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ARTICLE

RISK MANAGEMENT AT THE FINAL STAGE OF GAS FIELD DEVELOPMENT

Valeria A. Cheymetova*, Yuriy V. Vaganov

Tyumen Industrial University, Volodarskogo Street, 38, Tyumen, 625000, RUSSIA

ABSTRACT

The article introduces the problems of managing the risks of stimulating gas influx at the final stage of gas field development. The extraction of hydrocarbons, including gas, is carried out from numerous fields throughout the Russian Federation. The deposits differ in their properties and characteristics, which influence the indicators of the efficiency of extraction of hydrocarbon reserves, and are also distinguished by the extent of reserves depletion. In modern conditions of economic development at the macro- and micro levels, it is becoming increasingly important to extract gas reserves at the final stage of gas field development. This article is aimed at identifying the main risks and methods of their managing at the final stage of gas field development. The main problems at the final stage of gas field development are outlined. Risks in the gas field development with hard-to-recover gas reserves are highlighted and characterized. Actions to reduce the risks when carrying out mining works at the final stage of gas field development are presented. It is shown that the application of risk management methods at the final stage of gas field development includes, first of all, forecasting, as well as the introduction of a system of measures to reduce, prevent situations leading to damage and losses; herewith, risk management has to be implemented in stages. The effect of measures to manage risk reduction in the development of gas fields and the operation of field facilities will be shown through a reduction in the likelihood of risk. Nevertheless, it is currently not possible to completely eliminate the occurrence of risky cases, since this requires large investments (material, human, economic) to obtain additional information and conduct analytical and scientific research. This is also affected by the fact that it is fundamentally impossible to reliably predict the future state of the gas field and the environment.

KEY WORDS
hard-to-recover gas reserves, issues of gas extraction, cost of gas extraction, raw hydrocarbon reserves, risk management,

INTRODUCTION

Gas in Russia is extracted from numerous deposits and fields located throughout the country. The deposits are characterized by different geological and physical properties which exert strong influence on extraction efficiency of the reserves, on efficiency of deposit development, as well as by different depletion of reserves and fields. Under modern economic situation of the industry development, extraction of gas at final stage becomes increasingly important. Herewith, the mentioned properties of deposits vary in significant ranges, which predetermine different expenses for gas extraction at each single well. The largest and most unique gas deposits in the world are located in the Arctic and extreme northern regions of West Siberia, such as Urengoy, Yamburg, Bovanenkovo gas fields. According to predictions, total area of these deposits exceeds 769,250 km^2 [1]. In the ranges of the considered territory, oil and gas reserves were detected from Paleozoic deposits to Upper Cretaceous combined into five largest regional oil and gas complexes with overwhelming majority of deposits (up to 98%) in Aptian-Cenomanian, Neocomian, and Jurassic sediments. Herewith, more than 85% of explored gas reserves are embedded in exclusively gas fields confined to Aptian-Cenomanian gas bearing complex of northern regions [2]. The available studies of Russian companies as well as the experience of development of gas deposits demonstrate that final stage of raw hydrocarbon production is sufficiently complicated problem due to the following reasons:

- decrease in seam pressure;
- decrease in total gas extraction at deposits;
- complicated and more expensive operation of flooded wells.

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Under such conditions of deposit development, the expenses for gas extraction sharply increase, this demonstrates that the project is complicated and requires for unique approach to further development of gas field and subsequent use of the extracted gas [3- 5].

Development of gas deposit design is a multipurpose complex system of single life cycle with high risks and uncertainties. For project of such type it is highly important, though difficult, to estimate risks. Therefore, it is necessary to develop and apply measures for their decrease and elimination for each project stage, that is, to manage risks. Herewith, the main task it to minimize risks of a project at each stage of its execution.

At final stage of deposit development, the project is aimed at:

- increase in gas extraction from field, available technically and economically;
- provision of long-term social guaranties and living conditions for inhabitants and employees of gas production company since they reside in single-industry cities in gas producing regions or in the vicinity of large deposits.

***Corresponding Author**
Email:
chejmetovava@tyuiu.ru

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METHODS

Hard-to-recover gas reserves are characterized by significant difficulties of their extraction both in terms of technology and economy. This results in increased expenses, especially at initial stages, when innovation technologies of extraction are commissioned.

In order to initiate active production, it is required to develop and to approve appropriate regulatory decisions at top level. For instance, it could be proposed that in the case of implementation of complicated and large-scale projects of gas extraction, the mineral extraction taxes are reduced to 0% of standard rates. In the case of medium-scale projects, this reduction can equal to 60%, and in the simpler cases – to 40% [1, 6]. This preference concerning tax rate depending on the complexity of gas deposit development and subsequent production will be granted for ten, seven, and five years, respectively. If such innovations by top-level management are allowed and applied in the areas of extraction for a long time, then the mining industry will have real opportunities to continue secure gas extraction. This is related with the fact that gas extraction is accompanied by deep scientific studies and the need to purchase and to implement the innovative equipment and technology. All these results show increased expenses of deposit development.

Under such conditions, it is required to apply individual approach to each specific project. Only with such decision it is possible to expect compliance with all geological and engineering conditions for a specific deposit. It should be mentioned that key industries should be involved in development. At the same times, at present qualified experts in this sphere are nearly unavailable and it is necessary to train them, which requires for time and money [7, 8].

In addition, extraction of hard-to-recover hydrocarbons is accompanied by high risks. This is stipulated by the fact that at initial stage of scientific studies and implementation of new machinery and technology, they are not unified but experimental, suitable only for a certain deposit.

Some risks could be highlighted peculiar for the initial stage:

- uncertainty of energy policy at meso- and macro-level;
- growth containment of expenses as the main trend at companies of the industry;
- climate changes and environmental issues;
- unsteady prices and dependence on global markets;
- deficiency of qualified experts in the industry and scientific sphere;
- possible violations in deliveries due to vast territories;
- new difficulties of operational nature, including operation under unknown conditions (new risk);
- outdated infrastructure of companies of the industry;
- competition of new technologies, including alternative fuels.

Let us analyze the most important risks and their influence on extraction of hard-to-recover gas reserves. Geological risk is a consequence of occurring geological uncertainty since, at present, it is impossible to develop geological model of certain gas deposit, its effective seam, and surrounding water bearing basin with the required accuracy and details [7].

In order to develop geological model for large and unique gas deposits with the surface area of several thousand square kilometers, 30–50 exploration wells are drilled; however, geological cross sections are poorly correlated (especially when the structure of productive layer is complex) [9-11].

Preliminary seismic exploration is aimed at detection of structural forms of deposit seams; however, this does not allow to determine physical properties required for development of geological model: porosity, permeability, water saturation and gas saturation. These properties are determined by obtained cores from exploration wells. The consequences of the existing geological risks are technological risks. Therefore, it is required to estimate risks upon forecasting of production well capacities, this is especially important at final stage of deposit development.

It should be taken into account that during design of gas deposit estimation of risk of average well capacity is interrelated with:

- limited number of analyzed exploration wells;
- high scatter in well capacities.

Estimation of risks upon bulk watering of wells with seam and condensation waters takes place at final stage of deposit life cycle. Peculiar difficulty upon estimation of all risks is related with economic risks since it is very difficult to reveal and to analyze material and financial demands which appear at all stages of deposit lifecycle, especially at final stage [12- 14].

During development of large gas deposit at final stage, it is required to take into account high consumption of material and financial resources. Therefore, several alternative projects are developed and then the most reasonable one is selected according to specific targeted criteria based on previously determined target.

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As mentioned above, achievement of the formulated target requires for high consumptions of material, financial, human, information, and other resources. The leading aim of a project is provision of preset gas extraction regarding years of development. Nevertheless, it should be based on minimum consumption of resources: only in this case maximum profit can be received (which is another major purpose) [15, 16]. Application of risk management upon implementation of gas deposit project at final stage involves forecasting and implementation of a set of measures to decrease and to eliminate situations leading to damages and losses. The risk management is carried out in stages.

The first stage: detection of possible risks at all stages of development of gas deposit project, that is, identification of risks. The second stage: quantitative estimation of possible losses or damages in case of each risk event (development of gas deposit project is based on gas dynamic models for estimation of possible process variables in productive layer and economic mathematical models for prediction of possible material damage). The third stage: formation and development of measures to reduce and to prevent possible risk among the detected risks. The fourth stage: cost estimation of implementation of the developed measures and comparison with the cost of damages in each case of risk event.

Then the experts make final conclusions about application of these or those measures to reduce risks.

RESULTS AND DISCUSSION

Risk reduction actions at the final stage of gas deposit development

All actions to reduce risks always require for supplemental expenses. Therefore, a company faces the problem to detect the level of expenses for risk reduction, however, it should be taken into account that business activity of the company and its departments should remain efficient and profitable.

The risks during development of gas deposits as well as operation of all production facilities should be reduced as follows:

- provision of reliable operation of equipment at the deposit;
- development and improvement of control methods and tools for all production processes;
- development and implementation of CAD and management systems for development of gas deposits.

Application of modern machinery and technologies used for extraction of hard-to-recover gas reserves is unreasonable and, in some cases, impossible.

Stages of work in the development of deposits with hard-to-recover gas reserves

Therefore, development of deposits with hard-to-recover gas reserves requires for two stages. The first stage is comprised of arrangement of test sites for R&D activity:

- analysis of geology of cross section, core, fluids;
- test extraction of gas;
- verification of processing of raw materials extracted by these new technologies.

The second stage is comprised of:

- scaling up of the performed studies and activities;
- improvement of the technologies according to demands and unique essence of each gas deposit.

Each new project will require for supplemental financial investments for performing R&D studies, arranging pilot sites for preliminary developments as well as testing trial gas extraction.

It should be mentioned that upon further development of gas deposit, the risks related with implementation of innovative technologies are stipulated by difficulties of capacity forecasts and continuous watering of wells, which influences significantly the economic constituent.

Activities for rationalizing costs when developing fields with hard-to-recover gas reserves

Thus, in order to rationalize costs, at present it is necessary to perform a number of actions in a certain sequence:

- pilot tests using hydrodynamic simulator with consideration for various spatial disposition of wells and profiles of gas extraction in accordance with economic efficiency performances;
- additional 3D studies with development of 3D models at the area of at least 700 square kilometers [17, 15].

All activities should be performed in two years, thus eliminating numerous uncertainties, first of all, regarding geology. Herewith, the properties of deposits vary in significant ranges, which predetermines different expenses for gas extraction at each specific well.

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Determination of Hard-To-Recover Hydrocarbon Reserves

At present, the regulatory base of the Russian Federation does not define the notion of hard-to-recover hydrocarbon reserves. However, it should be mentioned that the existing scientific terminology clearly separates:

- reserves and resources;
- geological reserves and extractable reserves.

The Russian classification of reserves is based on the properties of hydrocarbon reserves used upon formation of United Nations Framework Classification:

- cost efficiency of field development;
- the degree of commercial development of the field;
- the degree of geological exploration of the deposit.

For the first time, the Russian classification of hydrocarbon reserves is supplemented by such notion as cost efficiency of deposit. Herewith, the criteria for groups of hydrocarbon reserves define not only commercial significance of the deposit but also the net present value determined by predicted indices of deposit development at fixed coefficients of discounting.

Thus, it is required to consider for the influence of various risks and uncertainty upon solution of weakly structured issues, including project development of any large has deposit, especially at final stage. This should be considered in management of various risks upon project development of gas deposit [7].

Therefore, hydrocarbon reserves can be considered as extractable, including hard-to-recover reserves, only when they are cost efficient upon extraction in competitive environment. Moreover, modern technical means and technologies of gas extraction should be used reasonably, complying with the requirements of protection of mineral resources and environment. The notion of hard-to-recover reserves is referred to deposits or developed sites characterized by unfavorable for gas extraction geological conditions and/or physical properties [18, 19].

Development of Cenomanian gas deposits in the north of West Siberia was based on step-wise commissioning of its individual sites determined by geological structure of deposit and asynchronous commissioning of facilities of integrated gas preparation. This circumstance stipulated heterogeneous lifting of gas water contact and heterogeneous distribution of seam pressure across deposits [20].

Herewith, the development of giant Cenomanian gas deposits in the north of West Siberia at present reaches its final stage, where the main negative factor influencing the coefficient of gas extraction is:

- watering of wells due to lifting of gas water contact;
- lateral penetration of marginal seam waters.

Increased watering of well products leads to formation of sand liquid plug at the bottom hole, hydrate formation, abrasive impact of sand on pipelines of casing connection and process equipment, which leads to unreasonable losses of formation energy. However, the main negative factor of penetration of formation water into the seam is pinching (formation of water barriers) of gas reserves. Only at Vyngapurovo deposit, the pinched reserves, according to simulations, equal to 7.8 bln m3 or 2% of initial reserves (Cenomanian deposit). After completion of deposit development using conventional methods of increase in gas recovery factor, the deposits will contain at least 1.5 tln m3 of gas, and more than 500 bln m3 of them will be low pressure gas in free state. This leads to decrease in final gas recovery, increase in development time, and, finally, to high material expenses for gas extraction. This factor stipulates deep analysis of motion of bottom waters, peculiarities and regulations of seam and well watering, mutual influx of liquids to bottom hole and studying of natural factors, promoting increase in waterless period of operation and improvement of technological conditions of deposit development aiming at the highest gas extraction [2].

CONCLUSION

The most preferable project of deposit development at the final stage should be based on predictions by criteria of economic efficiency both for the company and its single departments. However, the results of these predictions due to economic uncertainties at macro- and micro levels are characterized by high risks and can exert negative impact on selection of project alternatives. The effect of measures to decrease in risks upon development of gas deposits and operation of production facilities can be expressed by decrease in risk probability on the basis of:

- provision of reliability of facility operation (in particular, backing up of number of wells and field devices);
- implementation of methods and tools of control of production processes upon development of gas field at final stage;
- development and implementation of CAD and control systems of gas deposits.

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It is impossible to eliminate completely occurrence of risks, since it requires for high resource investments (material, human, economic) for acquisition of additional information and execution of analytical studies. Additional influence is caused by impossibility to forecast reliably future state of deposit and ambient environment (for instance, long-term economic situation in the world, probability of new sanctions).

Therefore, the analysis of issues of development of hard-to-recover gas reserves under conditions of market economy and provision of respective substantiated concept based on generalization of Russian and foreign experience are important and promising.

CONFLICT OF INTEREST

There is no conflict of interest.

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FINANCIAL DISCLOSURE

None.

REFERENCES[#]

[1] Vasil'ev YuN, Dubina NI. [2011] System approach and methods of system analysis upon design and development of gas deposits. Nedra, Moscow.
[2] Abdulin RS, et al. [2015] Technogenic risks upon production and transportation of hydrocarbons in Russian Polar Regions. Problemy sbora, podgotovki i transporta nefti i nefteproduktov. 1(99): 84-93.
[3] Vaganov YuV, Kustyshev AV. [2016] Estimation of economic efficiency of complicated maintenance of gas wells under varying operation conditions. Problemy ekonomiki i upravleniya neftegazovym kompleksom. 1: 13-16
[4] Vaganov YuV, et al. [2010] Improvement of maintenance in oil and gas wells of West Siberia. Stroitel'stvo neftyanykh i gazovykh skvazhin na sushe i na more. 8: 19-21.
[5] Vaganov YuV, et al. [2009] Estimation of construction quality of development wells in East Siberia. Tyumen: Oil and gas of West Siberia. Proceedings, International Conference devoted to 50-year anniversary of TyumII., TyumGNGU: 7-10.
[6] Ermilov OM et al. [2004] Features of geological structure and development of unique gas deposit at Far North of West Siberia. Russian Academy of Sciences, Siberian Brach, Novosibirsk.
[7] Vasil'ev YuN, et al. [2013] Uncertainties and risks upon design and management of gas deposit development. Vesti gazovoi nauki: Collection of works: Gazprom VNIIGAZ. 4(20): 16-29
[8] Kossov VV, Livshits VN, Shakhnazarov AG. (Eds.) [2000] Recommendations for efficiency estimation of investment projects. – 2-nd edition. Ministry of economy of the Russian Federation, National Committee for construction, architecture, and housing policy. Ekonomika, Moscow.
[9] Peaceman DW. [1978] Interpretation of Well block Pressures in Numerical Reservoir Simulation. SPEJ; Trans. AIME.
[10] Peaceman DW. [1983] Interpretation of Well block Pressures in Numerical Reservoir Simulation With Non square Grid blocks and Anisotropic Permeability, SPEJ, 23 (03): 531–543.
[11] Peaceman DW. Interpretation of Wellblock Pressures in Numerical Reservoir Simulation - Part 3: Some Additional Well Geometries. paper SPE 16976 presented at the 1987 SPE Annual Technical Conference and Exhibition, Dallas, 27-30.
[12] Ertekin T, Adewumi MA. [1995] Reservoir Simulation, Video Library for E&P Special-ists, Intl. Human Resources Development Corp., Boston, Massachusetts. USA
[13] Vaganov YuV, et al. [2017] Geological Aspects of Producing Reserves from Complex Gas Deposits. International Journal of Applied Engineering Research. 12(24): 16077-16082
[14] Phillips JL. [1984] Reservoir Simulation Technology-Results of a Survey, Proc., Boeing Computer Services Spring 1984 Colloquium for the Geosciences, Houston, USA.
[15] Kustyshev AV, et al. [2014] Estimation of environmental risks upon major overhaul and retrofitting of oil and gas wells]. Zashchita okruzhayushchei sredy v neftegazovom komplekse. 5:25-29.
[16] Emmanuel AS, Ranney JC. [1981] Studies of Offshore Reservoir With an Interfaced Reservoir/Piping Network Simulator. J Pet Technol 33 (03): 399–406.
[17] Kustyshev AV, et al. [2013] Estimation of risks upon maintenance of oil and gas wells. Bezopasnost' truda v promyshlennosti. 9:76-82.
[18] Nezhdanov AA, Turenkov NA. [2005] Modern geological and geophysical models of giant deposits of north regions of West Siberia. Gornye vedomosti. 3: 58-68.
[19] Oyewole A, Kelkar M, Pereyra E. [2018] Well performance modeling in unconventional oil and gas wells. SPE Annual Technical Conference and Exhibition 2018. Dallas, Texas, USA.
[20] Barbe JA. [1983] Reservoir Management at Dunlin. J Pet Technol 35 (01): 227–233.

[#]*English translations of the references are presented.*