Identifying of Production Facilities (Reservoirs) at Multilayer Oil and Gas Condensate Fields in the Yamal-Nenets Autonomous Okrug

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Abstract. The accumulated experience in the development of the multilayer oil and gas fields is sometimes evidenced by the inaccuracy of decisions in the area of identifying the production facilities used at the initial stages of development, when the amount of initial information necessary for design is very limited. A high degree of knowledge is typical for the drilled fields, when decisions regarding the identifying of production facilities are already taken and only their correction is possible. At the initial stages, the practice of combining a significant number of reservoirs into a single production facility has been often applied, which has led to the insufficiently complete production of the individual productive intervals, reducing the efficiency of the hydrocarbon extraction from the subsoil of the Earth. The paper presents a scheme for the identifying of the production facilities at the multilayer Yuzhno-Russkoye and Beregovoye oil and gas condensate fields, which consists of a stepwise analysis of each of the criteria for the possibility of combining the reservoirs into a single development facility presented in the paper. Decisions on the identifying of the production facilities according to the proposed algorithm were tested and entered into the feasibility study of the oil recovery factors at the mentioned fields. The proposed solutions make it possible not only to achieve high hydrocarbon extraction rates, but also to avoid a decrease in the economic efficiency in the late stages of the field development, caused by the need to drill an additional well stock when disconnecting the erroneously combined reservoirs at the initial stage.

1. Introduction

The development of the multilayer deposits containing various types of hydrocarbon fluids (oil, gas, gas condensate and water) is a difficult optimization task, from a competent solution of which it depends on how efficiently and rationally the subsoil will be exploited. The decisive role in solving this issue is played by the degree of the field study, namely, by the availability of the reliable information regarding the deposits configuration, geological and physical characteristics of the production reservoirs, their natural regimes, physical and chemical properties as well as component composition of hydrocarbon feedstocks.

A high degree of the field study allows us to minimize the risk of errors when choosing the production facilities, having formed the most rational scheme for their identifying. At the same time, it is obvious that a high degree of the field study is characteristic of drilled fields. Here decisions regarding the identifying of the production facilities have already been taken and only their correction
is possible.

Thus, the most relevant issue is the selection of the exploitation facilities precisely at the initial stage of the development. As a rule, the amount of the initial information for designing is very limited at this stage. In this regard, the choice of the optimal number of facilities is a multivalued task. As new information becomes available, their number can both increase and decrease significantly. Such changes can significantly affect both the technological and the economic efficiency of the project.

In this regard, it is advisable to turn to the practice of the developing of multilayer deposits in Western Siberia. The accumulated experience indicates that combining a significant number of reservoirs into a single production facility leads to the insufficiently complete production of the individual productive intervals. As examples Samotlorskoye, Ust-Balykskoye and other deposits can be given [1, 2]. The initially combined multilayer horizons were subsequently disaggregated. The reasons for this were primarily the discrepancy between the applied development technology and the geological and physical characteristics of the individual reservoirs. Moreover, in some cases, the erroneous unification of the uneven productive reservoirs into the unified development facilities caused an irreversible damage to the subsoil. And even drilling a significant number of additional wells did not fully contribute to the correcting the existing unfavorable situation with the reserves recovery. Therefore, in the initial stages of the field development, a more critical approach when combining the reservoirs into single production facilities, in our opinion, is the most justified, primarily from the standpoint of achieving high recovery rates.

The problem of the identifying of the operation facilities is closely related to the origin and development of the oil industry. At different times many domestic and foreign researchers dealt with it. They were A.I. Akulshin, Yu.E. Badyanov, E.P. Efremov, N.E. Bykov, V.S. Boyko, R.N. Diyashev, N.A. Eremin, V.G. Kanalin, V.D. Lysenko, M.I. Maksimov, M. Musket, I.T. Mishchenko, I.M. Muravyev, I.I. Nesterov, F.K. Salmanov, K.A. Shpilman, I.G. Permyakov and many others.

2. Results and discussion

Based on the papers of the above mentioned researchers, as well as on own experience of the authors of the given paper, an algorithm was developed for identifying the production facilities for multilayer oil and gas condensate fields in the Yamal-Nenets Autonomous Okrug, which has the following sequence.

1. At the first stage, independent facilities of development include reservoirs which belong to one reservoir group (PK, BT, AT or Yu). This limitation is primarily associated with the technological capabilities of the successful well operation;
2. The second stage is the consideration of the hydrocarbon deposits for their occurrence under each other, that is the combination of deposits in the plan;
3. Further, all deposits are differentiated by the saturation type. Three main groups are identified: gas (including gas condensate) oil and oil and gas ones. The integration into exploitation facilities was considered only within the groups, while in the presence of significant gas reserves in pure gas deposits, these are allocated to independent development facilities, for example, deposits of the Senonian or Turonian Stage;
4. At the fourth stage, previously combined deposits that coincide in plan are considered for the occurrence of identical saturation zones under each other, that is, poor oil reservoirs can be developed as a single filter only with poor oil reservoirs. It is known that the simultaneous operation of various saturation zones of deposits can adversely affect the indicators of development and the degree of extraction of oil and gas reserves, due to the significant differences between the processes and characteristics of displacement. Therefore, at this stage, the possibility of simultaneous exploitation of previously selected deposits into one facility that do not coincide in terms of the occurrence conditions of saturation zones is considered. For example, the simultaneous operation of the pure oil reservoir and the water-oil zone is not recommended, since the formation of a water cone and premature flooding in the oil-water zones, while operating simultaneously, will inevitably adversely affect the oil recovery of a deposit with a pure oil reservoir;
5. At the fifth stage, the disaggregation of deposits and their effective thicknesses are examined in detail. High indices of fragmentation allow the exploitation of the massive deposits, which reserves are classified as the contact ones, together with the pure oil and gas deposits. Natural clay barriers prevent the formation of cones of water and oil, which favorably affects the development of oil and gas reserves, allowing the achieving acceptable values of the recovery factors. Thus, the purely oil or gas deposits and reservoirs with contact reserves allocated at the fourth stage as separate facilities, at this stage, conceptually, can be combined into unified production facilities, if they are characterized by high levels of fragmentation. Also an important criterion considered at this stage is effective thicknesses, which should be close in value to prevent a variable-rate production, which is especially important when operating the contact reserves;

6. One of the determining parameters when combining the reservoirs into unified facilities is the filtration properties of the deposits, which are considered at the sixth stage. Approximate permeability values allow for a uniform production of oil and gas reserves;

7. Successful joint operation of two or more reservoirs with a unified filter also largely depends on the comparability of the physical and chemical properties of reservoir fluids, which are analyzed at the seventh stage;

8. At the final stage of the identifying of the production facilities, a detailed geological and field analysis is carried out. For this, the data from the logging diagrams, well test results, the practice of developing the analog deposits as well as the created geological and hydrodynamic models are involved.

Thus, at the initial stages (1-7), the initial scheme for the identifying of production facilities in the first approximation is formed. Subsequent adjustments to it are made as a result of a detailed geological-field analysis, the results of geological modeling and technological calculations performed using three-dimensional mathematical models.

Naturally, a significant number of criteria significantly increases the number of independent production facilities, however, such a critical approach to their identifying may be most justified in the conditions of the initial stage of the field study.

The multilayer Yamal deposits put into operation are a testing ground for applying the accumulated experience of development of the previous years. The Yuzhno-Russkoye and Beregovoye oil and gas condensate fields located near the city of Novy Urengoy are suitable for testing the above described approach for identifying production facilities.

There are multi-layer deposits, characterized by significant hydrocarbon saturation, for about 2000 meters. By the amount of the recoverable gas reserves, the fields are unique and large, and Yuzhno-Russkoye one is among the ten largest commercial fields in the Yamal-Nenets Autonomous Okrug.

At the beginning of 2011, at the Yuzhno-Russkoye field, commercial oil and gas bearing capacity was found in terrigenous deposits of the Turonian Stage (reservoirs T1-2) and Aptian, Albian and Cenomanian Stages (reservoirs PK1, PK6, PK9, PK10, PK12, PK13-1, PK13-2, PK14, PK15, PK16-1, PK16-2, PK17-1, PK17-2, PK18, PK19, PK20-1, PK20-2 and PK21-22), Neocomian sediments (reservoirs BT40, BT4, BT12, AT6 and AT11) in the Upper Jurassic deposits of the Sigovian (Yu11, Yu12, Yu13, Yu14-1 and Yu14-2) and Middle Jurassic sediments of the Tyumen series (reservoirs Yu21 and Yu22). In general, 31 productive reservoirs, represented by 70 deposits, were identified at the field, including 8 gas, 45 gas condensate, 12 oil and gas condensate and 5 oil ones. Gas deposits of the reservoirs T1-2 and PK1 containing the main gas reserves have already been identified as separate production facilities. The design stock for them is almost completely put into operation. In this regard, they will not be mentioned further in the paper.

At the stage of combining the deposits contours within the groups of reservoirs considered at the second stage, 15 production development facilities can be identified. Compliance with the further criteria significantly increased their number, brought to 31 at the seventh stage. Detailed geological and field analysis as well as results of three-dimensional hydrodynamic modeling have unequivocally shown the need to identify oil and gas deposits as separate production facilities since it is not possible to ensure the stable operation of the development system provided that a well opens two or more oil
and gas bearing reservoirs. In addition, the use of horizontal wells is mainly proposed for the development of such deposits. Thus, at the last stage, the number of the production facilities reached 34 units, including 18 gas, 4 oil and 12 oil and gas ones.

Once again, it should be noted that the identifying of such a significant number of production facilities is primarily due to the complex geological structure and the significant difference in the properties of the deposits. In this regard, the concept presented in relation to multilayer oil and gas condensate fields seems quite justified. The basis of its formation is primarily the principles of a rational subsoil use. Further, let us consider the results of the identifying of production facilities according to the proposed algorithm at the Beregovoye field.

3. Beregovoye field

Commercial inflows of oil, gas, and gas condensate at the Beregovoye field were obtained by the testing terrigenous sediments of the Aptian, Albian and Cenomanian Stages (reservoirs PK1, PK9, PK121, PK122, PK131, PK14, PK151, PK160, PK161, PK162, PK163, PK171, PK191, PK192 and PK20) in the Berriasian-Valanginian sediments (reservoirs AT62, AT7, AT81, AT82, AT9, AT101, BT0, BT11, BT12, BT21, BT42, BT53, BT10, BT11) and Jurassic deposits (reservoirs Yu2 and Yu4) at the Beregovoye and Yushno-Geologicheskoye deposits. In total, 31 productive reservoirs are distinguished at the fields, which are represented by 54 deposits, 27 of which are gas condensate, 18 gas, 4 oil and gas condensate, 4 oil and one gas and oil ones.

As a result of the identifying of the production facilities according to the proposed algorithm, 13 production facilities were obtained, including two gas, one gas and oil, five gas condensate, three oil and gas condensate and two oil ones.

4. Conclusion

Thus, the authors consider that the proposed algorithm for the identifying of the production facilities implemented at the Yuzhno-Russkoye and Beregovoye fields allows not only to achieve high hydrocarbon extraction rates, but also to avoid a decrease in economic efficiency in the later stages of the field development due to the need to drill an additional well stock when uncoupling the erroneously combined reservoirs at the initial stage.

5. References

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