THE PROSPECT OF GAS PRODUCTION AND SPECIFIC FEATURES OF DEVELOPMENT OF THE YAMAL PENINSULA

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ABSTRACT

The main resource base for developing the Russian gas industry in the prospect are gas and gas condensate fields of the Yamal peninsula and adjacent shelf prepared for industrial development (proven gas reserves only for the onshore part of Yamal are $10.5 \times 10^{12} \text{m}^3$). Potential possibilities of gas production from the Yamal fields equal to $250 \times 10^9 \text{m}^3$, about $4.5 \times 10^6$ gas condensate and almost $7 \times 10^6$ tons of oil annually.

The particular feature of the Yamal fields development is a complicated geological structure. In terms of difficulties of development, construction and operation of engineering facilities there no objects similar to Yamal in the world.

The investigation focus is made upon the located in complicated natural-climatic conditions intricate-structured gigantic accumulations of hydrocarbons of similar geological structure, which fact enables to work out a unified methodical approach in the process of their development and operation.

At present, there is accumulated unique experience in designing the development and exploration of unprecedented massif and formation-massif deposits of Medvejye, Urengoi, Yamburg and other fields of West Siberia which will be used in the practice of exploration and development of the Yamal fields.

The new technical approach to developing the field is the use of a single-pressure system of gas collection thus allowing to significantly reduce the scope of engineering surface constructions, which is extremely important for specific geo-cryologic conditions of Yamal.

The use of the unified system of gas preparation for distant transportation from gas and gas condensate deposits allows to make operation less expensive and secure higher reliability of site operation.

The use of the unified methodical approach while exploring multi-formation deposits allows to obtain a flexible system of development with maximum HC recovery.

New methodic approach allowed to create a reliable high-tech system of development with maximal reduction of metal consumption at the surface engineering facilities, which is very important to meet strict environmental rules of Yamal.

New technical solutions enabled obtaining significant economic effect and achieve profitable development with the existing world prices for HC feed.
1. PREAMBLE

The main regulations in the Energy Strategy of Russia for the period till 2020 forecast the gas production growth in the Russian Federation up to 615-655 $10^9$ m$^3$ in 2010 and 660-670 $10^9$ m$^3$ in 2020. Gazprom’s share in this production is to be no less than 530 $10^9$ m$^3$/yr.

The basic Gazprom's fields have entered a declining production period with an annual gas withdrawal decline by 20-25 $10^9$ m$^3$. This situation requires yearly development of new fields.

During the period till 2010 gas production decline on “base” fields will be compensated at the expense of the development of new fields of Nadym-Pur-Taz region.

After 2010, when the Nadym-Pur-Taz fields are depleted, deficient gas volumes can be compensated by the development of new gas-bearing regions (Yamal Peninsula, Gulf of Ob, Taz Bay and Barents Sea shelf) and Nadym-Pur-Taz Achimovian deposits.

Yamal Peninsula is a most promising oil and gas-bearing region of West Siberia. 11 gas and 15 oil and gas condensate fields have been discovered within this region. The Yamal gas potential including the adjacent shelf is estimated at 50.5 tcm of gas and 5 billion tons of liquid HC.

The structure of proven reserves of the discovered fields is as follows:

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<tr>
<td><strong>Gas</strong></td>
<td>$10.4 \times 10^{12}$ m$^3$</td>
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<tr>
<td><strong>Condensate (recoverable)</strong></td>
<td>228.3 $10^6$ ton</td>
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<tr>
<td><strong>Oil (recoverable)</strong></td>
<td>291.8 $10^6$ ton</td>
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The ultimate reserves of the Bovanenkovskoye, Kharasaveyskoye and Novoportovskoye fields the licenses on which belong to JSC Gazprom include:

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<tr>
<td><strong>Gas</strong></td>
<td>$5.8 \times 10^{12}$ m$^3$</td>
</tr>
<tr>
<td><strong>Condensate (recoverable)</strong></td>
<td>100.2 mln t</td>
</tr>
<tr>
<td><strong>Oil (recoverable)</strong></td>
<td>227.0 mln t</td>
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The reserves of a main Aptian-Cenomanian productive complex of the Bovanenkovskoye and Kharasaveyskoye fields have been prepared to commercial development. In future, a part of the Kharasaveyskoye field and Neocomian-Jurasic deposits of the Bovanenkovskoye field will require supplementary exploration.

Producing potential of the discovered land fields of Yamal Peninsula is estimated at 250 $10^9$ m$^3$/yr. This gas production level will enable a long-term (no less than 25 years) compensation of gas decline in Nadym-Pur-Taz region without putting into service additional reserves of other regions.

2. PROBLEMS OF YAMAL GAS FIELDS DEVELOPMENT

Considering the significance of the situation Gazprom’s institutes headed by VNIIGAZ and the Administration of Yamalo-Nenets Autonomous Area worked out in 2000-2002 a “Complex commercial development program for Yamal Peninsula and the adjacent offshore areas”.

The Program was drawn up by the results of multiyear research work carried out in VNIIGAZ together with other appropriate organizations (more than 100 research, project and production organizations) on the problem of the Yamal resource development including socio-economical and environmental aspects.

The main problems of the Yamal resource commercial development are related to environmental protection. To tackle this problem JSC Gazprom has worked out an Advanced research program unprecedented by scale and volume of financing. The program is intended for developing environmentally sound technologies, minimizing environmental impacts and preserving and developing unique culture, ethnos and traditional forms of activity of local nations.

The realization of this project has allowed to obtain extensive information about the Yamal ecosystem and to construct mathematical models for describing natural and technogenic processes that take place on the peninsula during construction and operation of oil and gas facilities.

The results obtained made it possible to conclude that the commercial development of the Bovanenkovskoye and Kharasaveyskoye fields, including the construction of gas mains and railway, will not lead to irreversible ecological consequences on the peninsula.

Now new engineering solutions for improving economic indices of the project and cutting starting investments are planned to introduce on the Bovanenkovskoye and Kharasaveyskoye fields. It is likely that the largest Bovanenkovskoye field will be the first that starts the development of the Yamal fields.

The Bovanenkovskoye oil and gas condensate field is located in the northwestern part of Yamal, 450 km north of the town of Salekhard.

The sedimentary cover of Yamal oil and gas-bearing province includes structural-lithologic complexes, simultaneously being oil and gas-bearing Albian-Cenomanian, Neocomian-Aptian and
Jurassic deposits. Productive layers are found in a stratigraphic interval at depth of 532-3207 m, from Cenomanian to Jurassic periods. In total, there are 24 productive layers, of which 9 upper formations are pure gas reservoirs. Achimovian section of Berriasian is expected to be productive.

3. CHARACTERISTICS OF YAMAL GAS FIELDS

From the viewpoint of development the Bovanenkovskoye field deposits can be divided into two thick multilayer complexes:

- **Upper** (532-1500 m) Cenomanian-Aptian (with gas accumulations)
- **Lower** (1700-3207 m) Neocomian-Jurassic (with gas condensate accumulations)

Pressure in the complexes corresponds to hydrostatic. By HC composition, the most gas accumulations contain non-commercial condensate (less than 2-3 g/m³). As for the structure, the accumulations are bedded and arched, in the top - mainly bedded-massif. In Aptian section, gas is accumulated in a roof part (horizons TP1-6 – Bovanenkovskoye, Kharasaveyskoye).

Gas accumulation in Cenomanian (PK1) and the upper part of Tanopchinian deposits (PK9, PK10, HM1, HM2, TP1-6, TP7-8, TP9, and TP10-11).

Gas reserves in Cenomanian-Aptian productive deposits, proved by the FSU State Committee on Reserves in 1982, amount to 3450.7 and 32.4 10¹² m³ respectively for Category C¹ and Category C².

Development of the Bovanenkovskoye field’s Senomanian-Aptian deposits has been designed since 1986 based on the requirements the gas industry was facing at that time.

The development design included the division of the productive interval into two parts, namely Cenomanian and Albian-Aptian. Originally, 780 producing wells had to be drilled, with an annual gas production aiming at 160 10⁹ m³. Each well cluster is expected to include up to 20 wells for penetrating the first and second productive intervals.

Different formation pressure in the intervals required the construction of two gathering systems, i.e. low and high pressure. In this case virtually each well cluster had to be connected to two field pipelines. The use of such system assumed gradual switching of the wells from the lower interval to the upper one and hence switching to the other gathering system. This approach allowed a quick growth in production and at the same time compensation of the decline in production for Gazprom in whole with maintaining required economic efficiency.

However, the decrease in gas demand in Russia and putting other fields of the developed Nadym-Pur-Taz province into service allowed postponing the Yamal resource development. In spite of this fact Gazprom’s research institutes went on their activity on improving approaches to the development of Yamal Peninsula, including its priority object - the Bovanenkovskoye field.

The gas sector development planning foresees a required volume of gas production on Yamal. For example, an optimal annual production of gas on the Bovanenkovskoye field was estimated at 115 bcm. The latest technologies on improving gas production efficiency were used in a new development project. In addition, summary efficiency of gas supplies to end-users was also evaluated with regard to the development of gas transmission systems including pipeline crossing of the Baidaratsk Bay, on-land pipelines across Yamal and gas supply to the Yamburg pipeline system.

Therefore, by 2000, when there existed the sufficient experience in designing and long operating (including directional and horizontal wells) the unique massif and bedded-massif deposits of the Medvezhye, Urengoi, Yamburg and other fields of West Siberia, approaches to the development had been refined.

4. NEW TECHNICAL APPROACHES

Much attention was given to developing new design techniques, especially computer technologies that allowed constructing 3D geological models of the Bovanenkovskoye and Kharasaveyskoye fields. The models were used for analyzing scenarios of several layers penetration with one well and combining groups of layers into development objects. A number and location of well cluster sites were defined again.

Well cluster sites were chosen based on the environmental requirements including high ice content in surface ground. This measure was undertaken to provide temperature conditions of wells under operation and to prevent permafrost thawing. Heat-insulated pipes were developed for tubing top part. The pipes have passed a 4-year test on drilled wells of the Bovanenkovskoye field. The results of this research activity made it possible to conclude that the distance between wellheads could be decreased to 20 meters and thus earth works and building materials for constructing well cluster sites could be considerably reduced.
Detailed geological and hydrodynamic models allowed substantiating a character of striking a productive formation of different objects. For example, for the main object (formations TP1-6) directional wells with a hole angle increasing with moving away the central domical part of limbed stratum. Horizontal and dual wells were recommended for strata with thin pay section. As a result, the revision of well design that was carried out for providing maximum outputs and eliminating production problems allowed cutting a well stock by 20%.

The analysis of different scenarios intended to provide planned gas production made it possible to suggest such a sequence of putting objects into service at which the use of one-head gas gathering system became possible. In this case new wells of other objects are connected to field gas gathering pipelines after wellhead pressures of a well cluster are equalized. A number of wells and working outputs are planned by years for each object in such a way at which gas is extracted without disturbance of permissible well operation conditions. In other words, all wells are operated without exceeding maximum pressure drawdown and outputs, without damaging bottom-hole zone and with cleaning bottom hole from liquid. The use of one-head gas gathering system enabled to reduce a number of field pipelines, postpone commissioning date for boosters and reduce construction costs.

Gas quality is a vital part of effective long-distance gas transportation. To solve this problem several variants of field gas conditioning, including adsorption and glycol dehydration and low-temperature separation (LTS), have been analyzed. A peculiarity of field gas conditioning was that some formations contained small concentrations of condensate (<2-3 g/m³). At the same time commissioning priority of separate objects was scheduled in such a way that a share of condensate-containing gas changed in time.

Besides, after 15 years of development gas is planned to produce from underlying formations with a high content of condensate (70-230 g/m³). In this case low-temperature separation will be used for field gas conditioning. At the time being, such gas is planned to treat at separate units. However, these units will be located and serviced at the same field as the units for treating Cenomanian-Aptian gas.

From the above, medium pressure LTS units are recommended for the Bovanenkovskoye field that will provide high guarantee of Cenomanian-Aptian gas quality even in case when condensate content exceed an estimated value. However, adsorption dehydration is less sensitive to a change in operation conditions of field equipment. Therefore, in detail evaluation of investments this technology will be considered as alternative.

Grouping of wells from different objects in one cluster will allow solution of one important problem more. The difference in thermobaric conditions of separate strata occurrence resulted in the use of hydrate inhibitor in wells of separate objects. This situation imposed the restrictions on design and length field gas gathering pipelines. The introduction of one-head gas gathering system made it possible to revise a gathering system and substantiate the construction of complex gas-conditioning units with high unit capacity. Currently two such units are planned to install on the Bovanenkovskoye field with a capacity being 30 and 60×10⁹ m³/yr. High capacity of the units will allow to cut investments and reduce environmental impacts.

5. RESULTS OF STUDIES

On the whole, one can state that new design options intended to improve engineering and economic indices and reduce starting investments have been suggested in the project of the Bovanenkovskoye field development:

- Advanced commissioning of Aptian-Albian deposits with an annual gas production of 115 bcm that will allow to shift a booster commissioning date to the 8th year of the field development. In future, when Cenomanian deposits are commissioned in the 13th year of the field development, the above gas production level will remain.
- The use of wells with increased diameter and subhorizontal ending and the decrease in their stock at the expense of enhanced reliability will allow to increase working outputs and reduce a number of producing wells.
- The recommended variant of the development of the Bovanenkovskoye field’s Cenomanian-Aptian deposits will allow meeting rigid ecological requirements and
  - reducing a well stock by 208 wells
  - decreasing a size of well cluster sites
  - postponing booster commissioning to 11 years
  - excluding the necessity in constructing the second low-pressure gas gathering system
6. CONCLUSION

Thus, the introduction of new engineering solutions into the Bovanenkovskoye field development will make it possible to cut considerably starting investments, to ensure operation safety of wells and field equipment, to reduce metal content and to meet ecological requirements. The improvement of economic indices made the project competitive in the current conditions and allowed considering it as one of the priority targets of JSC Gazprom.