties connected with different flow properties and compositions of fluids in multi-zone production contexts. Besides, the technology is conducive to cost-effective and oil-conserving activity at any development stage (*Erhui et al.*, 2019 [1]).

Proven advantages of DC technology employed in commingled production from two zones enable the following (*Salam and Emre*, 2019 [2])):

- Increase the production return through the other oil-fields targets exploration accompanied by putting selective noncommercial wells into the production.
- Extracted crude quantity metering on a target-by-target basis;
- Jumpstart development of bypassed oil reserves from other intervals through down-spacing;

** To whom correspondence should be addressed.*
+ E-mail: gusmanova-aigul@mail.ru r
● Other Address: “OPTIMUM” Design Institute LLP, Aktau, KAZAKHSTAN
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- Cut down drilling capital expenditure for new oil-fields;

- Drilling operations on the targets, whose particular productivity is low;

- Speed up oil-well recompleting activities.

The USA was the first country, which in 1936 began using dual completion operations (*Shawgi et al.,* 2020 [3])). The early Soviet-era developments related to crude production date to 1930. They were pilot fuss-free models only designed for free-flow production. Later, in 1950-1970, DC problems study, as well as DC technology and facilities development became the focus of interest of Soviet researchers and developers *R.A. Maksutov, V.A. Safin, V.N. Belen'ky, B.S. Krutikov, K.I. Ponamaryev* and *Sh.T. Dzhafarov*. Among the nowaday generation of researchers, who continue working on DC problems are *P.V. Donkov, M.Z. Sharifov, V.A. Leonov, A.M. Badretdinov, K.M. Garifov, R.G. Gabdullin*, and others (*Garifov et al.*, 2011 [4]).

Availability of reliable, serviceable, and time-proof equipment facilities, which can ensure successful employment of DC technologies, is one of the main requirements nowadays for multi-zone field operation. At present such manufacture-companies, as Paker, Geonik, Novomet-Perm, Technoproyekt, Elkamneftemash Geophizika petroleum companies, and others produce DC equipment, and the technology employment wise, such companies, as Tatneft, TNK-BP, Rosneft and Bashneft and others successfully apply it in their production operations (*Oney* and *Eric*, 2020 [15]); *Gabdulov et al.,* 2010 [6]); *Mukhametshin* and *Yamilov*, 2013 [7]); *Sharma et al*., 2020 [1])). Depending on the operating principle, production recovery mechanism, or function of a patented invention all the patents can be subdivided into the following groups:

- Technology of Dual Extraction (DE)
- Technology of Dual Injection (DI)
- Technology of Dual Extraction and Injection (DE&I).

Dual extraction technology can be used for both, a joint product lift by one elevator, and for a separate one. Predesigned exploitation mode (the production rate and bottom-hole pressure) depends on the pumping out techniques. One of them is the choking restriction of commingled production at the tubing intake so that the production in toto is pumped out with one pump. The second one implies the volume-based distribution of the production among separate pumps. Pumping machinery requiring volume distribution of production includes the following: two-zone deep-well pumps connected to one rod, double-acting pumps, differential pumps, multi-zone alternate exploitation pumps, and others.

DI facilities can be of single-channel and of multi-channel types. That of the first type is based on the choke restriction principle, which enables control of the injected water flows into the productive zones separated by packers. The choke points are usually installed in gas-lift mandrels (well-chambers on the special pump and compressor pipes (tubing)). In injection operations, as opposed to extractions, a hollow channel is formed in the pump tube, so all the required choke handling and retrieving processes can be operated by means of special intra-channel wirelines. In multi-channel facilities, water injection is realized through several trains of parallel or concentric tubes.

In Fig. 1 the represented is the classification scheme of DC technologies (*Conejeros* and *Lenoach*, 2004 [9])).

The question of whether DC technology should be employed or not should be based on the data of estimated original oil in the reservoir, physicochemical properties of fluids, and planned oil withdrawal rate for each layer.

Separate pumping out facilities represents a number of trains of parallel (dual tubing production) and concentric lifts. The latter type can, as a variant, consist of tubular hollow rods. This type of lift is designed for one reservoir.

DC Equipment and Technology

From 2010, the implementation of an intensive development system began in the Airankol field by combining several productive layers into one independent development object. In order to increase oil production from year to year, there was an increase in the number of joint wells operating in two layers. This approach, proceeding from economic considerations and not corresponding to the physical foundations of oil displacement in dissected and partially heterogeneous reservoirs, plays a negative role and leads to low coverage of their impact. At the same time, the negative influence of reservoir heterogeneity and the uneven advancement of the front of oil displacement by water in certain areas of the deposits are increasing. The wells of the joint-stock are mainly characterized by "combinations" of two layers. Throughout the history of

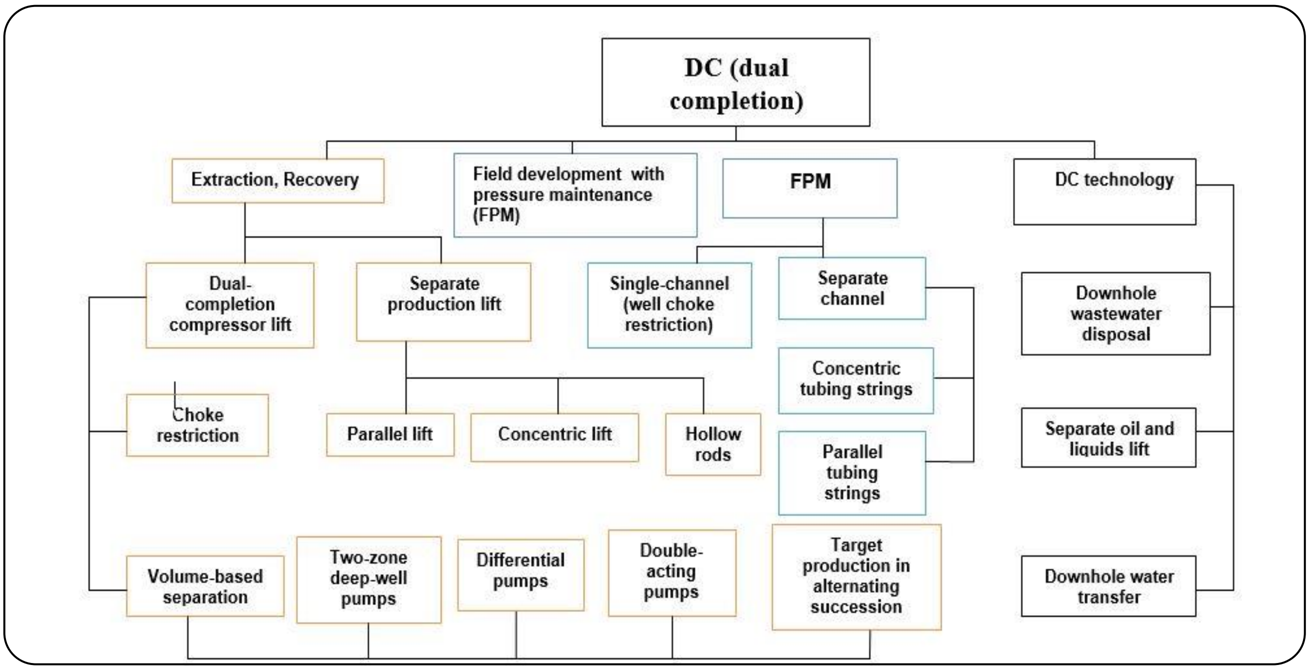

Figure 1. Classification of technological plans and DC equipment for oil-fields development

development, the share of joint production and injection wells has reached 50 %. The conditions for the withdrawal of fluid from the formations are changing, to ensure the specified rates of development, the watered formation requires the creation of large drawdowns and, possibly, the use of pumping equipment, and the other form is characterized by waterless oil, thus, the development of the formations with one filter becomes impractical. The decision on the need to use the method of separate operation of a group or a number of wells should be made after a thorough analysis of the state of reservoir development and the balance of reservoir energy, but the main criterion for the selection of candidate wells is the availability of recoverable reserves in the good drainage area. To assess the scale of the need to implement the dual completion technology at the Airankol field, a combined map of the field was built with an indication of wells that jointly exploit several horizons and overlapping horizons.

The analysis of oil fields in Kazakhstan shows that most of them are multilayer. Joint development with one filter, as a rule, leads to a loss of the total production rate by 20-40 %. At the same time, many oil fields are at a late stage of development, characterized by low flow rates and gas factors, high water cut, and fully mechanized production, therefore, simple process flow diagrams of simultaneous separate operation or dual completion operations are typical for fountain operation are not applicable.

The emergence of new highly reliable technical means (packers, borehole pumps, control devices) increases the efficiency of dual completion operations schemes. Therefore, the use of dual-completion operations in multilayer fields in Kazakhstan is very relevant. Simultaneous-separate operation of formations is characterized by several advantages, namely, increasing the profitability of wells by connecting to the development of other production facilities or layers of different properties of the same development target; repayment of the project well stock, reduction of drilling volumes due to the use of one wellbore; organization of a development system with simultaneous (joint) extraction of hydrocarbon reserves from different production facilities with one well network. The field experience of operating two reservoirs with one well using the dual completion operations method indicates its high efficiency. On average, capital investments and operating costs are reduced by 30 % compared to the costs of drilling and operating fields with separate grids for each layer. The dual completion operations method makes it possible to compact the grid of wells (production and injection) without additional drilling footage. Their use increases the profitability of individual wells due to the connection to them of other development objects or reservoirs of different productivity of the same development object.

Although the available well-stock is uneconomical, outdated, and, thereupon, inapplicable with DC equipment, nevertheless, there are some technological plans and options considered to be equivalent to DC technologies, and therefore they can be employed for separate monitoring purposes in multi-zone production conditions (*Ould-amer et al.,* 2004 [10])).

Some DC-system designs are only tailored for recording the geophysical properties of a productive layer, and not for operating the recovery process itself. One of the most practical fuss-free single-lift oil-meter monitoring schemes serviceable in commingled production from two zones includes a moveable УESP device adjustable for oil-well tracking and surveillance in nonseparable zones, thereof, it is recommended for the productions failing technical separation of reservoirs, when needed. Among the oil operators taken an interest in the technology are Buguruslanneft LLC (in 2008-2011), and Sorochinskneft CDO (in 2010-2011). It has been mentioned in the process of the technology applications that sometimes ball-ups of the flow gauge and opening-outs of the eccentric stabilizer can take place.

The ESPU+mandrels monitoring technology, which is targeted for pressure, temperature, moisture, and flow rate gauging and control, requires the employment of modified gas-lift equipment adjacent to special mandrels with appropriate built-in wireline operating chokes and logging tools, like commonly used self-contained gages with data memory units, and other devices with realtime data output function as well. The technology was applied in 2008 by Var'yeganneftegaz OJSC for 14 wells' potential gauging purposes, showing the flow rate over the 53 to 110 m^3/day range, with the run period being 365 days. However, during the trial run period (in 2010-2011), in Samotlorneftegaz OJSC and TNK-Nyagan OJSC some ballups of the flow gauge were marked (*Gao et al.*, 2020 [11]).

DE technological systems of tubular rod developed by Bashneft-Geoproject LLC have been exposed to testing period as early as in 2007 based on the equipment of companies Elkamneftemash and Paker companies and is widely employed today by oil-producing company Bashneft OJSC. Positive technological showings for the Russian and Kazakhstan oil fields have become the encouraging factor for the large-scale introduction of the technology beginning from 2009 (*Abutalipov*, 2010 [13])).

Introduction of DE facilities according to the scheme ESP + SRP with a tubular rod by the Tatneft OJSC encounters a problem related to sour crude production, as the company is conducting commingled development from the Lower Devonian and the upper carbonate hydrosulphuric zones. As a consequence, there is a quality loss in Devonian oil, and the necessity, hereupon, for removal of H_2S from the major part of the oil. Given such nuisance conditions comingled production there becomes disadvantageous.

Dual Completion Technologies Scientific Review

The single wellbore recovery technique is workable for both, commingled and stage development (separate) multi-zone production. The classical well stream "from the bottom up" is effective for maximum output and Oil Recoverability Factor (ORF), yet, when it is long used it makes recovery operations highly uneconomic. The issue's topicality urges the best technological developments related to commingled or isolated zonal exploitation. With this respect, hydrodynamic stimulation enabling the prediction of probabilities and contingencies for multi-zone systems development is instrumental for the most comfortable and advantageous options.

Researches (*Abutalipov*, 2010 [12]; *Ramirez*, 1987 [13]) look into the development problems of lithologically screened oil-lense and partly lithologic traps model. The conclusion of the review states that such a model is not viable and, therefore, unacceptable for commingled development, as there is a high probability of lense oil loss, apart from the arguable point concerning the reliability of lense oil meeting with water permeability in the wellbore area. The hydrophilic behavior of reservoirs saturating their void volume with bound and retained water is a decreasing factor for oil relative permeability, i.e. growing resistance to oil motion causes, at the same time, inversely low cumulative oil influx and oil flow rate. Given such conditions further oil-well exploitation requires special geological and technical arrangements to be conducted, which, conversely, can increase exploitation and lifting costs eventuating, in this vein, in the output decline.

Many research papers (*Sudaryanto* and *Yortsos*, 2000 [14]; *Al-Rbeawi*, 2018 [15]; *Bazitov et al.,* 2015 [16];

Daviau et al., 1988 [17]; *Guo et al.*, 2008 [18]) considering the problems of downhole cross flow in process of sandwich-type reservoirs development in different geological-technical settings state the conclusions, as follows:

1- The development of two productive zones with different P&PP on the basis of a single well strainer technique can provoke downhole fluid cross-flows from the high-permeable formation into the low-permeable one. The fluids withdrawal area in a low-permeable water-free reservoir became a highly water-saturated zone due to the cross-flows from the water-flooded high-permeable formation. This is the factor for oil relative permeability and oil rate decrease, which is conducive to final two-zone development efficiency loss.

2- Filter loss in the areas of injection or withdrawal operations, coupled with downhole fluids cross-flows in argilliferous reservoirs, if any, is provocative to the reservoirs being fenced off from any permeability impact. In case of full filter loss, the clayish reservoirs can remain really virgin even when water cutting of good production achieves the ultimate level, with the reservoir pressure being almost the same as that of the bottom-hole one in the flowing well. Meanwhile, a half filter loss gives partial oil cross-flow from the high-permeable reservoir into the low-permeable one, thus resulting in decreased cumulative oil uptake from oil wells, followed by full or partial pressure recovery in the low-permeable clayish zone.

3- Multi-zone oil production can become more efficient when DC technologies enabling technical separation of the pay zones are applied and special solvents capable to enhance waterflooding processes in argillaceous reservoirs are used.

When DC technologies are planned from the very beginning, i.e. they are considered and included in the feasibility study documents, then they can ensure the utmost economic effect allowing considerably low drilling budget. Inasmuch as oil fields require long-term development periods, oil companies operating in Kazakhstan constantly have to maintain the required production rates, and therefore they conduct the overburden rocks stripping activity, as well as commingled production from the zones, which often have different P&PP, grades of oils, reservoirs of different types and different modes of oil occurrence (*Raghavan* and *Ambastha*, 1998 [19]; *Tang et al.*, 2005 [20]; *Uzun et al.*, 2016 [21]).

The examples of commingled production from the zones with highly different reservoir and fluids properties are numerous, and oil companies reasoning from the expected low oil recovery index per each productive zone, in the absence of valid alternatives have to conduct this kind of budget-unfriendly activity. However, the employment of DC technologies with the unified well-spacing pattern included can become instrumental in the efficacious and expedient recovery of such arduous reserves.

The criteria for potential DC-commingled wells should follow appropriate DC technological requirements. These criteria can differ depending on the expected results and DC-technological plans designed for each oil field in view of their peculiar tasks. As for the technological plans themselves, they need to integrate with the current extraction and injection system and analyzed for future potential, practicability, and efficiency (*Wang* and *Economides*, 2009 [22]; *Xiance, et al.*, 2009 [23]; *Xing et al*., 2012 [24]; *Yildiz*, 2006 [25]).

The research paper follows the aim to carry out efficiency analysis for commingled oil recovery from Kazakhstan multilayer oil field.

EXPERIMENTAL SECTION

Airankol oil field is located in the South-Eastern part of the Caspian depression (South-Emba area). As for its administrative-territorial geography, the field belongs to Atyrau oblast, Kazakhstan. The administrative center of the oblast is Atyrau city located northwestward from the oil field, at a distance of 190 km far from it. The oil-field structural subdivisions include a permanent working utility block situated in the oil-field area, as well as a temporary utility block and a maintenance facility center situated in Kulsary town (Atyrau oblast).

Airankol oil field was discovered in 1979, when test-well G-2 saw oil influx after Early Cretaceous deposits on the Western structural high have been tested. Later oil occurrences were detected in the multi-zone field formations. The core intervals are enumerated year-wise, as follows:

- The year 2006: Jurassic sediments, both, on the Eastern and the Western structural highs;
- The year 2007: Early Cretaceous deposits (K1a) on the Eastern structural high, oil influx in test well R-3;

Table 1: Geological properties of horizons.

Object	Horizon	The density of the separated oil at 20 ºC, g/cm^3	Reservoir oil viscosity, mPa*s	Permeability, mPa	Productivity coefficient, m^3/day*MPa	Oil-water contact, m	Reservoir pressure, MPa
IX	YU -II	0.808	2.17	1.186	417.0	1153	10.7
X	YU -III	0.805	2.02	1.406	217.4	1232	11.9
XI	YU -IV	0.799	1.82	1.025	201.8	1340	12.2
XIII	YU -V	0.787	1.75	1.045	199.0	1364	13.1

- The year 2008: Early Cretaceous (K1a and Ne-I) and Jurassic sediments (YU-I) formations, oil influxes in test wells R-16 and R-5 situated within the range of Block IV.

Due to the core intersection of the Airankol oil field (test-well G-2) the supra sale sediments bedding a maximum 2200 m deep from the Quaternary Subera to Kungurian Lower Permian age layers have cropped out. Permian deposits are represented by Kungurian tier, their lithologies cover crystalline halite (rock salt) from the bottom part and carbonate-sulphatic formations (cap rock) from the upper part. Mesozoic Era comprises Triassic, Jura, and Cretaceous deposits, though the stratigraphic description of the era is incomplete. Permian-Triassic deposits are irregularly bedding on the Kungurian tier. The core interval's lithology includes different kinds of clays and malmrock. On the side of the Eastern structural high Permian-Triassic deposits are detected in almost all test wells, and within the Western structural high the deposits only crop out in two test wells (well G-2 and well R-10).

In the Middle Jurassic horizons Yu-IIA, Yu-IIB, Yu-IIIA, Yu-IIIB, Yu-IVA, Yu-IVB, Yu-VB, there is some fluctuation in gas content, saturation pressure, and other parameters. At the same time, there is no clear dependence of these parameters along the section and area of the field. An areal well placement system was used for this field. Table 1 shows the geological properties of horizons developed by one grid.

RESULTS AND DISCUSSION

The number of development targets in the field totals 14 now, but in 2010 Airankol oil operators planned to introduce dual completion technologies with the view of certain economic & technological efficiency gains prompted by enhancement of commingled development targets and their technological management. Hence, many targets (IX and X, XI and XIII and XII) have been selected to operate on the DC technological basis using the unified well-spacing pattern. The first DC experience of the oil field is connected with core intervals YU-IVA and YU-VA (well P-18), the commingled production of which began in April 2012. This event gave a start to incremental growth of oil output, making 37.0 tons/day. The highest number of Airankol commingled dual extraction wells promoting production output was achieved in 2016, as follows from the DC technologies histogram given in Fig. 2.

At the date of the analysis under review the majority of commingled DC wells (13 wells) operate in Targets IX and X, two commingled wells belong to Targets XI and XIII, and one DE well is operating in Targets XII.

Now let us consider the performance of development targets operating on DE basis. Commercial production of Target IX operating on depletion drive mode began in June 2011 with demothballing four oil wells.

Total paying well stock now makes 19 units. They are wells No.R-4, R-5, R-8, R-14, R-20, OC-21, OC-23, 141, 142, 156, 157, 158, 159, 171, 173, 176, 184, 187 and 188. All the wells are operated on an artificial lift basis, except wells No.R-4 and 184 operating on the free-flow production method.

At the date of the analysis under review, the average daily oil and fluids rate for the target made 29.1 and 34.6 tons/day. Water influx averaged 16.0 %, and the gas-oil ratio was 42.1 m^3/ton. Cumulative oil production made 865.2 thousand tons, that of fluids was 971.9 thousand tons, and that of gas made 28.1 million m^3.

Commercial production of Target X began in June 2011, with de-mothballing oil-well R-8. The production well stock includes 20 wells. They are wells No.R-5, R-8, R-14, OC-21, OC-22, OC-23, 141, 153, 154, 155, 156, 159, 163, 171, 173, 176, 177, 183, 187 and 188.

At the date of preparation of the report, the average daily oil and fluids rate made 38.7 and 49.0 tons/day.

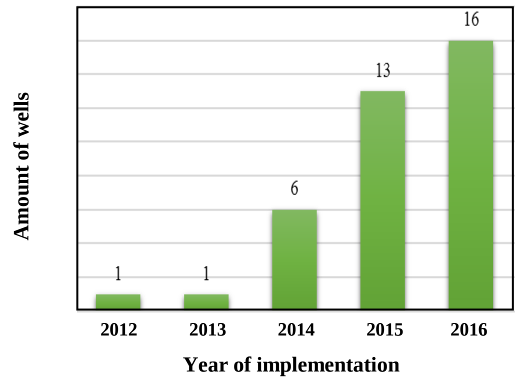

Fig. 2: Dynamics of DC employment in Airankol oil-field.

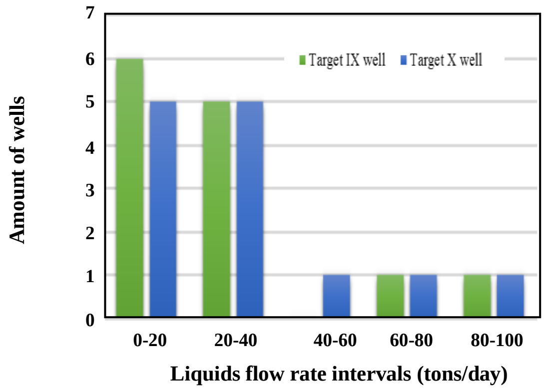

Fig. 3: Well-wise production rate distribution for fluids (in view of DC technological performance). Average well-wise production rates for liquids.

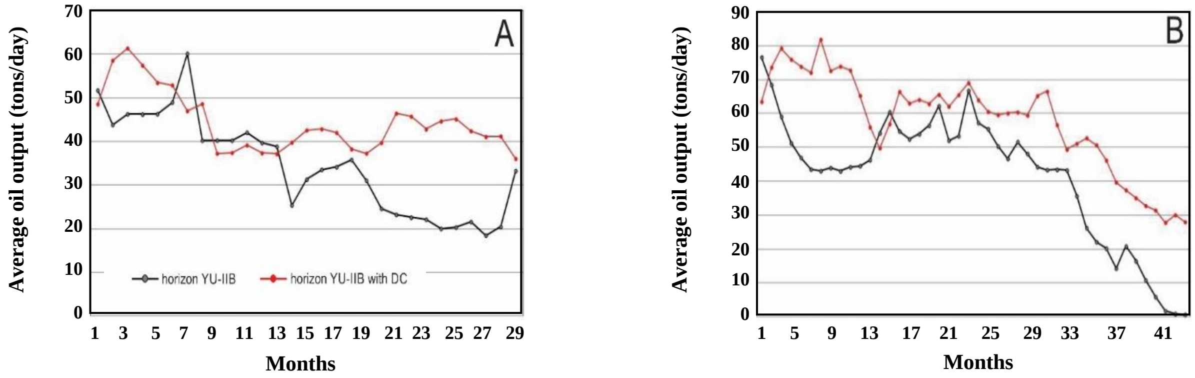

Fig. 4: Average production rates dynamics for Target IX dual completion- and stage development wells A – horizon Yu-IIB, B – multiple zone horizons YU-IIA+B.

Water influx averaged 21.0 %. The gas-oil ratio was 44.2 m^3 /ton. Past (cumulative) production made 1042.1 thousand tons of oil, 1223.7 thousand tons of fluids, and 36.5 million m^3 of dissolved gas.

Injection-well stock includes three production wells (No. 161, 162, and R-2). The average daily intake capacity of operating injection wells was 46.7 m^3 /day. From the beginning of the development period, cumulative working agent distribution made 50.8 thousand m^3.

DC (dual completion) technology for Targets IX (YU-IIA+YU-IIB) and X (YU-IIIA+YU-IIIB) was employed in April 2013. At the date of the analysis under review, there were 13 well operating on DC technological basis. They are wells No.R-5, R-8, R-14, OC-21, OC-23, 141, 156, 159, 171, 173, 176, 187 and 188.

According to Fig. 3 fluids, production rate distribution among dual completion wells was, as follows: for the majority of wells the fluids flow rate made up 20 tons/day, for Target IX it averaged 8.8 tons/day (6 wells), and for Target X it made 8.3 ton/day (5 wells). It should be noted that the well-wise distribution of fluids production rates was correlated with corresponding reservoirs' geologic characteristics.

Fig. 4 shows a comparative assessment of the average daily production rate for development target IX with DC technology applied. Target IX comprises zones A and B of horizon YU-II. Commingled DC wells mainly operate in zone YU-IIB and sometimes in zones YU-IIA + YU-IIB.

As follows from Graphic chart 4 there are insignificant discrepancies in the operation mode of dual completion wells and Target IX wells. This fact proves the correctness of the parameters of the pumping facilities' performance.

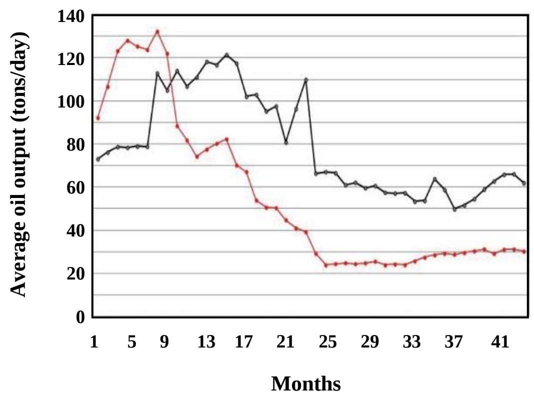

***Fig. 5:** Average production rate dynamics for Target X (YU-IIIB) dual completion- and stage development wells.*

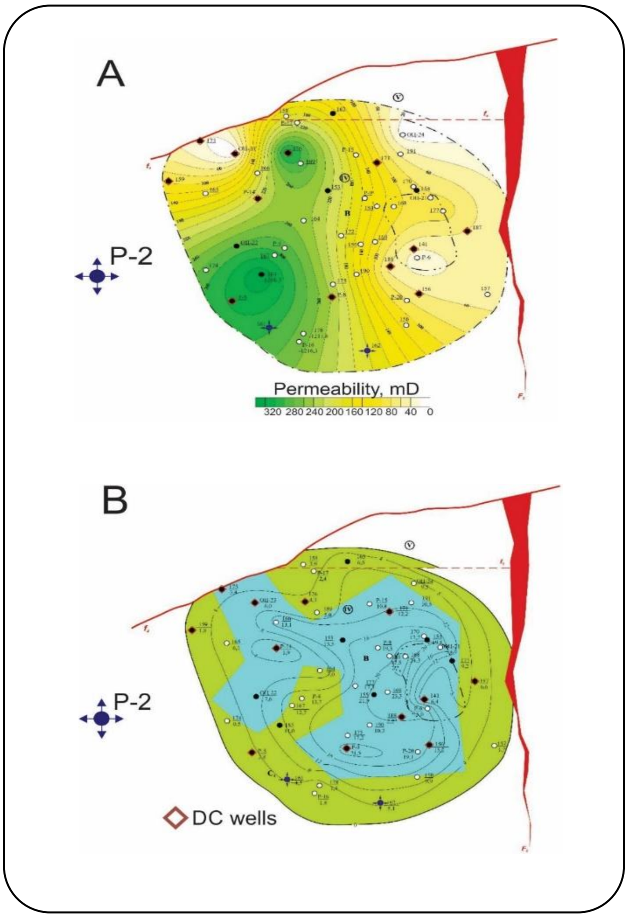

***Fig. 6:** Permeability map (A) and effective oil heights map (B) for Target X.*

A completely different type of situation occurs in Target X production wells. We single out the dynamics for YU-IIIB horizon, as the majority of DC wells are housed there. Compared production rates of stage development wells within the horizon are a bit higher than that of DC wells (see Fig. 5), probably, because the latter are situated in less productive zones (Fig. 6).

Now let us consider the benefits some production wells gain from the technology. Oil production based on dual completion technology in Targets XI (YU-IV) and XIII (YU-V) began in September 2013. At the date of the analysis under review, there were two operating DC wells (well No.164 and well No.168).

Finalizing liquids production rates for Targets XI and XIII in comparative histograms seemed futile there, as only a few single wells are operating there. It should be noted that the wells are distributed not in an even pattern, but depending on oil withdrawal data, and their average fluid-flow rates are, as follow:

- Target XI: 4.2 ton/day (well No.164) and 12.8 ton/day (well No.168);

- Target XIII: 18.2 ton/day (well No.164) and 17.9 ton/day (well No.168).

In Figure 7 the comparative flow-rate dynamics in reference to the stage and commingled development of Target XI are shown. It follows from the graphic chart that over the target development span the stage well stock BOPD (barrels of oil per day) is higher than that of the commingle well stock.

In Target XIII three wells are only operating, with two DC wells included, therefore making their flow-rate bar graphs would also be pointless. Besides, the wells are situated in different sites of the interval.

Development of Target XII, which was intended and predesigned for the energy depletion period, began in June 2011, with de-mothballing well No.R-11. Total active production-well stock there includes 5 wells (No.R-11, R-18, 180, 181, and 186).

At the date of the analysis under review, total cumulative production made 189.2 thousand tons of oil, 297.7 thousand tons of liquids, and 2.1 million m^3 of gas. The annual average water influx made 35.4 %, with the gas-oil ratio making 15.8 tons/m^3. The average daily production rate made 8.8 tons/day of oil, and 29.1 tons/day of liquids.

The DC wells of horizon YU-IVA (Target XII), as compared to stage development wells (Fig. 8), show high productivity throughout the development period on the whole, except for the first years of commingled production, when their production rates lagged behind those of the stage development wells.

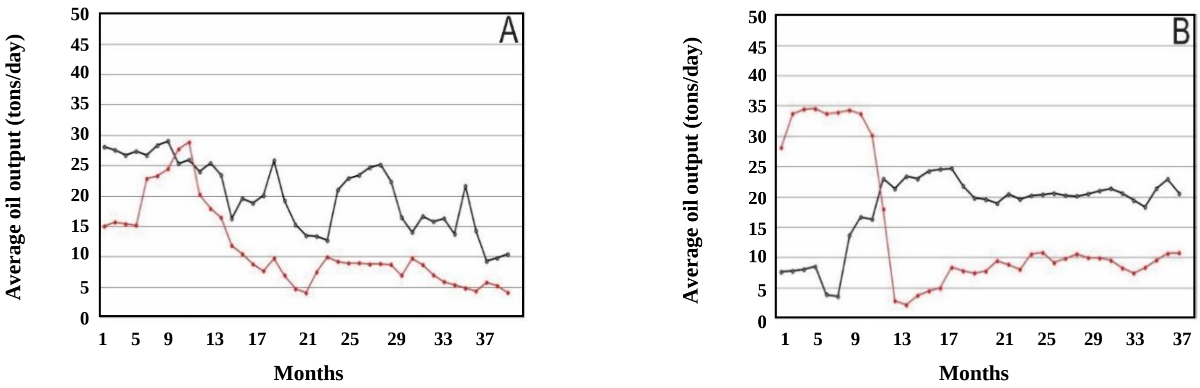

Fig. 7: Average production rate dynamics for Target XI dual completion- and stage development wells. A – horizon YU-IVA, B – multiple zone horizons YU-IVB.

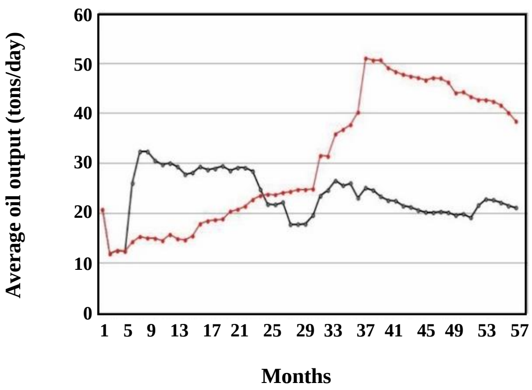

Fig. 8: Average production rate dynamics for Target XII (horizon YU-IVA) dual completion- and stage development wells.

Consequently, the successful introduction of the DC technologies in the Airankol oil field stems from the fully conforming performance of selected pumping facilities to potentialities of the productive zones, now involved in dual extraction activity. This fact testifies that reserves recovery activity in the oil field was evenly distributed, excluding cross-flows or other commingled production problems.

Geological and Physical Information Data-Based Selection Criteria for Dual Completion Package Installing

The priority selection criteria for wells adequate to DC technological requirements refer to technological expediency and practicability of the technologies introduction, thus ensuring final economic efficacy. Not with standing the issue has been given a comprehensive study, different companies use different criteria methods for DC wells selection. We suggest our own approach to the problem, considering technical requirements to scout well, geological settings of the productive zones, rock fluids properties, and state of development targets, for which the introduction of dual completion is planned, as the important aspects of the issue. Our method is shown in block schemes, the constituent parts of which are represented below.

A complicating and sometimes obstructing factor for DC technology introduction and employment is the worn-out state of the production casing. In order to avoid costly equipment failures or other related risks, the production casing integrity evaluation is required. The fit for service evaluation of the casing string for DC operations should be made within the final statement to the field geophysical survey.

Another important criterion is related to targets' geological settings, or, to be more precise, to productive intervals with different geologic and physical properties, and therefore requiring DC technologies employment. For a unified well-spacing pattern envisioned within the scope of DC technological enhancement, the required permeability difference for the reservoirs should be no less than 20 %.

One more important criterion here, from the geological point, refers to the difference in the top of reservoirs, as the insignificant difference in target zone depth is a pro-DC argument. Besides, the technology can become helpful when there are constraints for the packer setting.

Furthermore, physicochemical properties of reservoir fluids are also important in terms of DC solutions reasonable, when differential mobility of fluids from

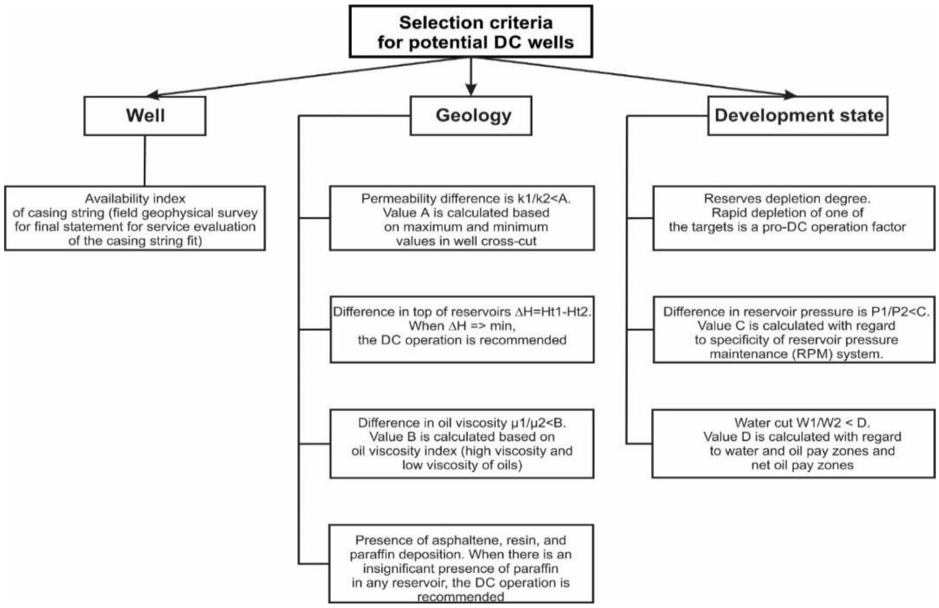

Fig. 9: Block scheme of selection criteria for potential DC wells.

two productive zones influencing their in-situ oil viscosity cause a difference in the related parameters. In this context presence of paraffin in reservoir fluids is an additional complicating factor for commingled production, therefore, the zones of heavy wax-bearing crude are recommended for separate development.

The final criterion for a good selection for DC purposes is connected with the development state. The reservoirs differing in degree of depletion, or having considerably different pressure and water cutting values should be among the priority target zones for dual completion realization plans.

In Fig. 9 the blocking scheme of selection criteria for potential DC wells is attached for illustrative purposes.

CONCLUSIONS

Thus, a visual comparison of the size of recoverable oil reserves by the reservoir and the estimated benchmark made it possible to identify a group of wells, each of the reservoirs, is represented by a high volume of recoverable reserves, which allows the well to provide high production rates for a long time and recoup the capital and operating costs of using the DC technology. In addition, the dynamics made it possible to rank the wells for the priority of implementing the DC technology in terms of reserves. Target IX and XII wells showed high average oil output.

The given multilayer fields development study carried out with regard to dual completion technologies employment shows the ineffectiveness of recording reserves recovery in particular commingled production zones. Hence, the designated task requires a multi-purpose hydrodynamic study to be conducted on a reservoir-by-reservoir basis, and thus would truly reflect the state of reservoir reserves for the present time. Hence, when two or more oil-bearing horizons affording development with a single well-spacing pattern differ in geologic, energy, and potentiality preconditions, then dual completion operation becomes of pivotal importance for the horizons, the greater is the difference, the more promising multi-zone production is for dual completion. The profitability of individual wells is increased due to the connection of other development objects or reservoirs of different properties of the same development object.

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REFERENCES

[1] Erhui L., Zifei F., Yongle H., Lun Z., Haiyan Z., Jianjun W., Congge H., Xing Z., A Dual-Porosity Dual-Permeability Model for Acidgas Injection Process Evaluation in Hydrogen-Carbonate Reservoirs, *International Journal of Hydrogen Energy*, **44(46)**: 25169-25179 (2019).

[2] Salam A-R., Emre A., Fishbone Type Horizontal Wellbore Completion: A Study for Pressure Behavior, Flow Regimes, and Productivity Index, *Journal of Petroleum Science and Engineering*, **176**: 172-202 (2019).

[3] Shawgi A., Saeed S., Chinedum E., Review of Gas Migration and Wellbore Leakage in Liner Hanger Dual Barrier System: Challenges and Implications For Industry, *Journal of Natural Gas Science and Engineering*, **78:** 103284 (2020).

[4] Garifov K.M., Ibragimov N.G., Kadyrov A.Kh., Zabbarov R.G., Fadeev V.G., "Simultaneous and Separate Reservoir Exploitation at Tatneft", Oil Industry, Moscow (2011). [In Russian]

[5] Oney Erge, Eric van Oort, Modeling the Effects of Drillstring Eccentricity, Pipe Rotation and Annular Blockage on Cuttings Transport in Deviated Wells, *Journal of Natural Gas Science and Engineering*, **79:** 103221 (2020).

[6] Gabdulov R.R., Agafonov A.A., Slivka P.I., Nikishov V.I., Experience in the Application of DC Technologies for the Multilayer Fields at Rosneft Oil Company, *Engineering Practice*, **1:** 30-37 (2010). [In Russian]

[7] Mukhametshin A.R., Yamilov R.R., Operational Experience of Operational Systems at Bashneft, *Engineering Practice*, **2:** 56-61 (2013). [In Russian]

[8] Sharma P., Al Saedi A., Kabir C.S., Assessing the Hyperbolic Trend in Well Response Involving Pressure, Fluid and Heat-Flow Rates, *Journal of Natural Gas Science and Engineering*, **78:** 103292 (2020).

[9] Conejeros R., Lenoach B., Model-Based Optimal Control of Dual Completion Wells, *Journal of Petroleum Science and Engineering*, **42:** 1-14 (2004).

[10] Ould-Amer Y., Chikha S., Naji H., Attenuation of Water Coning Using Dual Completion Technology, *Journal of Petroleum Science and Engineering*, **45:** 109-122 (2004).

[11] Gao R., Li J., Liu G., Yang H., Luo K., Zhai W., Zhang X., Zhang R., Experimental Study on Typical Characteristics of Borehole Breathing Under Different Pressure and Rock Type Conditions, *Journal of Natural Gas Science and Engineering*, **77:** 103241 (2020).

[12] Abutalipov U.M., Development and Application of DC Technologies at Bashneft, *Engineering practice*, **1:** 72-77 (2010). [In Russian]

[13] Ramirez W.F., "Application of Optimal Control Theory to Enhanced Oil Recovery" Elsevier, Amsterdam (1987).

[14] Sudaryanto B., Yortsos Y.C., Optimisation of Fluid Front Dynamics in Porous Media Using Rate Control: I. Equal Mobility Fluids, *Physics of Fluids*, **12:** 1656-1670 (2000).

[15] Al-Rbeawi S., Deep insights to Transient Pressure Behavior and Stabilized Productivity Index of Multilateral Well Wells in Laterally and Spatially Anisotropic Reservoirs, *Journal of Natural Gas Science and Engineering*, **54:** 240-265 (2018).

[16] Bazitov M.V., Golovko I.S., Konosov D.A., Mingazov A.N., Nigmatullin R.R., Lokot A.V., Malyasov V.Y., "First Fishbone Well Drilling at Vankorskoe Field", *SPE Russian Petroleum Technology Conference*, 26-28 October, Moscow, Russia, (2015).

[17] Daviau F., Mouronval G., Bourdarot G., Curutchet P., Pressure Analysis for Horizontal Wells, *SPE Formation Evaluation*, **3(4)**: 720-724 (1988).

[18] Guo B., Ghalambor A., Ling K., A Rigorous Composite-Inflow-Performance Relationship Model for Multilateral Wells, *SPE Production & Operations*, **23(2)**: 241-248 (2008).

[19] Raghavan R., Ambastha A.K., An Assessment of the Productivity of Multilateral Completions, *Journal of Canadian Petroleum Technology*, **37(10)**: 58-67 (1998).

[20] Tang Y., Yildiz T., Ozkan E., Kelkar M.G., Effects of Formation Damage and High-Velocity Flow on the Productivity of Perforated Horizontal Wells, *SPE Reservoir Evaluation & Engineering*, **8(4)**: 315-324 (2005).

[21] Uzun I., Kurtoglu B., Kazemi H., Multiphase Rate-Transient Analysis in Unconventional Reservoirs: Theory and Application, *PE Reservoir Evaluation & Engineering*, **19(4)**: 553-566 (2016).

[22] Wang X., Economides M., "Advanced Natural Gas Engineering", Gulf Publishing Company, Houston (2009).

[23] Xiance Y., Guo B., Ai C., Bu Z., "A Comparison Between Multi-Fractured Horizontal and Fishbone Wells for Development of Low-Permeability Fields", *SPE Asia Pacific Oil and Gas Conference and Exhibition,* 4-6 August, Jakarta, Indonesia, (2009).

[24] Xing G., Guo F., Song C., Sun Y., Yu J., Wang G., "Fishbone Well Drilling and Completion Technology in Ultra-Thin Reservoir", *SPE Asia Pacific Drilling Technology Conference & Exhibition*, 9-11 July, Tianjin, China, (2012).

[25] Yildiz T., Productivity of Selectively Perforated Horizontal Wells, *SPE Production & Operations*, **21(1)**: 75-80 (2006).