Digital transformation of gas production

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Abstract. The development of the digital transformation of the gas industry in the Russian Federation is mainly aimed at unique and giant fields. These fields provide the leading position of Russia in the world gas market and about 85 % of the total volume of gas production. The regulatory and technical base, the composition of the existing standards allows us to move to the practice of introducing digital gas technologies. The creation of a unified integrated model is being completed at the Bovanenkovo field. The creation of a digital twin of a unique gas field represents the transfer of a real field into virtual space through the use of Big data analytics and supercomputer technologies.

1. Introduction

In 2023, the size of global gas demand will exceed 4.1 trillion cubic meters compared to 3.74 trillion cubic meters in 2017 according to the International Energy Agency. About 40% of the world's gas production will fall in equal proportions to Russia and the United States in the next five to six years.

Until the mid-60s, automatic devices in gas fields were practically not used. The start of digitalization of oil and gas fields is associated with the joint project of «SmartFields» by FMC Kongsberg Subsea and Statoil, which started in January 1997 and in January 1999 A / S Norske Shell joined it [1]. The introduction of digital technologies in gas production allows reducing production costs, increasing technological and environmental safety and ensuring highly efficient gas recovery [2-11].

In recent decades, the process of digitalization has accelerated due to the large number of fields at the final stage of production. Distributed control technologies have become widely used in the gas industry according to the Program of phased deployment of works on the creation of an industry system of operational control of the Unified gas supply system of Russia, approved by Gazprom. At the late stage of field development, the role of operational information increases. The creation of technologies for managing residual reservoir pressure is required [3].

The introduction of simple pneumatic and mechanical devices, telemetry and automation systems provided an improvement in the technical and economic characteristics of the fields by at least 10-30%, saved from 5-15% of capital investments and operating costs of at least 10-30% of the design indicators [4, 5]. The activities carried out to equip production wells with digital monitoring and control systems can quickly optimize well operation in the well, as well as prevent the destruction of the bottom hole zone and increase daily production by 10-25% [2, 4, 7, 8 and 10].
The practice of gas field operation shows that for the effective use of assets, priority is given to:

- new technologies for gas recovery and production management;
- Big data technology, for predictive analysis of the situation and the adoption of proactive impacts;
- reduction of technological and environmental risks of operation;
- widespread use of industrial Internet in the fields;
- application of distributed registry technologies (blockchain);
- providing virtual reality and augmented reality at technological facilities [12].

The existing regulatory and technical base, the composition of existing standards and regulations allows us to switch to the practice of the widespread use of digital technologies in gas production [12].

2. The digital transformation of gas fields

Today, PJSC Gazprom implements and successfully operates a unified control structure and the main production facilities at the following levels: the Central production dispatching service of PJSC Gazprom (the Company) - the production dispatching service Gazprom production region (the base enterprise) - the gas production administration (support base of the base enterprise) - gas field (field) - a cluster of gas wells (gas wells or remote technological facilities of the field). The architecture of the digital field includes technological facilities, a real-time monitoring system for gas operations; integrated gas production model; center for integrated production management; fiber-optic system for collecting and transmitting Big geological and geophysical data; geo-production data processing center [3, 4, 12].

Digital gas production technology allows for dynamic optimization and improving the quality of field operation management and includes:

- Digital adjustment and ensuring the adequacy of the integrated geological and technological model;
- Integrated calculation of material balance for wells, fields and the field as a whole;
- Calculation of reserves and execution of the corresponding reporting forms for writing off and paying the tax on natural resources production or severance tax for the field;
- Optimization of load distribution among wells and planning of capital repairs and stimulation;
- Adaptation of the field management system.

In recent years, 352 digital and automation systems have been created and modernized at 53 units of integrated and preliminary gas treatment at unique and large Arctic gas fields.
At the meeting of the Council on the priority direction of the scientific and technological development of the Russian Federation on November 29, 2018, Dmitrievsky and Eremin made a short message. After the discussion, the council members approved the proposal for the formation of the “Scientific and technical program "Digital and technological modernization of the world's largest West Siberian oil and gas production center". As part of the implementation of this program, at a meeting at the Ministry of Energy of the Russian Federation on August 8, 2019, joint proposals of the OGRI RAS with partners for the creation of “digital twins” of a gas field and gas pipeline on land and at sea were presented. The creation of a digital twin of a unique gas field represents the transfer of a real field into virtual space through the use of Big data analytics and supercomputer technologies.

To fulfill the state task of creating the main gas production center in the Arctic, the Bovanenkovo field was commissioned, which is the base field in the center of Yamal gas production (Figure 1). The Bovanenkovo field has been developed by three gas production facilities, which were consecutively brought into operation in 2012, 2014, and 2018. Effective and safe management of complex gas fields is possible with the use of modern highly reliable digital control and management systems. As of 01.01.2019, the operating well stock was 437 out of 777 planned wells. Daily gas production will reach 317 in 2019 compared to 264 million cubic meters in 2018. The annual production of 115 billion cubic meters of gas is planned for 2022. Gas reserves at the Kharasavey field exceed 2 trillion m³. Full-scale development of the field with elements of digitalization began in March 2019. The gas production is going to start in 2023. The planned annual production level will be 32 billion m³ of gas per year from its Cenomanian-Aptian deposits. The program for the development of the giant Chayanda field assumes the widespread use of integrated control elements and a unified information space at all stages of the field’s life cycle (collection of data, modeling, design, creation, operation, diagnosis and management of field objects, analysis of service life, risks of threats and safe operation).

The creation of an integrated system of this field is being completed. Every gas production facility with well pads (clusters) uses integrated digital systems and lightly manned technologies (Figure 2). The implementation of the integrated approach in production will provide modeling of the entire field, visualization of geological and geophysical information, dynamic optimization and improvement of the gas recovery management in real time (Figure 3).

Effective and safe management of the complex gas field is carried out on the basis of the use of automated process control systems "Promysel-1" and "Neman-R". In 2019, the production well stock amounted to 437 out of 777 planned wells. The daily gas production in 2019 will be 317, compared with 264 million cubic meters in 2018. The maximum level of project production from the Cenomanian (520–700 meters deep) and Apt-Albian (1,200–2,000 meters deep) deposits in the amount of 115 billion cubic
meters of gas will be achieved in 2022. This volume is equal to the total supply of Russian gas to Germany, Italy, the UK, France, and the Czech Republic in 2018. In the medium term, it is expected to enter into the development of Neocom - Jurassic deposits, which will increase annual gas production to 140 billion cubic meters [12].

In 2019, the partly digital development of the Kharasavey field with gas reserves of 2 trillion m³ was started; the beginning of gas production – 2023; the projected level of annual production from Cenomanian deposits is 32 billion m³ of gas. In the future, it is planned to develop more deeply located Neocom-Jurassic deposits. The field is mainly located on land, partly in the Kara Sea. Wells for the offshore part of the field will be drilled from the shore.

Figure 3. Operator console Bovanenkovo field. Source: Gazprom.

In the medium term, it is planned to begin development of the Kruzenshtern field and the Tambey group of fields with its recoverable reserves of 7.7 trillion cubic meters.

The Chayanda field is the base field for the Yakutsk gas production center and a resource base for the "Power of Siberia" gas pipeline. At the field, 143 production gas wells were drilled as of 01/01/2019. The development program of the Botuobin and Hamakin horizons of the giant Chayanda oil and gas condensate field involves the widespread use of integrated control elements and a single information space at all stages of the field’s life cycle (collection of field data, modeling, design, creation, operation, diagnostics and field management, threat risks and safe operation). Gazprom will use lightly manned technologies that provide for control equipment and integrated facility management. In the framework of providing design solutions for the project, the “Concept for managing field facilities (an integrated process control system of the Chayanda oil and gas condensate field)” was approved. Algorithms for integrated management of all remote objects of the field are being tested. The field provides for the use of a single information space along the entire technological chain "gas well pad or cluster - gas collection network - gas pre-treatment unit - field pipeline - integrated gas treatment unit - central booster compressor station - the receiving node of the main gas pipeline". Industrial gas production and gas supply from the Chayanda oil and gas condensate field to the «Power of Siberia» gas pipeline with a total length of 2150 km was provided for the planned dates for filling and commissioning of
communication systems and telemechanic of linear facilities on the pipeline. The digital control and management system will ensure the technological and environmental safety of the export gas pipeline in real time. The control center for the digital technological complex of the Chayanda field was created on the basis of domestic software and hardware and high-speed communication channels that will provide modeling and monitoring of the state of technological objects, as well as information interaction and diagnostics of all elements of the production chain.

Taking into account the operating experience of gas production facilities implemented on the principles of remote management, it is necessary to develop the “Concept of creating digital gas fields” in accordance with the recommendations of the standard of organization Gazprom 2-2.1-1043-2016.

A global urgent task is to create an interdisciplinary design and research environment, i.e. integration and interaction of fundamental and applied science specialists, students and teachers, industrialists and researchers from different countries to solve specific problems of the gas production.

3. Conclusions
The use of digital technologies provides the ability to remotely, lightly manned and uninhabited to manage the unique and large gas fields in the harsh Arctic conditions. Among the innovative technologies in the Arctic can be identified quantization of the collection and transmission of Big volumes of geo-field data via secure fiber optic channels, a digital oil and gas university, artificial intelligence methods, petrorobotics, predictive analytics, oil and gas wireless and satellite petroleum Internet of things (PIoT) and domestic software PJSC «Gazprom avtomatizatsiya». The modern practice of developing gas fields demonstrates a gradual shift from the blind gas technocracy of the last century towards the digitalization and harmonization of gas business. The digital gas production technologies allow extending the terms of cost-effective exploitation of the unique gas fields at the stage of decreasing production. Current gas production appears to be hybrid, in which digital and traditional exploration, drilling and production technologies coexist equally, which contributes to increased labor productivity.

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