Concept of production facilities’ selection on multilayer oil-gas condensate fields in Yamal-Nenets Autonomous District

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Abstract. In the Russian terminology, the production facility is determined as a productive layer or a group of layers, extraction of hydrocarbons from which will be carried out by a unified well network. The gathered experience of multilayer oil and gas fields’ development sometimes demonstrates falsity of decisions in the selection of production facilities applied at the initial stages of development when the volume of initial information necessary for design is very limited. High degree of study is characteristic for drilled fields when decisions concerning selection of production facilities are already determined and only their adjustment is possible. At initial stages, practice of interconnection of a considerable number of layers in an integrated production facility was often applied that brought to insufficiently complete production of separate productive intervals, reducing the efficiency of hydrocarbon raw materials extraction from Earth subsoil. The scheme of production facilities’ selection in multilayer Southern Russian and the Beregoye oil-gas condensate fields, which consists in the stage-by-stage analysis of each criterion, presented in the article regarding the possibility of layers’ interconnection in united development facilities, is presented in the paper. Decisions of operational objects’ selection by the presented algorithm are approved and have been used in works on the techno-economic justification of oil recovery coefficients on considered fields. The proposed solutions allow one not only to reach high rates of hydrocarbon raw materials’ extraction, but also to avoid decline in economic activity at late development stages of the field caused by the necessity of additional well stock drilling at layers’ separation, which were connected at an initial stage by mistake.

1. Introduction

Development of multilayer fields containing different types of hydrocarbon fluids (oil, gas, gas condensate and water) is a difficult optimizing task on the competent solution of which the efficiency and rationality of subsurface resources production depends. The exploration degree plays the defining role, namely the presence of reliable information concerning the deposits’ configuration, geological and physical characteristics of productive layers, their natural modes, physical and chemical properties and component composition of hydrocarbon raw materials.

The high degree of study allows reducing as much as possible risk of mistake when choosing operational objects, having formed the most rational scheme of selection. At the same time, it is obvious that the high degree of study is characteristic for drilled fields, the decisions concerning the selection of production facilities have been already determined and only their adjustment is possible.
2. Results and Discussion

In this regard it is necessary to practice the development of multilayer fields in Western Siberia. The gathered experience demonstrates that interconnection of a considerable number of layers in the unified production facility results in insufficiently complete development of separate productive intervals. It is possible to give Samotlorskoye, Ust-Balykskoye and other fields as an example. Initially integrated multilayer horizons in consequence have been broken up into smaller units. First of all the noncompliance status of the applied development technology to geological and physical characteristics of separate layers was the reasons. And in some cases, the wrong interconnection in unified production formations has caused irreversible damage to subsurface. And drilling of a considerable number of additional wells promoted the correction of the adversity with reserves’ development even not in full. Therefore, according to the authors’ opinion, a more critical approach at layers’ interconnection is the most justified first of all from the position of achievement of high extraction coefficients at the initial stages of reserve’s development.

The problem of production facilities’ selection is closely connected with the origin and development of oil industry. Many domestic and foreign researchers Akulshin A.I., Badyanov Yu.E., Efremov E.P., Bykov V.S., Diyashev R.N., Eremin N.A., Kanalin V.G., Lysenko EL, Maximov M.I., Masket M., Mishchenko I.T., Muravyev I.M., Nesterov I.I., Salmanov F.K., Szpilman K.A., Perymjakov I.G. and many others researched it.

The authors of this paper, relying on works of the mentioned-above researchers and also on their own experience, determined the algorithm production facilities’ selection for multilayer oil-gas condensate fields in the Yamalo-Nenets Autonomous District:

1. at the first stage, the layers belonging to one geologically age group of layers are related to independent development formations. This restriction first of all is connected with technological capabilities of efficient well operation;
2. the second stage is the consideration of deposits of hydrocarbons regarding their bedding, i.e. the combination of deposits;
3. further, all deposits are differentiated according to the saturation. Three main groups are selected: gas (including gas-condensate), oil, and oil and gas. Association in the objects of operation was considered only within groups, at the same time in the presence of essential reserves of gas in purely gas deposits, those are allocated in independent subjects for development, for example, of the deposits of the Cenomanian or Turonian fields;
4. at the fourth stage, previously united deposits coinciding in the plan are considered regarding bedding of identical zones of saturation, i.e. net oil pay zones can be developed by the united filter only with net oil pay zones. It is known that the simultaneous development of various zones of deposits’ saturation can negatively affect indicators of development and the extent of development of oil and gas reserves because of essential differences of processes and characteristics of displacement. Therefore at this stage, the possibility of a simultaneous exploitation of previously allocated deposits in one object which are not coincident in plan under the bedding terms of saturation zones is considered. For example, the simultaneous exploitation of pure oil and water oil zones as the formation of a cone of water and premature flooding in water oil zones with simultaneous exploitation will inevitably negatively affect oil recovery of a deposit with a pure oil zone, which is not recommended;
5. at the fifth stage, indicators of reservoir compartmentalization and their effective thickness are considered in detail. High indicators of stratified rocks allow operating deposits of massive type, which reserves belong to contact-type, together with pure oil and pure gas deposits. Natural clay barriers prevent from the formation of water and oil cones that favorably affects development of oil and gas reserves, allowing reaching acceptable values of extraction coefficients. Thus, pure oil or pure gas deposits and layers selected at the fourth stage with contact reserves in separate objects, at this stage, in principle can be united in operational objects in case of high indicators of stratified rocks. Net reservoir thicknesses which have to be close to values for preventing the multispeed development that is especially important at operation of contact reserves are also considered as the important criterion;
6. one of defining parameters in layers combination into unified objects is filtration characteristics of deposits which are considered at the sixth stage. Similar values of permeability allow providing even development of oil and gas reserves;

7. efficient commingle well operation of two and more layers with joint filter in many respects depends on comparability of physical and chemical properties of formation fluids which are analyzed at the seventh stage;

8. on a closing stage of production facilities’ selection the detailed geological field analysis is carried out. Data of logs, results of wells’ test, the experience of development of fields-analogs and created geological and hydrodynamic models are considered as well.

Thus, at the starting stages (1-7) the initial scheme of production facilities’ selection in a first approximation is formed. The subsequent corrections are made as a result of the detailed geological field analysis performance, results of geological simulation and process calculations executed by means of three-dimensional mathematical models.

It is unmistakable that the considerable number of criteria significantly increases the quantity of independent operational objects. This approach is the most justified in terms of an initial stage of the exploration maturity of a deposit.

The multilayer fields of Yamal brought into development are the technological test site for the gathered development experience application historically. The Southern Russian and Beregovoye oil-gas condensate fields located near Novy Urengoy are suitable for the approbation of the above described approach in production facilities’ selection.

Multilayer fields are characterized by the considerable oil-and-gas-saturated layer (about 2000 meters). Fields belong to unique and large-scale deposits. The Southern Russian field is a top ten large-scale deposit of YaNAD.

At the beginning of 2011 the commercial oil-and-gas content is established in terrigenous deposits, the Turonian and apt-alb-Cenomanian, deposits of a neolump, in the Upper-Jurassic deposits Sigovsky and the Middle-Jurassic deposits of Tyumen sunk on the Southern Russian field. In general 31 productive layers presented by 70 deposits are allocated, among them: 8 – gas deposits, 45 – gas-condensate deposits, 12 - oil-gas condensate deposits and 5 oil deposits on the field. Gas deposits of T1-2 and PK1 layers containing main reserves of gas have been already allocated as independent operational objects. The project fund is almost completely realized. In this regard authors did not mention about them in the paper.

At the joint stage of deposit outlines within group of strata considered at the second stage, it is possible to allocate 15 operational development sites. Further the criteria performance has significantly increased the quantity, having brought to 31 at the seventh stage. The detailed geological field analysis, and also the results of three-dimensional hydrodynamic imitation have unambiguously represented the necessity of oil and gas deposits’ selection in independent operational objects, as it is not possible to enable steady functioning of the development system in terms of drilling of two and more oil and gas layers by the formation. An additional point that the drilling of horizontal wells is mainly offered for the development of similar deposits. Thus, the quantity of operational objects has reached 34 fields, among them 18 gas fields, 4 oil fields and 12 oil and gas fields at the last stage.

It should be noted that the selection of such essential quantity of operational objects is caused, first of all, by a complex geological structure and a considerable difference of deposits’ characteristics. In this regard the submitted concept in relation to multilayer oil-gas condensate fields is presented quite justified. In a basis of the formation first of all the principles of rational subsurface use are underlain. Further authors consider results of operational objects’ selection by the offered algorithm on the Beregovoye field.

Commercial oil, gas and gas condensate flows on the Beregovoye field are achieved at approbation of terrigenous deposits of Aptian-alb-Cenomanian, in deposits of Berriasian-Valangin and the Jurassic deposits on Beregovoye and Southern Geological fields. In total 31 productive layers which are presented by 54 deposits, among them- 27 gas-condensate deposits, 18 gas deposits, 4-oil and gas condensate deposits and 4 oil deposits and 1 gas-oil deposit are allocated on fields.
13 process facilities, among them 2-gas, 1-gas and oil, 5-gas-condensate, 3-oil-gas condensate and 2-oil deposits have been recovered as a result of production facilities’ selection by means of the offered algorithm.

3. Conclusion
Thus, the authors regard that the offered algorithm of production facilities’ selection realized on the Southern Russian and Beregovoye field allows one not only to reach high rates of hydrocarbon raw materials’ extraction, but also to avoid a decline in economic activity at late development stages of the field caused by the necessity of drilling of an additional well stock during dissociation of layers, which are mistakenly united at an initial stage.

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